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REPORT ON THE

2013 U.S. Environmental Protection Agency (EPA) International Decontamination Research and Development Conference

Office of Research and Development
National Homeland Security Research Center

REPORT ON THE

2013 U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA) INTERNATIONAL DECONTAMINATION RESEARCH AND DEVELOPMENT CONFERENCE

NATIONAL HOMELAND SECURITY RESEARCH CENTER
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

DISCLAIMER

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Questions concerning this report or its application should be addressed to:

Lukas Oudejans, Ph.D.
National Homeland Security Research Center
Office of Research and Development (E-343-06)
U.S. Environmental Protection Agency
109 T.W. Alexander Drive
Research Triangle Park, NC 27711
(919) 541 2973
oudejans.lukas@epa.gov

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EXECUTIVE SUMMARY

The 2013 U.S. Environmental Protection Agency (EPA) International Decontamination Research and Development Conference brought together scientists who are conducting chemical, biological, and radiological (CBR) recovery research, practitioners who are conducting remediation activities and those who set policies related to CBR decontamination. For three days at EPA's campus in Research Triangle Park, North Carolina, more than 170 national and international participants representing local, state, and federal government agencies, academia, industry, and public advocacy groups viewed presentations and actively engaged in panel discussions and a poster viewing session. This diverse audience brought together experts in emergency response, decision support tools, risk communication, sampling, detection, treatment, decontamination methods, and waste management related to biological, chemical, and radiological agents to explore current issues and future directions.

This Executive Summary outlines the events and presentations of the conference. The information is organized by topic; the Plenary Session, General Sessions, and Poster Session topics are outlined first, followed by topics covered during the Concurrent Sessions. Links to more detailed information are provided.

Plenary Session

Dr. Shawn Ryan, Division Director of the Decontamination and Consequence Management Division (DCMD) with EPA's National Homeland Security Research Center (NHSRC), Dr. Lukas Oudejans, Chairperson of the NHSRC Conference Organizing Committee, and Dr. Greg Sayles, Acting Director of NHSRC, welcomed participants to the conference and provided opening remarks. Dr. Greg Sayles introduced Mr. Lek Kadeli, the Acting Assistant Administrator of EPA's Office of Research and Development (ORD). Mr. Kadeli quoted EPA Administrator Gina McCarthy's First 100 Days message: "Each day my goal is to make EPA's work relevant and important to every community in the United States…everyone wants to ensure that their kids are healthy, that their communities and drinking water are safe and that their economies are strong". Mr. Kadeli recognized that these are the hallmarks of community sustainability and that's why EPA's mission to protect human health and the environment now encompasses every facet of preparing communities for the challenges ahead and strengthening their resiliency to bounce back the next time disaster strikes.

Dr. Peter Jutro (EPA) introduced the keynote speaker, the Honorable Dr. Richard J. Danzig, expert consultant to the Departments of Defense and Homeland Security and current Chairman of the Board of Directors for the Center for a New American Security. Previously, Dr. Danzig served as the 71st Secretary of the Navy (November 1998 – January 2001) and was a senior advisor to then Senator Obama on national security issues during the 2008 Presidential campaign.

Dr. Danzig underscored the importance of heroes, not only the traditional idea of leaders who step forward in a crisis, but also those who foresee the potential crisis and begin to prepare for it. As an example, the preparation for remediation following a wide area biological release is fraught with difficulties due to the unpredictable nature of such crises, including the type and amount of pathogen, the type of delivery, and the distribution of the resulting contamination. Dr. Danzig commended efforts such as the federal multi-agency Bioresponse Operational Testing and Evaluation (BOTE) study and the Scientific Program on Reaerosolization and Exposure (SPORE) program and stressed the need for similar tools that the scientific community can use to provide definitive answers to policy makers based on conclusive data. Dr. Danzig also discussed the issues of time and scale, emphasizing the importance of identifying priorities, demanding more situational awareness information, and communicating clear and concise information to policy makers now to prepare an "all-hazards" response rather than waiting to respond once a crisis has already occurred. **Section 2 of this report provides additional detail on the opening remarks, keynote presentation and other points raised during the plenary session.**

General Session 1 – Outcome Tabletop Exercise, Guidance, and Response

The first general session consisted of seven presentations from representatives from federal agencies of the United States, Canada, United Kingdom, and Japan. The first presentation explained how the private sector in Canada can help with the assessment and remediation process following a chemical, biological, radiological, nuclear or explosive (CBRNE) weapon incident. The second and third presentations given by representatives from Public Health England outlined guidance available in the United Kingdom, including Recovery Handbooks for chemical and biological incidents. These documents are not considered substitutes for specialist advice but would aid decision makers in the development of a recovery strategy.

The fourth presentation summarized ongoing research surrounding the accident at the Fukushima Daiichi nuclear power plant. The behavior of the radionuclides emitted into the environment and the appropriate treatment and disposal technologies for the radioactively contaminated waste were described. The fifth presentation showed the Hazard Mitigation Science and Technology Program for the U.S. Department of Defense (DoD), which funds research to find new technologies and methods with the goal of limiting the spread of contamination, returning equipment and facilities to normal mission operation, and enabling operations at reduced levels of protection, among other goals.

The DoD presentation was followed by a presentation on the United Kingdom Government Decontamination Service. In addition to providing an overview of the agency's ongoing activities, this presentation identified efforts of developing and testing standard operating procedures in response to a wide area biological release. A discussion on the Biological Response and Recovery Science and Technology Roadmap wrapped up the first general session. This working document helps categorize key scientific gaps in the response to a biological incident, identify specific technological solutions, and prioritize research activities to enable the government to make decisions more effectively. **Section 3 of this report provides additional details on these presentations and other points raised during this first general session.**

General Session 2 – Decision Support Tools

The common theme for the nine presentations in this session was to provide the conference attendees with information on available software tools that can be used as part of a structured decision-making process for response and remediation. Presenters described the tools and applications related to:

- quick urban and industrial complex (QUIC) dispersion modeling (Los Alamos National Laboratory),
- comprehensive decision support tool for agricultural security (Sandia National Laboratories and DHS)
- visual sampling plan (VSP) tool (Pacific Northwest National Laboratory),
- decision support toolset for weapons of mass destruction crisis management (US DOD Defense Threat Reduction Agency),
- utility of the tactical dynamic operational guided sampling (TAcDOGS) tool (Johns Hopkins University Applied Physics Laboratory),
- decontamination strategy and technology selection tool (DeconST) (Sandia National Laboratories and US EPA),
- decision support tool for use in carcass management (Cubic Applications, Inc.),
- update of the waste estimation support tool (WEST) (US EPA), and
- interactive all-hazards waste management plan development tool (US EPA).

All tool developers participated in a one-hour panel discussion regarding the use, training, inter-connectivity, and future of these tools. Conference participants then attended demonstrations of these tools. **Section 4 of this report provides additional detail on the decision support tool presentations given during this session.**

General Session 3 – Risk Communication and Systems Approach & Food Safety-Decontamination and Disposal Issues

The second day of the conference began with a general session focused on risk communication and systems approach. The importance of professional and public perception, risk communication messaging, and social media following a contamination event and subsequent decontamination and remediation was emphasized. The first presentation compared professional and public assessments of critical information needs and evaluated messages developed during previous workshops for appropriateness and effectiveness. The second presentation focused on the research need for risk communication practices during the remediation phase of a biological incident. One conclusion of that study was that emergency management personnel may benefit from including the influence of social media in their risk communication, because the social media provide a tool that is not fully utilized at this time. A third presentation on a systems approach to characterize the social environment for decontamination and resilience concluded that meeting technical clearance goals after remediation may not be enough to ensure re-occupancy and reuse of an area as social factors such as community ties and sense of place influence re-occupancy decisions. **Section 5 of this report provides additional detail on these three presentations and other points raised during this third general session.**

The final presentation of the third general session focused on food defense defined as efforts to prevent the intentional contamination of food products by biological, chemical, physical, or radiological agents. Lessons learned are also applicable to accidental contamination. The presentation highlighted the current research and challenges in the detection, decontamination, and disposal of contaminated food. **Section 6 of this report provides additional details on this presentation.**

General Session 4 – Low Tech/Self Help

The third and final day of the conference commenced with the fourth general session highlighting low tech and self-help approaches to decontamination. The first presenter discussed laundering of radioactively contaminated materials to reduce exposure to radiation. Washing clothing was found to be effective in removal of radiological contamination with the majority of the contamination transferred to the wastewater. The second presenter reported an experimental study in which high efficiency particulate air (HEPA) vacuuming and compressed air dusting were used to remove radiological contamination from sensitive (electronic) devices such as cell phones, numerical keypads, and responder bags. Both approaches were highly effective in removing contamination although the compressed air had a tendency to spread contamination. A third presentation summarized the efficacy of sporicidal wipes and addressed the question of whether or not these wipes can be used to treat anthrax “hotspots” on nonporous surfaces. Sporicidal wipes containing bleach were found to be more efficacious than others. The presenter also noted that disinfecting wipes as typically found in grocery stores showed no sporicidal activity. The final presentation in this session commented on the use of chlorine bleach solution to treat contaminated wastewater. Results showed that both pH-adjusted bleach (as per National Response team (NRT) guidelines) and diluted bleach are both highly effective for inactivation of *B. atrophaeus* spp. *globigii* (*Bg*), a surrogate for *B. anthracis*, in wash waters. **Section 14 of this report provides additional detail on these presentations.**

General Session 5 – Foreign Animal Disease Research

The fifth and final general session wrapped up the conference with a focus on foreign animal disease-related research. The first presenter reported on lessons learned from low pathogenic avian influenza outbreaks in Virginia and their relevance to an agro-terror attack or foreign animal disease (FAD) outbreak. Transportation and disposal issues following a large scale FAD outbreak were the main topic of the second presentation in this session. The third presenter showed an approach to decontaminate vehicles using a fully autonomous and portable wash tunnel. Although originally designed to be used in response to an FAD outbreak, the system could also be used during the response phase following a biological or radiological incident. The last presenter in this session described the findings from a combustion study involving disposal of contaminated livestock using a pilot-scale air curtain burner. Initial results showed no viable spores in the burner exhaust gases, indicating satisfactory combustion conditions. **Section 20 of this report provides additional detail on the presentations given during this session.**

Mr. Juan Reyes, Acting Associate Administrator with EPA's Office of Homeland Security and Lukas Oudejans (EPA) made final remarks, thanked the conference planning team, and dismissed the conference.

Poster Session

An afternoon poster session on the second day of the conference provided a break between sessions, with 18 posters representing a range of decontamination-related issues. Topics included techniques for decontamination of various surfaces and environments, emerging technologies that allow faster and more accurate evaluation of onsite contamination and fate and transport studies of various contaminants in environmental and municipal systems. **Section 11 of this report provides the abstracts of the posters presented during this session.**

Concurrent Sessions

The following biological, chemical and radiological agent sessions were conducted concurrently during the second and third day of the conference to allow broader coverage of topic areas. The concurrent sessions focused on various aspects of biological, chemical, and radiological contaminants and decontamination techniques, including sessions specifically covering water and wastewater management.

Biological Agents:

Decontamination

The first of two biological agent decontamination sessions opened with a presentation on new processes for decontamination using aqueous gels and foams. Various products were described with specific mechanisms (e.g., self-drying and cracking gels or gelling foams) to decontaminate surfaces or volumes contaminated with radiological, biological, or chemical agents. Next, the results of a study assessing the efficacy of low level chlorine dioxide fumigation for anthrax decontamination in a mock office environment were presented to allow more companies that can generate low concentration chlorine dioxide to assist in remediation efforts. The next presentation explored the efficacy of methyl iodide fumigation techniques for a variety of surfaces contaminated with anthrax with a focus on remediation of irreplaceable historical artifacts. Methyl iodide was found to be more detrimental to historic pictures than methyl bromide while methyl iodide may be more appropriate for nonporous surfaces. The session concluded with a video about returning Gruinard Island, Scotland, to an environmentally acceptable state appropriate for civilian use following an anthrax biological warfare test by the British military in 1942. **Section 7 of this report provides additional detail on the presentations given during this first biological agent decontamination session.**

Biological agent decontamination was also covered during a second concurrent session on the following day. This session opened with a presentation of the results of research evaluating six decontamination technologies used to inactivate anthrax cells in soils. Four of the tested approaches resulted in better than 6 log reduction in both *B. anthracis* and the surrogate *B. subtilis* spores. Another study examined various chlorine dioxide formulations as a biocide alternative to methyl bromide in the decontamination of soil. A third presentation elaborated on survival of anthrax after exposure to hot humid air as a decontamination method for sensitive equipment with no impact on the functionality. The final presentation during this session explored aerosol delivery of liquid decontaminants (oxidants, enzymes) as an aid in decontaminating complex, confined, or "hard-to-reach" spaces. **Section 18 of this report provides more information about the presentations given and points raised during this session.**

Sampling and Detection

The biological agent sampling and detection session opened with two presentations that provided results of evaluations of various vacuum sampling methods for anthrax spores. The first presentation evaluated previously identified vacuum technologies by optimizing sample processing protocols while the second presentation focused on results obtained by sampling using robot cleaners in an effort to cover larger areas with one sample that would result in lower cost and risk to the sampling personnel. This presentation was followed by a summary of findings after assessing available commercial off-the-shelf (COTS) hand-portable biodetection equipment. The session concluded with a presentation on the effects of various agents (i.e., pH-adjusted bleach, chlorine dioxide, and vaporous hydrogen peroxide) used for anthrax decontamination on the rapid viability polymerase chain reaction (RV-PCR) method of anthrax spore detection. Data showed that the RV-PCR method could allow higher throughput analysis of post-decontamination clearance samples as compared to the traditional culture-based analysis. **Section 9 of this report provides more detail on these four presentations.**

Fate and Transport

The biological agent fate and transport session kicked off with a presentation on the quantification of the re-aerosolization of bacterial spores deposited on flooring (carpet and vinyl) by decontamination personnel walking across the surfaces. The next three presentations were associated with the Scientific Program on Reaerosolization and Exposure (SPORE), a cooperative effort involving multiple federal agencies. The first presentation provided an overview of the SPORE initiatives and objectives. Four priority gaps were identified, namely, development of appropriate and validated air sample collection methods for reaerosolized viable and inhalable spores, determination of the degree of reaerosolization, determination of suitable surrogates or simulants, and determination of sampling and analytical methods as well as sampling strategies. This presentation was followed by a detailed description of a SPORE project focused on quantitative resuspension of anthrax spores from common surfaces. This session was wrapped up with the description of another SPORE project to evaluate suitability of *Bacillus thuringiensis* var. *kurstaki* (*Btk*) as a behaviorally representative surrogate for *B. anthracis*. **Section 12 of this report provides additional details on the presentations regarding fate and transport of biological agents.**

Persistence

The biological agent persistence session began by presenting the results of a large-scale sampling of soil across the U.S. for *Bacillus* sp. and *Bacillus anthracis.* Threshold values were identified as prospective investigative tools in determining whether an anthrax outbreak was 'potential' or 'probable' at any given geographic location in the contiguous United States. This presentation was followed by an assessment of the persistence of vegetative *B. anthracis* in the environment as a function of relative humidity and after ultraviolet (UV) exposure. **Section 15 of this report provides additional details on these two presentations.**

Chemical Agents:

Sampling and Detection

The session on chemical agent sampling and detection began with a presentation reviewing methods used at U.S. Army chemical agent disposal facilities for decontamination, waste management, and verification techniques to allow closure of facilities and return of the facilities to public use. Near real time and/or sorbent tube monitoring was used to detect residual agent, and unventilated air monitoring was used to verify whether decontamination was effective. The presentation also discussed the events and lessons learned from the ESS Pursuit incident. The next speaker described the results of a study conducted to evaluate analytical laboratory protocols for identifying and measuring chemical warfare agents (CWAs) in environmental matrices. The speaker also discussed the shelf lives of the ultra-dilute solutions that allow EPA to handle CWAs. The third presentation introduced EPA's mobile laboratory asset, the Portable High-Throughput Integrated Laboratory Identification Systems (PHILIS). The presentation explained how its successful onsite analysis aided the cleanup of residential areas in Vermont. This application illustrates the dual use of these mobile assets as their mission includes the ability to analyze CWAs and toxic industrial chemicals (TICs) in environmental samples. The next presentation wrapped up the session with a description of EPA's Trace Atmospheric Gas Analyzer (TAGA) mobile laboratory containing a direct air monitoring instrument employing triple quadrupole mass spectrometry. Work on the real-time detection of CWAs will have the potential to help first responders in the event of such releases. **Section 8 of this report provides additional detail on chemical agent sampling and detection.**

Fate, Persistence and Transport

The chemical agent fate, persistence, and transport session began with a presentation that focused on efforts to model and predict fate and transport processes of CWAs on surfaces following chemical contamination. Modeling efforts of laboratory experiments were successful in many cases. However, some data suggest agent transport limitations across the surface of droplets exists, leading to the conclusion that modeling and experimentation must be coupled to become more useful in prediction of the fate of CWAs. The second and last presentation in this session discussed the effects of temperature and humidity on adsorption and desorption of CWAs by activated carbon beds that informs the engineering controls required during hot air decontamination. Results for sulfur mustard and sarin indicate that breakthrough times from carbon beds are affected by temperature, but not in a consistent manner across various carbon types. **Section 13 of this report provides more detail on these two presentations.**

Decontamination

The chemical agent decontamination session kicked off with a presentation explaining the issues and potential evaluation of sampling and decontamination techniques associated with improper indoor use of pesticides to control pests (e.g., bed bugs). Three project goals were identified: develop sampling and modeling approaches to evaluate surface residues, develop surface concentration threshold values to determine if remediation is needed, and determine the efficacy of decontaminants. Challenges associated with the analysis of Lewisite during decontamination studies were discussed in a second presentation. Various analytical approaches including cool on-column gas chromatography and derivatization of Lewisite followed by gas chromatography were discussed as possible aids to determine Lewisite decontamination. The third presentation focused on the effectiveness of various textile technologies (wipes) in decontaminating skin and personal protective equipment. Wipes were evaluated against various chemical warfare agents, and the results indicate performance equal to a Fuller's Earth pad. The session closed with a presentation explaining the development of the Hazard Mitigation, Material and Equipment Restoration (HaMMER) advanced technology demonstration program, designed to advance the assessment and integration of new products into hazard mitigation. Results from this DoD program indicate that the decontamination processes and products tested can significantly reduce remaining chemical agent hazards to well below military requirements if used in a synergistic manner. **Section 17 of this report provides additional detail on these presentations relating to chemical agent decontamination.**

Radiological Agents:

Fate, Transport, and Decontamination

The radiological agent fate, transport and decontamination session started with a presentation exploring the fate and transport of radionuclides on common urban surfaces, followed by a presentation of an investigation of the sorption and speciation of the same radionuclides. The third presentation explained the challenges and knowledge gaps involved in applying various tested radiological decontamination technologies to urban environments. The session concluded with a presentation on humic acid-based sorbents applied to toxic substances. **Section 10 of this report provides additional details of these presentations regarding radiological agents.**

Water and Waste Water Management

The first water and waste water management session began with a presentation outlining an investigation of the United Kingdom's capability to manage contaminated water in drinking water treatment facilities and sewage treatment plants. Water treatment facilities generally know what treatment processes to use; however, with many counties participating, no data harmonization occurs, hence detailed information would be required on actual capacities to identify any area at risk. An update on water decontamination activities followed, including an outline of the Critical Infrastructure Partnership Advisory Council's (CIPAC's) framework for decision makers to aid in decontamination of chemical, biological, and radiological agents from water systems. A disposal guide and preparedness tool that serves as a reference to assist water utility actions was discussed. **Section 16 of this report provides additional detail on these two presentations on waste water management.**

The second waste and waste water management session opened with the author presenting selected results from the US EPA Homeland Security Research Program's projects to evaluate treatment and system decontamination options for water and wastewater. Of particular interest is the design and development of a water security test bed (WSTB) to investigate chemical, biological, and radiological detectors, decontaminants, and decontamination procedures at full scale. The next presenter outlined a report released by the National Homeland Security Research Center titled "Decontamination of Drinking Water Infrastructure: A Literature Review and Summary." The same presenter also provided a more detailed description of aforementioned planned WSTB experiments. This presentation was followed by a presentation elaborating on the Irreversible Wash Aid Additive Process, which washes radioactive cesium from surfaces and renders the radionuclide environmentally immobile. The presentation on the Irreversible Wash Aid Additive Process also included results from a full scale demonstration to decontaminate a vehicle while preventing the release of contaminated water into the environment through the use of rapidly deployable barriers. The session concluded with a presentation on the fate of radionuclides deposited on various components of drinking water distribution systems. **Section 19 of this report provides more detail on these presentations and other points raised during this second waste water management session.**

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Acronyms and Abbreviations

Abbreviation/Acronym	Definition
AAHP	Aerosolized Activated Hydrogen Peroxide (project)
ABS	acrylonitrile butadiene styrene
ACB	air curtain burner
AG	agricultural
AHLC	(U.S.) Army human lethal concentration
AOP	advanced oxidation processes
APCI	atmospheric pressure chemical ionization
APHIS	Animal and Plant Health Inspection Service
ASTM	American Society for Testing and Materials
ATD	Advanced Technology Demonstration
AWARE	analyzer for wide-area restoration effectiveness
AZTD	Arizona Test Dust
Ba	*B. anthracis*
Bg	*B. atrophaeus* spp. *globigii*
BOTE	Bioresponse Operational Testing and Evaluation
BROOM	Building Restoration Operations Optimization Model
Bt(k)	*B. thuringiensis (var kurstaki)*
°C	degree(s) Celsius
CAD	compressed air dusting
CARC-W	water-dispersible chemical agent resistant coating
CBDP	Chemical and Biological Defense Program
CBR	chemical, biological, and radiological
CBRNE	chemical, biological, radiological, nuclear or explosive
CD	chlorine dioxide
CDC	Centers for Disease Control and Prevention
CEA	(French Atomic Energy) and Alternatives Energies Commission
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
CFU	colony forming unit(s)
CFIA	Canadian Food Inspection Agency
CIDAS	Contamination Indication/Decontamination Assurance System
CIPAC	Critical Infrastructure Partnership Advisory Council
ClO_2	chlorine dioxide
cm	centimeter(s)
CM	countermeasure
CMA	Chemical Materials Activity
CMAT	(U.S. EPA OEM) Consequence Management Advisory Team
COMMANDER	(U.S. EPA's) Consequence Management and Decontamination Evaluation Room
COTS	commercial off-the-shelf
CT	contact time
CVAA	2-chlorovinyl arsonous acid
CVAOA	2-chlorovinyl arsonic acid
CW	contaminated water
CWA	chemical warfare agent
DAT	days after treatment
DCM	dichloromethane (methylene chloride)
DCMD	Decontamination and Consequence Management Division
DeconST	decontamination strategy and technology selection tool

Abbreviation/Acronym	Definition
DHS	(U.S.) Department of Homeland Security
DHHS	(U.S.) Department of Health and Human Services
DI	deionized (water)
DOD	(U.S.) Department of Defense
DOE	(U.S.) Department of Energy
DQO	data quality objective
DST	Decision Support Tool
DTRA	(DOD) Defense Threat Reduction Agency
ECBC	Edgewood Chemical Biological Center
ECD	electron capture detection
ECIS	Electric Cell-substrate Impedance Sensing
EDTA	ethylenediaminetetraacetic acid
EHS	environmental health and safety
EPA	(U.S.) Environmental Protection Agency
ERLN	(U.S. EPA's) Environmental Response Laboratory Network
ESF	Emergency Support Function
FAD	foreign animal disease
FDPP	Fukushima Daiichi (Nuclear) Power Plant
FDA	Food and Drug Administration
FE	Fuller's Earth
FEMA	Federal Emergency Management Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FMD	Foot and Mouth Disease
GB	Sarin, Isopropyl methyl phosphonofluoridate
GC/MS, GCMS	gas chromatography mass spectrometer
GD	Soman, *O*-Pinacolyl methylphosphonofluoridate
GDS	Government Decontamination Service
GF	Cyclohexylsarin, cyclohexyl methylphosphonofluoridate
GIS	Geographical Information System
GPD	General Purpose Decontaminant
GPD-HME	General Purpose Decontaminant for Hardened Military Equipment
HA	humic acid
HaMMER	Hazard Mitigation, Material and Equipment Restoration
HEPA	high efficiency particulate air
HD	bis(2-chloroethyl)sulfide
HLC	(U.S. EPA) human lethal concentration
HSRP	(U.S.) Homeland Security Research Program
HTH	high test hypochlorite
HVAC	heating, ventilation, and air conditioning
I-WASTE	Incident Waste Assessment and Tonnage Estimator
IC	Incident Command
ICs	interference chemicals
IDTES	Integrated Decontamination Test and Evaluation System
ISTC	International Science and Technology Center
IT	Information Technology
JBADS	Joint Biological Agent Decontamination System
JHU/APL	John Hopkins University Applied Physics Laboratory

Abbreviation/Acronym	Definition
JPM E (P)	Joint Program Manager Elimination (Provisional)
JPM P	Joint Project Manager for Protection
JSEW	Joint Sensitive Equipment Wipe
K_d	distribution coefficient
kg	kilogram(s)
L	Lewisite
L-1	2-chlorovinyl dichloroarsine (Lewisite)
L-2	bis(2-chlorovinyl) chloroarsine
L-3	tris(2-chlorovinyl) arsine
LCFI	CEA Laboratory of Chemistry of Complex Fluids and Irradiation
LC/MS	liquid chromatography/mass spectrometry
LDPE	Low-density polyethylene
LR	log reduction
m	meter(s)
µg	microgram(s)
µm	micrometer(s)
µM	micromolar(s)
MCL	maximum contaminant level
MDI	metered dose inhaler
MeBr	methyl bromide
MEG	(U.S. Army) military exposure guideline
mm	millimeter(s)
mM	millimolar
MS	mass spectrometry
MSW	municipal solid waste
MU	measurement uncertainty
NCDA&CS	North Carolina Department of Agriculture and Consumer Services
NELAC	National Environmental Laboratory Accreditation Conference
NFC	near-field communication
NHSRC	(U.S. EPA) National Homeland Security Research Center
NIDS	Nano-Intelligent Detection System
NIES	National Institute for Environmental Studies, Japan
NIST	National Institute of Standards and Technology
NRC	(U.S.) National Research Council
NRT	National Response Team
NTC	Naval ship topcoat
OEM	(U.S. EPA) Office of Emergency Management
OP	organophosphate
ORCR	(U.S. EPA) Office of Resource Conservation and Recovery
ORD	(U.S. EPA) Office of Research and Development
OSTP	(White House) Office of Science and Technology Policy
PAH	polycyclic aromatic hydrocarbon
PATH	prioritization analysis tool for all-hazards
PBST	phosphate buffer with 0.02 % Tween® 20
PCB	polychlorinated biphenyl
PCR	polymerase chain reaction
PCVD	plasma-based chemical vapor deposition

Abbreviation/Acronym	Definition
PDED	(U.S. EPA) pipe decontamination experimental design
PHILIS	Portable High-Throughput Integrated Laboratory Identification Systems
PHE	Public Health England
PNNL	Pacific Northwest National Laboratory
PPE	personal protective equipment
ppm	part(s) per million
PTFE	polytetrafluoroethylene
PVC	polyvinylchloride
qPCR	quantitative polymerase chain reaction
QUIC	quick urban & industrial complex
R&D	research and development
RDD	radiological dispersal device
RAM	(Time Critical) Removal Action Memo
RH	relative humidity
RIP	radiocesium interception potential
RRS	Rapid Return to Service
RTP	Research Triangle Park
RTSFM	radiologically tagged simulated fallout material
RV-PCR	rapid viability polymerase chain reaction
RWT	resuspension wind tunnel
S&T	(DHS) Science and Technology Directorate
SE	sensitive equipment
SHEDS	Stochastic Human Exposure and Dose Simulation
SNL	Sandia National Laboratories
SOP	standard operating procedure
SPEEDI	System for Prediction of Environmental Emergency Dose Information
SPORE	Scientific Program on Reaerosolization and Exposure
STW	sewage treatment works
SVOC	semivolatile organic compound
TaCBRD	Transatlantic Collaborative Biological Resiliency Demonstration
TacDOGS	tactical dynamic operational guided sampling (tool)
TAGA	Trace Atmospheric Gas Analyzer
TOF	time-of-flight
TIC	toxic industrial chemical
TWG	technical working group
UC	unified command
UMT	unventilated monitoring testing
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UV	ultraviolet
VAC	vacuuming
VHP	vaporous hydrogen peroxide
VOC	volatile organic compound
VPHP	vapor-phase hydrogen peroxide
VSP	Visual Sampling Plan
VX	O-ethyl-S-(2-diisopropylaminoethyl) methylphosphonothiolate

Abbreviation/Acronym	Definition
WCIT	Water Contaminant Information Tool
WEST	Waste Estimation Support Tool
WMD	weapon of mass destruction
WMP	waste management plan
WSD	Water Security Division
WSTB	water security test bed
WTW	water treatment works
YRM	yeast reference material

1. Introduction

This report summarizes presentations and discussions from the "2013 U.S Environmental Protection Agency (EPA) International Decontamination Research and Development Conference," held November 5–7, 2013 at the U.S. EPA facilities in Research Triangle Park, North Carolina. The technical content of this report is based entirely on information and discussions from this conference.

The conference consisted of more than 68 speaker presentations organized into five plenary sessions and five concurrent sessions, followed by brief question-and-answer sessions. A poster session (20 posters) was held on the second day of the conference. Mr. Lek Kadeli, the Assistant Administrator for EPA's Office of Research and Development (ORD), opened the Plenary Session, and the Honorable Dr. Richard J. Danzig, former Secretary of the Navy and current Chairman of the Board of Directors for the Center for a New American Security, served as the keynote speaker. Approximately 160 workshop participants represented federal, state, and local government agencies and laboratories; international organizations (eight countries other than the United States); academia; and the private sector.

This report provides an overview of the Plenary Session and summarizes each presentation given during the Conference. Each presentation summary consists of the abstract as provided by the speaker and a review of the brief question-and-answer session that followed the presentation. The speakers' presentation slides, which include additional detailed information, are found in Appendix C of this report. This report is organized according to the Conference agenda by general session and by concurrent sessions related to biological, chemical, radiological decontamination, and water and waste water management as follows:

- Section 2 summarizes the Plenary Session.
- Sections 3–20 contain the abstracts and question-and-answer summaries for nearly 50 presentations given over the course of the three-day conference, as well as abstracts for the posters presented on Day 2 of the Conference. The presentations are organized according to the nine sessions included in the meeting agenda.
- Appendix A provides the meeting agenda, which lists the presentations and speakers in chronological order, as the presentations occurred during the workshop.
- Appendix B lists the workshop participants.
- Appendix C includes presentation slides for speakers who approved them for distribution.

2. Plenary Session

2.1 Opening Comments from US EPA

Dr. Shawn Ryan, Divison Director of NHSRC's Decontamination and Consequence Management Division, welcomed all conference participants and presenters to the 7th Decontamination Research and Development Conference. Dr. Ryan noted the continued growth in attendees for this conference to over 180 registrants for this conference with more than 20 participants from outside the United States. He acknowledged the contributions of the organizing committee and its chairperson, Dr. Lukas Oudejans, in organizing this conference. He then introduced Dr. Lukas Oudejans as the chairperson of the conference.

Dr. Oudejans acknowledged the contributions of the organizing committee members and provided logistical information on the conference. He then introduced Dr. Greg Sayles, Acting Director of the National Homeland Security Research Center who introduced Mr. Lek Kadeli, Acting Assistant Administrator of EPA's Office of Research and Development.

Mr. Kadeli mentioned that EPA Administrator McCarthy was sworn in last July [2013] and her first hundred days accomplishments report stated the goal of making EPA relevant to everyone around the world with solution-oriented research and new technologies. Whether it is sharing our expertise in cleaning up Japanese communities hard hit by their 2011 earthquake, tsunami and power plant meltdown, eliminating ricin exposures on Capitol Hill and in post office mailrooms, getting water supplies back in operation throughout the five states slammed by Hurricane Sandy last year, everyone wants to ensure that their kids are healthy, that their communities and drinking water are safe and that their economies are strong. Mr Kadeli continued to say that all these are the hallmarks of community sustainability and that's why EPA's mission to protect human health and the environment encompasses every facet of preparing communities for the challenges ahead and strengthen their resiliency to bounce back the next time a disaster strikes. He looked forward to hearing about the many research products and advances that are in the pipeline. Mr Kadeli concluded his remarks with the observation that the work being done here is relevant and important, more so now than ever before.

Dr. Greg Sayles continued the opening remarks for EPA by identifying the purpose and objective of the conference. According to Dr. Sayles, one component is for scientists from around the world to discuss our work and to bring the scientific community together with the practitioners who actually perform cleanups and take measurements in the field. One should celebrate the transfer of information from scientists to practitioners and build a community with no boundaries. He noted the large variety of people attending the conference including federal employees and many international participants. Dr. Sayles identified some of the expected highlights from this conference to be a report on Japan's research activities in environmental studies; a decision support tool demonstration session; and talks on risk communication, detection, treatment, and decontamination methods. Dr. Sayles concluded his remarks with the introduction of Dr. Peter Jutro, Deputy Director for Science and Policy for NHSRC.

Dr. Jutro introduced the keynote speaker of this year's conference, the Honorable Dr. Richard Danzig. Dr. Danzig is the Vice-Chair of the RAND Corporation Board of Trustees and serves as a consultant to the Departments of Defense and Homeland Security on biological terrorism. Dr. Danzig is currently a member of the Board of Directors for the Center for a New American Security. Previously, Dr. Danzig served as the 71st Secretary of the Navy and was a senior advisor to then Senator Obama on national security issues during the 2008 presidential election. His keynote address was entitled "Decontamination: Can You Tell Decision Makers What They Need to Know After (and Before) a CBRN Attack?"

2.2 Keynote Speaker - Decontamination: Can You Tell Decision Makers What They Need to Know After (and Before) a CBRN Attack?

Richard Danzig | *Former Secretary of the Navy and Vice-Chair of the RAND Corporation Board of trustees*

Secretary Danzig addressed conference participants from his perspective as a decision maker/policy maker with an appreciation for how researchers --scientists and engineers -- can support decision makers during and following national security incidents, those that are intentionally planned and those that are accidental. Recent events such as the Japanese/American collaboration in responding to the cascading disasters in Fukushima offer insight into various kinds of issues that arise. Secretary Danzig spoke about the nature of heroism. He offered a different view: "While American society and maybe all societies exalt leaders who take charge during a crisis, I think that it's the people who foresee a crisis, prepare for it and support those who deal with it, who are the real heroes".

Secretary Danzig identified a number of obstacles that decision makers face in preparing for a crisis:

- *The unpredictability of crises*. For example, when responding to an anthrax incident, there are many different strains of anthrax, modes of agent delivery, spore sizes, volumes of contaminant dispersed, etc., to consider. Beginning to think about what an incident commander should say about the nature, extent and feasibility of decontaminating anthrax following an attack depends on many variables.

- *Few decision makers spend much time on preparing for crises.* They may not know about health and environmental risks or vulnerable populations at risk. Information flows that that have been prepared in advance are often lost, and timelines are compressed during a crisis. Understanding critical data is often a problem for decision makers. Public intuition may go against model predictions and compound response and recovery issues, for example, as seen during the initial response to the Fukushima disaster

- *Translating science into useful information for decision makers takes special skill and experience*. Decision makers want to know what they need to do, not which uncertainties accompany the data that scientists and engineers have to offer. The essence of being a good scientist/engineer is to say, "We need more data, but here's what you can say based on what we know now and the level of uncertainty we have about our data". Providing an answer loaded with uncertainties to a crisis management team's question is not the most popular answer to give, despite that fact that the scientist or researcher may be the only person who can provide such insight.

- *Scientists and engineers can be very helpful to decision makers by providing the best available science when disaster strikes*. There are always unanswered questions about any crisis, which scientists and engineers can anticipate in advance. For example, following an anthrax attack, more insight can be derived from large-scale studies like EPA's BOTE or SPORE studies. Scientists need to understand *a priori* what would happen if anthrax were dispersed throughout a wide area or in the transit system in a major city, where anthrax spores are likely to adhere and reaerosolize. There is no consensus on these phenomena, but if there's an incident, scientists/engineers need to provide scientifically-sound data and expertise often based on inconclusive data.

- *Scientists' and engineers' time, scale and resources will be limited during and following a crisis.* Responders, scientists, and engineers will be swamped in a crisis. Often they are asked to do the work of 5-10 people on double- or triple-time. Anything that has been done up until that point may be valuable; anything done during the crisis has the potential to be misleading and waste precious resources. Scientists and engineers may have methodical plans for sampling a neighborhood or a subway system during field tests, but what they need to be able to describe is how their field testing scales to a wide-area release and contamination, coming full circle in developing the response and cleanup strategies that depend on a specific scale, timeline or sampling methods. Following an anthrax incident, no one will know how much agent was released, when, under what meteorological conditions, etc. The number of people that were exposed will be unknown until responders, scientists, and engineers are called in. Although their contributions are often useful, issues and questions of decision makers will differ from the types of questions that researchers typically ask.

Secretary Danzig affirmed his belief that scientists and engineers can do excellent work when supporting decision makers before, during and following crises. The scientists and engineers need to anticipate and confront bigger issues that will arise in other, larger contexts. By participating in tabletop and preparedness exercises, the scientists and engineers can help decision makers thoughtfully prepare for and anticipate crises BEFORE they strike.

In concluding his remarks, Secretary Danzig offered his view that responding to decision maker needs during and following a crisis will understandably pull some scientists and engineers out of their comfort zone(s). He said, "Don't lose sight of the valuable contribution you can make, exploit your talents and available resources and then use them in ways that decision makers will value long-term. This will always be a good investment of your time and resources; it will also make decision makers appreciate what you do."

Questions, Answers, and Comments

- Q: There is a daily problem of trying to explain complex issues in bottom line language. As scientists and engineers, our brains are suited for detailed analysis. Others are attuned to interpersonal relations and communications. Their brains work differently. How do we pull ourselves out of our natural way of thinking?
- A: It is very helpful to talk to others and explain to others. Anytime you can find people who don't know what you are talking about and you can distill it for them is good practice. When constructing something based on fine grained analysis, you write a paper that constructed a building and left the scaffolding in place. They only need to see the building; they don't need the scaffolding. There is a need to distill information even though it requires scrapping some of the detailed scientific evidence. But you are capable of doing that. The reality is that policy makers have to have a rudimentary understanding and one can teach it to them in a way they can handle. I do think it's doable though it is a central challenge.
- Q: You mentioned big solutions to practical problems, including your comments about Fukushima that how the public reacts is a big unknown. Besides public response and psychology, what other uncontrolled complexities may arise that we cannot account for?
- A: Several aspects come to mind: 1. A delayed notification of an event. BioWatch reports come in 24-36 hours after an event, and a lot happens in that interval. 2. Problems associated with indoor and residual issues like reclamation or tall buildings. 3. The need to minimize economic impact; as an example, how quickly can you get the stock market back online? 4. Implications of mandatory evacuations; it would be difficult to evacuate major cities. 5. Political figures will think about things that you won't think about that have longer term consequences. In Japan, huge decontamination efforts are driven by psychology and are logically difficult to defend. 6. The psychology of residents wanting to leave as well as people wanting to return and restore their lives; people are motivated by economic needs and the desire to return to their environment. 7. People don't trust the government for advice and rely on local doctors, neighbors, etc., so they get multiple sources of information. If a debate hasn't arrived at a consensus in an event, then the effect is going to be whatever the effects are physically, and they are amplified psychologically.
- Q: In a broader lesson that you put forward, you said the essence is surprise and our inability to deal with it or to do research more applicable to surprise.

- A: One needs to develop capabilities and needs to put a high premium on flexibility. One needs to adopt something closer to an "all hazards" response. We need to push for broad capabilities and test them against the events that arise and don't optimize against a particular scenario.
- Q: Constraints in the scientific communication are also about institutional constraints; what are some things that can remove some of these obstacles in the communication that you are talking about?
- A: The diagnosis is correct, but the tendency is to make structural changes to solve the problem and in a very high fraction of the time, this approach doesn't succeed. My standpoint is work with what you've got
- Q: I'm fascinated by the concept of plausible insight; I've been a researcher and a first responder. People who work for me want to be trained in procedures and are afraid of giving the wrong answer. How do we draw those people out so that they are unafraid to offer that insight and be "heroes"?
- A: I have two instincts: Put them in real-world situations as often as possible. They will grow accustomed by practice to those tough decisions. A second alternative is to create as vivid a sense of that as you can. Real exercises are best, but the next best is a close re-creation.
- Q: You have a vast experience. The policy makers and political leaders also have learned things. When it comes to risk tolerance, what kind of message do they have to bring to the table? We would like to have some kind of peace of mind that we will give bottom line answers, but how much of that message will actually get through to the political figures?
- A: The general view is that policy makers will tolerate zero risk on any problem they are presented; that they could eradicate that risk; but over time they come to accept the background risk. We see that with water standards and air pollution we accept a certain level of imperfection; but cleaning up after anthrax exposure is a zero tolerance policy; my view is that over time we mature and it takes time and education.
- Q: Do you have thoughts about how we can get a mindset to get more budget money for consequence management activities? We spend billions of dollars in protection and millions in consequence management, but the last decade has seen three major events that weren't the fault of the protection side.
- A: I agree with your thought but I do think it's reasonable to assert that all three of those could have been averted with a more manmade protection investment; there is a case for making investments of that kind; everything is obvious once you know the answer. Your thought is retrospective because we can't predict which consequences we need to be prepared for. An all-hazards approach is good investment. We need to generalize capability as much as possible, which prepares us for the unpredictable and makes for a much stronger budget case. We can learn things about evacuation, we can learn things about Fukushima; the basic point that we need to invest more heavily is correct.

3. General Session 1
Outcome Tabletop Exercise, Guidance, and Response

Moderated by Hiba Ernst and Richard Rupert

The Role of the Private Sector in the Assessment and Remediation of Areas Impacted by a CBRNE Incident

P.G. Lambert, M. Goldthorp, K. Volchek, **C.E. Brown (Presenter)** | *Emergencies Science & Technology Section, Environment Canada*
F. Scaffidi, K. Corriveau | *Transportation of Dangerous Goods Directorate, Transport Canada*
Norman Yanofsky | *Centre for Security Science, Defence R&D Canada*

Abstract

In the past decade, Environment Canada, Transport Canada, Defence Research and Development Canada's Centre for Security Science have undertaken projects to improve Canada's resilience to potential CBRNE events. Recently, these organizations developed and delivered a tabletop exercise in Hamilton, Ontario. The exercise

examined the role of private industry during the response to a CBRNE event involving emergency services from all levels of government. An overview of the exercise including a discussion of some of the lessons learned will be presented. The exercise was part of a larger program with the objective of integrating private sector capabilities in all aspects of response to a CBRNE event.

Questions, Answers, and Comments

- Q: Did you exercise any notifications or communications and how can industry help with communicating about the incident with the public?
- A: There were mock releases of information in the exercise, but we did not actually notify the public. If it had been real, we would have notified the public. I think industry is ready and we read about their capabilities. It is important for us to understand their experience. We need to allow them to help us.
- Q: Had this event happened in an agricultural community, would the Canadian Food Inspection Agency be involved?
- A: They were not involved in this specific incident – only Agrium, they are involved with the production of ammonium.
- Q: Do you have plans if this happened in an agricultural community?
- A: Yes, it is something we would like to address in future exercises.

U.K. Recovery Guidance and Advice for the Remediation of the Environment Following a Chemical Incident (The U.K. Recovery Handbook for Chemical Incidents)

S. Wyke (Presenter), N. Brooke, A.V. Nisbet, R. Duarte-Davidson | *Public Health England, Centre for Radiation, Chemical and Environmental Hazards*

Abstract

What is the Chemical Recovery Handbook?

Public Health England (PHE) in collaboration with, and support from the Department for Environment, Food and Rural Affairs, Food Standards Agency, Home Office, Northern Ireland Environment Agency and Scottish Government has now published the UK Recovery Handbook for Radiation Incidents[1] and the UK Recovery Handbook for Chemical Incidents[2].

The UK Chemical Recovery Handbook includes guidance and advice on the recovery and remediation of the environment in the post-accident (post-acute) phase and focusses on environmental clean-up methods. The Handbook provides a framework for developing and selecting an effective recovery strategy following a chemical incident, and contains a compendium of practicable, evidence based recovery options for Inhabited Areas, Food Production Systems and Water Environments[1,2]. The Handbook recommends a number of recovery options (remediation techniques), which have the primary aim to reduce exposure from the consumption of contaminated foodstuffs and water, or from exposure to contaminated surfaces in an inhabited area via dermal or inhalation of re-suspended material. A secondary objective is to provide reassurance to consumers and people living in contaminated areas about their levels of exposure. Recovery options can be implemented at different phases of the response, beginning just after the incident and continuing for the days, weeks, months or even years after the incident.

The UK Recovery Handbook for Chemical Incidents is a technical guidance document, containing well-focused and broadly applicable state-of-the-art information on scientific, technical and societal aspects relevant to recovery and remediation of contaminated environments. The Handbook has been developed to ensure that guidance and advice is robust and practicable, based on an evaluation of the evidence base[3].

The Handbook can also be used to generate awareness amongst emergency planners and those who might deal with the aftermath of a chemical incident, and promote constructive dialogue between all stakeholders tasked with recovery following a chemical incident.

What next?

The UK Recovery Handbook for Biological Incidents is being developed as part of a three-year project (2012 – 2015) by Public Health England, and will apply to areas or environments that have been contaminated by accidental or deliberate biological releases and environmental contamination.

Public Health England are also developing a chemical and radiation recovery decision support tool, in collaboration with UK Government Departments and Agencies. It is envisaged that the decision support tool will assist users navigating through the radiation[1] and chemical[2] recovery handbooks and provide a consistent methodology to compare remediation techniques and a framework for documenting the parameters, assumptions and information used to reach the decision on how to remediate the affected environment following a chemical or radiation incident.

References

1. NISBET, A.F. et al. UK Recovery Handbooks for Radiation Incidents: 2009. HPA-RPD-064. Available from Health Protection Agency, UK.

2. WYKE-SANDERS, S. et al. The UK Recovery Handbook for Chemical Incidents. Available from the Health Protection Agency, UK.

3. WYKE-SANDERS S. et al. Evaluating the evidence base for recovery, remediation and decontamination methods – The UK Recovery Handbook for Chemical Incidents. Chemical Hazards and Poisons Report; 2012: 21: 35-37.

Questions, Answers, and Comments

- C: I would suggest to not rely too much on an electronic version in case things go wrong.
- A: The recovery handbooks will still be available to print off and keep as hardcopies (PDFs of the recovery handbooks are accessible from https://www.gov.uk/government/collections/recovery-remediation-and-environmental-decontamination). The decision-support tool is essentially an add-on to help people navigate through the steps in developing a recovery strategy.

Cleaning up Afterwards. The UK Recovery Handbook for Biological Incidents

Thomas Pottage, Emma Goode, Sara Speight, **Allan Bennett (Presenter)** | *Public Health England Porton*
Stacey Wyke-Sanders | *Centre for Radiation, Chemicals and Environmental Hazards, Public Health England*

Abstract

Incidents involving biological agents can result in outbreaks of human infection and may also lead to contamination of the environment. This contamination may cause restrictions and access controls to the environment (i.e. farm, school, hospital or water supply) until the contamination is dealt with and the environment declared safe to use or re-enter. A project has been undertaken by the Health Protection Agency to develop a biological recovery handbook as a decision making framework tool technical guidance for local authorities and others involved in the clean-up and recovery phase following a biological incident or infectious agent outbreak (both naturally occurring and through intentional release). This project follows on and uses some of the tools and methodologies developed by the UK Recovery Handbook for Radiation Incidents (v3, 2009) and the UK Recovery Handbook for Chemical Incidents (2012).

The UK Recovery Handbook for Biological Incidents project has begun with an extensive literature review of the environmental persistence of a range of microorganisms and their resistance/susceptibility to chemical and physical decontamination techniques. These reviews will inform the technical guidance, decision-aiding framework, checklists and recovery option data sheets that are being developed as part of the UK Recovery Handbook for Biological Incidents. Following the approach taken for the radiation recovery handbook, different environments (food production systems, inhabited areas and water management systems) will be addressed separately and stakeholder groups convened to comment on the practicability of the recovery options recommended for each environment. Information on previous incidents and the efficacy of recovery options will

be obtained as part of the literature review, but the project also involves a retrospective questionnaire study (online survey followed up by a telephone interview) to capture experience from incidents that are not well reported, and will be collated and distilled into the recovery options database.

It is envisaged that the UK Recovery Handbook for Biological Incidents will facilitate decision makers' access to expert opinion and scientific advice by presenting this information in an easy to use decision-aiding framework format, and will also enable the decisions made during the recovery process to be documented (i.e. why were decisions made to implement various clean-up techniques). The UK Recovery Handbook for Biological Incidents will be an openly available free to download document from the project's website http://www.hpa.org.uk/ProductsServices/ResearchAndTesting/BiosafetyUnit/RecoveryHandbookForBiologicalIncidents/ Publication is expected in 2015 and will also be useful for training and preparedness activities.

Questions, Answers, and Comments

- Q: In your handbook, have you learned how to prioritize samples?
- A: We are not doing this as part of the project; however, there is a project in the UK looking at this. My organization will be processing clinical samples as a priority. Sometimes, you get to a situation where the diagnosis will be done on a symptomatic basis. It is important to do both clinical and environmental sampling.
- Q: You were mentioning that there were weeks to months before you could clean up the garage. Was there a political reason? In the future, do you think you have processes in place?
- A: I think yes. The problem with a naturally occurring incident is that we think we should just clean it up one way. For example, for anthrax, we used chlorine dioxide. In addition, there was potential for prosecuting the people who made the drums, so there was a lot of antagonism. You are decontaminating a house where people live, and they do not think it needs to be decontaminated. In London, we just used the bleach and it was much quicker (1-2 weeks).
- Q: One of your slides showed a matrix of disinfection methods versus different agents, and a lot of the data was not available. Is there a plan to fill in any of those boxes? Is there hope they will be research projects in academia, or is the government going to address that?
- A: I hope it will bring awareness. It also highlights the needs for surrogates.

Research Activities of the Japan National Institute of Environmental Studies on Fukushima Nuclear Power Plant Accident

Noriuki Suzuki (Presenter) | *Center for Environmental Risk Research, National Institute for Environmental Studies*
Shoji Nakayama | *Center for Environmental Health Sciences, National Institute for Environmental Studies*
Nagahisa Hirayama | *Center for Material Cycles and Waste Management Research, National Institute for Environmental Studies*

Abstract

The Japan National Institute for Environmental Studies (NIES) reacted quickly to the disastrous earthquake and tsunami event on 11 March 2011 that resulted in the Fukushima Daiichi Nuclear Power Plant (FDPP) incident. We have conducted a variety of research on waste management; air/water quality monitoring including radioactive and non-radioactive contaminants; and fate modeling of radioactive substances released from the FDPP. In this presentation, our research on environmental fate and transport of the radionuclides released from FDPP and radioactive contaminated waste management will be presented. Fate and transport research aims to predict long-term trend and distribution of radioactive nuclides in the terrestrial and aquatic environment as well as in living organisms; build a sound model to estimate long-term general population exposure dose; and contribute to better understanding of the impacts on human, wildlife and ecosystem health. Multimedia fate models are being developed to cover atmospheric, oceanic, and terrestrial environments. Active field measurements have been conducted to characterize sources and movement of radioactive nuclides. New techniques to effectively analyze dissolved cesium, strontium, and iodine 129 are developed. A human exposure model has revealed that external

exposure is a major source for the human total dose. An oxidative stress marker was found in wild mice. The waste management studies are to accumulate the knowledge of treatment and disposal technologies; set technical standards; and promote safe and effective waste management. The best technologies for radioactive waste incineration and landfill have been studied. Our Institute has been committed to conduct further research in Fukushima. The research will focus on not only the understanding of the current situation but also on the recreation of the original and more resilient communities and the preparation for future disasters.

There were no questions for this presenter.

Hazard Mitigation Science and Technology Program for the DoD Chemical and Biological Defense Program (CBDP)

Charles Bass (Presenter), Glenn Lawson, Revell Phillips, Mark Morgan | *Defense Threat Reduction Agency*

No slides were made available for inclusion.

Abstract

Defense Threat Reduction Agency (DTRA) manages science and technology investments for the DoD Chemical and Biological Defense Program with a mission to expand our knowledge of threat agents and transition technologies into joint acquisition programs. Hazard Mitigation, a major sub-program area, funds research to find new technologies and methods with the goal to save lives, limit the spread of contamination, return equipment to normal mission operation and enable operations at reduced levels of protection. The research portfolio spans a range between near-term, mature technologies to far-term, higher risk research. Projects are directed at eight efforts:

1. Support joint programs for the fielding of equipment decontamination: General Purpose Decontaminant (GPD), Joint Sensitive Equipment Wipe (JSEW), and Contamination Indication/Decontamination Assurance System (CIDAS)

2. Develop a "Dial-a-Decon" technology that allows adjustments at the point-of-use based on agent type, material substrate, and environmental conditions

3. Support a USAF demonstration: Joint Biological Agent Decontamination System (JBADS) which is based on hot, humid air and focused on large airframes

4. Develop enzyme-based formulations for chemical decontamination of sensitive equipment

5. Facilitate the development of improved, easy to decontaminate coatings

6. Develop and demonstrate novel, low-logistical burden approaches to wide-area decontamination of *B. anthracis* spores

7. Improve decontamination processes for decontamination of personnel and mass casualties

8. Develop processes for safe repatriation of chemically and biologically contaminated human remains

These efforts are integrated with current and planned acquisition programs to address capability shortfalls identified by the services. Research takes place at DoD service laboratories, private industry, and academia. DTRA provides a critical link by managing these efforts to ensure that needed capabilities are delivered to the warfighter.

Questions, Answers, and Comments

- Q: With the strippable coating, is it possible to put it on the vehicle before it enters?
- A: Yes, that is the idea. It is short-lived and needs to be reapplied every year, or you need to have a process to do it before the equipment deploys.
- Q: Are paints hostile to microbes growing on them?

- A: We have not been that successful with chemicals. We have been more successful with biologicals. We worked with DARPA to get one log destruction of the spores. Coatings are primarily there for corrosion control.

The U.K. Government Decontamination Service (GDS)

Sara Casey | *GDS, United Kingdom*

Abstract

The Government Decontamination Service (GDS) is a cross-government service, offering advice, guidance and practical support both during, and in preparing for a CBRN or major HAZMAT incident. GDS utilise a broad base of private and public sector capability and capacity to create a robust and operationally ready CBRN Recovery Service. This is underpinned by a programme of work, including applied research and development, carefully aligned to UK Government requirements that focuses on capability assurance, gap analysis and the closure of capability gaps.

A brief overview will be given of the work carried out by GDS over the last 12 months, which will include 1) procurement of the new GDS framework suppliers 2) the methods used to assure the framework suppliers have the required capability during CBRN recovery, 3) an introduction to the research and development programme 4) collaborative work with academia, UK Government Agencies and Departments, plus future planned collaboration with the US EPA and DHS and 5) other future work.

Questions, Answers, and Comments

- Q: What about indoor decontamination?
- A: The daily business of companies we used is indoor decontamination. Throwing an outdoors decontamination at them was designed to test responders. They changed their methods to address this.
- Q: During an event, would you let them pursue the decontamination of their choice become the standard operating procedure?
- A: No, unless we thought that would be effective; we would not let them run rampant.
- Q: How did you contaminate the indoor setting?
- A: Aerosolized *Bacillus atrophaeus*.
- Q: After you did it, how did you measure it? Did you measure uniformity?
- A: The area was sprayed and left overnight and was sampled the next day; we do not have results yet.

Biological Response and Recovery Science and Technology Roadmap

Brooke Pearson | *Cubic Applications, Inc.*

Abstract

A catastrophic biological incident could threaten the Nation's human, animal, plant, environmental, and economic health, as well as America's national security. Such an event would demand swift and effective responses in order to minimize loss of life and other adverse consequences or, in the case of suspected criminal activity or terrorism, to prevent additional attacks.

Standing ready to respond to a biological incident requires ongoing data and information collection, data integration and scientific analysis, evidence-based review, strategic decision making, and continuous coordination across government and with nongovernmental partners. In addition, an effective response and recovery process requires the coordination of data and capabilities from several sectors—such as public health, law enforcement, waste management, infrastructure management, transportation, and more.

The White House Office of Science and Technology Policy (OSTP) released a *Biological Incident Response and Recovery Science and Technology Roadmap* to help ensure that decision makers and first responders are equipped with the information and tools needed to effectively respond to and recover from a biological

incident—whether naturally occurring (such as an influenza pandemic), accidental (such as a laboratory spill), or intentional (such as a bioterror attack).

The *Roadmap* aims to strengthen these processes by categorizing key scientific gaps, identifying specific technological solutions, and prioritizing research activities to enable government—at all levels—to make decisions more effectively. Key near-term R&D priorities and objectives outlined in the Roadmap include:

- Develop reliable estimates of risk of exposure for a multitude of environments, matrices, and conditions associated with wide-area release scenarios;
- Develop reliable estimates of risk to humans, animals, and plants through various exposure and transmission routes;
- Evaluate population infection prevention measures (e.g., quarantine, isolation, and social distancing) used to reduce incident impact and develop a strong scientific basis for recommending these measures; and
- Apply insights from risk-communication research to guide dissemination of appropriate messages to decision makers, first responders, and others.

The *Roadmap* was developed by the interagency Biological Response and Recovery Science and Technology Working Group under the National Science and Technology Council's Committee on Homeland and National Security, and complements the *National Biosurveillance Science and Technology Roadmap* that was published in June 2013.

There were no questions for this presenter.

4. General Session 2 Decision Support Tools

Moderated by Leroy Mickelsen and Timothy Boe

Utilization of the QUIC Urban T&D Modeling System for Pre-Planning, Sensor Siting, and Post-Event Analysis of CBR Dispersal Events

Michael Brown | *Los Alamos National Laboratory, Systems Analysis & Surveillance Group*

Abstract

The Quick Urban & Industrial Complex (QUIC) dispersion modeling system rapidly computes 3D wind, concentration, and deposition fields around building complexes. Chemical, biological, and radiological (CBR) agent dispersion can be computed on building to neighborhood scales in tens of seconds to tens of minutes. It is used to provide vulnerability assessments, realistic training scenarios and tabletop exercise support, post-event clean up analysis, optimal sensor siting for special events, and wind fields in a real-time response system. QUIC is composed of a wind model, a random-walk transport and dispersion model, and a graphical user interface. It has unique algorithms to account for radiological dispersal device (RDD) detonations, dense gas toxic industrial chemical dispersion, chemical weapon releases, and dry and wet biological agent sources in cities. QUIC accounts for topography, buoyancy, droplet evaporation, 2 phase droplet-vapor mixtures, multi-particle size distributions, gravitational settling, infiltration into buildings, and deposition onto buildings and trees. The model includes a US day-night population database that is linked to different health effects models (e.g., toxic load, AEGL's) to quickly compute casualties. Recently, the code has been modified to include a CONTAM exporter to provide outdoor plume concentration and building pressure time series at inlets around buildings in order for CONTAM to compute concentrations within buildings. In this presentation we will give a brief overview of the QUIC model capabilities, some example applications focused on bio and rad agent deposition, comparisons between flat-earth and building-aware plume calculations, and model evaluation studies.

Questions, Answers, and Comments

- Q: Did you test for resolution?
- A: We do tests of different resolution. We can get good results at 5 m horizontal resolution and a few meters vertical.
- Q: Can you mention the crude building infiltration scheme and how that could aid in prioritizing resources for sampling indoors?
- A: We have a building infiltration scheme. Every single building in the code has an infiltration parameter (leakiness of HVAC or other filtration systems). It takes concentrations around the building, takes leakiness factor, to get a crude estimate of concentration indoors. We do not account for the walls inside. We can link up to the CONTAM model from NIST that can account for this.

A Comprehensive Decision Support Tool for Agricultural Security

Robert Knowlton (Presenter), Mark Tucker, Mark Kinnan, Brad Melton, James Davies | *Sandia National Laboratories*
Lori Miller | *U.S. Department of Homeland Security*

Abstract

The threat of an infectious Foreign Animal Disease (FAD) outbreak, such as Foot and Mouth Disease (FMD), poses significant economic consequences to the United States (US) food production industry. FMD can infect cloven-hooved animals, such as cattle, swine, sheep, and goats, as well as deer. There has not been an outbreak of FMD in the US since 1929. More recently, there have been outbreaks in other countries that have caused billions of dollars in cleanup costs and economic devastation. Even though FMD is not transmitted to humans, infected livestock cannot be used in or as food products. International trade would also be negatively affected. It could take considerable time, about a year and a half, to certify a country to be free of infected livestock before international trade could resume. Therefore, a decision support system that can be used to evaluate alternative response and recovery operations is desired. Sandia National Laboratories (SNL) is developing a comprehensive decision support tool to analyze response and recovery actions from an FAD outbreak. The FAD tool is a module of SNL's Prioritization Analysis Tool for All-Hazards/Analyzer for Wide Area Restoration Effectiveness (PATH/AWARE), which was developed for use on potential wide-area biological, chemical or radiological releases. The tool allows a user to manage resources and estimate costs and timelines for response and recovery actions. The tool has a built-in database and an embedded Geographical Information System (GIS), which allows the user to display and input spatial information. The FAD module accounts for processes such as vaccination, depopulation, rendering, incineration, composting, burial, and decontamination. The FAD module also codifies some tools developed by the US Department of Agriculture (USDA) within the Animal and Plant Health Inspection Service (APHIS). These tools include a checklist, a Disposal Decision Tree, and a Disposal Options Matrix. A case study will be presented to illustrate the functionality of the tool and its usefulness in the decision making process.

Questions for presenter were postponed until Panel Discussion at the conclusion of the Decision Support Tool Session.

Toward Feasible Sampling Plans

Landon Sego | *Pacific Northwest National Laboratory*

Abstract

Since the anthrax events of 2001 and subsequent responses, there has been considerable discussion regarding the best approach for developing defensible sampling strategies. In particular, the merits of "judgmental" and "probabilistic" have received close attention. Yet, too often the two strategies are portrayed as being at odds with each other—and the phrase "judgmental versus probabilistic" is frequently used when describing the challenge of developing sampling strategies. We advocate the importance of both judgmental and probabilistic

sampling in creating rigorous, yet feasible, sampling designs. We explore the purpose of judgmental sampling, probabilistic sampling, and the power of combining the two. We discuss how these combined strategies can be used to 1) discover contamination, 2) characterize the location and extent of contamination, and 3) clear remediated (or unaffected) areas for reoccupation.

All relevant information should be used when developing sampling plans. Ideally, sampling strategies should leverage knowledge about the spatial distribution of the contaminant, agent fate, the interaction of the agent with various surface types, the efficacy of decontamination techniques, etc. We refer to this as the “lines of evidence” approach, which will lead to sampling designs that require fewer samples than would otherwise be needed to achieve the desired sampling objectives. In addition to these concepts, we will illustrate how these techniques have been (or will be) incorporated into Visual Sample Plan (VSP), a freely available software tool for the design of environmental sampling plans and analysis of sampling data.

Questions for presenter were postponed until Panel Discussion at the conclusion of the Decision Support Tool Session.

Decision Support Toolset for Weapons of Mass Destruction (WMD) Crisis Management

Brooke Pearson (Presenter), William Ginley, Ryan Madden | *Edgewood Chemical Biological Center*

Abstract

The Transatlantic Collaborative Biological Resiliency Demonstration (TaCBRD) is an Advanced Technology Demonstration (ATD) focused on remediating the effects of a wide-area biological event on a population center. The TaCBRD ATD through a series of workshops has identified some key concepts and tools that will assist the recovery teams in recovering from an attack. The information technology tools span the concepts of biosurveillance, detection, sampling, decontamination and assessment. Many of these tools were developed independently from each other and are being unified in a common architecture known as TaCBoaRD so they can interoperate. TaCBoaRD is not an acronym; it is a concept for sharing biological recovery information utilizing sharepoint technology.

The TaCBRD ATD utilizing TaCBoaRD will provide recovery organizations with tools organized as portlets. Each tool or portlet performs a specific mission during the timeline of pre-attack through trans-attack to post-attack. TaCBoaRD provides a central location to plan, monitor and execute recovery functions with status updates.

TaCBoaRD portlets will be transitioned to other chemical biological defense program efforts such as the Biosurveillance Portal and Installation Protection Integration Platform.

Questions for presenter were postponed until Panel Discussion at the conclusion of the Decision Support Tool Session.

Tactical Dynamic Operational Guided Sampling (TacDOGS) Tool for the TransAtlantic Collaborative Biological Resiliency Demonstration (TaCBRD) Program

Dan Dutrow (Presenter), Sean Kinahan, Scott Stanchfield, Suma Subbarao, Philip Koshute, Alex Proescher | *The Johns Hopkins University Applied Physics Laboratory*

Abstract

The Tactical Dynamic Operational Guided Sampling (TacDOGS) tool is a software product being developed by John Hopkins University Applied Physics Laboratory (JHU/APL) in support of the Transatlantic Collaborative Biological Resiliency Demonstration (TaCBRD) program to provide guidance for the development and execution of sampling plans in context of a wide-area outdoor biological release. At each level of the command structure, the commander may utilize TacDOGS to organize available assets to maximize their operational utility. Sampling after a large-scale wide-area biological release requires an extraordinary amount of time, coordination, and cost.

Depending on the scenario and phase of the response, sampling objectives will vary. These objectives form the basis for selecting sampling methods, collection instruments, sampling schedules, analysis methods, and interpretation of results. The sampling plan of action depends on the biological threats and release properties. The TacDOGS tool will offer increased situational awareness of the factors to consider in selecting sampling missions to meet objectives. The tool optimizes the selection of material and equipment available through multiple response assets based on the current sampling capabilities and detection sensitivities of expected contamination. This optimization process increases the capability to assign response assets to missions, while providing the end user with an understanding of the limitations inherent in the chosen sampling and analysis methods. Information related to sample planning and collection is gathered through the use of Android devices and NFC communication to record, transfer, and track sampling related data. Matching capabilities to suspected contamination concentrations also increases the potential to detect that contamination. The TacDOGS application uses judgment and the outputs of physics-based modeling to guide dynamic assessment of results and potential movement of contamination during the course of response.

Questions for presenter were postponed until Panel Discussion at the conclusion of the Decision Support Tool Session.

Decon ST: Decontamination Strategy and Technology Selection Tool

D. Edwards (Presenter), J. Freutel, L. Yang, P. Krauter* | *Sandia National Laboratories (*retired)*
S. Ryan, P. Lemieux, L. Mickelsen | *U.S. Environmental Protection Agency*

Abstract

In order to support decision-making to select decontamination options for specific contaminated buildings following a biological contamination incident, Sandia National Laboratories (SNL) and the U.S. Environmental Protection Agency (USEPA) have built a decontamination strategy and technology selection tool (DeconST). The DeconST addresses contamination of a building with *Bacillus anthracis* spores, but is expandable to address other agents.

The DeconST takes user input of building type, size, sampling frequency, and information regarding ambient weather conditions, and provides relevant information on facility-specific decontamination methods and associated waste implications. The DeconST provides a comparison of the relative costs, efficacy and associated destructiveness and waste generated by each of the candidate decontamination technologies. The cost comparison includes the costs of the decontamination process itself (including incident command, characterization and clearance sampling and analysis, decontamination, and long-term monitoring) plus the costs associated with managing the waste generated by the technologies on the structural and interior materials and contents of the facility (including the costs for removing, decontaminating, disposing of, and replacing all materials and contents damaged and/or not decontaminated by the technology). The technologies in the DeconST include currently available biological-agent decontamination technologies with published efficacy data. Building demolition is also included for comparison purposes.

The DeconST is intended to be used by a technical working group (TWG) functioning under a Unified Command (UC) to provide recommendations to the Incident Command (IC) on decontamination technologies appropriate to a given building. The DeconST, which runs as an MS Excel 2010 spreadsheet, is not an expert system, meaning that it does not tell the IC/UC what technology to use, but rather it presents a series of options and recommendations, with color-coded estimates of likelihood of success of decontamination, cost implications, and waste estimates. The DeconST tool's outputs, including tables of waste composition, cost distribution charts, and other information that would justify recommendations, are provided as detailed reports suitable for inclusion in the records of the IC/UC.

Questions for presenter were postponed until Panel Discussion at the conclusion of the Decision Support Tool Session.

Carcass Management Decision Support Tools

Brooke Pearson (Presenter), Wayne Einfeld, Stacey Tyler, Emilie Hill | *Cubic Applications, Inc.*

Abstract

In 2011, US livestock receipts accounted for 44% ($166 billion) of total farm receipts. Each year, US animal agriculture contributes approximately 26 billion pounds of beef, 23 billion pounds of pork, and 38 billion pounds of poultry to the food supply. These products are derived from animals that are vulnerable to death due to accidental disease, severe weather, or an act of bioterrorism. While livestock producers are accustomed to handling routine mortalities, high numbers of livestock deaths in a disaster situation pose daunting challenges. If not met quickly and effectively, carcass management issues can result in devastating economic losses as well as long-term public health and environmental issues.

Decision makers within the emergency response community are often unfamiliar with the unique concerns of the livestock industry and may be faced with little familiarity of carcass disposal options and the unique challenges they pose. For example, unlined on-site burial may be a valid option for small numbers of animals, but large numbers of buried carcasses can create contaminated leachate, which could infiltrate groundwater resources and create a public health risk. Additionally, not all disposal methods are suitable for every disease agent. A high-level decision support tool with accompanying checklist and training modules can assist in the rapid determination of which disposal option best meets the user's needs.

A simple spreadsheet-based tool has been developed to allow users to quickly narrow down their disposal options by answering just five simple questions. By defining the nature of the event (viral, bacterial, spore, prion, chemical, radiological or natural disaster), the tool eliminates unsuitable disposal options based on disease agent considerations for environmental and public health factors. The tool also calculates the time to depopulate, the resource capacity ratio (e.g., adequacy of land and transport), the estimated time to complete disposal, and the estimated cost for the entire disposal operation. The results of these calculations allow users to quickly narrow the number of suitable disposal options. The user is then directed to disposal checklists that can be used to further narrow down the top disposal options. Finally, users are directed to on-line training courses, which provide detailed information about the planning and operational requirements of each possible disposal option.

This suite of tools is designed for use by emergency response personnel who may possess little knowledge in this area. The user can efficiently rule out unsuitable options for a scenario-specific solution requiring carcass disposal. The tools allow for rapid, effective, and justifiable decisions about carcass management to be made. Rapid response, made possible by this suite of tools, is vital to minimizing livestock losses, economic impacts, and public health hazards.

Questions for presenter were postponed until Panel Discussion at the conclusion of the Decision Support Tool Session.

Waste Estimation Support Tool: An Overview, Updates, and Demonstration

Timothy Boe (Presenter) | *Oak Ridge Institute for Science and Education*
Paul Lemieux | *U.S. Environmental Protection Agency*
Colin Hayes | *Eastern Research Group, Inc.*

Abstract

As a result of ongoing research efforts, the EPA's Homeland Security Research Program (HSRP) has developed the Waste Estimation Support Tool (WEST) for estimating the potential volume and radioactivity levels of waste generated by a radiological incident and subsequent decontamination efforts. The HSRP is continuing to support and further develop the WEST to addressing the evolving needs of its partners. Upcoming updates will feature an occupancy based infrastructure scheme, universal building stock capabilities, occupancy based infrastructure scheme, improved GIS functionality, embedded report and graph generation, and an intuitive scenario

management interface. This presentation will feature an overview of the WEST, planned updates, and a live demonstration.

Questions for presenter were postponed until Panel Discussion at the conclusion of the Decision Support Tool Session.

Interactive All Hazards Waste Management Plan Development Tool

Anna Tschursin | *U.S. Environmental Protection Agency, Office of Resource Conservation and Recovery, Materials Recovery and Waste Management Division, Waste Characterization Branch*

Abstract

Many manmade and natural incidents have the potential to produce significant amounts of waste. The Environmental Protection Agency (EPA) believes that communities should have a waste management plan (WMP) that addresses everything from natural disasters and foreign animal disease outbreaks to chemical spills and nuclear incidents to terrorist attacks involving conventional, chemical, radiological, or biological means. These homeland security incidents can create more waste than a community typically manages on a regular basis, as well as waste streams a community does not normally handle. Past experience has shown that communities with comprehensive and well-coordinated WMPs recover more quickly and at less cost from these incidents, making these communities more resilient. Unfortunately, planning for waste management during large-scale homeland security incidents has been identified as a major capability gap in overall Homeland Security Response and Recovery Preparedness.

To assist emergency managers, planners, and responders in the public and private sectors in creating or updating a comprehensive plan for managing waste generated from manmade and natural incidents, the ORCR Materials Recovery and Waste Management Division, in collaboration with Regions 3 and 5, the Office of Homeland Security and The National Homeland Security Research Center, has been researching the potential development of an interactive on-line waste management planning tool intended to provide step by step advice on creating a comprehensive pre-incident WMP. This tool would provide a framework to help managers, planners, and responders initiate plan development, providing variable degrees of assistance from providing a simple outline of plan contents, to creating customizable language, to providing scenario-specific default waste quantity values to use in developing a plan. The tool will not only provide an adaptable format for drafting the plan itself but, in addition, is envisioned to provide users with the ability to view plans developed and shared by other users, as well as links to other resources such as fact sheets, databases, and integration with other online tools such as I-WASTE. EPA has developed the initial contents for the tool, solicited input from Regional and State representatives, and is now identifying IT platforms, which would allow for the features envisioned, resources permitting.

Questions for presenter were postponed until Panel Discussion at the conclusion of the Decision Support Tool Session.

Panel Discussion

Michael Brown | *Los Alamos National Laboratory*
Robert Knowlton | *Sandia National Laboratories*
Landon Sego | *Pacific Northwest National Laboratory*
Brooke Pearson | *Cubic Applications, Inc.*
Dan Dutrow | *John Hopkins University APL*
Donna Edwards | *Sandia National Laboratories*
Timothy Boe | *Oak Ridge Institute for Science and Education*
Anna Tschursin | *U.S. Environmental Protection Agency*

Notes

Question 1 to the panel:
Every decision support tool (DST) discussed here today addresses some form of need or problem. When designing your DSTs, how are you collaborating with your customers to ensure you meet their needs?

Summary of the responses from panel:

- Training sessions not only serve as a venue to familiarize end-users with DSTs, but also allow end-users to provide feedback.
- Consider collaborating with partners through an interactive process, such as a stakeholder working group, in order to promote input.
- Developers tend to wait until DSTs are nearly finished before requesting feedback. Preliminary tech demos push developers to release DSTs early on, which allows stakeholders to review and address issues during the development process.
- The user base in which a DST was intended may broaden over time. This is especially evident as DSTs progress based on expanding needs (e.g., all hazards approach), depending its intended or unintended application.
- Some end-users may not be receptive to a particular DST due to limitations in policy or financial restraints.
- End-users need to be patient with developers and vice versa.

Question 2 to the panel:
Static software is dead software and becomes useless over time if not continuously updated. How do we change the funding model?

Summary of responses from panel:

- Once completed, allocating funding to support DSTs can be a formidable task and often requires some form of perpetual investment for the DST to remain operational.
- The metaphor, "Cadillac vs. Hyundai" was used to distinguish between high-end DSTs (e.g., dispersion model) versus low-end DSTs (e.g., Excel spreadsheet). High-end DSTs often require periodic investments in order to remain relevant. Low-end DSTs, on the other hand, do not. The option of a high-end or low-end really depends on the problem at hand.
- Release updates on a *pro re nata* basis; a critical update is likely a worthwhile investment.
- Consider enabling reach-back by some sort of funding mechanism. The United Kingdom (UK) has set a good precedent by retaining contractors until the need arises.

Question 3 to the panel:
Very seldom do we get out in the field and respond to a modeled threat. These DSTs are great resources, but there is a real world. How flexible are these tools? How easy will it be for software engineers to improve upon them in the future?

Summary of responses from the panel:

- Create technical working groups composed of power users who regularly interact with the DST. These groups often expand applications beyond their original intention.
- Tools geared towards an all-hazards approach are easier to sustain rather than those addressing a specific need. Conceptual models currently do not address every foreseeable disaster. Efforts should focus more on risk versus probability. Risks with high probability that are likely to invoke secondary hazards should be the primary focus (e.g., Fukushima Daiichi nuclear disaster).
- Consider using software development environments that allow developers to push updates to the end-user.

- Over time, if DSTs are not routinely updated, customers run the risk of brain drain (e.g., initial developers relocated or require time to re-acclimate with code).

Question 4 to the panel:
Each DST presented here today represents a different phase or process in emergency response. Moving forward, how can we holistically connect these tools so they are more efficient, yet cost effective?

Summary of responses from the panel:
- Typically not possible to integrate software that wasn't intended to do so. DSTs can, however, share outputs via a common file scheme (i.e., text file), or have extensions or components that interact with each other.
- Using an open source development model promotes universal access and common standards. By utilizing open source, DSTs can be enhanced or integrated when the need arises with little or no support from outside sources.
- EPA has limited resources to manage DSTs and recommends they be relocated to a sustainable yet efficient home. An example of this is the EPA's GeoPlatform, which houses a variety of applications under one roof.
- A DST shouldn't be developed to address a specific need. Instead, DSTs should be modular by design, allowing them to expand functionality based on a need. Doing so would save the agency both time and money.

5. General Session 3 Risk Communication and Systems Approach

Moderated by Brendan Doyle

Professional and Public Perceptions of Information Needs During a Drinking Water Contamination Event

Scott Minamyer, **Cynthia Yund (Presenter)** | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
Richard Tardiff | *Oak Ridge Institute for Science and Education*

Abstract

A critical need has been identified for the development of methodologies to effectively communicate risks associated with water security emergencies. The EPA sponsored three workshops in 2005 and 2006 to prepare messages for such emergencies. Messages were developed through the cooperative efforts of experts from water agencies, public health, emergency response, law enforcement, as well as experts in risk communication.

This current investigation was a follow up to the former workshops to conduct formative research to: (1) compare professional and public assessments of critical information needs; and (2) evaluate messages developed during the above-mentioned workshops for appropriateness and effectiveness. A hypothetical contamination scenario of a municipal water supply was presented for discussion. The purpose was to identify the layperson's perception of relevant risk, so professionals can be prepared to supply critical information and dispel misconceptions.

Information was collected by means of personal interviews with water-sector professionals followed by focus groups comprised of water consumers in Boston, Massachusetts; Charlotte, North Carolina; Chicago, Illinois, and San Diego, California. Professionals began by providing a list of questions addressing what questions they thought the public would have during a drinking water contamination incident. The initial scenario was intentionally non-specific. Later they were asked to add issues that would arise if the incident were known to be intentional, such as a terrorist attack. Members of the public were presented the same scenario and generated a list of questions related to information they would most need during the water contamination incident.

Responses from both groups were very similar and can be categorized into the following themes:

- Who is affected
- Exposure Issues
- Uses of Tap Water
- Alternate Sources of Water
- Consumer Personal Actions
- Response and Recovery

The priorities for professionals were event control, remediation, and public health protection. For the public, priorities were personal safety and individual action. Research findings can be used as a critical crisis communication planning resource for responders, utility managers, and public information officers to prepare appropriate information for delivery to the public during a water emergency.

Questions, Answers, and Comments

- Q: What kind of response have you had from the water utility industry? How do they view this study and are they refining their risk communication messages?
- A: I hope they are. We had 1700 people attend the webinar, which gives you a sense of how utilities will use the tool. We have partnerships that will help promote our tool, and it is moving forward.
- Q: What was the public response toward the need for specific information, e.g., nature of the problem?
- A: They wanted specifics but only of what you knew. The public wanted honesty that you did not know all of the answers and they could tell if you were trying to fudge. The individual community level is where we need to work.
- Q: How do you think this translates to natural disasters?
- A: The questions in this tool are very general, e.g., where do I get a supply? Do I boil the water? When do I get to normal? It is very applicable.

Perceptions of Risk Communication Messages During a Long-Term Biological Remediation

Charlena Bowling (Presenter), Cynthia Yund | *U.S. Environmental Protection Agency*
David Malet | *University of Mebourne*
Mark Korbitz | *Otero Junior College*
Jody Carrillo | *Pueblo County/City Health Department*

Abstract

Risk communicators need to involve stakeholders and the public throughout all stages of an environmental contamination event. It is important to explain the magnitude and severity of risks associated with such an event. Effective communication strategies to ensure public trust must reflect the needs of broad, diversified audiences consisting of greatly varied educational levels and technical knowledge while addressing security concerns. In 2011, EPA's National Homeland Security Research Center (NHSRC), in conjunction with the Pueblo City/County Health Department of Colorado, began a three-year study of effective risk communication practices during the remediation phase of a biological event. The objective of this research effort is to determine the preferred mechanism of message delivery that make it more likely that risk communications will be trustworthy and understood by target audiences.

Phase 1 of the study has been completed. A panel of 43 federal, state, and local emergency response professionals and other public officials provided responses to 17 mock risk communication messages, distributed via email over a six month long scenario, that describe the remediation of a major bioterrorist attack. Phase 1 findings suggest that (1) local policy- and decision makers use readily available information and make assumptions that high level agencies will assume clean up responsibilities; (2) panel members expect cleanup to

“zero” residual risk; (3) more positive emotions emerged as the scenario progressed and neared the end; and (4) panel members indicated that the public would be informed of activities and information via hotlines, websites, and social media – even though social media generally could not be accessed from these agency workplaces and many of the participating agencies were not using social media at the time of this study.

This presentation will describe results from the Phase 1 study. The data indicate emergency management personnel do not have uniform preparedness capabilities to respond to all aspects of a significant bioterrorist attack. Recommendations confirm the need for state and local emergency response personnel to work together on response activities. While social media may offer a tool to expedite risk communication messaging, it appears that many of these agencies are not fully capitalizing on such a methodology. State and local level homeland security planners need to be more involved in lessons learned from terrorist events and exercises similar to those at the at the Federal level. The findings from this research will yield data useful to public health officials and communicators on the mechanism of message delivery and content, and provide insight into improving the reception to risk communication messages by the public, especially during the remediation phase of an event, given the time lag between response and recovery.

Questions, Answers, and Comments

- Q: You have stressed not alarming people and the importance of preparation of messages, but what is more challenging is that situations are extremely dynamic. There tends to be a lot of agreement about what to do. The media think this is boring and want people who will wreak havoc. Have you figured out what the strategy is for being quickly adaptive to other people’s messaging?
- A: I think it all goes out to preparation. You cannot prepare for everything, but any preparations will help you. If you know the conflicting messages are going to be there, you should be ready to answer them.
- Q: When I see simple messages released, my initial reaction is skepticism that they are placating the public. Have you considered a dual form of messaging with one simple, concise messaging and a link with data and technical detail?
- A: I think that has been used, e.g., BP oil spill. That is a good approach and makes sense to have an opportunity for those interested to see the data that supports the messaging.
- Q: You were mentioning key words to monitor. Which ones are those and which ones should we avoid?
- A: The keywords were participant suggestions. Avoid strong words like terrorism. We did not touch as much on those in this study.
- Q: Do you have plans to monitor social media to see how the public responds?
- A: Yes and no. Not ORD, but EPA’s Office of Public Affairs has this job. This is a huge area of research.
- Q: You anticipated tailoring your message to monitoring. Did you discover anything in this phase?
- A: This is more applicable to Phase two. I mentioned that we had another study going on with University of Kentucky. Their Phase 2 is looking at small pockets of minority groups and those findings will be out next year.

A Systems Approach to Characterizing the Social Environment for Decontamination and Resilience

Keely Maxwell | *U.S. Environmental Protection Agency*

Abstract

After a natural disaster, technological accident, or terrorist attack, the EPA utilizes scientific analysis and technical criteria to assess risk and remediate contaminated environments. In order to make sure that decontamination supports community resilience, it is necessary to develop a systems approach to characterizing the social environment of the affected community. This research utilizes a coupled human-natural systems approach to identify the social system variables that influence risk and resilience. For example, we often think of vulnerability, or susceptibility to hazard risk, as determined by health or environmental factors. Yet vulnerability is also conditioned by social factors such as poverty and household composition. This research draws upon case studies

of recent incidents to demonstrate how these system variables affect the social and environmental outcomes of decontamination. These variables come into play throughout the decontamination process. After Hurricane Katrina, sediment sampling for contaminants in Orleans Parish produced a wealth of chemical data, but this information may not have served residents' clean-up needs. Amerithrax risk assessment did not ameliorate postal workers' perceptions of risk. Nor did it take their local environmental knowledge into account, which might have reduced the incident's costs. Remediation after the Fukushima disaster faces significant technical challenges. It also faces significant social challenges, including a lack of trust in institutions. Meeting technical clearance goals after remediation may not be enough to ensure re-occupancy and reuse of an area. Community ties and sense of place influence a family's re-occupancy decisions. Re-occupancy also depends on whether the remediated area is able to meet critical community functions such as education and commerce. Waste disposal decisions require attention to environmental justice. This presentation discusses indicators and lessons learned that will help practitioners avoid unintended consequences of decontamination efforts, reduce barriers to effective interventions, and prioritize resilience strategies.

Questions, Answers, and Comments

- Q: Is there a line where we can involve the public too much?
- A: Definitely. There were things the public was demanding that were not feasible or not under the jurisdiction. There is a line, but it is hard to draw a hard and fast one.
- Q: What are the practical implications for risk communicators?
- A: Risk communication needs to happen before an event and how to facilitate people's basic knowledge before the event. Not everybody knows that his or her water is not sterile. Risk communication needs to explicitly understand the values of the public.
- Q: As a responder, I see a lack of empathy in the response community and local governments. How can this information improve that?
- A: A shift in perception of people from victims to people who can bring valuable assets to bring to the table, e.g., environmental knowledge.

6. General Session 3 Food Safety – Decontamination and Disposal Issues

Moderated by Lukas Oudejans

Intentional Contamination of Food: Detection, Decontamination, and Disposal Research and Needs

Nicholas Bauer (Presenter), Kim Green | *Food Safety and Inspection Service*

Abstract

Terrorist organizations have expressed interest in and knowledge of methods to attack the food supply in the U.S. Independent actors intent on doing harm, such as disgruntled employees, have proven capable of causing significant economic and public health impacts. Furthermore, intentional adulteration of food for economic gain is common, and illustrates the vulnerability of the food supply to intentional contamination.

Intentional contamination of the food supply presents numerous challenges for detection, decontamination, and disposal. In the event of an attack, or even the threat of an attack, suspect product would need to be identified, managed, tested, treated, and disposed of. The food processing facilities and infrastructure, such as transportation equipment, storage facilities, and retail stores, would similarly need to be tested and decontaminated. Even a medium-size meat-processing establishment produces 1 million pounds of product per week, which could be shipped to 50 states and international customers within days of manufacture. Therefore,

intentional contamination of the food supply could necessitate a massive and geographically widespread treatment, disposal, and decontamination effort.

USDA has helped to fund research to address some of these challenges for some high-toxicity chemical agents, including development of analytical methods for food matrices, determination of oral toxicity and stability in food matrices, and evaluation of potential decontamination technologies. This presentation will briefly summarize this completed research, and highlight data gaps. The presentation will also address USDA needs regarding additional research and discuss agency capabilities, roles, and responsibilities during response to an intentional contamination event.

Questions, Answers, and Comments

- Q: How involved would you get in telling people that food is safe? If it is FMD affected beef and we go for a vaccine approach. It is no risk to human health. We have been talking about that messaging amongst ourselves.
- A: There is going to be a question of which food is safe. We have not set up the communications that have been talked about in the risk communication presentations. In the case of FMD, it is a little further along than an intentional contamination of the food supply.
- Q: You mentioned toxicity testing of different threat agents. Do you have any information on how heating food agents in a food matrix would affect stability?
- A: Yes, we have looked at stability of agents and storage and cooking.

7. Concurrent Sessions 1 Biological Agent Decontamination

Moderated by Shawn Ryan

Smart Aqueous Gels and Foams for RB Decontamination

Dr. S. Faure (Presenter), Dr. F. Goettmann | *CEA, DEN Nuclear Energy Division, DTCD/SPDE/LCFI, Laboratoire de Chimie des Fluides Complexes et d'Irradiation*
Dr. V. Tanchou | *CEA, DSV Life Science Division, IBEB/SBTN/LDCAE*
Dr. C. Bossuet | *CEA, DAM Military Apllications Division, DSNP*

Abstract

To face the future challenges in the field of RB solids decontamination, the Laboratory of Chemistry of Complex Fluids and Irradiation (LCFI) from the French Atomic Energy and Alternatives Energies Commission (CEA) is developing new processes for decontamination of solids. These new techniques are secure and easily deployable by end users and strongly reduce the cost, the secondary wastes production and the workers exposure.

We have focused in the last past years on the use of two soft matter states to develop new patented decontamination processes: aqueous gels and foams. The major objectives of our studies are:

- To formulate smart complex fluids, aqueous gels and foams, that do not damage the surface of the materials (soft homogeneous corrosion) and transfer or inactivate rapidly the contaminants into the complex fluid phase
- To obtain less generated secondary liquid effluent or avoid liquid effluent (self drying and cracking gels)
- To enhance the efficiency of the decontamination technique by adding surfactants, chelatants and or particles.

The proposed lecture will give an overview of these two ways to decontaminate a solid surface.

The major applications and results obtained on real RB decontamination operations will be presented for each process.

For R decontamination gels, a new generation of mineral gels –ie silica colloidal suspensions- called “self drying and cracking gels“ were world patented [1,2] The advantages of the process are considerable because these gel formulations are obtained from mineral materials in order to avoid non stable organic compounds. They can be sprayed like paints to obtain a thin film (500 µm) on the surface using a pump system at low (2-7 bars) or high (10-30 bars) pressure. The gel film dries in a few hours at room temperatures and the decontamination reaction stops. The drying forms cracks on the gel film that lead to millimetric solid pellets easily recovered by vacuum cleaning or by brushing. For B decontamination we developed more recently dedicated vacuumable gel formulations to reach a biocide effectiveness on Bacillus thuringiensis spores (a surrogate of anthrax) [3]. From the academic point of view, we will see that the adsorption density of additives surfactants or polymers on these colloids could have both significant effects on the rheological, drying and cracking properties of the gel.

For RB decontamination foams, an approach using polymers and/or particles in water is defended to generate high life time stable foams that are able to decontaminate huge and complex shape materials in a static way, such as rooms, tanks, tubes, galleries [4,5]. The static way is original: the facility to decontaminate is filled with foam that wets all the surfaces to treat and drains freely for several hours. The drained liquid containing the R contaminants or the killed B contaminants could be treated by classical liquid effluents treatment. We will show how we could modify the drainage kinetic i.e. the liquid flow rate between the foam bubbles using biodegradable yield stress polymers or colloidal hydrophilic fumed silica aggregates [6, 7].

[1] S. Faure, B. Fournel, P. Fuentes and Y. Lallot., *Method for treating a surface with a treating gel and treating gel*. World Patent WO 03/008529, 2003.

[2] S. Faure, P. Fuentes and Y. Lallot. *Vacuumable gel for decontaminating surfaces and use thereof*, World Patent WO 07/039598, 2007.

[3] F. Cuer and S. Faure. Biological decontamination gel, and method for decontaminating surfaces using said gel. World Patent WO 12/001046, 2012.

[4] Faure S., Fournel B., Fuentes P. (2004). *Composition, foam, and method for surface decontamination*. World patent WO2004/00846

[5] Guignot S and Faure S. *Decontamination foams containing particles*, French Patent n° FR 07 53286, 2007

[6] C. Dame, C. Fritz, O. Pitois, S. Faure, “Relations between physicochemical properties and instability of decontamination foams”, Colloid and Surfaces A : Physicochem. Eng. Aspects, 2005, n° 282, 65-74

[7] S. Guignot, S. Faure, M. Vignes-Adler, O. Pitois “Liquid and particle in foamed suspensions” Chemical Engineering Science, Volume 65, Issue 8, 15 April 2010, Pages 2579-2585

There were no questions for this presenter.

Anthrax Decontamination of a Mock Office Using Low Level Chlorine Dioxide Fumigation

Matthew Clayton (Presenter), Abderrahmane Touati, Nicole Griffin-Gatchalian | *ARCADIS, Inc.*
Joseph Wood, Michael Worth Calfee, Shawn Ryan | *U.S. Environmental Protection Agency*

Abstract

In the event of a large urban release of *Bacillus anthracis* spores, extensive resources would be required in the recovery effort. Chlorine dioxide (ClO_2) fumigation would most likely be utilized in such efforts, since it has been demonstrated in the laboratory and at full-scale to be an effective decontaminant at levels of 1,000-3,000 parts per million (PPM). However, it is believed there may be only a few contractors in the US capable of fumigating large buildings at these high levels.

The present study was conducted to assess decontamination efficacy of ClO_2 fumigation at relatively low concentrations but longer contact times. Demonstration of successful decontamination with ClO_2 gas at low

concentrations would allow for a greater number of vendors to participate in remediation efforts following a large anthrax spore release. That is, vendors with technologies that produce ClO_2, but perhaps at relatively lower generation rates, would still be able to meet and maintain these lower target fumigation concentrations within a large building.

All ClO_2 fumigation tests were conducted in EPA's Consequence Management and Decontamination Evaluation Room, or COMMANDER. COMMANDER is a stainless steel-lined chamber built specifically for decontamination testing, with internal dimensions of approximately 11 ft wide, 8 ft deep, and 9 ft high. It includes an airlock and exterior steel shell. Temperature, relative humidity (RH), and other parameters are controlled and monitored. All tests were conducted at lab ambient temperature and 75% RH.

To facilitate a realistic decontamination challenge, a mock office was built (including carpet, drop ceiling, painted drywall) and furnished within COMMANDER. The mock office also included a laminated desk, an office chair, a file cabinet, pin cushion screen, books/catalogues, and a computer with monitor and keyboard.

Bacillus atrophaeus was used as the *B. anthracis* surrogate, and disseminated in powder form using a fluidized bed aerosol generator, to achieve a target loading of 10^5 to 10^7 colony forming units (CFU) per square foot.

ClO_2 was generated using a ClorDiSys Model GMP, which includes a photometric detector for continuous measurement of ClO_2. ClO_2 levels within the chamber were also measured using a wet chemistry method, and ranged from 100 to 1000 PPM.

The general sequence of events for each test was as follows:

1. "Reset" the mock office by fumigating with hydrogen peroxide vapor.
2. Sample the mock office to determine background levels of any residual viable spores.
3. Disseminate spores.
4. Sample surfaces to determine the initial levels of spores.
5. Monitor temperature and establish 75% RH.
6. Charge chamber with ClO_2 to achieve the target concentration.
7. Maintain target ClO_2 concentration and RH for desired contact time.
8. Aerate chamber.
9. Conduct post-fumigation sampling.

Bacterial spore samples were recovered from surfaces in the office using wipes, swabs, or hand-held HEPA vacuums (sock sampler). Other assays included the use of reference measurement coupons and bio-aerosol collection cassettes. Spores were extracted from collection media, serially diluted and plated, incubated, and then colonies counted.

The decontamination results for the more than ten chamber tests that were conducted in the study will be presented at the conference.

Questions, Answers, and Comments

- Q: Did you try to repeat the low-level concentration fumigations a number of times to see if the efficiency increased?
- A: We had a couple of goals. One was to maximize decontamination efficacy. We did a number of low level chlorine dioxide fumigations.
- Q: Did you extend the time? When does it become asymptotic? When do you stop killing spores?
- A: We did a 24-hour test. We did not see a good correlation with extra time.
- C: As you drop below 70 % RH, ClO_2 fumigation becomes much less effective. There has been some effort to go to 4000 ppm, lower relative humidity, and longer contact time.
- Q: Did you see a relationship between reductions based on commercial biological indicators compared to the disseminated spores?

- A: The biological indicators we used were much less resistant to fumigation. I think we got no growth.
- Q: What was your extraction method from your swipes? Did you use multiple preparations of your spores? Why was *B atrophaeus* that does not have an exosporium used?
- A: PBST extraction method for wipes and vacuum socks. For chlorine dioxide fumigation, *B. atrophaeus* has been used as a surrogate for years.
- Q: Your lab has done a lot of studies with ClO_2. 9000 ppm-hours was effective. It looks like you have achieved the same efficacy at a much lower value. Why do you think there is a difference between this study and other previous studies?
- C: There was work by Shawn Ryan [NHSRC] that concluded that contact time was important. We explored that in a glove box (small-scale) and showed great effectiveness with low ppm levels and longer contact times. The point was to do the test more realistically at a larger scale to see if a longer contact time would be more effective.

Methyl Iodide Fumigation of Bacillus Anthracis Spores

Mark Sutton (Presenter), Staci R. Kane, Jessica R. Wollard | *Lawrence Livermore National Laboratory*

Abstract

Fumigation techniques such as chlorine dioxide, vaporous hydrogen peroxide and paraformaldehyde used to decontaminate items, rooms and buildings following contamination with Bacillus anthracis spores are often incompatible with materials found in a variety of buildings. This results in necessary removal of a variety of organic or electrical materials before fumigation to increase efficacy and minimize both material damage and waste volume. Alternative fumigation with methyl bromide is subject to strict international regulation and requires a crisis exemption from the EPA. Methyl iodide fumigation offers excellent efficacy at both room temperature and elevated temperature.

Bacillus anthracis Sterne spores applied to stainless steel were subjected to methyl iodide fumigation at room temperature and at 55°C. Additionally, spore fumigation on concrete was performed at 55°C. Efficacy was measured on a log-scale with a 6-log reduction in colony forming units being considered successful. Efficacies greater than 6 orders of magnitude were obtained after just 1 hour at 55°C and after 12 hours at room temperature for stainless steel samples. No detrimental effects were observed on glassware or PTFE O-rings. Additional studies will be directed towards assessing the effect of methyl iodide on sensitive or valuable materials such as electronic equipment, fabric, artwork and documents.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-617953.

Questions, Answers, and Comments

- Q: Do you know how methyl bromide and methyl iodide compare in terms of ozone level depletion?
- A: I do not. There is an EPA document that talked about it. A reference is in the report on this subject.
- Q: You mentioned a study at 55 °C. Is it possible to raise the temperature of a building to this level?
- A: DTRA was interested in fumigating an aircraft, so they said this was a reasonable temperature. It is doable in a military vehicle, maybe not in a building. We have shown it is effective after 12 hours at lower temperatures.

Gruinard Island Returns to Civil Use

Stephen Hibbs | *Defense Science & Technology Laboratory*

Video presentation; no slides were made available for inclusion in report.

No abstract was provided.

Questions, Answers, and Comments

- Q: Was there any residual contamination from the formaldehyde treatment?
- A: The decontamination of the Island was carried out in the summer of 1986. Soil samples were taken three months following this process, and a very small area of low contamination remained where an aerial bomb containing anthrax had been dropped. This area was re-treated in the autumn and soil cores taken the following spring. All soil samples were split into two halves and were analysed by ourselves at DSTL and also by independent assessors at the Central Veterinary Laboratory at Weybridge.
- Q: Do you have any cases of human infection during the entire process?
- A: No cases at all during the original trials or the decontamination process.
- Q: What is happening with the island today? We would have expected a larger area of contamination.
- A: The whole Island was assessed for the presence of Anthrax spores. Most of the spores were located at a depth of 5 cm or lower due to high rainfall and peaty soil, and decontamination was carried out accordingly with this in mind. We are confident all of the spores have been successfully decontaminated to a level of three spores per gram of soil. This does not pose a health risk.
- Q: Were there any air samples collected?
- A: No, strictly soil samples. The island was a wet, peaty, boggy domain with no risk of aerosols. After the first year we were there, we didn't have to wear respirators but did wear Wellington boots, latex gloves and white disposable suits over our underwear. The suits and gloves were disposed of and the Wellington boots washed off with disinfectant at a decontamination station.
- Q: How did methods for this decontamination compare to methods available today?
- A: This method was proved successful. To hand it back in public ownership was a big leap of faith. I know there are efforts to be environmentally friendly when you decontaminate.
- Q: You had a method that could detect three spores per sample?
- A: We used PletMedia. The idea is that the anthrax spores are more tolerant to that toxic mixture than soil microorganisms, so they could grow and the soil microorganisms were killed.
- Q: Would they allow the use of the formaldehyde solution today?
- C: We [Health Protection England] tried to duplicate Gruinard in 1990s, but we weren't allowed to do it. People have strong attitudes against formaldehyde despite that it occurs naturally. If you get it in the soil, it won't be there after a couple of weeks. This method of decontamination was ideal this location. The Island was uninhabited and about a mile off shore from the mainland of Scotland. The formaldehyde used was inactivated in the environment relatively quickly and there was no issue with any potential drinking water courses. The risk of airborne infection was remote as the climate in this part of the world is cool and wet.

8. Concurrent Sessions 1
Chemical Agent Sampling and Detection

Moderated by Stuart Willison

Decontamination Screening Techniques Used At U.S. Army Chemical Agent Disposal Facilities and Applications for Clearing Contaminated Areas

Theodore Ruff (Presenter), Joseph Padayhag | *Centers for Disease Control and Prevention, National Center for Environmental Health/Agency for Toxic Substances Disease Registry, Division of Emergency and Environmental Health Services, Environmental Health Readiness Branch*

Abstract

This presentation will review the approach and methods for decontamination and decontamination verification used at U.S. Army Chemical Agent Disposal Facilities and discuss their application for clearing contaminated areas in other contexts. These methods include decontamination followed by screening for chemical warfare agents: air "headspace" analysis (isolating the area or equipment from ventilation through tenting or bagging and air-monitoring the isolated space), surface sampling and analysis, and finally headspace analysis of unventilated rooms. The most important factors for selecting verification criteria are the future use of the area and the potential health hazards.

CMA decommissioning and decontamination process involves evaluating potential health hazards; removing selected equipment; decontamination of floors, walls, and remaining items; and verifying decontamination. Facility personnel review the history of known chemical warfare agent spills and elevated concentrations of chemical warfare agent in air. After gross decontamination is completed, equipment that is heavily contaminated or difficult to decontaminate is removed and further treated for agent removal (or further decontamination). Additionally, personnel conduct an enclosed space and porous material survey to find areas where chemical warfare agent may be prevented from volatizing. These areas are mitigated, generally through disassembly or removal and further decontamination. Surface sampling may be conducted after developing statistical and/or judgmental sampling plans for the walls and floors, followed by analysis for chemical agents. As areas are decontaminated, initial verification is conducted through headspace analysis. As a final verification step, facility personnel isolate larger areas to perform unventilated monitoring testing (UMT). Here, entire rooms are isolated from facility ventilation and air monitored for detection of chemical agent. After the UMT is complete, ventilation is resumed. Similar methods, with appropriate considerations for future use and health hazard potential, may be used in the event of chemical warfare agent contamination of other non-military facilities or vessels.

Two contamination scenarios will be explored: 1) a fixed facility, with occupancy to include the general public and 2) a marine vessel with worker occupancy. Considerations include nature and extent of contamination, evaluation of hazards (e.g. respiratory, dermal), future use of facility, decontamination methods, verification screening, and final verification of decontamination. These examples will illustrate the potential for transferring the experience from decontaminating and decommissioning chemical agent disposal facilities to planning for recovery and reuse after contamination incidents.

Questions, Answers, and Comments

- Q: Headspace monitoring – what was the endpoint you were looking for? There were no volatile agents. What about nonvolatile agents?
- A: Nonvolatile agents are volatile enough that the instrument will still pick it up; one facility had trouble picking up stuff under an I – beam, so they tented it and probed it, and that's how they located the place where they had residual contamination, so even for nonvolatiles it proved to be pretty good; some sites did concrete samples as well, so you did get auxiliary evidence through those as well.
- Q: Who performed the analysis?
- A: The U.S. Army; agent samples were mostly analyzed on site.
- Q: How did CMA arrive at the risk level for transportation?
- A: That was based on action scenarios and based on the probability of an accident. They are based on a very conservative precise scenario.
- C: There was also a maximum concentration per drum to account for risk to any workers around the drum.
- Q: Was the use of hot air considered as a decontamination method; was that considered for traditional chemical warfare agents? It would be a relatively cheap method for a larger facility.
- A: Don't know if it was used for VX or not.
- Q: Waste that was shipped offsite, were there any special arrangements? Disposal facilities?

- A: For waste that still had agent remaining, CMA did the transport risk assessment for those drums, modeling the impacts from that agent.
- C: As drums were loaded at the disposal facility, they were supposed to be fed as quickly as possible to the furnace; US Army has done a risk assessment of that facility.

Multi-Laboratory Study of Analytical Protocols for Chemical Warfare Agents in Environmental Matrices

Romy Campisano (Presenter) | *U.S. Environmental Protection Agency, Office of Research and Development, National Homeland Security Research Center*
Carolyn Koester | *Lawrence Livermore National Laboratory*
Eric Boring, Joan Cuddeback | *Computer Sciences Corporation (CSC)*
Terry Smith | *U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency Management*

Abstract

The US Environmental Protection Agency (USEPA) National Homeland Security Center (NHSRC) and Office of Emergency Management (OEM), in collaboration with experts from across USEPA and other state and federal agencies continue to develop analytical protocols for laboratory identification and measurement of target agents during site remediation. These methods will be used to assist in determining the presence of contamination, the effectiveness of decontamination, and site clearance following decontamination. These studies improve laboratory capability and capacity, thus enhancing response and recovery to intentional or unintentional chemical contamination incidents.

Results of a NHSRC and OEM collaborative multi-laboratory study evaluating analytical protocols for identification and measurement of chemical warfare agents (CWAs) in water, soil and surface wipe matrices are presented. CWAs included in this study are sarin (GB), soman (GD), cyclohexylsarin (GF), sulfur mustard (HD), and VX. These protocols were developed to achieve high laboratory throughput, while providing analytical detection limits necessary for thorough remediation of CWA contaminated environments during response activities. Specific procedures for all matrices and CWAs include microscale extraction techniques using methylene chloride followed by gas chromatography/mass spectrometry (GC/MS) analysis. An additional extraction step using "tris buffer" was required to effectively remove VX from soil matrices. GC/MS analysis included use of quadrupole and time-of-flight (TOF) mass spectrometers.

Preliminary results of the study indicate the protocols can achieve analytical method detection limits of approximately 1 µg/L for water, 2 µg/kg for soil, and 0.04 µg/wipe for surface wipe matrices for GB using quadrupole mass spectrometry, and approximately one order of magnitude lower using TOF.

Stability studies for ultra-dilute (10 ppm) CWA standards were determined. Results for individual standards stored in sealed ampules showed that the CWA standards made in methylene chloride were stable for up to one year. Data for individual standards stored in vials that were periodically reopened showed that most CWAs were stable for six months. Exceptions were GB, which was stable for only five months, and VX, which degraded after two months.

Questions, Answers, and Comments

- Q: Do you have any plans for doing vacuum samples or other kinds of samples? How about composite samples or multiple wipes?
- A: Microbiologists and analytical colleagues are moving more towards sponge samples as samplers. The sponge sticks are easy to use, and we have contemplated investigating sponge sticks in chemical sampling, but no motions yet.

- C: Obviously one thing to worry about is whether the chemical is going to be picked up by that material and whether the people in the field would use it.
- Q: Are you also looking at recoveries? In Army facility research, concrete has a degradative effect on agents.
- A: We definitely looked at recovery. The experiment has controls over what you spike and what you analyze. The environmental samples are widespread and we consider the nature of the matrices.
- Q: What were those recoveries for glass and metal? What kind of recoveries did you get from those?
- A: I believe we got fairly good recoveries from stainless steel and glass. These are fairly small coupons because we did do a direct extraction of the surface as well as comparable wiping. For more permeable surfaces we are using two sizes of coupons, including a larger surface to see if we get comparable recoveries to see whether small scale wipe results translate up.
- Q: Have you spoken to ECBC? Researchers there are looking at these types of samples plus some you are moving on to; they have protocols already in place.
- A: Absolutely, we try to network and collaborate; we did have a strong partnership with ECBC, but diverged a little in aims and goals, but we should reconnect.
- C: Australia also has an equivalent to this network. Anecdotally, we found the same stability issues; we use screw cap vials. We use cotton swabs; if we find a liquid or device with a film we take a swab and stick it into a vial.
- Q: Was there a difference in solvents? Some solvents will melt plastic, do you get better recoveries with dichloromethylene?
- A: We found that dichloromethane worked best for our purposes.

Accelerated Clean-up of A Residential Site Using On-site Analytics

Lawrence Kaelin (Presenter), Terry Smith | *U.S. Environmental Protection Agency, OSWER, OEM, CMAT*
Michael Nalipinski | *U.S. Environmental Protection Agency, Region 1*

Abstract

In May 2012, the US Environmental Protection Agency (EPA) Region 1 conducted an extent of contamination survey for coal tar wastes contamination at selected residential properties in St. Albans, VT. Samples of surface and subsurface soils, sump pump waters, sediments, soil gas, and indoor air were collected for analysis. Rapid, on site analytical results were provided by the EPA's Office of Emergency Management (OEM) CBRN Consequence Management Advisory Team (CMAT), using CMAT's mobile laboratory assets called PHILIS. PHILIS, which stands for *Portable High-throughput Integrated Laboratory Identification System*, is a mobile laboratory platform accredited through the NELAC program for the analysis VOCs, SVOCs and PCB analysis, and holds membership in EPA's Environmental Response Laboratory Network (ERLN). The site contaminants of concern included benzene, naphthalene and PAHs. In the course of approximately 4 days, over 250 samples were collected and analyzed on-site for contamination. The PHILIS provided same-day confirmatory data, allowing the EPA to make on-site decision without the need for secondary laboratory confirmation. The EPA was able to confer with the state of VT representatives on a daily basis using the most recent analytical data allowing for timely interpretation of data and better planning of the use on-site assets. The EPA prepared a Time Critical Removal Action Memo (RAM) recommending soil excavation as the site clean-up process and the installation of a vapor capture system to mitigate in-door air contamination posed by the coal tar wastes. The on-site analytical abilities provided by PHILIS allowed the EPA to complete all the site soil assessments, excavation, and removal and site restoration activities within 90 days, based on the results from a single, 4-day site visit. Greater time and cost savings were realized using on-site analytical assets (PHILIS) by the more effective use of their on-site assets in an accelerated time frame. On-site analysis allowed the EPA to remediate the site in a single site visit, a "one & done" accelerated remediation approach.

PHILIS has also been approved by the ERLN, for the analysis of a select group of chemical warfare agents (CWAs), at detection limits sufficient to support on-site risk based clearance goals. In the event of a CWA terrorist attack, PHILIS can be deployed directly to the incident to provide daily on-site data to help determine extent of contamination, direct field assets, confirm decon efforts and expedite the overall clean-up and remediation of the incident site.

Questions, Answers, and Comments

- Q: You mentioned 250 samples over four days, what is really the CWA throughput?
- A: The actual chemical warfare agent capability of PHILIS is expected at a minimum of 100 samples per day if only one CWA or one class of CWAs is present
- Q: What is the procedure for getting a response to a state request?
- A: The best approach is to call Headquarters/EPA's Office of Emergency Management; the EPA chemical spill number will probably get to us as well; one can also go through a Regional EPA Office. The other thing is with this international audience, we want to push for international partnerships. There is capability and we want to share it.

Advancing the Trace Atmospheric Gas Analyzer (TAGA) Triple Quadrupole Mass Spectrometer Fitted with an Atmospheric Pressure Chemical Ionization (APCI) Source to Provide Analytical Assistance for a Chemical Warfare Agent (CWA) Release

Dave Mickunas (Presenter), Stephen Blaze | *Environmental Response Team, U.S. Environmental Protection Agency*
Danielle McCall | *Lockheed Martin Corporation*

Abstract

Under the Presidential Policy Directive/PPD-8: National Preparedness (DHS, 2011), this directive is aimed at strengthening the security and resilience of the United States through systematic preparation for the threats that pose the greatest risk to the security of the Nation, including acts of terrorism, cyber attacks, pandemics, and catastrophic natural disasters. Furthermore, the National Response Framework's Emergency Support Function Annex (ESF) #10 – Oil and Hazardous Materials Response (FEMA 2008) provides Federal support in response to an actual or potential discharge and/or uncontrolled release of oil or hazardous material when activated. For purposes of this annex, "hazardous materials" is a general term intended to mean hazardous substances, pollutants, and contaminants as defined in the National Contingency Plan (CFR, 1994). Hazardous materials include chemical, biological, and radiological substances, whether accidentally or intentionally released. The United States Environmental Protection Agency (US EPA) is the ESF #10 Coordinator and, therefore, the US EPA has the responsibility to provide the appropriate actions to prepare for, respond to, and recover from a threat to public health, welfare, or the environment caused by actual or potential oil and hazardous materials incidents.

The Trace Atmospheric Gas Analyzer (TAGA) technology, which is a direct air monitoring instrument employing triple quadrupole mass spectroscopy with a corona discharge source operated at atmospheric pressure, has demonstrated a potential to support analytical needs that would be required to respond to a CWA release. To advance the US EPA's preparedness, several elements were investigated. First, US EPA members and their contractors gained experience analyzing the CWAs with the US EPA's TAGA system. Second, the precursor and product spectra for these materials were collected using a prescribed tune that would be employed at an event. Third, detection limits and quantitation limits for each compound were determined using the aforementioned tuning strategy to provide an expected analytical capability. Fourth, the introduction of a charge transfer compound and its effects on the response for HD was reviewed. Fifth, materials spiked with various concentrations of a CWA were examined to provide evidence of the mass loading per area of a CWA that is needed to be detected by the TAGA. For this initial study, the following CWAs were investigated: Isopropyl methyl phosphonofluoridate (GB), O-ethyl-S-(2-diisopropylaminoethyl)methylphosphono-thiolate (VX), and Bis(2-chloroethyl)sulfide (HD).

Questions, Answers, and Comments

- Q: Is your vision for CWAs that you would have the TAGA on a cart and go through a building?
- A: The TAGA would be used after the decontamination process was completed. The TAGA would be moved through the previously contaminated area with the sampling port directly above the surface to determine if any compound(s) of concern could be detected. This technique would supplement other clearance sampling and analysis efforts.
- Q: How about detection for Lewisite?
- A: The TAGA cannot currently detect Lewisite but tests were conducted with Lewisite present with sulfur mustard; Lewisite does not interfere with the detection of sulfur mustard (HD). ECBC is currently derivatizing Lewisite to analyze the same on a GC. A gas phase derivatization may be possible and should be explored.
- Q: Are you further investigating matrix interferences?
- A: Yes, additional work needs to be performed. Previous testing used laboratory air with vaporized CWAs spiked into the air stream.

9. Concurrent Sessions 2 Biological Agent Sampling and Detection

Moderated by Worth Calfee

Development of Processing Protocols for Vacuum Sampling Devices

Laura Rose (Presenter) | *Centers for Disease Control and Prevention*
M. Worth Calfee | *U.S. Environmental Protection Agency, Home Security Research Center*

Abstract

The Centers for Disease Control and Prevention, U.S. Environmental Protection Agency and Department of Homeland Security sampling strategies for *Bacillus anthracis* spores frequently suggest the use of vacuum-based methods for porous surfaces, though no standard protocols exist for the extraction of spores from these devices. The CDC evaluated processing methods for extraction of spores from heating, ventilation and air conditioning (HVAC) filter media and three vacuum sampling devices; 37 mm filter cassette, vacuum sock, and the 3M™ Forensic Vacuum Filter. Vacuum pumps were evaluated and selected for each device. All filter materials were inoculated with a liquid suspension of *B. atrophaeus* spores, and allowed to dry before processing. Extraction of spores from the filter material by several methods (sonication, vortexing, shaking or stomaching) were compared in different elution buffers volumes, and containers. The highest percent of spores were recovered from the 37 mm filters when sonicated 3 min in 5 ml of phosphate buffer with 0.02% Tween® 20 (PBST), while the highest percent recovery from the trace evidence filters was accomplished by stomaching 1 min at 360 rpm in PBST. Vacuum socks were cut and shaken in 20 ml PBST, while HVAC filter sections (4 in2) were shaken in 200 mL PBST, both at 300 rpm for 30 min for the optimum recovery of spores. The optimized extraction methods were used to evaluate sampling and recovery of aerosolized spores from various surface materials.

Questions, Answers, and Comments

- Q: Have you considered gelatin membrane filters? You can hook them up to a vacuum and you get very good results.
- A: The problem is you are picking up so many other things if you are vacuuming a carpet, the spores might be masked.
- C: We take the sampling head linked up to a vacuum and use it to sample a surface. If you heat shock it, you do not have to worry about background.
- Q: We used the gel filters, and what we found is that they would dry out after about 40 minutes. Could you tell me what the scale was in the new sampler?

- A: The nozzle cross sectional is 45 mm^2, 45 mm wide and 1 mm tall.
- Q: I was glad to see you are thinking about making a bridge between *B. anthracis* and *B. atrophaeus*. Have you considered adding a stimulant that has an exosporium the way a*nthracis* does? How many preparations did you use? How were they prepared?
- A: They were a Dugway prep and loaded into a MDI. Now we can do this ourselves.

Evaluation of Surface Sampling for Bacillus Spores Using Commercially-Available Cleaning Robots

Sang Don Lee, M. Worth Calfee | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
Leroy Mickelsen (Presenter), Jayson Griffin | *U.S. Environmental Protection Agency, Office of Emergency Management*
Stephen Wolfe | *U.S. Environmental Protection Agency, Region 5*
Matt Clayton, Nicole Griffin-Gatchalian, Abderrahmane Touati | *ARCADIS Geraghty & Miller, Inc.*

Abstract

This project evaluated floor cleaning robots for *anthracis* spore sampling. From EPA's perspective, the proposed sampling device would be beneficial following a wide-area attack, where deploying a robotic vacuum sampler would allow large areas of outdoor space and numerous building interiors to be sampled rapidly and with reduced personnel. Five commercially available cleaning robots were evaluated for collection of *anthracis* spores. Five robots include three vacuum types, one wet vacuum, and one wet wipe. Tests were conducted as a function of surface type and spore surface loading. Aerosol deposited *B. atrophaeus* spores were used as surrogate of *B. anthracis* spores. Tested surfaces were carpet, laminate, and tile and the targeted surface loadings were 10^2, 10^4, and 10^6 colony forming units per ft^2. Spores were loaded on the surfaces (2' x 2') and the surfaces were sampled with robots in a chamber (3' x 3' x 1'). Chamber air was sampled using a bio filter sampler for potential resuspension of spores during sampling. After sampling, the spore collection media from robots were extracted and analyzed for the number of spores. Test results were compared to currently-used surface sampling methods (vacuum sock and sponge wipe) and the most efficient device was determined. Depending on the test results, the project will improve the robots by modifying the sampling mechanisms to obtain a comparable sampling efficiency to the surface sampling methods.

Questions, Answers, and Comments

- Q: Do you have a calculation of the time per square foot to sample?
- A: The garage is 2x2 ft, the shortest robot time was approximately 20 seconds, and the longest was about five minutes. According to the manufacturer, it takes 45 minutes to cover 200-400 ft^2.
- Q: Are these robots programmable? Could you do transects? Will it detect edges?
- A: We did not modify any of the robots. If it sees a drop, it should not go over it according to the manufacturer's instructions. They have different types of logics – we just used them as default (factory setting).
- C: It is an off-the-shelf device. If you mess with the logics, there might not be as many to deploy.
- Q: For the wet sampling devices, did you use the solutions they gave you?
- A: It was their wipe, but we used PBST rather than the manufacturer's detergent.
- Q: Any thought to decontaminating the device going from one room to another?
- A: We decontaminated them after use and considered them disposable.

Evaluation of Commercial Off the Shelf (COTS) Biological Detection Technologies for Transition to First Responder Community

Rachel Bartholomew (Presenter), Heather Colburn, Richard Ozanich, Kristin Victry, Timothy Straub, Cheryl Baird, and Cindy Bruckner-Lea | *Pacific Northwest National Laboratory*

Abstract

The Department of Homeland Security (DHS), Science and Technology (S&T) Directorate administers programs to develop, field test, and transition to commercialization next-generation technologies required to effectively counter potential attacks on the Nation. The Chem/Bio Division of S&T supports this mission by identifying and developing technologies that DHS operational components can use to reduce the probability and potential consequences of a biological pathogen or a chemical attack on the nation's civilian population, its infrastructure, or its agricultural system. In this regard, PNNL has been tasked by DHS to assess hand portable DNA-based commercial off the shelf (COTS) biodetection technology with the end goal of transitioning this technology to the first responder community. One main challenge first responders face when responding to a potential biological event is the identification of a threat, often a "white powder" event, to determine the critical next steps to response. As part of this effort, PNNL has conducted a thorough technology foraging effort, including surveying members of the first responder community to identify critical biodetection needs. First responders desire rapid, accurate detection with low cost reagents providing a high confidence result, with the two key threat agents of interest being Anthrax (*Bacillus anthracis*) and Ricin toxin. PNNL has evaluated several COTS biodetection technologies for the detection of 15 different strains of *Bacillus anthracis* DNA, and evaluation with near-neighbor DNA is underway. Overall, the tested COTS technologies detected *Bacillus anthracis* DNA as expected, with only a few instances of failures. Future work includes testing of additional platforms, evaluation of the impact of white powders, actual spore testing, and the evaluation of these technologies by first responders in field training exercises. The information gathered in the foraging exercise along with the test data will provide the first responder community with objective information to guide appropriate instrument procurement and use to improve response to critical biological events.

Questions, Answers, and Comments

- C: Some powders you listed are tested with spikes. You would expect the extraction methodology to clean those out so you could detect them.

Evaluation of Effect of Decontamination Agents on the Rapid Viability PCR Method for Detection of Bacillus Anthracis Spores

Sanjiv Shah (Presenter) | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
S. Kane, G. Murphy, T. Alfaro, J. Avila | *Lawrence Livermore National Laboratory*

No slides were made available for inclusion.

Abstract

Rapid methods for *Bacillus anthracis* viability determination are needed to alleviate the sample analysis bottleneck for the remediation phase of the response to a wide-area anthrax attack. The Rapid Viability (RV)-PCR method provides more rapid results than current culture-based methods by combining high throughput sample processing with real-time PCR analysis before and after a short incubation period to determine the presence/absence of viable *Bacillus anthracis* spores. The 10-spore level was consistently detected using RV-PCR for surface, air filter, and water samples even in backgrounds of reference debris, 10^6 live non-target cells/spores, or 10^6 killed target spores. The approach showed >97% agreement with culture-based analysis for *B. atrophaeus* spores exposed to surface treatment with pH-adjusted bleach or fumigation with either chlorine dioxide (CD) or vaporous hydrogen peroxide (VHP) in the EPA-led, multi-agency Bio-Response Operational Testing and Evaluation (BOTE). In the current effort, the RV-PCR method was further tested in a systematic study for any negative effect of three decontamination agents, pH-adjusted bleach, CD, and VHP. Exposure tests with these decontamination agents were designed to detect low levels of live spores in a background of high levels of dead spores. Results showed that RV-PCR accurately detected live *B. anthracis* spores at the ≤ 10^2-level after CD, VHP, or bleach treatment, which caused a 4-log or greater reduction in viable spores. In addition, *B. anthracis* spores were tested

with bleach residual expected from wipe sampling. Results showed that the presence of bleach residual did not negatively impact RV-PCR results relative to control treatments. In summary, these data showed that the RV-PCR method could allow rapid and hence higher throughput analysis of post-decontamination clearance samples compared to the traditional culture-based analysis.

Questions, Answers, and Comments

- Q: How robust is it for other strains?
- A: We tested with other strains, but we have not fully characterized the PCR assays. We are keeping the doors open for anybody who has better ones.
- Q: Have you tried to tighten up the growth window?
- A: Yes, I would like to cut the incubation time down from nine hours to four hours. We already have shown that with the plasmid gene PCR assay, the LOD can be maintained after six hours of incubation.

10. Concurrent Sessions 2 Radiological Agent Fate, Transport, and Decontamination

Moderated by Jeff Szabo

Migration of Radiocesium, Radiostrontium and Radiocobalt in Urban Building Materials and their Wash-Off by Rainwater

K. Maslova, A. Gusarov, **A. Konoplev (Presenter)**, V. Popov, I. Stepina | *RPA "Typhoon"*
S.D. Lee | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

An expanded understanding of interactions of radiocesium, radiostrontium and radiocobalt with urban surfaces under varied atmospheric conditions will aid in the development of more effective decontamination techniques and strategies. The objective of the work is to investigate fate and transport of dissolved radiocesium, radiostrontium and radiocobalt deposited on common urban surfaces. The research was performed in frame of International Science and Technology Center (ISTC) Project # 4007.

Wash-off of ^{137}Cs, ^{60}Co and ^{85}Sr from coupons of common building materials including asphalt, brick, concrete, granite, and limestone deposited as a liquid aerosol was studied by simulating heavy rain (20 mm/hr for 30 minutes) after aging at 30 and 87% of air relative humidity (RH) for 1 or 28 days at different temperatures. At 20^{o}C and 30% RH the ^{137}Cs and ^{60}Co wash-off for asphalt ranged from 32 to 44% and for granite from 13 to 27 %. The ^{85}Sr wash-off for asphalt was 76-80% and for granite 11-22%. For other materials the radionuclide wash-off was typically 2-6%. Increasing the RH from 30 to 87 % affected wash-off of all radionuclides for granite and asphalt and ^{137}Cs for concrete and brick. The most pronounced RH effect was observed for ^{60}Co behavior in asphalt (^{60}Co wash-off decreased from 34-47% to 11-25% and from 29-45% to 2-5% when RH increased from 30 to 87% for 1 and 28 days of aging correspondently). Temperature of incubation (5, 20 or 35 °C) did not affect significantly the wash-off of radionuclides from the building materials at 30% RH.

An effective method to study the radionuclide depth distribution in building materials using layer-by-layer sanding has been developed. Using this method, the ^{137}Cs, ^{60}Co and ^{85}Sr distribution in depth of selected building materials at different air humidity, time and temperature was studied. The median penetration depth (90% of radioactivity in the solid phase) of ^{137}Cs and ^{60}Co in asphalt and concrete aged for 28 days did not exceed 0.4-1.0 mm with or without rain. RH was found to influence significantly the ^{85}Sr depth distribution in case of asphalt and ^{137}Cs in case of granite (5-6 fold difference). Penetration of radionuclides in granite was remarkably high being 0.3-2.9 mm for ^{137}Cs, 4-6 mm for ^{60}Co, and 2-11 mm for ^{85}Sr depending on RH, aging and rain conditions.

Questions, Answers, and Comments

- Q: Why do these differences occur? Because of differences in RH?
- A: We can't explain the high penetration of Sr into granite; this is unexpected and surprising. In terms of wash-off, we can explain this. The highest efficacy values for wash-off are characteristic for materials with low porosity like asphalt and granite so the radionuclide is more available on the surface to such materials and doesn't penetrate to the porous materials. It is also not fixed in the pores.
- Q: Was any subsequent rainfall part of the simulation testing?
- A: No, because we have limited resources of materials and time, we did two replicates for only a fixed rain rate and duration. It will be useful to continue experiments with various duration and intensity of rain.
- C: Granite penetration is surprising. It might be connected to the very fine microscopic crystalline structure of granite, the same way fracture in bedrock could allow penetration.
- C: That is our speculation. When we look at the granite property data, it shows that pore size is smaller and the connectivity of the pores is limited. However, it is relevant to how we prepare the coupons. We had to cut it and some micro fractures may have been created. We did coat the other five sides to prevent water transport.
- Q: You are using soluble radionuclides; could you comment on the source terms in the environment?
- A: We suppose that in case of explosive devices solutions could be used.
- C: The initial tests used cesium chloride powder. Since we are testing with rain and humidity, we speculated that the wet form of cesium chloride would be most conservative and most difficult to remove.
- Q: Did you compare the mass of the coupon before and after you applied the solution?
- A: Yes, it was weighed before and after the application; the change in weight was taken into account.
- C: Before injection the coupons were equilibrated at specific RH.

Scalability Challenges for Deployment of Commercially Available Radiological Decontamination Technologies in the Wide Area Urban Environment

John Drake (Presenter) | *U.S. Environmental Protection Agency Office of Research and Development, National Homeland Security Research Center*
Rick Demmer | *Battelle Energy Alliance*
Ryan James | *Battelle Memorial Institute*

Abstract

NHSRC has conducted in-house and extramural experimental work to evaluate the efficacy and applicability of a number of commercially available radiological decontamination technologies. This work has focused on decontamination of various radionuclides, from a range of urban building materials, based on accepted radiological dispersal device (RDD) scenarios. Many of these technologies may, or may not, be applicable to decontamination on a wide area scale. Based on these evaluations and input from USEPA emergency response personnel and other industry and government sources, a compendium of available technologies was assembled. These technologies were then evaluated to identify potential challenges (e.g., scalability) and knowledge gaps involved in applying them in the wide area urban environment after an RDD incident. Finally, this effort produced a set of recommendations for further development of promising methods and processes.

Questions, Answers, and Comments

- Q: Does the government retain rights to a new compound or technology?
- A: It depends, if it's a patented by the company the government pays every time they use it.
- Q: In your literature search for different techniques and methods, how comfortable do you feel that you looked internationally?
- A: We probably have not looked everywhere. One technology was presented this morning that I was not aware of. We think we did a defensible job but are willing to add more.

- Q: Do you plan to conduct a large scale experiment or demonstration?
- A: That will be driven by budget. We do have research plans that would include some large-scale demo of these technologies
- Q: Is there a possibility to incorporate Chernobyl or Fukushima lessons learned?
- A: Absolutely. Fukushima is an ideal testing ground; the EPA's Consequence Management Advisory Team (CMAT) is the principal contact between us and Fukushima; we also have a collaboration with a research center in Armenia; there are contract vehicles via which we can do that, we would be interested in others.
- C: A bilateral commission is helping Japan now; we talked to the Japanese Ministry of the Environment about potential projects especially in exclusion zones. We are trying out some of these untried techniques with the opportunity to develop new ones; that's a likely scenario for DOE to be engaged in.

Sorption and Speciation of ^{137}Cs, ^{60}Co and ^{85}Sr in Building Materials

I. Stepina, A. Gusarov, A. Konoplev, **K. Maslova (Presenter)**, V. Popov | *RPA "Typhoon"*
S.D. Lee | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

Radionuclide binding to building materials is determined by a number of processes. Of them the key are sorption by ion exchange, complexation and fixation due to different mechanisms. They play an important role in migration and transformation of radionuclides on urban surfaces and should be thoroughly considered under development of decontamination techniques and strategies in case of radiological incidents such as nuclear accidents or terrorist attacks.

The objective of the work is to investigate sorption and speciation of dissolved radiocesium, radiostrontium and radiocobalt after deposition on common urban surfaces under varied atmospheric conditions for developing effective decontamination techniques and strategies. The research was performed in frame of International Science and Technology Center (ISTC) Project # 4007.

Kinetics of ^{137}Cs, ^{60}Co and ^{85}Sr sorption on powdered building materials in aqueous suspensions at 20°C for the interaction time 1, 7, 14 and 28 days was studied. The ^{137}Cs distribution coefficient (K_d) values for all building materials except limestone practically did not change during 28 days of sorption. The highest value of K_d (^{60}Co) was observed for limestone. For other building materials K_d (^{60}Co) values varied from 800 to 5000 dm^3/kg. It should be noted that for all building materials except granite the values vary insignificantly with time. The K_d (^{85}Sr) was several orders of magnitude lower than K_d (^{60}Co). The highest values were observed for asphalt and granite. For other materials K_d (^{85}Sr) values slowly changed with time and did not exceed 40 dm^3/kg.

The ability of materials under study to bind radiocesium was characterized in terms of radiocesium interception potential (RIP). The RIP(K) value has been shown to range from 20 to 300 mM/kg and increase in the order: limestone < brick < concrete < granite < asphalt. The fine fraction of building materials (<0.125 mm) sorbs ^{137}Cs better than the coarse fraction (0.125-0.25 mm).

Mechanisms of radionuclide binding with components of building materials can be assessed by sequential extractions with various solutions. It was found that the major fraction of sorbed ^{137}Cs (from 30% to 51%) was extracted by a solution of hydroxylamine hydrochloride. The ^{137}Cs percentage in the residual fraction decreased in the order: concrete > limestone > granite > brick. Sodium acetate solution (pH=5) extracted most of ^{60}Co. This fraction decreased in the order: limestone (74%) > brick (64%) > granite (57%) > concrete (47%) > asphalt (38%). The ^{85}Sr and ^{60}Co concentration in the residual fraction did not exceed 1%. The predominant fraction for ^{85}Sr after 28 days of interaction was the exchangeable fraction: from 24% (in limestone) to 72% (in asphalt).

There were no questions for this presenter.

Humic Acid-Based Sorbents for Area Decontamination

A. Sosnov, S.V. Sadovnikov | *NP OrCheMed, Russia Academy of Sciences*
Y.G. Putsykin, A.A. Shapovalov | *Agrosyntez, LLC*
K. Volchek, W. Kuang, P. Azmi, **C.E. Brown (Presenter)** | *Environment Canada*

Abstract

The paper describes formulations of humic acids (HA) which can be used as selective adsorbents for toxic chemical substances, such as cations of heavy metals, and for radionuclides. HA-based adsorbents are typically produced from lignate (brown coal), leonardite, and peat. HA activation involves desorption of non-active constituents while retaining the chemical skeleton of natural HA that is necessary for a reversible polymerization of HA. A subsequent microbiological treatment helps further purify the HA.

Several different types of adsorbents based on activated HA were developed in this study. These include a powder (45% of extractable HA), a neutral aqueous gel (10% of HA as emulsion), and an aqueous solution (10% of HA as potassium salts). The capacity of these adsorbents for cations of heavy metals and radionuclides can be as high at 10% (w/w). Cesium can be removed using HA derivatives containing additional inorganic compounds.

An addition to being promising sequestering agents for toxic chemicals and radionuclides, HA-based sorbents are effective in remediation of oil-contaminated soil. This makes them usable in a variety of environmental emergency response scenarios.

The focus of current research is on: a) development of standard samples of HA adsorbents for testing and evaluation; b) application of adsorbents for area mitigation after radiological incidents; and c) development of methods for environmental remediation of contaminated sites. The research is funded in part by the Canadian Safety and Security Program.

Questions, Answers, and Comments

- Q: How stable is the activated humic acid?
- A: Not sure. Where they added microorganisms, it was stable for at least a year.
- Q: Has any of these formulations been suspended in water to do removal from water?
- A: Yes, that was one of the formulations.

11. Poster Session

1. Surface and Vapour Decontamination by Aerosolized Micro-Emulsion Decontaminant

Linda Ang, George Ng M H, Lim M Y, Tan K R, Eunice Sim S H | *DSO National Laboratories*

Abstract

In buildings and structures, bulk liquid spraying of decontaminant is the basic protocol for spot and area decontamination of surfaces contaminated by chemical warfare agents (CWAs). Other than bulk-liquid decontamination, aerosolization or fogging is another means of dispensing the decontaminant in indoor areas. Such method could be more practical as aerosols are capable of reaching to almost every aspect of an area including difficult to reach places, such as air ducts.

Here, we present a preliminary work in exploring the deployment of our newly developed in-house decontaminant in the form of an aerosol to decontaminate spatial and surface areas contaminated by CWA. The decontaminant has previously been evaluated as a bulk liquid spray for chemical and biological threats.

Our approach was to first create a CWA vapour atmosphere in a customized 0.6 m^3 stainless steel chamber with an unique adjoining inflatable bag that serves to uptake the voluminous incoming aerosol-laden air jet from a

commercial-off-the-shelf (COTS) pneumatic air-assisted portable atomizer (COTS fogger). A few indoor material types, arranged at 3 spatial orientations were also placed inside the chamber prior to CWA vapour generation. After 1.5 hours, the decontaminating aerosol was generated and introduced by the COTS fogger into the chamber. CWA-aerosol interaction was allowed overnight, and regular air sampling was performed using Tenax® adsorption tubes. The tubes were subsequently analyzed by Thermal desorption/Gas Chromatography/Mass Spectrometer (ATD/GC/MS). The material surfaces were retrieved at ~22 hours after fogging and the residual agents on sample materials were extracted with appropriate solvents. The poster will provide a brief description of the methodology and results of the study.

2. Development of Solid Peracetic Acid (PES-Solid) for Decontamination

Kathryn Burns | *Naval Surface Warfare Center Dahlgren Division*

Abstract

Current decontamination solutions are based on oxidative chemistry in aqueous systems. To avoid transporting extra water, it is desirable to reduce the logistical footprint of decontaminants by identifying solids to be mixed on site. One of the more challenging components is the oxidizing agent. While currently fielded high test hypochlorite (HTH) is a solid, it is also a harsh, halogenated material with poor materials compatibility. Non-halogenated peroxygen compounds are of interest as oxidizers because of their low impact on the environment and their relatively low toxicity. PES-Solid, made by Solvay Chemicals Inc., is a solid peracid-containing borate salt that releases 25-30 wt% peracetic acid immediately upon dissolving in water. Peracetic acid is therefore immediately available for reaction with threat agents and is neither delayed by nor dependent upon the kinetics of *in situ* generation. Dahlgren Decontaminant, a Navy patented decontaminant formulation incorporating PES-Solid in a surfactant blend, has been shown to provide improved decontaminant efficacy against both biological and traditional chemical agents, improved materials compatibility and offers the desired reduced logistical footprint. Dahlgren Decontaminant was successfully evaluated as part of the Defense Threat Reduction Agency (DTRA) Hazard Mitigation, Materiel and Equipment Restoration Advanced Technology Demonstration (HaMMER ATD) and is currently being evaluated in the Joint Project Manager for Protection (JPM P) General Purpose Decontaminant for Hardened Military Equipment (GPD-HME) Competitive Prototype testing.

3. On-Site qPCR for Detection of Biological Threat Agents – Sources of Measurement Uncertainty

S.M. Da Silva, L. Vang, N.D. Olson, N.J. Lin, J.B. Morrow | *Biosystems and Biomaterials Division, National Institute of Standards and Technology*

Abstract

Quantitative polymerase chain reaction (qPCR) is a well-established technique often used to detect biological threat agents due to its selectivity and sensitivity in identifying targeted nucleic acids. However, obtaining accurate and reliable data can be significantly hindered by a number of factors within the process, sample, and environment. For example, qPCR for environmental biosurveillance (e.g. *Bacillus anthracis*) is challenging due lack of sampling validation and standards (GAO-05-251, 2005) and to variables encountered in real-case scenarios; unreliable biosurveillance data can jeopardize public safety. Reliability of qPCR data can be impacted prior to sample collection by the "environmental sample matrix," which can include background organisms, chemical interference from decontamination procedures, or scenarios involving high human activity. Additional factors that can impact uncertainty in qPCR field detection include sample collection, sample processing, nucleic acid extraction, qPCR measurement, data interpretation, and operator skill. Not all factors contribute equally to data variability, thus it is important to identify factors with the greatest impact on measurement uncertainty (MU) by evaluating their source(s) and significance (EURACHEM / CITAC Guide CG 4). Knowledge of the impact of these factors is important for robust experimental design, data accuracy in a given protocol, and data analysis (Arbeli et

al, Int. Biodeterior. Biodegrad., 62(1), 14, 2008). In order to address the metrological aspects of on-site qPCR MU for biosurveillance, we will discuss factors contributing to qPCR MU relevant to field detection. Moreover, we will propose the use of a non-biothreat yeast reference material (YRM) containing a unique DNA marker to challenge the analytical process of on-site qPCR and offer a tool for further identifying sources of uncertainty. Advantages of the YRM include elimination of false positives from near-neighbor organisms and the absence of health and security risks. The YRM is expected to be useful as a training tool for a given protocol or technology, a test material in a simulated real-case scenario exercise relevant to emergency preparedness, a confidence checker to assess performance of a given technology or user skills, and a means for proficiency testing. Together, the MU assessment and the YRM enable the tracking and consequent minimization of sources of uncertainty for qPCR.

4. Survival and Demise of Biological or Chemical Agents in Municipal Solid Waste Landfill Leachate

Wendy Davis-Hoover | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
Mary Margaret Wade, Harry Salem | *Edgewood Chemical Biological Center*

Abstract

The primary objective of the study was to examine the fate or persistence of selected biological and chemical agents in municipal solid waste (MSW) landfill leachate. Raw MSW landfill leachate samples were individually spiked with chemical (Tabun, Sarin, Soman, Mustard Gas, Lewisite, or VX) or biological agents (*Francisella tularensis, Yersinia pestis, Bacillius anthracis* spores, or *Clostridium botulinum*). While most of the chemical agents (except Lewisite and VX) are unable to survive long in MSW landfill leachate at 12° C, the biological agents of *Bacillus anthracis* spores survive for > 7 years at 12° C, and 6 to 7 years at 37° C while *Clostridium botulinum* survives for > 7 years at 120 C, and< 7 years (but >6 years) at 37° C. *Francisella tularensis*, and *Yersinia pestis* did not survive past 20 and 6 days, respectively at 35-37 and 28° C., respectively. Survivability of agents in landfill leachates and landfills emphasize the need to carefully evaluate the work place and long term containment in landfills. (Temperatures vary in landfills, so the temperatures used in this research were to simulate temperatures where the agents are likely to survive or grow.)

5. Method of Improving Chemical Resistance of Coatings by Surface Modification.

Erin Durke Davis, Wesley O. Gordon, Gregory W. Peterson | *OptiMetrics, Inc./DCS Corp.*

Abstract

Coatings are required to demonstrate chemical resistance in order to protect material, vehicles, and personnel. Numerous other requirements for the development of new coatings often involve substantial reformulation efforts in order to adapt to changing conditions and applications. One method to improve chemical resistance of coatings is to modify the surface of the paint to reduce surface energy without changing the bulk properties. Plasma-based chemical vapor deposition (PCVD) of perfluorinated compounds has been used for years to improve resistance of fabrics and materials to water and other chemicals. For example, there are several reports in the literature of superhydrophobic fabrics developed using PCVD. Here we report the application of a PCVD method that not only induces superhydrophobicity to a real world coating, but also dramatically improves the resistance of the coating to the spreading and absorption of the chemical warfare agents, HD and VX. Over the 30 min age time, droplets remained pinned and are therefore more easily decontaminated or removed physically. Surface analysis confirms modification of the surface with fluorinated species and also shows etching of the organic components of the paint. This treatment suggests that surface modification strategies may be effective in improving chemical resistivity without changing the bulk properties or requiring a significant reformulation effort.

6. Sample Sizes and Placement of Tests Following Building/Area Decontamination

Martin A. Heller, Amarjit Budhiraja, Ross Leadbetter | *University of North Carolina*

Abstract

Following fumigation after an anthrax or similar attack, a building is typically tested intensively for residual contaminant. Sampling at the (say N) points of a grid sufficiently closely spaced to ensure complete coverage may be prohibitive even for such crucial situations, for example requiring a sample per square foot of building. It is thus important to assess the confidence in complete clearance when just n ($<N$) samples are taken and all "test negative". Calculation of C requires statistical modeling of the contamination pattern, using any known ("prior") information about causes and distribution. Commonly it is assumed that contamination is statistically independent at all N grid points, each having the same probability p of being contaminated, where information about p is reflected in a so-called Beta "prior distribution". The underlying calculations have been extensively programmed by Pacific NW National Laboratory, as "VSP" (Visual Sample Plan) software, for varied applications including this decontamination context.

This software uses standard statistical means to provide the number n of sampled sites needed for any desired confidence level C of clearance, and has a wide capability to produce maps suggesting sample locations for user-selected area patterns. The confidence obtained depends only on the number n of sites tested and not on their locations. For example samples taken contiguously in the corner of a room yield the same confidence as those spread uniformly throughout the room. This disquieting fact suggests that the basic assumptions should be reexamined, and some dependence structure between sites introduced.

Given some pattern of dependence, two strategies seem natural: (1) sample in a uniform way over the area, including regions of unlikely contamination, using just n of the N grid points, or (2) sample solely in the areas where contamination is likely to be higher. With such factors in mind we have combined their good features and developed a sampling algorithm, which emphasizes suspected areas of higher contamination likelihood, but automatically builds in diversity of location. The basic ingredients are preliminary values of the probabilities p_1, p_2, …, p_N of contamination of each of the N sites, using any prior information regarding placement and movement. The algorithm starts from an initial arbitrary choice of n sites, replacing them one by one with sites of greater individual probability according to specific rules that ensure diversity of location. To test the algorithm in particular cases we have simulated contamination patterns with complex ("*Branching Process*") dependence structure. As will be shown in the talk, it performs significantly better than Strategies (1) and (2) in a variety of such cases. While the type of example is very special it provides a useful comparison of methods, showing that the algorithm gives a quite promising procedure.

Finally the algorithm has been designed and tested for obtaining the confidence in complete clearance. In "less toxic" cases where some non-zero contamination level is acceptable (e.g. in some radiological situations) it is expected that modifications of the algorithm will be useful, and this is under current study.

7. Technology Evaluation of Army Toxicity Sensors

Ryan James, Elizabeth Hanft | *Battelle*
Sharron Serre | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
David E. Trader, Linda M. Brennan, Mark W. Widder, William H. van der Schalie | *U.S. Army Center for Environmental Health Research*

Abstract

U.S. EPA National Homeland Security Research Center evaluated the performance characteristics of two rapid toxicity sensors that will be used as part of the U.S. Army Environmental Sentinel Biomonitoring program to test for the presence of a wide variety of chemical contaminants in drinking water. The sensors evaluated were Electric Cell-substrate Impedance Sensing (ECIS) and the Nano-Intelligent Detection System (NIDS) ACE™ Rapid Test for Acetylcholinesterase Inhibitors. The sensors do not identify or quantify the chemicals; rather they serve as screening tools to establish whether or not drinking water is potentially toxic or remains toxic following treatment or decontamination. The sensors were evaluated with 18 different individual industrial chemicals,

pesticides and rodenticides. Solutions of the contaminated water (CW) samples using a minimum of three concentrations of each chemical with four replicates for each concentration were prepared in deionized water (DI). In addition to the CW samples, six interference chemicals (ICs) were also tested. The ICs samples were prepared using chemicals that might be present in clean drinking water, such as chlorine and chloramines. These were analyzed with four replicates of a single concentration. The sensors were also evaluated for operational factors such as ease of use, field portability, and throughput.

CW samples were considered detected if the sensor responded positively to all four replicates. Because the ultimate goal is for these two sensors to be combined into a single analysis tool, results will be presented that provide an overall summary (percent of contaminants detected) for each sensor individually and combined to the EPA human lethal concentration (EPA HLC), the Army human lethal concentration (AHLC), and the Army military exposure guideline (MEG). Combined, the ECIS and ACE™ sensors were able to detect 83% of the contaminants at the EPA HLC, 67% of the contaminants at the Army HLC, and only 6% (one contaminant) at the MEG. There was minimal response from either sensor to six different possible interfering chemicals. Both sensors had a low rate of false positive results in response to deionized water, 8% for the ECIS sensor, and 0% for the ACE™ sensor.

The views expressed are those of the authors and do not constitute endorsement by the U.S. Army.

8. Identification of Hazard Mitigation Agents to Neutralize Dry Powder Biological Materials

Aimee Ketner | *Naval Surface Warfare Center Dahlgren Division*

Abstract

The threat of adversaries using biological weapons reinforces the need for hazard mitigation strategies targeting harmful biological materials. Currently, there is a lack of expedient decontamination methodologies for dry powder biologicals such as *Bacillus* spores. Efforts including high heat, explosives, and gaseous acids have been tried in the past and were unsuccessful. We are currently pursuing a new hazard mitigation strategy that involves a combination of a sporicidal agent and a solvent with the aim of wetting the dry powder, allowing the sporicidal agent to fully contact the biological material.

We identified 43 potential sporicidal agents and 24 solvents, producing a matrix of 1,032 combinations. We down selected to a single optimized formulation through a series of qualitative and quantitative tests. We successfully tested the optimized Counter Measure (CM) solution against five milliliters of target spores and 125 milliliters of target spores.

Following the selection of the optimized CM solution, we ran several studies to help characterize it. These included: testing the optimized CM solution on spores in different container materials to determine if there is any adverse effect of the container material on the decontamination efficacy of the CM solution, and environmental testing of the CM solution to characterize the product across a range of realistic environment conditions. Future work includes characterizing the shelf life of the CM solution and testing against target materials with a range of different physical characteristics representing the realm of the possible in terms of dry agent that may be encountered. The end result of this effort will be a solution that can be used to neutralize the threat posed by a dry powder biological agent.

9. Decontamination of Surfaces Exposed to Organophosphates by Vapor Phase Hydrogen Peroxide

Marek Kuzma, Jaroslav Červený | *Laboratory of Molecular Structure Characterization, Institute of Microbiology*
Kamila Syslová, Petr Kačer | *Department of Organic Technology, ICT - Prague*
Libor Pánek | *BLOCK a.s.*

Abstract

In recent history, chemical and biological counter-terrorism have come to the forefront of defense due to the immense threat to public health and national security. It is evident that after the release of any chemical and/or biological agent some level of decontamination is required before normal activities on the site affected can resume.

Particular decontamination methods were tested and approved for some applications and have their advantages and disadvantages. The use of vapor decontamination methods is quite easy and can be applied for a wide space. Vapor phase hydrogen peroxide (VPHP) is very progressive technology. This agent seems to be very active for decontamination and its elimination from decontaminated space is environmentally friendly, because it decomposes to water and oxygen. There is rising interest in application of VPHP for decontamination of chemical warfare and biologically active compounds. But there is only limited information about influence of VPHP on chemical substances.

We were dealing with degradation of organic substances derived from phosphoric acid by VPHP. It was studied insecticides, which represent a group of widespread toxic substances with structure features related to nerve warfare agents. It was studied influence of various functional groups on the course of degradation and degradation products. The decontamination process was followed by analytical methods to get information not only about the kinetics of the process but to elucidate the structure of decontamination products. We have studied both the effect of VPHP and potentiation of its action, especially with tertiary amines and UV radiation.

The results indicate substantial influence of the structure on the course of the decontamination and its products. It was approved that already VPHP can decontaminate various phosphoric acid derivatives. The presence of the sulfur atom substantially increases reactivity. In the case where the sulfur atom connects the phosphate group to the rest of the molecule, it can result in disintegration of the molecule. We can expect that the same mechanism would be probably also applied to the decontamination of warfare agent VX, which possesses such structure moiety in the molecule. It was also studied synergic effect of VPHP with UV radiation and/or amine on the course of the decontamination and degradation products.

Therefore, we guess that appropriate combination of VPHP with amine and UV radiation can be a powerful decontamination method, which can be easily applied in large rooms or buildings exposed to warfare agents.

Acknowledgements

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10. Rapid uptake of cesium and americium by sequestering agents from complex decontamination solutions

Carol Mertz, Michael Kaminski, Nadia Kivenas, Angela Tisch, Luis Ortega | *Argonne National Laboratory*

Abstract

After a malicious release of radioactivity, large urban areas may be contaminated compromising efforts by first responders and law enforcement officials. Large-scale implementation of urban substrate decontamination requires a balance between finding an effective decontamination formulation for the urban substrates and maximizing sorption based upon the sequestering properties in the presence of the wash solution additives. In addition, the technology should minimize hazards to the environment and personnel, and provide a rapid, easily deployed and implemented decontamination effort that is cost-effective for full-scale implementation. We are developing an inexpensive, water-based means of decontaminating an urban setting for restoring critical infrastructure and operational activities after a radiological release to address these decontamination requirements. Our decontamination technology is based on inexpensive and readily-available materials in large-

scale quantities. Water-soluble additives were tailored to preferentially remove the radioactive contaminants from urban substrates followed by sequestration of the contaminant from the wash solution using a sequestering agent. Results from batch partitioning measurements will be presented on the evaluation of various sequestering agents for the sorption efficiency of cesium and americium in the presence of wash solution additives. The sequestering materials tested were natural minerals and some man-made compounds, including illite, vermiculite, silicon dioxide, chabazite, birnessite, clinoptilolite, montmorillonite and crystalline silicotitanate. Testing examined the kinetics of cesium and americium sorption onto the materials from five minutes to one day. In addition, wash solution additives and concentrations of additives were selected based upon previous work to optimize removal of radioactive cesium and americium from urban substrates, such as concrete, asphalt, brick, limestone and granite. Final recovery of cesium or americium using sequestering agents will be presented.

11. Energy density-response relationships of bacterial spores to ultraviolet radiation: a test of Haber's Law

Karen Pongrance, Deborah Schepers | *Excet Incorporated*
Jana Kesavan, Jason Edmonds | *U.S. Army Edgewood Chemical Biological Center*

Abstract

Ultraviolet radiation has been thoroughly studied as a method to inactivate bacterial spores, making it a commonly used decontamination method by the military, healthcare industry, food industry and others. This investigation studied the effects of UVC radiation intensity levels and dosage time on *Bacillus thuringiensis*, a surrogate for *Bacillus anthracis*. Although the bactericidal effects of UVC radiation have been well studied, it is difficult to compare studies in the literature to one another because they use different wavelengths of light, intensities, and exposure times. Haber's Law states that the severity of a toxic effect depends on the total exposure concentration times the duration time of exposure. This investigation thoroughly characterized the energy density-response relationships of bacterial single spores and monodispersed clusters to ultraviolet radiation. Three different time/intensity combinations were used where the total fluence delivered to the particles remained constant in accordance with Haber's Law. A low-power continuous lamp source (254 nm) was used. The intensity was adjusted both by increasing or decreasing the distance between the lamp and the samples, and by screening the lamp to achieve different intensity levels. Both single spores and clusters up to 10 micrometers of *Bacillus thuringiensis* were seeded onto filters and exposed to the UVC radiation. Culture analysis was used to quantify the level of inactivation. Applicability of Haber's Law to this relationship is discussed. The goal of this work was to understand the fundamental interaction between photons and organisms in order to allow for advances in the effectiveness of UV irradiation applications, and allow a point of comparison for studies in the literature.

12. Can You Beat a Garden Sprayer? Novel Methods of Decontamination *of Bacillus Anthracis* Contaminated Soil

T. Pottage, A. Bennett, A. Crook, S. Hawkey | *Health Protection Agency*
L. Baillie | *School of Pharmacy and Pharmaceutical Sciences, Cardiff University*

Abstract

Bacillus anthracis is the causative agent of the disease anthrax. Anthrax is a potentially deadly disease to both animals and humans, which is endemic in some areas of the world such as the Caucasus region on the border of Europe and Asia. In some areas economic and time pressures lead to animals remaining unvaccinated, and the disposal of some fatally infected animals is inadequate leading to the contamination of the surrounding area and then potential future infection of animals and humans. A UK Home Office funded project lead by Cardiff University in conjunction with the Health Protection Agency, UK, and Kafkas University, Turkey, investigated using novel chemical and physical decontamination methods to remediate anthrax contaminated soil.

The investigations studied whether the addition of two germinants (alanine and inosine) to anthrax contaminated soil would increase the effectiveness of two commonly available biocides, PeraSafe and hydrogen peroxide. The biocides were tested under a range of conditions from: a) direct liquid addition to soil within the laboratory, b) application to an anthrax contaminated burial site using a garden backpack sprayer, c) using an atomiser to produce a vapour of the biocides and d) the additions of the biocides to the soil then processed through a commercial reactor technology.

Preliminary studies were completed in the laboratory on small soil samples to determine the effectiveness of the germinants and biocide combinations *in vitro*. The results from these studies showed a concentration of 5000ppm PeraSafe was the most effective biocide. These parameters were then scaled up and tested in the field using the three technologies at different burial sites and separately with collected contaminated soil. The reactor technology was unable to achieve the necessary temperature to decontaminate the soil passed through it; Further complications whilst using hydrogen peroxide lead to trials being stopped with this device and the PeraSafe biocide then being focused on for the remaining duration of the study. Exposure of soil to germinants for 1 hour and then PeraSafe for a further hour, applied using a backpack sprayer, saw a decrease in numbers of vegetative organisms and total spore numbers of 1 log. The site exposed to the germinants and then PeraSafe using the vapour atomiser did not see any reductions in vegetative organism numbers and only an approximate 0.5 log reduction in spore numbers.

The vapour atomiser and backpack sprayer were effective methods of delivering biocide to the areas, but microorganism reduction is dependent on biocide concentration and the composition of the soil. The reactor technology was found to be unsuitable for the application of soil decontamination.

13. Degradation of Aerosolized BG Spores via Ultraviolet Light

Jonathan Sabol | *Excet Incorporated*
Donna Carlile, Jason Edmonds | *U.S. Army Edgewood Chemical Biological Center*

Abstract

The ability to decontaminate air is a universal problem as aerosolized particles posing a risk to health are ubiquitous. Some material, such as dust and molds, can be removed, at high efficiency from indoor air by filtration. Any particulates that escape the mechanical capture rarely cause a serious health risk and are more of an irritant and inconvenience. However, other airborne particulates, in the form of infectious microorganisms, are still a serious health concern for building occupants. This is of great concern for high risk facilities, such as hospitals, as well as governmental buildings vulnerable to malicious intent as witnessed in the 2001 anthrax attacks. Hospitals have invested in air purification systems to reduce the airborne particulates, which can infect hospital personnel, and to minimize the risk of exposing individuals with already compromised immune systems to other infectious diseases. One technology which has been extensively studied is the degradation of microorganisms by Ultraviolet irradiation. In our study, we have investigated the efficiency of UVC decontamination of *Bacillus* spores as a function of irradiation levels and particulate size. Our results demonstrate that larger particles are relatively unsusceptible to UV irradiation. While individual spores within a particle may be inactivated, the particle as a whole unit potentially remains infectious.

14. Use of Fixatives to Prevent *Bacillus anthracis* Spore Reaerosolization

Mark Sutton, Staci R. Kane, Marilyn J. Ramsey, A. Celena Carrillo | *Lawrence Livermore National Laboratory*

Abstract

Many challenges exist in the successful outdoor decontamination of *B. anthracis* spores. High disinfectant concentrations increase operational costs and risk to human health and the environment. Disinfectants are corrosive, potentially damaging to surfaces and sensitive materials, and may be consumed by organic/chemical backgrounds in the environment. No disinfectants have been demonstrated to be effective in soils or vegetation,

and they pose long-term human health and environmental impacts. Additionally, some traditional decontamination activities could promote spore transport through reaerosolization.

Fixatives are commonly used in a variety of hazardous material mitigation applications, such as radiological contamination, methamphetamine cleanup, hazardous waste management, soil contamination encapsulation (common for PCBs), asbestos encapsulation and dust suppression.

The application of fixatives can temporarily or permanently fix *B. anthracis* spores to surfaces. Through agglomeration and fixation, the concentration of spores that may be resuspended in the respirable particle size range (1-10 µm) should be reduced. Thus, fixative applications may then be employed as a risk mitigation step during first response and initial recovery activities to limit exposure and further spread of contamination.

Fixatives may be an inexpensive, rapid, and effective means to prevent reaerosolization and subsequent spread of outdoor biological/radiological agents needed for large-scale incidents. Where limited resources are available for decontamination, recovery efforts can focus on high priority locations and infrastructure. Lower priority areas can be stabilized with fixatives to prevent resuspension, thus reducing inhalation health risks and subsequent recontamination of cleared areas. Fixatives provide for Rapid Return to Service (RRS) for key transportation corridors (roads) and critical infrastructure.

The fixative materials for this evaluation have previously been deployed in Japan following the events at the Fukushima Diiachi plant to suppress the resuspension and subsequent migration and inhalation of radioactive particles. Additionally, some fixatives are peelable from the surface after curing to trap and remove contaminant particles. We have also investigating natural-based products such as horticultural oil as a means of preventing resuspension and agglomeration of spores to larger than the inhalable range.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-618052.

15. I-WASTE: EPA's Suite of Homeland Security Decision Support Tools for Waste and Disaster Debris Management and Disposal

S. Thorneloe, P. Lemieux | *U.S. Environmental Protection Agency, Office of Research and Development*
M. Rodgers | *Eastern Research Group, Inc.*

Abstract

In the U.S., a single comprehensive approach to all-hazards domestic incident management has been established by the Department of Homeland Security through the National Response Framework. This helps prevent, prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies. A significant component of responding to and recovering from wide-area or isolated events, whether natural, accidental, or intentional (including chemical, biological, and radiological incidents), is the management of waste resulting from the incident itself or from activities cleaning up after the incident. To facilitate the proper management of incident-derived waste, EPA developed the Incident Waste Assessment and Tonnage Estimator (I-WASTE). I-WASTE was developed by the U.S. EPA's Homeland Security Research Program in partnership with EPA program and regional offices, other U.S. government agencies, industry, and state and local emergency response programs.

I-WASTE is an online web-based suite of decision support tools that provides quick and easy access to information needed for making decisions associated with handling, transport, treatment, and disposal of waste and disaster debris. I-WASTE includes calculators to rapidly provide rough estimates of the quantities and characteristics of waste that would be produced by contamination incidents and subsequent cleanup activities in various building types. It provides location-specific information to identify specific facilities and key contacts for managing waste and debris. I-WASTE provides references to technical information, regulations, and other information that is important for the protection of public health, first responders, and the environment. This presentation provides an overview of I-WASTE and examples of recent uses.

16. Assessment of Contamination Following Simulated Chemical and Biological Attacks in a Public Building

Bob Muir, Erin James, Steve Wilkinson, Anusha Menon | *ChemCentre, Resources and Chemistry Precinct*

Abstract

There is currently a gap in Australia's preparedness for a large-scale chemical or biological attack on a public building or other significant infrastructure. This paper reports on a project which addresses the gap relating to the procedures of evacuation, contamination assessment and decontamination of public buildings following a terrorist release event. The research performed simulates a fictitious chemical (methyl isocyanate) and biological (Anthrax) terrorist attack on a public building of political importance in Western Australia.

The physical and chemical properties of either pathogenic organisms or toxic substances make them attractive weapons for terrorists to use against civilians. A chemical attack would be more effective if it took place in areas where the toxic material could be confined and where people are likely to gather en masse. For example, a subway system or government buildings are prime candidates.

A recent Australian Government CBRN Risk Environment Statement states, "Toxic chemical attacks are of concern due to recent terrorist use of these materials overseas. The consequences of an attack are potentially very serious, and there are significant vulnerabilities to be addressed" (CBRNSSC, 2011).

Toxic chemicals (Tokyo subway Sarin attack 1995) and Biological agents (the Amerithrax incident) have been used in the past against civilian populations. In addition to causing a number of deaths, many more were wounded and hospitals and first responders were overwhelmed.

To characterise the spread of such contaminants and determine the effectiveness of decontamination efforts in order to declare a facility safe for public occupancy requires significant effort.

A disused laboratory/office facility was used in this project where we released both sulfur hexafluoride (SF6) as a simulant for methylisocyanate and Bacillus thuringiensis (Bt) formulation (Dipel®) as a simulant for Anthrax. The Bt spores were tracked by collection on deposition plates and the SF_6 by real time measurement with infrared spectrometry and by sample collection in foil bags followed by laboratory analysis by gas chromatography with electron capture detection (GC-ECD).

A Data Quality Object (DQO) document was written to capture all information pertinent to the decision making process for pre and post-decontamination phases of the study. The sampling plan was determined and the degree of contamination subsequently visualised using software tools (VSP).

Pseudo-real time monitoring of chemical and biological simulant species allowed the flux and dispersion of 'agents' to be evaluated. A simple model of the building compartments was built (using CONTAM) and the results compared to the experimental data. Of interest are the findings that spores travel to the building periphery in a short timescale and that months after the building had been left unoccupied it was possible to re-suspend viable spores simply by walking through the affected area. This has implications for first responders investigating suspicious substance or "white powder" incidents.

17. Screening *Bacillus thuringiensis* Isolates for Characteristics that Simulate *B. anthracis* and are Useful for Environmental Tests

T.L. Buhr, A.A. Young, Z.A. Minter, C.A. Johnson, N. Kennihan, D.C. McPherson | *Naval Surface Warfare Center Dahlgren Division*

Abstract

Seventeen *B. thuringiensis* isolates were phenotypically characterized for potential as *B. anthracis* simulants. Spore preparations were screened for pre-harvest heat-resistant titers (threshold > 1e8 spores mL^{-1}; objective > 1e9 spores mL^{-1}), spore purity (threshold >90% purity; objective >95% purity), a spherical-equivalent spore

diameter with a statistical mode of 1-1.5 µM, presence of exosporium, and the absence of crystal toxin. Each isolate was also screened on tryptic soy agar for colonies that could be isolated and easily quantified. Eleven *B. thuringiensis* isolates surpassed all of the phenotypic criteria thresholds and eight isolates passed the phenotypic criteria objectives as simulants for *B. anthracis* spores. These *B. thuringiensis* isolates may potentially be used for repeated environmental releases to test biological detection and re-aerosolization.

18. Decontamination of Materials Contaminated with Bacillus anthracis and Bacillus thuringiensis Al Hakam Spores Using PES-Solid, a Solid Source of Peracetic Acid

T.L. Buhr, C.M. Wells, A.A. Young, Z.A. Minter, C.A. Johnson, A.N. Payne and D.C. McPherson | *Naval Surface Warfare Center Dahlgren Division*

Abstract

Aims: To develop test methods and evaluate survival of Bacillus anthracis Ames, B. anthracis ΔSterne and B. thuringiensis Al Hakam spores after exposure to PES-Solid (a solid source of peracetic acid), including PES-Solid formulations with bacteriostatic surfactants.

Methods and Results: Spores (≥7 logs) were dried on seven different test materials and treated with three different PES-Solid formulations (or preneutralized controls) at room temperature for 15 min. There was either no spore survival or less than 1 log (<10 spores) of spore survival in 56 of 63 test combinations (strain, formulation and substrate). Less than 2.7 logs (<180 spores) survived in the remaining seven test combinations. The highest spore survival rates were seen on water-dispersible chemical agent resistant coating (CARC-W) and Naval ship topcoat (NTC). Electron microscopy and Coulter analysis showed that all spore structures were intact after spore inactivation with PES-Solid.

Conclusions: Three PES-Solid formulations inactivated Bacillus spores that were dried on seven different materials.

Significance and Impact of the Study: A test method was developed to show that PES-Solid formulations effectively inactivate Bacillus spores on different materials.

19. UV-C Decontamination of Aerosolized and Surface Bound Single Spores and Bioclusters

Jana Kesavan, Deborah Schepers, Jerold Bottiger, and Jason Edmonds | *U.S. Army Edgewood Chemical Biological Center*

Abstract

Biological particles that are intentionally and un-intentionally produced are rarely composed purely of individual organisms but rather are clusters of organisms physically bound to one another. The organisms residing on the surface of a cluster are susceptible to environmental stresses and decontaminants, but they protect the organisms within the core of the cluster, resulting in decontaminating biological clusters harder to achieve. The use of ultraviolet irradiation is an option for decontaminating biological particles on surfaces and in air, and previous studies have been conducted with surface fixed particles, aerosolized single spores, or poorly characterized polydispersed aerosol particles making comparisons between studies difficult. This study is intended to evaluate the effect of UV-C irradiation on monodispersed spore clusters with mean diameters of 2.8 µm and 4.4 µm, and compare them to single spores of *Bacillus atrophaeus* subspecies *globigii* (BG) on fixed surfaces and in air. The data were fitted to decay models and the rate constants were determined. The results showed that the rate constants were higher for single spores and it decreased as the size of the cluster increased. The D_{90}, the value at which 90% of the colony forming units has been rendered non-culturable, for single spores on surfaces is 138 J/m^2, and 725 J/m^2 and 1128 J/m^2 for the 2.8 µm and 4.4 µm particles, respectively. The D_{90} value for single spores in air is 27 J/m^2, and 42 J/m^2 and 86-94 J/m^2 for the 2.8 µm and 4.4 µm particles in air, respectively. The study demonstrates that the decay rate of spores contained in the clusters is universally

dependent upon the overall particle size and it is harder to inactivate clusters on surfaces compared to clusters in air.

20. Decontamination, Decommissioning and Closure of the U.S. Chemical Stockpile Disposal Facilities

Amy Dean | *JPEO-CBD*

Abstract

With completion of the destruction of the U.S. chemical weapons stockpile under the Joint Program Manager Elimination (Provisional) (JPM E (P)) (formerly part of Chemical Materials Activity (CMA)), the JPM E (P)'s focus transitioned to the decontamination and decommissioning of the chemical agent destruction facilities. The strategy established by JPM E (P) to support the decontamination and closure efforts is endorsed by the National Research Council (NRC), U.S. Environmental Protection Agency (EPA), various state environmental agencies, and the Centers for Disease Control and Prevention (CDC). The closure strategy was crucial in managing the closure effort and communicating the approach to affected stakeholders.

The destruction facilities are complex industrial facilities that require a suite of decontamination methods including chemical, mechanical, and thermal techniques. JPM E (P) developed expertise and cultivated a well-trained workforce in these decontamination methods and capabilities. Examples include: room isolation; contamination control; air monitoring methods for verification of contamination levels; waste characterization; transportation and disposal; development and validation of sampling methodologies and risk assessments/models. Sampling and air modeling protocols, training and procedures were created to ensure accurate assessment of contaminated areas and an "all hazards" approach to the decontamination process was applied. Potentially contaminated facilities are evaluated by room or area, using grid area sampling methodologies, tenting and air monitoring, and additional techniques to assess levels of contamination. These established methods support prompt decision making in the field during decontamination operations. Laboratory systems for air monitoring are built with fixed and mobile options and are capable of expedited analysis to provide continuous feedback of decontamination progress to focus cleanup operations. Additionally, JPM E (P) is managing unique and mixed waste media encountered during decontamination and decommissioning that often require innovative characterization and management. JPM E (P) has successfully decontaminated and closed four facilities and by the end of 2013 will have completed closure of four additional facilities.

Currently, JPM E (P) is working with Department of Homeland Security (DHS), EPA and CDC on methods to address the nation's response to a terrorist attack involving chemical agent. Specifically, JPM E (P) is proving recommendations based on their experience with tenting and sampling methodologies to determine whether decontamination of an area or facility has been successful. JPM E (P) is also recommending unventilated monitoring testing procedures to verify decontamination levels are achieved so that facilities can be released back to workers or the public in the shortest amount of time possible. Waste management of chemical agent contaminated material is another groundbreaking area where JPM E (P) has developed standards and protocols that are being leveraged for emerging threats.

JPM E (P)'s decades of research and experience with decontaminating large industrial sites has proven instrumental in supporting U.S. domestic preparedness efforts. JPM E (P) has real world experience to handle real world risk.

12. Concurrent Sessions 3
Biological Agent Fate and Transport

Moderated by Marshall Gray

Reaerosolisation of Bacterial Spores from Indoor Surfaces

Susan Macken, Simon Parks, Jimmy Walker, **Allan Bennett (Presenter)** | *Public Health England*

Abstract

Contamination of indoor surfaces with biological agents will occur in the event of a bioterrorism incident. These deposited micro-organisms will provide an exposure risk for those who enter these areas. While direct contact with surfaces can be minimized there will be a risk of re-aerosolisation of deposited agent as personnel walk across flooring. This risk may lead to access to areas being limited to those wearing high level PPE prior to decontamination. This study has quantified re-aerosolisation, caused by a walking person, from two commonly used flooring surfaces to understand the risks of exposure to personnel from floors contaminated with pathogens.

A smooth PVC monolayer and a cut-pile industrial carpet, such as might be found in offices and other indoor settings, were contaminated with Bacillus atrophaeus spores deposited from a fine aerosol using an artist's air brush. A range of air samplers placed at different heights (Andersen 6-stage, Sartorius MD8, Casella slit sampler) were utilised to quantify and fractionate the aerosol generated when a person walked over these floor coverings, in an environmental chamber. Results were expressed as a percentage re-aerosolisation factor to represent the ratio of air to surface concentration. The results demonstrated a highly significant difference between re-aerosolisation factors from carpet and PVC. Aerosol concentrations were greatest at floor level. The aerosol concentrations obtained at a height of 1.5m were on average ca50% of the floor concentration. Average aerodynamic particle diameter for aerosols derived at 1m from carpets and PVC was 2.18µm and 3.24µm, respectively; which are within respirable range. There was greater contamination on boots worn by the operator following activities on carpet, compared to PVC.

These studies are continuing and are planned to investigate the effect of factors such as deposition method, environmental factors and a wider range of floorings and participants.

Questions, Answers, and Comments

- Q: Do you know when you used the sprayer whether the droplets reached the surface wet? Do you think recovery efficiency on a nonpolar surface could explain a lower fraction on the nonpolar surface?
- A: It was wet. What we measured is a ratio of what we recovered, not the actual deposition. We did studies on efficacy and about half a log of that difference was due to recovery efficiency, but the difference was three logs.
- Q: Was there an order in results to the type of steps?
- A: The difference between them was very subjective. Heavy walking resulted in less reaerosolization than medium walking.

Informing Response and Recovery Decisions: The Scientific Program on Reaerosolization and Exposure (SPORE), A Program Overview

M. Gray (Presenter) | *U.S. Environmental Protection Agency*

D. Bansleben, M. Moe | *U.S. Department of Homeland Security*

S. Paikoff | *U.S. Department of Defense*

A. Weber | *U.S. Department of Health and Human Services, Centers for Disease Control and Prevention*

J. Koerner | *U.S. Department of Health and Human Services, Assistant Secretary for Preparedness and Response*

Abstract

Knowledge gaps exist in the understanding of the public health and environmental impacts of reaerosolization of Bacillus anthracis (anthrax) in an outdoor environment. Fundamental questions such as reaerosolization rates, the use of surrogates, spore preparation, effect of surface variability, temperature and humidity influences, fate and

transport, temporal decay, and other factors may influence response and recovery decisions related to reaerosolization.

To address these gaps, the Department of Defense (DOD), the Department of Health and Human Services (DHHS), the Department of Homeland Security (DHS), and the Environmental Protection Agency (EPA) are partnered in the interagency Scientific Program on Reaerosolization and Exposure (SPORE).

The session will provide an overview of the SPORE initiatives, objectives, current research, and future plans.

There were no questions for this presenter.

Quantitative Analysis of Resuspension

R.W. Wiener (Presenter), M. Gray, W. Calfee, S.D. Lee | *U.S. Environmental Protection Agency*
D. Bansleben, M. Moe, J. Hogan | *U.S. Department of Homeland Security*
T. Kar | *U.S. Department of Defense*
A. Eisner | *ALION*

Abstract

The Scientific Program on Reaerosolization and Exposure (SPORE) seeks to provide an understanding of reaerosolization to make informed decisions to reduce risk in the event of a release of a biological agent. The biological agent of key interest is Bacillus anthracis (anthrax) spores, which have the capacity to produce mass casualties and are highly persistent in the environment.

If a bioagent, such as anthrax, were released in an urban area there is a high likelihood that the release would go undetected for a period of days. Once the release has been identified decision makers will have to determine the continued exposure risk to the population and the need for decontamination of the area contaminated by the agent. The continuing risk of exposure to the population after the initial release may be principally due to resuspension of the agent by natural and anthropogenic forces.

The purpose of this research project is to develop a quantitative understanding of the resuspension of anthrax spores from common environmental surfaces. Additionally, we will determine the confidence and suitability of the biological simulants Bacillus thuringiensis var kurstaki (Btk) or Bacillus atrophaeus subspecies globigii (formerly Bacillus globigii [Bg]) for B. anthracis (Ames strain) for use in environmental studies where particle resuspension is the critical parameter. The materials to be tested include concrete, asphalt, and glass. Tests will be performed at the Dugway Proving Grounds, UT, and at the Environmental Protection Agency, Research Triangle Park, NC.

There were no questions for this presenter.

Experimental and Sampling Design for a Quantitative Investigation of the Resuspension of Anthrax and Surrogates under Controlled Conditions

A.D. Eisner (Presenter), Z. Drake | *ALION*
R. Wiener, M. Gray | *U.S. Environmental Protection Agency*

No slides were made available for inclusion.

Abstract

Over the past decade the release of the Class A biological agent Bacillus anthracis (anthrax) has been deemed a serious public health risk. Such a release has the potential to produce mass casualties, and its spores are highly persistent in the environment. Numerous studies have identified the potential for anthrax to resuspend, after it has been released outdoors and has settled onto surfaces. Unfortunately, there has been a dearth of quantitative information about the behavior of anthrax spores. The mechanisms governing resuspension are complex, and developing a quantitative database is difficult and time consuming.

The Department of Defense (DOD), the Department of Health and Human Services (DHHS), the Department of Homeland Security (DHS), and the Environmental Protection Agency (EPA) are now collaborating in the Scientific Program on Reaerosolization and Exposure (SPORE), which has provided the funding and direction for this study. The primary objective of SPORE is to develop a quantitative assessment of the risk of public health exposure from the resuspension of B. anthracis spores should an event happen in which anthrax is released outdoors into an urban environment.

One of the aims is to determine the suitability of the biological simulants Bacillus thuringiensis var kurstaki (Btk) as a surrogate for B. anthracis (Ames strain) in terms of resuspension from surfaces, represented in this research by coupons made of variety of outdoor materials. The end point for the experimentation is to compare two sets of data, one acquired from EPA using surrogates and the second from DPG using Ba-Ames. For the purpose of these experiments two small resuspension wind tunnels (RWT) and two resuspension chambers have been built. Design of the RWTs was predicated on extensive CFD modeling of particles' detachment and movement under the impact of the novel slotted traversing jet. The height of the jet, the angle of the impinging air on the coupon, and the speed of the actuator can all be changed as desired. The operational principle of the detachment experiment is based on a total collection of all detached spores. The biological extraction requirements imposed a need to have filters no larger than 10 cm in diameter. Therefore, multiple filters have been installed to obtain a reasonable air velocity and directionality in the tunnel. The experimental variables that have been selected for this study are spore type (Btk, Bg, and Ba-Ames), spore preparation (liquid slurry, dry powder, and refined powder), jet velocity (low, medium, and high), surface type (glass, roofing material, and concrete), and roughness level of each surface type (smooth, rough, and very rough).

A series of tests was conducted to establish nozzle jet impact on various surfaces. In these tests coupons laden with Btk spores were subject to a series of jet sweeps under step-wise increased jet air pressure. We found that in the case of smooth glass, spore resuspension increased by order of magnitude when nozzle jet velocity increased from 10 to 15 m/s. In case of smooth concrete and rough glass, increase of resuspension was more gradual as jet velocity was increased from 0 to 15 m/s. The total percent resuspended calculated from the filter data was 0.083% for smooth glass, 0.013% for rough glass, and 5.4% for smooth concrete.

Questions, Answers, and Comments

- Q: You said spores were deposited wet, but when you ran the experiments, had they dried?
- A: We established droplets initially that were 20 microns in size. We than waited to ensure everything settled. The coupons were left to dry entirely. By measuring the water content in various coupons, we established how many hours they need to equilibrate in the temperature humidity chamber.
- Q: Is there a pulse or a slowly ramping up jet?
- A: The pressure is preset and the valve is opened. Compressed air is delivered with a huge volume. The velocity is established almost instantaneously. Once it is going, the switch is flipped to start the traverse. The entire surface of the coupon is subjected to the same force. The length of the jet was essentially the length of the coupon.
- Q: The level of the surface is across the bottom. Why did you do that?
- A: In the literature, you find researchers that put the test surface in the middle of the tunnel to achieve the highest velocity. We decided to use an air jet as a major source of particle detachment, so we think it is a better way than a wind tunnel. In terms of potential losses behind the coupon (3/4 inch high), they were insignificant
- Q: Do you use another fan?
- A: Yes, there is one in the exit part of the tunnel to generate the main motion that is responsible for particle delivery.
- Q: What if you put the fan in front instead of the back?

- A: In terms of air movement, it is determined by pressure gradient. It is just a matter of convenience. I don't think it matters. There are other engineering issues; fans warm up the air and if you pressurize the system, there could have been spores flying out through gaps.

13. Concurrent Sessions 3
Chemical Agent Fate, Persistence and Transport

Moderated by Larry Kaelin

Predictive Modeling of Transport Processes at Environmental Interfaces Following Chemical or Radiological Contamination

James Hunt (Presenter) | *Beaufort*
Adam Love | *Johnson Wright, Inc.*

Abstract

Predictive transport models are necessary for development of operational plans under different scenarios regarding emergency response and subsequent remediation to lower future risk. The environmental fate of chemical, radiological and biological weapons has sufficiently matured to consider the development of predictive models that could be extended beyond the experimental conditions that were utilized in model development. While experimental measurements can be fit to various models, the goal has been to develop models that can predict transport under the range of conditions expected for the environment, the relevant surfaces, and the specific agent. The development of predictive models is illustrated using chemical warfare agent evaporation data collected at Edgewood Chemical and Biological Center (ECBC) in their 5 cm wind tunnels. The model utilizes chemical agent vapor pressure as a function of temperature, estimates of turbulent interfacial mass transfer coefficients, and assumed liquid agent geometry on an impermeable surface. The model is calibrated using one set of experimental results and model applicability is demonstrated for experimental conditions involving different temperatures, wind speeds, and liquid droplet volumes. Overall, droplet lifetimes are predictable within a factor of 2 – an accuracy that meets typical operation planning needs. Two challenges in model predictability are illustrated with observations from field experiments where liquid water dynamics within porous media are coupled with chemical and radiological agent transport processes. The first example is the "rain event" where chemical agent releases from field soils following light rain was unanticipated and placed field personnel at risk. The other example is the movement of cesium into porous media following a simulated explosive device that also mobilized liquid water. The coupling of chemical and radiological agents to liquid water dynamics within porous media has not been fully explored. These examples illustrate an approach to agent transport and remediation that combines experimental measurements with predictive modeling. Thus, additional fate and transport expertise is necessary to ensure robust operational plans can incorporate these common variations in environmental conditions. More generally, there remains a need for an integrated modeling approach that can assess overall system sensitivity to individual processes, which is needed in planning, risk assessment, and remediation.

Questions, Answers, and Comments

- Q: Was it possible to test what had evaporated off?
- A: Edgewood (ECBC) did that, Lawrence Livermore National Labs analyzed the coupons for agent that was remaining but neither lab did both at the same time.
- Q: Talking about GB maybe forming a skin or surface and impeding evaporation. Do you think that would be more typical for sulfur mustard? Was there any clue on why it acted that way?
- A: That's the problem, this analysis was after the experiments were done; there is no way to go back and ask.

Adsorption and Desorption of Chemical Warfare Agents on Activated Carbons: Impact of Temperature and Relative Humidity

Lukas Oudejans (Presenter) | *U.S. Environmental Protection Agency*
Kent Hofacre, John Shaw, Anbo Wang | *Battelle Memorial Institute*

Abstract

The known threat of a chemical agent release in a building or transportation hub is necessitating the development of a research program that evaluates potential decontamination strategies. Hot air ventilation is being considered as an approach for the decontamination of surfaces contaminated with chemical warfare agents (CWAs). It is, however, likely that the effluent during hot air fumigation will contain CWA vapors well above the airborne exposure limit, which will need to be captured prior to release of the CWA-loaded hot air to the ambient environment. A building's heating, ventilation, and air conditioning (HVAC) system could be used to capture the CWAs if equipped with carbon filters. It is expected that such capture will occur from air flows at elevated temperatures and relative humidity (RH), because of the nature of the decontamination approach. Temperature and RH may affect the capability of carbon in the air filtration system to capture the CWA (or CWA decontamination by-products). Results are presented from a systematic study to determine the dynamic adsorptive capacity for GB and HD on activated carbon beds through measurement of the breakthrough curves as function of temperature, and RH. The subsequent measurement of desorption curves of the CWA from the activated carbon indicates whether off-gassing from activated carbon air filters is a potential concern when they are removed from service. Results of this study are intended to be used by decision makers to facilitate the development of remediation plans following a chemical contamination incident where a hot air decontamination process is considered.

Questions, Answers, and Comments

- Q: Are the carbon beds at time zero at the temperature of the experiment? Or are you relying on the temperature of the air flowing through it?
- A: The temperature sensor was located just above the carbon bed and is in a controlled environment where the temperature is controlled, plus the carbon bed was equilibrated for 24 hours, so at time zero the temperatures are the same.
- Q: Using hot air for decontamination and bringing the temperature up and pulling it through the system, by the time it gets to the filter, hopefully we've had a drop in temperature, wouldn't that increase the filter efficiency?
- A: That's a valid point, indeed sometimes the HVAC system the filters may be much further away and there may be cooling equipment or even stay at the same temperature which also provides a chance of condensation.
- Q: Are you sold on using the carbon? Is it necessary? Isn't it easier just to take the exhaust and put it through a wet scrubber? Bubble it through water?
- A: Those are other alternatives; there is a presumed presence of activated carbon beds already in HVAC systems, that may be the first option; but there may be alternatives.
- C: Usually you would have a second carbon bed behind it and have a second stack behind it to make banks

14. General Session 4
Low Tech/Self Help

Moderated by Emily Snyder and Charlie Fitzsimmons

Assessment of RDD Contamination Removal from Laundering Soft Porous and Bulky Materials

Karen Riggs (Presenter) | *Battelle Pacific Northwest Division*

Emily Snyder, John Drake, Kathy Hall, Jeff Szabo | *U.S. Environmental Protection Agency, Office of Research and Development, National Homeland Security Research Center*
John Cardarell | *U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Office of Emergency Management's Consequence Management Advisory Team*
Elizabeth Hanft, Michael Lindberg | *Battelle Memorial Institute*

Abstract

Radiation contamination from the release of a radiological dispersal device (RDD) or an accident at a nuclear reactor facility is a potential threat. The U.S. Environmental Protection Agency (EPA) is responsible for environmental cleanup after the release of contamination from an RDD and may provide recommendations for actions that can be taken by the public to mitigate their exposures. Current guidelines for handling contaminated clothing recommend removing the contaminated item and placing it in a bag. The general public may unknowingly wash contaminated items or they may wish to launder items to reduce the contamination. The impacts of the general public knowingly or unknowingly washing their contaminated clothing are not fully characterized.

Previous research has demonstrated methods for determining the effectiveness of laundering for removing cesium, a potential contaminant that could be used in an RDD.

Results showed that laundering cloth swatches removed 92-97% of the contamination. The focus of the recently completed research was to build on previous studies in this area. Specifically, the current studies are focused on the efficacy of laundering soft porous and bulky materials, repeat washing, and laundering without detergent. The effect of laundering the contaminated swatches with uncontaminated clothing was also examined. Swatches of cotton and polyester materials (15 cm x 15 cm) were used to simulate clothing, and swatches prepared from a cotton comforter and towels (30 cm x 30 cm) were used to represent more bulky household items that could be laundered. A front-loading washing machine and liquid Tide HE detergent were used for this research. The swatches were contaminated with Cs-137 and laundered under different temperature conditions with and without detergent.

Laundering the swatches removed greater than 91% of the contamination for all materials studied in this work, except for the swatches made from a cotton comforter, for which 68% of the contamination was removed. The wastewater exiting the washing machine was collected after each load and measured for activity. A material balance indicated that the majority of the Cs-137 contamination ended up in this wastewater. Additionally, in tests where uncontaminated clothing was laundered with contaminated swatches, approximately 30% of the Cs-137 ended up on the uncontaminated clothing. Finally, there appeared to be an accumulation of the contamination in the washer over the testing period. These results will be presented and discussed.

Questions, Answers, and Comments

- Q: How realistic do you think the clothing contamination was as compared to an actual RDD incident?
- A: After the materials were spiked with the liquid solution, they were dried prior putting them in the washing machine. This may not be entirely representative of how the materials would be contaminated after an RDD. We're open to suggestions.
- Q: You measured the activity on the clothes after decontamination. How do you measure this activity?
- A: We used a BEGe detector to measure ^{137}Cs gamma radiation.
- C: The follow-on study with the dryer would be very valuable. I would be interested to see if the fabric sheets might make a difference.
- Q: Did you consider any of the residual contamination in the washing machine?
- A: Yes, we did a quick non-destructive analysis count of the entire washing machine using the BEGe detector. We did not pull it apart. We did detect some residual contamination in the machine.

Evaluation of Compressed Air Dusting and Vacuuming for Radiological Decontamination of Sensitive Equipment

Ryan James (Presenter), Ryan Stowe, Eric Burckle | *Battelle*
Emily Snyder | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

In a Nuclear Incident Response Team Federal Emergency Management Agency funded effort, EPA's Homeland Security Research Program is conducting experiments that have determined the efficacy of compressed air dusting (CAD) and vacuuming (VAC) for the removal of radiologically tagged simulated fallout material (RTSFM) from the surfaces of several types of sensitive equipment (SE). SE refers to items that would be immediately important for decontamination and recovery efforts after the detonation of an Improvised Nuclear Device. The RTSFM was generated using sand that was sieved to isolate three distinct three particle size ranges: less than 150 micrometers (µm), 150-250 µm, and greater than 250 µm. Each particle size range was then tagged with a unique radionuclide. The smallest particles were tagged with cesium-137, the middle particle sizes were tagged with cobalt-60, and the largest particles were tagged with strontium-85. The removal of the RTSFM using these two methods (CAD and VAC) was tested on six different types of model SEs (number pad keyboards, cell phones, handheld radios, pulse oximeter, automated external defibrillator, and a fabric medical kit). The RTSFM was applied to the surface of the SE via dry particle deposition. Following deposition of the RTSFM, the gamma radiation from the contaminated SE was measured. The CAD and VAC was then be used to decontaminate each piece of SE. The residual gamma radiation emitted from the "decontaminated" SE was then measured and a decontamination factor (i.e., efficiency of radionuclide removal) was calculated. Results will be presented that include the quantitative (i.e., decontamination factor) and qualitative performance (operational considerations) of the CAD and VAC on each type of SE.

Questions, Answers, and Comments

- Q: Would a recommendation to responders be to use keyboards with touch pads?
- A: Absolutely. Looking at these data, any equipment with open space or hidden space is going to be hard to decontaminate. Anything with a flat plastic surface would be better to decontaminate with these tools; blowing the keyboards with compressed air was not effective and risked the spread of contamination.
- Q: Before contamination, were the surfaces greasy or cleaned?
- A: They were new equipment. No additional cleaning was performed.

Efficacy of Sporicidal Wipes on Select Surfaces

Kathryn Meyer (Presenter) | *ORISE*
M. Worth Calfee, Lukas Oudejans | *U.S. Environmental Protection Agency*

Abstract

Four sporicidal wipes (three with sodium hypochlorite and one with hydrogen peroxide/peracetic acid active ingredients) and two disinfecting wipes were quantitatively evaluated for their ability to inactivate *Bacillus atrophaeus* spores dried onto non-porous surfaces. Using the ASTM WK32908 method, liquid aliquots of *B. atrophaeus* spores were dried onto glass Petri dishes and exposed to the test chemical of either a sporicidal wipe (Clorox™ Bleach Germicidal, Sani-Cloth® Bleach Germicidal, Dispatch® Hospital Cleaner, Steriplex® SD) or disinfecting wipe (Lysol® Disinfecting, Clorox® Disinfecting) through a prescribed pattern of wiping. Following exposure for a specified time of contact, survivorship of the spores was assessed by quantification of the remaining viable spores, both on the glass Petri dish and on the wipe itself. Preliminary results suggest the *Bacillus* spore removal/inactivation efficacy varies considerably by active ingredient. Additionally, results show that the commercially available disinfecting wipes were not able to kill *Bacillus* spores. Ongoing work will test the top three performing wipes on test coupons made of several indoor building materials to determine their

effectiveness in a larger-scale environment. Results of this study are intended to be used by decision makers to facilitate the development of remediation plans following a biological contamination incident.

Questions, Answers, and Comments

- Q: You mentioned painted drywall, what was it painted with?
- A: It was a latex-based paint.
- Q: Did you measure how wet the towels were compared to each other?
- A: Yes; pretty consistent, 0.01-0.02 g/cm^2.
- Q: Did the plates stay wet the entire contact time recommended by manufacturers?
- A: We wanted to test wipes for entire contact time, and if the surface dried, the manufacturers recommended to re-wet it with a second wipe. We did have to do that for some wipes.
- Q: Have you used these wipes on any PPE materials?
- A: Not yet, the LDPE simulates sample bags or other plastics, thus far we've tested everything flat.

Inactivation of Bacillus Spores in Decontamination Wash Down Wastewater using Chlorine Bleach Solution

Vincente J. Gallardo (Presenter), K. Scott Minamyer, Eugene W. Rice | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
Donald A. Schupp | *Shaw Environmental & Infrastructure, Inc., a CB&I Company*

Abstract

Wash water from the decontamination of various hard surfaces and personal protective equipment was generated and spiked with *Bacillus atrophaeus* subspecies *globigii* spores to simulate wash down wastewater containing anthrax spores. This spiked wash water was treated either with diluted household bleach (1:100, 2:100, 3:100, or 5:100 volume ratios of bleach:wastewater), or with a diluted bleach and vinegar solution (a 1:1:10 volume ratio of bleach:vinegar:wastewater), and the amount of spore inactivation measured. The majority of the inactivation experiments were conducted at the 5:100 bleach:wastewater ratio. Prior to dilution, the household bleach contained 6% sodium hypochlorite by weight. Inactivation testing was conducted at two different temperatures: 22 °C and 4 °C. The chlorine level was monitored during the length of the inactivation test (typically 30 minutes to 2 hours), and no decrease in the level was observed. The goal of this work was to produce results that would form guidelines for using household bleach to treat wash down wastewater generated during a cleanup of a building or other area contaminated with anthrax spores. Inactivation results will be given for different wastewater types, bleach levels and water temperatures. At the higher temperature, greater than 99.9999% (6 log) removal was usually obtained in 30 minutes of contact time with the disinfectant. At the lower temperature, a longer time (60 minutes) was often needed to obtain the same amount of removal.

Questions, Answers, and Comments

- C: One challenge at this [US EPA RTP] site was meeting our mercury limits in the waste water. We did an inventory of everything going down the drain and had to test bleach and Alquinox. I think it would be useful in the future to maybe take a mercury sample just to see what's there.
- A: I didn't realize that mercury was a problem when using bleach.
- Q: Are there MCL targets for anthrax spores?
- A: I would guess probably not. Before 9/11, no one cared about anthrax in drinking water.
- C: In drinking water, you want to be able to show log reduction, you want to use a process that shows certain performance rather than that you are meeting the target. You use a method that has been shown in the past to give a certain reduction.
- C: There are no MCLs; most are treatment techniques. For anthrax it's even more unknown, but there are no regulatory requirements, what we aim for is no detectable spores.

- C: It is extremely important for drinking water to use a certain contact time to have good removal.
- C: About the use of a surrogate here; this goes back to the study that shows that they are less susceptible to chlorine than anthracis. They are quite different, hydrophilic vs. hydrophobic, external spore, etc. We looked at this on hairless guinea pigs as part of a human remains study. One study showed bleach was working, but didn't work on guinea pigs. It would be good to go back and test the virulent strain so that you don't outsmart yourself with a tried and true simulant.
- C: To answer the question about the difference between BA and BG as a surrogate, if you recall the data presented earlier, when we reduced the time to three minutes, we could get 99 % kill; so I know there are differences, but I don't think they are very important in a suspension environment.
- C: Great comments and one piece of the research we aren't seeing today is that there is a lot of work done on different surfaces vs. these surrogates and decontamination methods; we want to come up with more resistant/conservative surrogates; whether or not you can see surface differences or contaminant-specific factors are what these studies show; great point and important thing is that there is a body of work supporting the use.

15. Concurrent Sessions 4
Biological Agent Persistence

Moderated by Matthew Magnuson

A Large-Scale Soil Survey of Genetic Markers Associated with Bacillus Anthracis and Bacillus Species Across the Contiguous United States: A Joint USGS/USEPA Project

D.W. Griffin (Presenter) | *U.S. Geological Survey, Coastal and Marine Science Center*
E. Silvestri, C.Y. Bowling, T.L. Nichols | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
V.A. Luna | *University of South Florida, Center for Biological Defense*
C.A.O. Jean-Babtiste, D. Harbin, L.A. Hempel | *Formerly at U.S. Geological Survey*
T. Boe | *Oak Ridge Institute for Science and Education Fellow with the U.S. Environmental Protection Agency, National Homeland Security Research Center*
D. Smith | *U.S. Geological Survey*

No slides were made available for inclusion.

Abstract

Soil samples collected for the U.S. Geological Survey (USGS) Geochemical Landscape Project, which covered the contiguous United States on a sample site scale of ~1,600 km^2 (4,770 samples), were screened for the presence of *Bacillus* sp. and *Bacillus anthracis* using a multiplex-polymerase chain reaction (PCR) method. Species of *Bacillus* were detected in 60.3% of the samples (in 43 of the 48 States). B. anthracis was presumptively identified by PCR in 83 samples. Subsets of these samples were sent to the University of South Florida's Center for Biological Defense for *B. anthracis* confirmatory analysis. Ten of the presumptive PCR positive samples were confirmed to contain PX01 *pag* and *lef* and pX02 *cap* virulence markers (three samples in Alabama, two in Kansas and one each in Maine, Missouri, New York, and West Virginia). Seven of the other presumptive PCR positive samples were positive for the pX02 *cap* marker and two of these were also positive for the pX01 *pag* marker. PCR data were evaluated statistically against land type, precipitation totals 1-day and 7-days prior to sample collection date, soil moisture, and geochemical data. A significant correlation was noted between *Bacillus* sp. PCR positive samples and total precipitation for 1-week prior to sample collection. No relationship was noted for *B. anthracis*. Statistical analyses of geochemical data indicated numerous correlations with the variables examined for Bacillus sp. (both negative and positive statistical correlations) and B. anthracis (negative statistical correlations). To evaluate the

strength of the statistically significant PCR-based observations, geochemical data from sample sites located in counties that reported cases or outbreaks of anthrax since 2000 were evaluated against counties within the same states (MN, MT, ND, NV, OR, SD and TX) that did not report cases or outbreaks. Those data identified the elements calcium (Ca), manganese (Mn), phosphorus (P), and strontium (Sr) as having strong positive correlations with counties reporting anthrax outbreaks and questioned the strength of the PCR-based elemental correlations. Threshold values based on the lowest geochemical concentrations of each of these elements and the lowest significant average concentrations that gave a correlation were identified as prospective investigative tools in determining whether an anthrax outbreak was 'potential' or 'probable' at any given geographic location in the contiguous United States. While these elemental threshold values are preliminary in nature, they present potential investigative tools that can be refined through future high-resolution studies.

Questions, Answers, and Comments

- Q: Did you do an isotopic breakdown of any elements?
- A: No. Not that it can't be done; it was an issue of funding.
- Q: Do you have any criteria for temporal area and depth?
- A: The depth was at the surface. The sites were generated randomly through a program for sampling. There were adjustments because access was denied to certain areas that are individually owned. There was a variety of soil types and we didn't target just one.

Persistence of Vegetative *Bacillus Anthracis* with and without Exposure to Ultraviolet Radiation to Simulate Sunlight

Thomas Kelly (Presenter), Andrew Lastivka, Morgan Wendling | *Battelle*
Joseph Wood | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

The goal of this study is to assess the persistence (loss of viability over time) of vegetative *Bacillus anthracis* cells on common materials and in soil, under normal laboratory conditions and when exposed to levels of ultraviolet (UV) radiation simulating natural sunlight.

A fundamental part of the work has been the development of methods to reliably prepare high titer 100% vegetative cell suspensions of *B. anthracis* with no formation of endospores. That development included selecting initial inoculation conditions, confirming the effectiveness of heat shock procedures to distinguish vegetative and sporulated *B. anthracis*, defining the growth curve of *B. anthracis* in liquid culture, monitoring this culture via microscopy, and identifying the optimum point in the growth curve to maximize the cell titer while still achieving a purely vegetative culture.

Persistence was quantified using colony forming units recovered from test samples at various elapsed times. Qualitative techniques were also employed in some tests to assess growth or no growth of cells after 1 and 7 days incubation time. Heat shocking of sample extracts was used to assess any sporulation of cells.

The resulting preparation procedure was employed in a series of tests including:

- Persistence of vegetative *B. anthracis* on material coupons of four types (topsoil, glass, bare pine wood, and unpainted concrete) over a period of 1 hour under relative humidity (RH) conditions of approximately 30% and 75%. These were initial scoping tests conducted under normal laboratory lighting conditions to assess impact of material and RH on persistence.
- Persistence of vegetative *B. anthracis* on glass coupons over periods ranging from 15 minutes to 8 hours at approximately 30% RH under normal laboratory lighting conditions. This test was conducted to facilitate assessment of kinetics and compare results gathered from qualitative and quantitative assays.

- Persistence of vegetative *B. anthracis* on topsoil coupons over periods from 1 to 120 hours at approximately 30% RH, with and without exposure to simulated sunlight. Since vegetative *B. anthracis* was most persistent in soil, longer term tests were conducted using only this material.

The results of the persistence tests, including parallel tests with and without UV exposure, will be presented.

Questions, Answers, and Comments

- Q: How are you certain the organism you were looking at was actually Ba?
- A: It was based on colony morphology and plating and growing of the organisms.
- C: All of the soil and other coupon materials were sterilized before use.
- Q: Is it fair to say that after five days, if an outdoor area was contaminated with weaponized anthrax, it would no longer be an issue as long as there was no rainfall?
- A: No. If you treated it with a germicide, you could be better off in terms of destroying the vegetative cells.
- Q: Could you explain how your sterilized the soil? In another program, they found that if you autoclaved soil, spores can't grow.
- A: It is autoclaved in bulk and portioned out to make the coupons. I have heard about that work you are referring to, and I think it is an issue that needs to be looked at.

16. Concurrent Sessions 4 Water and Waste Water Treatment

Moderated by Matthew Magnuson

Investigation into U.K. Capability to Manage Contaminated Water

Carmel Ramwell (Presenter), Paul Robb, Nigel Cook | *The Food and Environment Research Agency*
Hasmitta Stewart | *Government Decontamination Service*

Abstract

As a part of a suite of wider work, a review was undertaken to investigate the UK capability to manage water contaminated with chemical and/or biological entities.

The objectives of the study were to:

- Assess the current status of different treatment processes at sewage treatment works (STW) and (drinking) water treatment works (WTW) in the UK
- Examine the current knowledge with regards to the fate of chemical and biological entities, and decontaminants in treatment processes
- Examine the roles and responsibilities of government agencies and other governmental departments for managing contaminated water, and
- Identify data gaps and make recommendations.

Although contaminated water will largely be dealt with at an STW, any losses to surface water can ultimately be abstracted at a WTW, hence both STW and WTW were considered.

The suitability of different drinking water treatment methods for a number of chemical classes was taken mainly from the US EPA Water Contaminant Information Tool (WCIT).

Common water treatment processes can treat a range of chemical and biological entities, but processes such as activated carbon will only exist if the catchment has a specific risk e.g. pesticides. Only 1 biological was likely to pose a potential risk as the relevant treatment method is not commonplace at UK WTWs. Another limiting factor may be the capacity at the WTW to physically hold/dose sufficient disinfectant. Disinfection by-products can generally be treated with standard WTW processes. WTWs associated with aquifers are unlikely to cope with

contaminated water as the water abstracted is ordinarily of high quality, thus only basic treatment processes will be in place.

Common decontaminants are already used in the general day-to-day operation of STWs. Decontaminants will not automatically have an adverse impact on STWs – depending on the dose in the incoming water.

Information on biologicals in STW was limited but it appears that biological agents are unlikely to be affected by sewage treatment plants.

Generalizing, chemical agents that are water soluble, have a low sorption potential and a high volatilization potential are unlikely to be removed within an STW, although such compounds may volatilize, particularly during aeration.

The technology to manage highly contaminated and toxic wastewater exists due to use in, for example, chemical/pesticide industries.

Data on the range of concentrations/volumes of waste water containing chemical/biological agents and decontaminants that could enter STW are required in order to assess their risk.

A unified process for recording information on processes at individual WTW and STW processes would be highly beneficial to quantifying capability to manage contaminated water at a national scale, particularly for England where there are several different water and wastewater providers.

Questions, Answers, and Comments

- Q: Regarding biological nutrient removal, do you anticipate increased stability to remove these contaminants or are these systems already in place?
- A: Whether we have that on the plant depends on the water body to which the effluent is being discharged. If the water body is not that sensitive, then you do not need that type of treatment.

Decontamination for the Water Sector

Marissa Lynch (Presenter), George Gardenier | *U.S. Environmental Protection Agency*

Abstract

The Critical Infrastructure Partnership Advisory Council (CIPAC) Water Sector Decontamination Working Group identified the need for the development of a decision-making framework for the decontamination of chemical, biological, and radiological agents in water systems specifically to be used by utilities, responders, and other decision makers.

The decontamination and recovery process of a water system following a contamination incident will vary on a case-by-case basis. Therefore, water utilities and responders need decision-making information that can be adapted to specific situations and incidents as appropriate for consideration during planning and rapid decision making. The decision-making framework highlights the critical steps taken during the characterization, decontamination and clearance phases of remediation/cleanup for a chemical, biological, or radiological incident affecting water and wastewater systems.

The decision-making frameworks for water utilities and responders on containment, treatment, and disposal of contaminated water, are aimed at preparing utilities for all-hazard events. This information may include, but not be limited to applicable statutory and regulatory requirements, potential treatment methods, and containment and disposal options.

To address this need, EPA leveraged existing guidance and developed an interactive set of decision-making frameworks for water and wastewater. The frameworks pose situation- specific questions to users and guide them through subsequent steps.

References and links to relevant tools are also provided. The frameworks were vetted through two rounds of work group meetings.

The Water Security Division (WSD) in collaboration with National Homeland Security Research Center (NHSRC) is working to incorporate advanced decontamination research results into the Water Contaminant Information Tool (WCIT). This peer-reviewed information includes decontamination methods on contaminants of concern to utilities and responders.

In 2013, WSD launched a decontamination website. All of WSD's latest decontamination efforts will be summarized on the website. Links to other EPA led decontamination efforts will also be provided.

This presentation will provide a summary of EPA's development efforts in producing decision-making frameworks. The decision-making frameworks are supported by a recently published EPA guidance document, "Containment and Disposal of Large Amounts of Contaminated Water: A Support Guide for Water Utilities" which will also be discussed in the presentation. The presentation will also highlight other potential projects currently being worked on to enhance preparedness such as the work WSD is performing in collaboration with NHSRC and the decontamination website.

Building upon the conference theme of decontamination this presentation will address progress made to enhance tools and guidance available to utilities, responders and other decision makers involved in decontamination efforts.

There were no questions for this presenter.

17. Concurrent Sessions 4 Chemical Agent Decontamination

Moderated by Lukas Oudejans

Developing Decontamination Tools and Approaches to Address Indoor Pesticide Contamination from Improper Bed Bug Treatments

Emily Snyder (Presenter), Lukas Oudejans, Paul Lemieux | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Dan M. Stout II (Presenter), Halûk Özkaynak, Kristin Isaacs, James Starr | *U.S. Environmental Protection Agency, National Exposure Research Laboratory*

Amy Mysz | *U.S. Environmental Protection Agency, Region 5, Land & Chemicals Division, Pesticides Section*

Jeanelle Martinez | *U.S. Environmental Protection Agency, OSWER, Office of Emergency Management, Chemical, Biological and Nuclear Consequence Management Advisory Team (CBRN CMAT)*

Dennis Tabor | *U.S. Environmental Protection Agency, National Risk Management Research Laboratory*

Keith Houck | *U.S. Environmental Protection Agency, National Center for Computational Toxicology*

Abstract

There has been an increase in reported pesticide misuse incidents for controlling insects, including bed bugs, in indoor environments. These incidents include pesticide products not registered by the US EPA for indoor use or the application of approved pesticide products at concentrations that far exceed the labeled rates or in a manner that violates the product labeling. It is generally expected that the bed bug epidemic will result in a growing number of incidents of misuse EPA Regional Offices are often called on to assist local communities in remediating homes and businesses following indoor misapplications where pesticide levels may be deemed "unsafe". Currently, there are no validated tools for adequately evaluating pesticide residues on indoor surfaces to evaluate potential risk to occupants, or cleaning procedures with known efficacies to reduce pesticide levels in contaminated structures. Occupants of contaminated homes may be exposed to a potentially high concentration of pesticides, be forced to evacuate their homes, or be compelled to attempt decontamination themselves, possibly creating toxic by-products or administering decontamination agents with their own inherent risks.

This research aims to provide responding agencies with information to evaluate indoor pesticide misuse incidents and reduce occupant exposures. Findings will guide remediation needs and will illustrate the potential effectiveness of cleaning efforts.

The presentation will describe the effort to accomplish these objectives for malathion and carbaryl on select surfaces. The results from wipe sampling method development and initial surface decontamination studies will be presented. The use of the Stochastic Human Exposure and Dose Simulation (SHEDS) Lite model to generate predicted pesticide concentration distributions, which will be used to determine likely exposures, associated with minimal health impacts or health impacts of potential concern will also be discussed.

Questions, Answers, and Comments

- Q: Can you speculate on the poor total recovery of carbaryl using three wipes?
- A: There may be a limited solubility of carbaryl in isopropanol.
- Q: How did you conduct the small coupon decontamination study?
- C: The decontamination solution was applied to the coupon and it did not run off. Everything was extracted.

Challenges in Lewisite Decontamination Studies

Harry Stone (Presenter), Lukas Oudejans, Sarah Perkins, Autumn Smiley | *Battelle*
Emily Snyder | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

The US EPA may be tasked to lead efforts to decontaminate facilities following a release of a chemical warfare agent (CWA); Lewisite (L) is one of those CWAs. Whereas other CWAs may evaporate quickly or decompose into less harmful by-products, L is an arsenic-based vesicant with low volatility and its decomposition by-products are particularly challenging to decontaminate because of they may still have vesicant properties and may be more persistent than L itself. L is composed of three similar arsenic-based compounds known as: L1 [2-chlorovinylarsonous dichloride, 90%], L2 [bis(2-chlorovinyl)arsonous dichloride, 9%], and L3 [tris(2-chlorovinyl)arsine, 1%]. L2 and L3 are relatively less volatile compared to L1. Further complicating matters, L1 rapidly hydrolyzes and oxidizes in the environment into 2-chlorovinyl arsonous acid (CVAA), 2-chlorovinyl arsonic acid (CVAOA), and Lewisite oxide (L oxide; a vesicant). In this effort we are examining methods for inactivation/neutralization (conversion to compounds without vesicant properties) of L; specifically, we are looking at the ability of deionized water, bleach, hydrogen peroxide liquid to convert L to less toxic by-products. Neutralization and degradation of L leave residual arsenic compounds like CVAA, CVAOA, and L oxide. Removal methods of these by-products are also evaluated that may be used subsequently to L neutralization and degradation.

Methods for successful extraction and analysis of L and its degradation by-products from building materials do not currently exist. Extraction methods developed for environmental and clinical samples were modified for this purpose; specifically, extraction efficiency for L1 on four building materials by three solvents (toluene, hexane, and acetone) was evaluated. The analysis of samples containing L is complicated by the presence of L1-L3 and their hydrolysis and oxidation by-products. In general, analytical methods used direct detection or derivatization prior to detection. Direct detection of the L1 and L2 in the extracts was demonstrated using gas chromatography/mass spectrometry with a cool-on-column inlet. LC/MS and derivatization by butanethiol reaction were evaluated as methods for detecting by-products. An update on EPA's progress addressing the challenges in extracting and analyzing L and its degradation by-products in the extracts will be presented.

Questions, Answers, and Comments

- Q: Are you thinking of extending LC/MS to cover parent compounds, so you have one method? Can't you see L1 and L2 with LC/MS?

- A: You want to measure L1 and the byproducts; we don't have that method. The presence of water will hydrolyze L1 too quickly. There is not a single method for this.
- Q: How long did you leave your Lewisite on substrates before decontamination?
- A: 30 min.
- Q: For your substrates, how did you condition them? Did you dry them to avoid water in concrete and wood?
- A: I'm not aware of anything special we did. Coupons prepared in advance inside of a lab.
- Q: Did you perform any calculations on arsenic to see how much surface loading of Lewisite?
- A: We haven't, but it would be easy to do. We know what we put on and what we are wiping off. Easy to look at this.

Advanced Absorbent Wipes for Personnel and Personal Equipment Decontamination

Stuart Notman | *Defense Science & Technology Laboratory*

Abstract

There are a number of potential technologies (wipes, powders, cloths and lotions) that have the potential to be used to decontaminate CWA from personnel and personal equipment. The patent literature shows that industry has invested heavily to develop Commercial-Off-The-Self (COTS) wipes for use in a number of sectors including personal care, household cleaning and industrial cleaning.

This presentation describes an experimental project undertaken to determine whether or not modern textile technology (Wipes) could be used as an alternative to fullers' earth (FE) for CWA decontamination of skin and personal equipment. An additional aim was to determine whether it is possible to improve efficacy of personal equipment decontamination.

We used a rotary wiping rig, designed to remove operator variability, to evaluate flat surface decontamination. Manual wiping was used to evaluate decontamination of geometrically complex surfaces. The performance of Wipes was compared to an FE pad and FE powder.

In total 33 different wipes from personal care, household cleaning, industrial cleaning and specialty fabrics sectors were tested during this project. Simulants were used to select best-performing wipes, and to determine the relative importance of different parameters (e.g. drop size, applied pressure) and procedures on wiping efficacy. Eight wipes were selected for further testing using an optimised wiping process against flat surfaces contaminated with the chemical agents HD, GD and VX. The results from these wipes were compared to the FE pad and FE powder.

Questions, Answers, and Comments

- Q: Did you test only one microfiber? You can get them in a range of types.
- A: Yes, we tested several types including one with a smooth finish and one more like flannel. We wanted to test broad range of wipes.
- Q: If you tested punch woven containing carbon containing how did they perform?
- A: Yes we tested two carbon-based wipes both performed well, but not to LoQ for mustard.
- Q: Were you able to draw general conclusions on physical attributes that decrease efficacy?
- A: Most manufacturers will not disclose the construction of the material. We found microfiber performed well; carbon fiber leaves a lot of carbon behind which could be a toxic hazard.
- Q: What process do you think is involved: capillary forces or dissolution?
- A: Mostly capillary forces where liquid sucked in; most of the wipes tested were dry.
- Q: Did you see variation in viscosity of fluid?
- A: Yes there was variation in viscosity and surface tension. Mustard was found as discrete drops; VX stretches out. This is probably related to why surfaces with VX don't decontaminate as well.
- Q: If you explore temperature could you look at viscosity?

- A: We would not be able to do this in our lab.
- Q: Were the same wipes effective for more than one contaminant?
- A: Yes, microfiber worked on all three contaminants.
- Q: Did you consider using other powders?
- A: Yes we did consider, but given time constraints we just used FE powder. You could go back and do more powders and proper agent materials
- Q: Have you accounted for losses from evaporation?
- A: For the flat surface we weighed just before decontamination and did not see loss from evaporation. For the silicon there was a delay before decontamination of about two minutes. We weighed before decontamination also and did not see losses from evaporation.

Large Panel CWA Efficacy Testing of Hazard Mitigation Products and Processes

Adam Judd (Presenter), George Wrenn, Scott Mason, John Shaw | *Battelle*
Shawn Funk | *Edgewood Chemical Biological Center*

No slides were made available for inclusion.

Abstract

The Hazard Mitigation, Materiel and Equipment Restoration (HaMMER) Advanced Technology Demonstration (ATD) Program is an integration effort to optimize, build, and demonstrate a Family of Systems (FoS) for decontamination. HaMMER includes the assessment and integration of novel products and the development of hardware to apply the products in an efficient manner that successfully performs hazard mitigation while minimizing logistics and waste.

Historically, chemical warfare agent (CWA) decontaminants were tested inside of a chemical fume hood using small material coupons ranging from one to a few square inches in area. Although effective for screening large numbers of decontamination products and materials, small coupon testing did not initially provide a realistic test environment. Over the years, attempts were made to improve the realism of the small coupon test environment such as adding temperature control, changing the physical orientation of the coupons, and modifying the shape of the coupons. Although improvements to the overall process, the steps failed to address a fundamental shortcoming of coupon testing — the ability to assess the effect of various physical removal processes while simultaneously integrating a variety of hazard mitigation technologies into the decontamination process. Physical processes such as rinsing, brushing, and scrubbing can be important parts of the overall decontamination process but cannot be effectively replicated at the small coupon level.

Through support from the Joint Program Manager, Protection and the Defense Threat Reduction Agency, Battelle designed and assembled the Integrated Decontamination Test and Evaluation System (IDTES) to allow for more realistic larger scale decontamination testing. The IDTES operates as an 10-foot long environmentally controlled glove box located behind conventional fume hood faces in a large item test facility. For HaMMER, multiple liquid spray nozzles were integrated into the IDTES and connected to decontaminant applicators representative of those demonstrated during the HaMMER program. The IDTES applicators delivered water, soaps, decontaminants, and indicator sprays at operationally relevant pressures and volumes. HaMMER testing used large flat panels placed in near vertical and near horizontal positions that were contaminated with neat HD or VX and evaluated using contact hazard and, for a select number of trials, vapor hazard test methods.

HaMMER large panel CWA testing began with a process efficacy study using VX to identify optimal decontaminant delivery parameters. The process efficacy study used a design of experiments approach and statistical modeling to estimate and subsequently verify effective process steps that were used in follow on testing. The optimal process steps included a low pressure soap application and rinse followed by multiple low pressure applications of decontaminant. The decontamination process steps were then combined with several hazard mitigation technologies including strippable coatings, surfactants, reactive decontaminants, and chemical agent disclosure

sprays and tested on large panels in the IDTES. Results indicate that the decontamination processes and products tested can significantly reduce remaining chemical agent hazards to well below military requirements if used in a synergistic manner. This presentation will provide details on test methodology as well as results for the products tested.

Questions, Answers, and Comments

- Q: Does the vapor off-gassing recreate a condition of contact hazard?
- A: We did have vapor hazard for VX, so we had to redesign. Yes, it is a problem we found that will recondense out of the vapor phase.
- Q: Were there foams included in your program?
- A: Dahlgren's Decon is somewhat of a microemulsion foam. We didn't look at decontamination foams. We wanted to look at what DoD didn't look at. We did look at some enzyme products.
- Q: Is Dahlgren decontamination foam commercially available?
- A: No, not commercially available. Navy will not manufacture and supply and they are looking for companies to license and make it commercially available.
- Q: You mentioned high pressure washing at the end. Did you look at redistribution on other surfaces?
- A: We took agent discloser spray and sprayed on inside of area and it was all over. HaMMER is a low-pressure decontamination. High-pressure hits run off and no contact time. High pressure for super soap was a bit of a mess.

18. Concurrent Sessions 5 Biological Agent Decontamination

Moderated by Sanjiv Shah

Decontamination of Soil Contaminated with Bacillus Anthracis Spores

Joseph Wood (Presenter) | *U.S. Environmental Protection Agency*
M.Q.S. Wendling, A.T. Lastivka, Y.W. Choi, J.V. Rogers | *Battelle Memorial Institute*

Abstract

Background:

Remediation efforts could be extensive following a large aerosol release of *B. anthracis* spores in an urban area, and will greatly challenge the capabilities of government agencies and decontamination contractors to respond. In such a scenario, many different types of materials and environments may need to be decontaminated, including soils. The focus of this presentation will be on soil decontamination, but a few other related data will also be presented.

Methods:

This research evaluated the inactivation efficacy of six decontamination technologies on topsoil and Arizona Test Dust (AZTD). Tests were conducted with either *B. anthracis* (Ames strain) or *B. subtilis* (a potential surrogate) spores. The technologies were tested under a range of applications and conditions, and included chlorine dioxide (ClO_2) gas, aqueous ClO_2, methyl bromide (MeBr), metam sodium, pH-amended bleach, and sodium persulfate with hydrogen peroxide (H_2O_2). Efficacy, e.g., log reduction (LR), was determined based on the difference between spore recovery from positive controls (not subject to decontamination treatment) and recovery from test samples.

Results:

ClO_2 gas: In all tests with AZTD and 1 cm topsoil, > 6 LR was achieved with 3,000 ppm ClO_2, 75% relative humidity; ClO_2 gas was only moderately effective in decontaminating 2 cm topsoil.

Aqueous ClO_2: Minimal (essentially zero) LR was achieved with this technology on topsoil. Results for the decontamination of other materials using aqueous ClO_2 will also be presented.

pH-amended bleach: For the AZTD, complete inactivation of *B. anthracis* was achieved with a contact time of 2 hours with 4 applications, and > 7 LR for *B. subtilis* at the same condition. Minimal LR (essentially zero) for both microorganisms was obtained for the topsoil samples.

Sodium persulfate with H_2O_2: Greater than 7 LR was achieved for *B. anthracis* in topsoil and AZTD with three applications. *B. subtilis* was significantly more resistant to this decontaminant chemical compared to *B. anthracis*.

MeBr: Complete inactivation of *B. anthracis* was achieved in AZTD at 212 mg/L for 36 hours, while > 7 LR was achieved for topsoil at this same condition. *B. subtilis* was significantly more resistant to MeBr compared to *B. anthracis*.

Metam sodium: Testing is currently underway for this soil decontaminant, and final results will be included in the presentation. Preliminary results show that > 6 LR is achievable for this technology, depending on application regimen.

Conclusions:

Topsoil was generally more difficult to decontaminate than the AZTD, most likely due to its organic content. Nevertheless, the sodium persulfate/H_2O_2, MeBr, ClO_2 gas, and metam sodium technologies all showed favorable decontamination efficacy (> 6 LR) on topsoil in one or more of the conditions tested. The use of pH-amended bleach and aqueous ClO_2 is contraindicated for topsoil.

Questions, Answers, and Comments

- Q: Has anyone looked at elemental enrichment of topsoil as a potential way to decontaminate? Could we treat soil with sulfur?
- A: We have looked at calcium sulfide for soil decontamination, but that had minimal efficacy,
- Q: What is the final concept for decontamination of soil? Just treat the surface?
- A: Metam Sodium would be applied by liquid injection and then covered with a tarp; others that are gases would need to be applied after the soil is tarped. The pesticidal chemicals are already being used in agricultural applications and we could translate those approaches to decontamination for anthrax.
- C: Fumigation in agriculture typically requires tarp over soil. In this study, capping the sample jars in the laboratory study achieved the same effect.

Decontamination of Nursery Potting Soil with Chlorine Dioxide

Craig Ramsey (Presenter), Steven Newman | *U.S. Department of Agriculture*

Abstract

The goal of the study was to determine whether chlorine dioxide could be an alternative biocide for methyl bromide applications to decontaminate nursery potting soil. The study objective was to evaluate the microbial efficacy of nine different formulations of chlorine dioxide in a soil column study, using soil respiration as the microbial response variable. Chlorine dioxide formulations were applied to a mix of potting soil (75%) and play sand (25%) that was added to 12” tall soil columns made of ABS plastic. Six of the chlorine dioxide formulations were granules that converted into a gas phase fumigant, upon contact with an activator. Three of the formulations were applied as liquids that saturated the soil, which released the chlorine dioxide that was diffused as a gas in the liquid. Soil respiration was measured with a LICOR 6400 XT gas exchange instrument, before the biocide application and 38 and 60 days after application. Soil respiration is the combined carbon dioxide flux from both soil microbes, and soil organic matter reactions and decay. The soil respiration flux averaged 5.3 µmol $CO_2/m^2/s$, across all the soil columns, before chlorine dioxide was added to the soil. The untreated control had a soil respiration rate of 2.96 µmol $CO_2/m^2/s$ at 60 days after treatment (DAT). At 60 DAT there were six formulations with respiration rates below the average untreated, control rate. The chlorine dioxide formulation

with the lowest respiration flux was a granule + activator (1.5g + 6g), which had a flux of 0.99 µmol $CO_2/m^2/s$, at 60 days after treatment. This is a 67% reduction in soil respiration when compared to the untreated, control, at two months after treatment. Oxidant biocides breakdown rapidly in the soil, are relatively inexpensive, and have potential to be a good alternative to methyl bromide treatments for decontamination of soil.

There were no questions for this presenter.

Test Method Development to Evaluate Hot, Humid Air Decontamination of Materials Contaminated with *Bacillus Anthracis* ΔSterne and *B. Thuringiensis* Al Hakam Spores

T.L. Buhr, **A.A. Young (Presenter)**, Z.A. Minter, C.M. Wells, D.C. McPherson, C.L. Hooban, C.A. Johnson, E.J. Prokop, J.R. Crigler | *Naval Surface Warfare Center, Dahlgren Division*

Abstract

Aims: To develop test methods and evaluate the survival of *Bacillus anthracis* ΔSterne and *Bacillus thuringiensis* Al Hakam spores after exposure to hot, humid air.

Methods and Results: Spores (>7 logs) of both strains were dried on six different test materials. Response surface methodology was employed to identify the limits of spore survival at optimal test combinations of temperature (60, 68, 77°C), relative humidity (60, 75, 90%) and time (1, 4, 7 days). No spores survived the harshest test run (77°C, 90% R.H., 7 days), while > 6.5 logs of spores survived the mildest test run (60°C, 60% R.H.,1 day). Spores of both strains inoculated on nylon webbing and polypropylene had greater survival rates at 68°C, 75% R.H., 4 days than spores on other materials. Electron microscopy showed no obvious physical damage to spores using hot, humid air, which contrasted with pH-adjusted bleach decontamination.

Conclusions: Test methods were developed to show that hot, humid air effectively inactivates *B. anthracis* ΔSterne and *B. thuringiensis* Al Hakam spores with similar kinetics.

Significance and Impact of the Study: Hot, humid air is a potential alternative to conventional chemical decontamination.

Questions, Answers, and Comments

- C&Q: Decontamination and mechanisms that destroy spores differ by approach. According to FIFRA, surrogates should be as resistant as or slightly more resistant than the agent they are meant to represent. The appropriateness of any surrogate should first be verified for any decon approach, using side-by-side studies. Surrogates should not be chosen based upon their genetic homology to an agent or their similarities with regards to cellular architecture. Surrogates must be chosen based upon similarities in kill kinetics, when using them for decon studies. Exosporiums have been shown by Thompson et al. not to confer chemical, heat, or UV resistance. Did you first check the similarities with regards to heat resistance of Bt Al Hakam when compared to virulent strains of B. anthracis?
- A: Agree, surrogates should be chosen based on similar resistance. We picked a temperature/RH/exposure length because we knew had complete kill; than reduced temp/RH based on info from manufacturers to preserve integrity of materials.
- C: The US Air Force brought this technology to the researchers; a full-scale demonstration will begin May 2014 based on trials performed on two different aircraft; method will heat both sides of the aircraft (interior and exterior) inside a portable hangar in a controlled manner.
- C: Thermophiles were used in the initial trial but they did not survive as well; data are available, though.
- C: One should find a surrogate that is very close to actual Ba to avoid having to raise temperature or relative humidity higher than needed.

Aerosol Delivery of Liquid Decontaminants: A Novel Approach for Decontamination of Complex Interior Spaces

Mark Tucker | *Sandia National Laboratories*

Abstract

A fundamental technology gap exists for the decontamination of chemical and biological warfare agents in "hard-to-reach places" such as aircraft interiors, other vehicle platforms, and other complex interior spaces. Direct application of liquid formulations to these spaces is difficult. Therefore, methods such as gas- or vapor–based technologies are better suited to decontaminate these spaces. However, most gas and vapor technologies have significant shortcomings because they are toxic and/or corrosive and can be difficult to deploy.

Liquid decontaminants have a greater flexibility in formulation than gas- or vapor-phase decontaminants and consequently can be made with lower toxicity and corrosivity properties. Typically a liquid decontaminant is directly applied by spraying or foaming making application to hidden surfaces in complex geometries difficult. An alternative to direct application of liquids to surfaces is the use of aerosol-delivered decontaminants. Aerosols can remain airborne for a long enough time to be transported by airflow into hidden regions of complex geometries and in this sense resemble the application of a gas- or vapor-phase decontaminant. Aerosol delivery of decontamination materials is a novel, innovative approach to decontamination allowing liquid decontaminant materials to be delivered to surfaces with complex geometries and hidden areas. This method has the potential to be as effective as toxic and corrosive gas- or vapor- phase decontamination methods with the advantage of a much simpler delivery system using more benign decontamination materials, which can be selected and optimized based on the application and agent of interest.

We have conducted several projects that have significantly advanced the science and understanding of aerosol delivery of liquid decontaminants in complex, confined spaces. Through modeling and experimentation, we have investigated the fundamental parameters of this approach such as droplet penetration, size, charge, deposition rate, and impact angle resulting in a detailed understanding of the process variables. One project, the Aerosolized Activated Hydrogen Peroxide (AAHP) project, was funded by the Defense Threat Reduction Agency (DTRA) with the objective of developing an aerosol system for decontamination of vehicle interiors. Aerosols of modified Sandia-developed DF-200 were deployed in a large test chamber to investigate the effectiveness of penetration of aerosols into small spaces to uniformly coat surfaces. Excellent film uniformity was observed at depths of greater than 24 inches into small, tight spaces. Tests were also conducted using the anthrax simulant *Bacillus globigii* spores to investigate the effectiveness of aerosolized-delivered decontamination formulations in penetrating complex geometries to kill spores. Complete kill of spores occurred in less than one hour with very little decontamination agent. Additionally, a project investigating spore kill with the sequential aerosol-based delivery of a "germination solution" (to cause spores to convert into vegetative cells) followed by aerosol delivery of a mild "kill solution" (to kill the vegetative cells) was conducted. High levels of kill of *Bacillus globigii* spores were also achieved with this method.

There were no questions for this presenter.

19. Concurrent Sessions 5
Water and Waste Water Management

Moderated by Marissa Lynch

Selected Projects of EPA's Homeland Security Research Program (HSRP) for Water and Wastewater Treatment and Decontamination

Matthew Magnuson | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

Selected results for HSRP projects for drinking water and wastewater treatment and system decontamination following chemical, biological, and radiological (CBR) contamination incidents will be briefly presented. Please contact the presenter for more details. Some projects will also be discussed in separate presentations.

MANAGEMENT AND TREATMENT OF COPIOUS AMOUNTS OF CBR CONTAMINATED WATER AND WASTEWATER RESIDUALS:

1) Investigation of advanced oxidation processes (AOP) for treatment and disposal of contaminated water prior to release into public sewer (collection) systems. This work studies the ability of AOPs to break down chemical contaminants in order to make the resulting wastewater suitable for public sewer discharge, i.e., so that it does not harm "normal" plant operations.
2) *Fate of Organophosphates (OPs) in municipal wastewater treatment systems.* Investigates the ability of municipal wastewater treatment activated sludge to biodegrade and sorb OPs.
3) *Inactivation of Bacillus spores in decontamination wash down wastewater using chlorine bleach solution.* The goal of this work is data that supports National Response Team guidelines for using household bleach to treat wash down wastewater generated during a cleanup of *B. anthracis* spores.
4) *Inactivation of bacterial bioterrorism agents in water.* This report summarizes seven drinking water inactivation studies using non-disease causing surrogates for *Bacillus anthracis* and other microbes identified as potential bioterrorism agents.
5) *Irreversible wash aid additive for Cs-137 contamination.* The additive consists of a solution to wash down contaminated structures, roadways, and vehicles and a sequestering agent to bind the radionuclides from the wash water and render them environmentally immobile. The sequestering agent also facilitates separation of the radionuclides from the bulk water for transport and disposal.

DECONTAMINATION AND RESTORATION OF CRITICAL WATER AND WASTEWATER INFRASTRUCTURE:

1) *State of science review of water system decon.* This summarizes the publically available research on decontamination of drinking water infrastructure and gives suggestions about what the best path may be for decontamination of CBR contaminants and future research directions.
2) Persistence and removal of CBR contaminants from drinking water pipes studied with USEPA's pipe decontamination experimental design (PDED). This work simulates drinking water pipes adsorbing toxic chemicals that are introduced either accidentally or intentionally. The PDED allows multiple labs to generate reproducible and comparable data regarding to adsorption and removal of contaminants.
3) *Impact of CBR contaminated sediments on flushing and decontamination of drinking water storage facilities.* Sediments in water storage tanks and reservoirs can serve as sinks for contaminants and must be taken into account when developing treatment and decontamination strategies. This research is focused on better understanding the adherence and persistence of selected contaminants on storage facility sediments and methods for flushing and decontamination.
4) *Decision support tools for responding to water distribution incidents.* This project examines a combination of isolation and flushing strategies to develop response action plans. It also evaluates response strategies for water distribution systems using computerized simulation studies.

There were no questions for this presenter.

NHSRC Drinking Water Infrastructure Decontamination Overview

Jeff Szabo (Presenter), Scott Minamyer | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

EPA's National Homeland Security Research Center (NHSRC) recently released a report titled "Decontamination of Drinking Water Infrastructure: A Literature Review and Summary". This report summarizes data from the open literature on chemical, biological and radiological contaminant persistence on drinking water infrastructure and the effectiveness of decontamination methods. The report includes suggestions for future research based on current data gaps and provides insight into how persistence and decontamination data could be applied to a real contamination event. Using the report results, this presentation will include a summary of the present state of decontamination research in drinking water for chemical, biological and radiological agents. Data will be presented for nine chemical agents. Biological agents will be divided into spore forming bacteria, vegetative bacteria and viruses. Radiological agents will include cesium, strontium and cobalt. The presentation will also cover the future direction of decontamination research in drinking water systems for NHSRC. This discussion will include the proposed work in the decontamination pipe loop at the Test and Evaluation Facility in Cincinnati, OH as well as the Water Security Test Bed at Idaho National Laboratory in Idaho Falls, ID.

Questions, Answers, and Comments

- Q: You said that the radiological materials were only effectively removed under acidic conditions. Can you clarify what is meant by acidic?
- A: This is only referring to Co; other materials were not tested. Acidic meant about pH of 2. Changes from Co-2 to Co-3 makes Co insoluble.
- Q: In the literature review everything is in public domain. Are there concerns about providing information?
- A: Yes, there is a concern. This information goes through an intense security review before release to the public.

Demonstration of Unit Operations for the Irreversible Wash Aid Additive for Cs-137 Contamination

Michael Kaminski (Presenter) | *Argonne National Laboratory*
Matthew Magnuson | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
Jack Schwalbach | *Separmatic Filter Systems*
Dennis Barkenmeyer | *HESCO Bastion Environmental, Inc.*

Abstract

The Irreversible Wash Aid Additive process has been under development by the U.S. EPA and Argonne National Laboratory. The process for radioactive cesium mitigation consists of a solution to wash down contaminated structures, roadways, and vehicles and a sequestering agent to bind the radionuclides from the wash water and render them environmentally immobile. The sequestering agent also facilitates separation of the radionuclides from the bulk water for transport and disposal. The wash solution is designed to be easily disseminated by first responders using eductors and nozzles already used by firefighters to distribute foaming agent.

To elaborate, the wash solution consists of a salt solution with a surfactant additive to improve the wettability of asphalt and other hydrophobic surfaces. The salts that we found work best are potassium and ammonium. A saturated, surfactant brine can be created in smaller tanks and drawn into a fire hose by the educator system to achieve the desired salt concentration (>0.1 molarity and preferably 0.5M molarity).

Based on the literature and experiments, the sequestering agents of choice are montmorillonite and vermiculite clay with vermiculite being preferred. The clay is distributed across the ground in the affected zone and within the artificial reservoirs set-up downgrade from the wash activities.

We expect to contain the contaminated water for filtration and reuse by deploying a system of berms to create reservoirs at the street level. As the wash waters and clay material collect in the reservoirs, we will begin slurry collection and filtration operations. From experiment, we expect up to 80% of the cesium to be bound within the

clay sequestering agent within the reservoir. Additional separations can reduce contamination levels to permit wash water reuse or disposal.

Disposal of materials is a key aspect of the technology. By using the clay and filtration system, we can be reasonably assured that the wash waters will be suitable for direct disposal as treated waters (not low-level radioactive liquid waste).

Recently, the process was demonstrated at the Wide-Area Recovery and Resiliency Program meeting under the Department of Homeland Security and the Denver Urban Area Security Initiative. We down-selected technologies for integration and demonstration at the pilot-scale level. The scope of the demonstration included the primary unit operations of the Irreversible Wash Aid Additive technology -- wash down, collection, and filtration of "radioactive" wash waters. With the technologies selected, we coordinated with local city and public works officials, regional EPA, and federal officials to establish a location for the demonstration and logistics for receipt of materials. We will summarize the demonstration and the lesson's learned.

Questions, Answers, and Comments

- Q: In real world application, is there a necessity for more contact between material and the water; does the decanted water [which contains the radionuclides] have enough contact for sufficient mixing?
- A: I don't think there is sufficient contact as shown here. The clay settles quickly and a lot of it might not be transported to the filtration system but there are ways of improving the mixing. People that remove sludge out of cooling towers have a similar problem, and they have a pump system that circulates water continuously within the basin so there is always a slurry instead of supernatant. Thus, [the system shown here] could have a mixing system added on the front end to ensure good mixing, followed by transport of the slurry into the filtration system.
- Q: When washing the truck, it collected 6-8 inches of water. How long would it take to pump 6-8 inches of water?
- A: I don't have a per-horsepower of pump measurement, but the size of the pump is the limitation. No one [commercial firm] has the ability to store big inventory of large pumps; that is the limit on the flow through. The biggest of the pumps are made to order.
- Q: Did you observe any leakage?
- A: There was a bit of leakage that we saw. The surface was fairly smooth with the setup of the berm across a divot to see how it did. That wasn't where the leakage was. Leakage [the water seen outside the berm] might have only been from original water pumping. Berms [from this supplier] are designed for the containment of water despite a large head behind them. They [the supplier] were confident [because of the normal deployment scenarios for the berms] that they would work even on city streets with curbs and irregularities.

Radiocesium, Radiostrontium and Radiocobalt Sorption/Desorption on Components of Drinking Water Distribution Systems

A. Konoplev, V. Popov, I. **Stepina (Presenter)** | *RPA "Typhoon"*
J. Szabo | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

The objective of the work is to investigate the fate of dissolved radiocesium, radiostrontium and radiocobalt deposited on components of drinking water distribution systems (iron, copper, plastic and concrete pipes) for developing effective decontamination techniques and strategies. The research was performed in frame of International Science and Technology Center (ISTC) Project # 4007.

Sections of drinking water pipes made of four different materials: iron, concrete lined iron, copper and polyvinylchloride have been mounted vertically in the lab and fed from the bottom by a radionuclide solution in

tap water using a peristaltic pump MasterFlex 77120-62. The experiments were designed so that the water pipe could be regarded as a closed or open-type chemical reactors.

It was found that radionuclide distribution in the tap water - water supply pipe system strongly depends on the pipe material. ^{60}Co was sorbed very well by all types of pipes except the copper pipe. Only 1.5-3% of the spiked ^{60}Co is desorbed by tap water. Note should also be made of the high sorption of ^{85}Sr by two types of iron pipes (the sorption being 98%). The desorption of ^{85}Sr from these pipes by tap water was only 2.5-4.5%. The sorption of ^{137}Cs by plastic pipe was not high and equal to 2.9%, and practically all sorbed ^{137}Cs was desorbed by tap water. About 30% of ^{137}Cs was sorbed and 7% desorbed by the iron pipe without coating.

The use of 0.1M solution of tartaric acid for decontaminating these pipes is an effective measure for their decontamination from radionuclides besides concrete lined iron pipe because of neutralizing of the acid by coating. 0.1M EDTA solution was found as efficient desorbing agent for ^{60}Co from the pipes. This solution extracted all sorbed ^{60}Co from the iron pipes, and about 80% of ^{60}Co from concrete and plastic pipes.

There were no questions for this presenter.

20. General Session 5 Foreign Animal Disease Research

Moderated by Joe Wood and Benjamin Franco

Decontamination of Agricultural Facilities Following a Bioterrorism Attack or Disease Outbreak: Learning from Outbreaks of Low Pathogenic Avian Influenza in Virginia

Gary Flory (Presenter), Robert Peer | *Virginia Department of Environmental Quality*

Abstract

The food supply represents a high-risk vulnerability for every nation. The food and agricultural sector of the U.S. economy contributes as much as $1 trillion to the Gross Domestic Product and accounts for an estimated 15 percent of the total workforce. The decontamination of agricultural facilities following infection—either intentional or unintentional—with biological agents poses a significant challenge to recovery.

Outbreaks of low pathogenic avian influenza in Virginia in 1983, 1999, 2002 and 2007 have resulted in the development of decontamination protocols that have been tested and improved under full-scale disease eradication conditions. These same procedures can provide valuable insights when preparing facility decontamination protocols for other biological agents.

This presentation will address lessons learned from the Virginia experience and include the following topics to support the development and enhancement of agricultural facility decontamination procedures:

- Timing of depopulation and carcass disposal activities
- On-site and off-site carcass disposal methods
- Transportation of infected materials
- Litter/manure management
- Sealing structures and controlling access
- Pest management inside and outside of the effected structures
- Cleaning structures and equipment
- Disinfectant selection
- Disinfecting large areas
- Disinfecting porous surfaces

- Environmental sampling
- Quarantine release

It is our desire that sharing these lessons and supporting the transfer of these principles to broader biological agent response efforts will result in a higher level of preparedness and as a result, reduce the desirability of the use of these agents by those wishing to do us harm.

Questions, Answers, and Comments

- Q: How did Virginia facilitate cooperation between agricultural and environmental agencies and the agricultural industry?
- A: A Poultry Disease Task Force was developed in Virginia following the 2002 outbreak to keep processes up-to-date and ensure readiness. We have now created a task force for large animal industry and found that establishing relationships between agencies is key.
- Q: In Virginia, who pays for depopulation, disposal and decontamination procedures following a disease outbreak like Avian Influenza?
- A: Because Virginia has an approved avian influenza response plan, our activities were funded by the Indemnity Program through the Federal Government.

Animal Disease Outbreak Emergency Response

Michael Mayes (Presenter), Jimmy Tickel | *North Carolina Department of Agriculture and Consumer Services*

Abstract

The North Carolina Department of Agriculture and Consumer Services (NCDA&CS) has been tasked as the lead agency to research logistical issues related to a Foreign Animal Disease (FAD) outbreak in the United States. The logistical issues of the project are transporting, permitting, decontamination, and disposal of diseased animal carcasses.

This project focuses on developing a model of best transportation guidelines for hauling diseased cargo intra and interstate as the need would arise during an outbreak. This effort, entitled “Animal Disease Outbreak Emergency Response Logistical Infrastructure – North Carolina Region”, will focus on the dairy and swine industries. This is part of an umbrella project in which West Texas A&M will research the same logistical issues within the beef cattle industry.

Of primary concern are how to decontaminate vehicles prior to and during transport, as well as equipment and personnel at disposal facilities. The project will look at issues regarding decontamination of all facilities and equipment after the outbreak is contained. Furthermore, the project will consider how to safely move infected carcasses without further disease propagation.

To insure a national perspective and gain consensus, experts from the State of North Carolina will collaborate with other states’ experts to identify areas for movement of infected carcasses within the guidelines established by this project. In this project, a draft model will be designed within North Carolina using experts from the state, and then with collaboration with other states’ experts across the nation, information will be gathered to refine and expand the draft model. The final model will be offered to USDA as a best guidelines approach to safely transport and dispose of infected carcasses.

Questions, Answers, and Comments

- Q: Is this effort pointing towards on-farm composting?
- A: Yes, composting is an option.
- C: The sequence and timing of the process is complicated and variable.

Portable Vehicle Wash Tunnel

Bob Henderson | *Integrated Solutions For Systems (IS4S)*

No slides were made available for inclusion.

Abstract

Highly contagious foreign animal disease (FAD) outbreaks such as Foot and Mouth Disease and Vesicular Stomatitis for cattle and highly pathogenic avian influenza for poultry can have devastating impacts on export markets, the economic stability of farms, and world confidence in the integrity of the US food supply. Lost export business, and containment and eradication costs are the main sources of financial loss. If not contained in a timely manner, a single outbreak can wreak havoc in the marketplace and invoke long term financial and logistic impacts.

Complete recovery from the disease is not complete until the outbreak is contained and the pathogen(s) are eliminated. The primary means of spreading FAD are through the movement of contaminated material such as soil, animal bedding, or infected livestock through human and vehicular transport. Rapid boundary and access control with effective disinfection at ingress/egress points is the key to minimizing propagation.

Disinfection of humans and vehicles is difficult and expensive. Conventional portable vehicle wash stations are large, difficult to transport, and require substantial human and logistic support. The costs of decontamination necessarily increase the overall cost of the containment effort for as long as the outbreak continues.

The Portable Vehicle Wash Tunnel system provides a reliable, easily deployable, autonomous vehicle wash system that can rapidly disinfect small and large vehicles at a reasonable cost. The tunnel can disinfect a 70 ft, 18 wheeled heavy truck in less than 13 minutes at a cost of approximately $34.15. At full capacity, a single tunnel can process over 110 heavy trucks or 240 passenger cars every 24 hours. This represents a significant reduction in cost and time over conventional decontamination methods.

The Portable Vehicle Wash Tunnel system is available in short (35 ft.) and long (80 ft.) lengths. Both are available in single and dual lane versions, and all variants are transportable in a small trailer. All be deployed by two to four people in less than 4 hours. The system is fully autonomous and can be operated bi-directionally. Other applications include rapid response decontamination for vehicles and people during bio-terrorism attacks and nuclear plant incidents.

Questions, Answers, and Comments

- C: A full-scale wheel wash and tread wash system might be implemented later.
- C: The tunnel is divided into three zones and the middle zone is the largest. It is subdivided into six zones, however, it cannot shut off the top wash only.
- C: The beginning of a wash outside the tunnel is a common approach. Any reaerosolization/spread of pathogens during that process is going into the contaminated area. One could add a section onto the tunnel as area for triage.
- C: To clean farm equipment in a cold setting, it takes four people who could work maximum of two hours at a time. The process took four hours to complete. Assuming the labor rate & benefits is $100/hr/person, replacing that setup with one of these units is paid for quickly.

Combustion of Contaminated Livestock in a Pilot-Scale Air Curtain Burner

P. Lemieux (Presenter), J. Wood, W. Calfee | *U.S. Environmental Protection Agency*
B. Hall | *ARCADIS*

Abstract

In the event of a foreign animal disease (FAD) outbreak, the response will likely include decontamination of agricultural sites, depopulation of affected livestock, and disposal of the resulting animal carcasses. For highly

contagious FADs such as foot and mouth disease (FMD) virus, on-farm disposal is preferred so that additional contamination is minimized. One transportable technology for on-farm disposal of contaminated animal carcasses is air curtain burners (ACBs). ACBs are mobile incinerators that utilize the general concept that a high-volume sheet of air is blown at a slight downward angle across the top of, and into, an open-topped combustion vessel. The air serves a dual purpose: 1) combustion is enhanced (when compared to open burning) by providing a steady supply of forced excess air with turbulent mixing resulting in higher temperatures and more thorough consumption of the solid materials used as fuel as well as any other combustible materials fed into the burn chamber (e.g., animal carcasses); and 2) the injection of the air at a slightly incident angle forms a "curtain" that creates a recirculation zone that serves to encourage burnout of unburned materials prior to release into the atmosphere. ACBs have been deployed on numerous occasions by the U.S. Forest Service and the U.S. Army Corps of Engineers for the reduction of vegetative waste and in some cases for destruction of animal carcasses. ACBs can be mobilized to where they're needed as a potential means of reducing the waste volume while minimizing potentially harmful environmental impacts and spread of pathogens. This presentation reports on a series of tests at the pilot-scale, to identify and analyze operational issues as well as efficacy of spore destruction while processing large amounts of animal carcasses in an ACB. The tests utilized Cornish game hens as the animal carcasses, which were inoculated with *G. stearothermophilus* spores. A combination of aerosol and wipe sampling was used to characterize residual spores remaining after the test burns.

Questions, Answers, and Comments

- C: There is limited data for these air curtain burners on a field scale; the state of Virginia has data after burning 641,000 carcasses that they could share; also a high interest in viral surrogates was expressed.

APPENDIX A

Agenda

DAY 1: TUESDAY, November 5, 2013 Auditorium, C-111	
7:30 AM	**Registration Begins**
8:15 AM	**Welcome and Logistics** Shawn Ryan, Lukas Oudejans | *U.S. Environmental Protection Agency* **Homeland Security from the EPA's Office of Research and Development Perspective** Lek Kadeli | *U.S. Environmental Protection Agency* **Purpose and Objectives of the Conference** Gregory Sales | *U.S. Environmental Protection Agency* **Introduction of the Keynote Speaker** Peter Jutro| *U.S. Environmental Protection Agency*
9:00 AM	**Keynote Speaker** **Decontamination: Can You Tell Decision Makers What They Need to Know After (and Before) a CBRN Attack?** Richard Danzig | *Former Secretary of the Navy and Vice-Chair of the RAND Corporation Board of trustees*
9:45–10:10	**Break**
General Session 1—Outcome Tabletop Exercise, Guidance, and Response Auditorium, C-111. Presentations and Q&A moderated by Hiba Ernst and Richard Rupert	
10:10 AM	**The Role of the Private Sector in the Assessment and Remediation of Areas Impacted by a CBRNE Incident** Carl Brown | *Environment Canada*
10:35 AM	**U.K. Recovery Guidance and Advice for the Remediation of the Environment Following a Chemical Incident (The U.K. Recovery Handbook for Chemical Incidents)** Stacey Wyke | *Public Health England*
11:00 AM	**Cleaning up Afterwards. The UK Recovery Handbook for Biological Incidents** Alan Bennett | *Public Health England*
11:25 AM	**Research Activities of the Japan National Institute of Environmental Studies on Fukushima Nuclear Power Plant Accident** Noriuki Suzuki | *National Institute for Environmental Studies, Japan*
11:50–1:00	**Lunch**
1:00 PM	**Hazard Mitigation Science and Technology Program for the DoD Chemical and Biological Defense Program (CBDP)** Charles Bass | *Defense Threat Reduction Agency*
1:25 PM	**U.K. Government Decontamination Service (GDS)** Sara Casey | *Government Decontamination Service, United Kingdom*
1:50 PM	**Biological Response and Recovery Science and Technology Roadmap** Brooke Pearson | *Cubic Applications, Inc.*
General Session 2—Decision Support Tools Auditorium, C-111A/B/C. Presentations and Q&A moderated by Leroy Mickelsen and Timothy Boe.	
2:00 PM	**Utilization of the QUIC Urban T&D Modeling System for Pre-Planning, Sensor Siting, and Post-Event**

	Analysis of CBR Dispersal Events Michael Brown | *Los Alamos National Laboratory*
2:20 PM	**A Comprehensive Decision Support Tool for Agricultural Security** Robert Knowlton | *Sandia National Laboratories*
2:30 PM	**Toward Feasible Sampling Plans** Landon Sego | *Pacific Northwest National Laboratory*
2:40–3:00	**Break**
3:00 PM	**Decision Support Toolset for Weapons of Mass Destruction (WMD) Crisis Management** Brooke Pearson | *Cubic Applications, Inc.*
3:10 PM	**Tactical Dynamic Operational Guided Sampling (TacDOGS) Tool for the Transatlantic Collaborative Biological Resiliency Demonstration (TaCBRD) Program** Dan Dutrow | *John Hopkins University APL*
3:20 PM	**Decon ST: Decontamination Strategy and Technology Selection Tool** Donna Edwards | *Sandia National Laboratories*
3:30 PM	**Carcass Management Decision Support Tools** Brooke Pearson | *Cubic Applications, Inc.*
3:40 PM	**Waste Estimation Support Tool: An Overview, Updates, and Demonstration** Timothy Boe | *Oak Ridge Institute for Science and Education*
3:50 PM	**Interactive All Hazards Waste Management Plan Development Tool** Anna Tschursin | *U.S. Environmental Protection Agency*
4:00 PM	**Panel Discussion**
4:30 PM	**Decision Support Tools Demonstration:** Auditorium, C111 A/B/C and C114
5:30 PM	**Day 1 Adjourns**

DAY 2: WEDNESDAY, November 6, 2013		
8:00 AM	**Reflections on Day 1** Juan Reyes | *U.S. Environmental Protection Agency*	
General Session 3—Risk Communication and Systems Approach Auditorium, C-111A/B/C. Presentations and Q&A moderated by Brendan Doyle		
8:15 AM	**Professional and Public Perceptions of Information Needs During a Drinking Water Contamination Event** Cynthia Yund | *U.S. Environmental Protection Agency*	
8:40 AM	**Perceptions of Risk Communication Messages During a Long-Term Biological Remediation** Charlena Bowling | *U.S. Environmental Protection Agency*	
9:05 AM	**A Systems Approach to Characterizing the Social Environment for Decontamination and Resilience** Keely Maxwell | *U.S. Environmental Protection Agency*	
General Session 3—Food Safety-Decontamination and Disposal Issues Auditorium, C-111. Presentations and Q&A moderated by Brendan Doyle		
9:30 AM	**Intentional Contamination of Food: Detection, Decontamination, and Disposal Research and Needs** Nicholas Bauer | *Food Safety and Inspection Service*	
9:55–10:20	**Break**	
Concurrent Sessions 1		
	Biological Agent Decontamination Auditorium, C-111A/B/C. Presentations and Q&A moderated by Shawn Ryan	**Chemical Agent Sampling and Detection** C-113 Presentations and Q&A moderated by Stuart Willison
10:20 AM	**Smart Aqueous Gels and Foams for RB Decontamination** Sylvain Faure | *CEA Marcoule, France*	**Decontamination Screening Techniques Used At U.S. Army Chemical Agent Disposal Facilities and Applications for Clearing Contaminated Areas** Theodore Ruff | *Centers for Disease Control and Prevention*
10:45 AM	**Anthrax Decontamination of a Mock Office Using Low Level Chlorine Dioxide Fumigation** Matthew Clayton | *ARCADIS*	**Multi-Laboratory Study of Analytical Protocols for Chemical Warfare Agents in Environmental Matrices** Romy Campisano | *U.S. Environmental Protection Agency*
11:10 AM	**Methyl Iodide Fumigation of *Bacillus Anthracis* Spores** Mark Sutton | *Lawrence Livermore National Laboratory*	**Accelerated Clean-up of A Residential Site Using On-site Analytics** Lawrence Kaelin | *U.S. Environmental Protection Agency*

11:35 AM	**Gruinard Island Returns to Civil Use** Stephen Hibbs | *Defence Science & Technology Laboratories, United Kingdom*	**Advancing the Trace Atmospheric Gas Analyzer (TAGA) Triple Quadrupole Mass Spectrometer Fitted with an Atmospheric Pressure Chemical Ionization (APCI) Source to Provide Analytical Assistance for a Chemical Warfare Agent (CWA) Release** Dave Mickunas | *U.S. Environmental Protection Agency*
12:00–1:00	**Lunch**	
Concurrent Sessions 2		
	Biological Agent Sampling and Detection Auditorium, C-111A/B/C. Presentations and Q&A moderated by Worth Calfee	Radiological Agent Fate, Transport, and Decontamination C-113. Presentations and Q&A moderated by Jeff Szabo
1:00 PM	**Development of Processing Protocols for Vacuum Sampling Devices** Laura Rose | *Centers for Disease Control and Prevention*	**Migration of Radiocesium, Radiostrontium and Radiocobalt in Urban Building Materials and their Wash-Off by Rainwater** Aleksei Konoplev | *RPA "Typhoon", Russia*
1:25 PM	**Evaluation of Surface Sampling for Bacillus Spores Using Commercially-Available Cleaning Robots** Leroy Mickelsen | *U.S. Environmental Protection Agency*	**Scalability Challenges for Deployment of Commercially Available Radiological Decontamination Technologies in the Wide Area Urban Environment** John Drake | *U.S. Environmental Protection Agency*
1:50 PM	**Evaluation of Commercial Off the Shelf (COTS) Biological Detection Technologies for Transition to First Responder Community** Rachel Bartholomew | *Pacific Northwest National Laboratory*	**Sorption and Speciation of ^{137}Cs, ^{60}Co and ^{85}Sr in Building Materials** Katerina Maslova | *RPA "Typhoon", Russia*
2:15 PM	**Evaluation of Effect of Decontamination Agents on the Rapid Viability PCR Method for Detection of Bacillus Anthracis Spores** Sanjiv Shah | *U.S. Environmental Protection Agency*	**Humic Acid-Based Sorbents for Area Decontamination** Andrey Sosnov | *NP OrCheMed, Russia*; presented by Carl Brown | *Environment Canada*

Poster Session
Building B Atrium

2:40–4:00	**Poster Session of the Decontamination R&D Conference** Join us in the Building B Atrium to view posters and interact with poster presenters.

1	Surface and Vapour Decontamination by Aerosolized Micro-Emulsion Decontaminant
2	Development of Solid Peracetic Acid (PES-Solid) for Decontamination
3	On-Site qPCR for Detection of Biological Threat Agents – Sources of Measurement Uncertainty
4	Survival and Demise of Biological or Chemical Agents in Municipal Solid Waste Landfill Leachate
5	Method of Improving Chemical Resistance of Coatings by Surface Modification.
6	Sample Sizes and Placement of Tests Following Building / Area Decontamination
7	Technology Evaluation of Army Toxicity Sensors
8	Identification of Hazard Mitigation Agents to Neutralize Dry Powder Biological Materials
9	Decontamination of Surfaces Exposed to Organophosphates by Vapor Phase Hydrogen Pe
10	Rapid Uptake of Cesium and Americium by Sequestering Agents from Complex Decontamination Solutions
11	Energy Density-Response Relationships of Bacterial Spores to Ultraviolet Radiation: a Test of Haber's Law
12	Can You Beat a Garden Sprayer? Novel Methods of Decontamination of *Bacillus anthracis* Contaminated Soil
13	Degradation of Aerosolized BG Spores via Ultraviolet Light
14	Use of Fixatives to Prevent Bacillus anthracis Spore Reaerosolization
15	I-WASTE: EPA's Suite of Homeland Security Decision Support Tools for Waste and Disaster Debris Management and Disposal
16	Assessment of Contamination Following Simulated Chemical and Biological Attacks in a Public Building
17	Screening *Bacillus thuringiensis* Isolates for Characteristics that Simulate *B. anthracis* and are Useful for Environmental Tests
18	Decontamination of Materials Contaminated with *Bacillus anthracis* and *Bacillus thuringiensis* Al Hakam Spores Using PES-Solid, a Solid Source of Peracetic Acid
19	UV-C Decontamination of Aerosolized and Surface Bound Single Spores and Bioclusters
20	Decontamination, Decommissioning and Closure of the U.S. Chemical Stockpile Disposal Facilities

Concurrent Sessions 3		
	Biological Agent Fate and Transport Auditorium, C-111A/B/C. Presentations and Q&A moderated by Marshall Gray	Chemical Agent Fate, Persistence and Transport C-113. Presentations and Q&A moderated by Larry Kaelin
4:00 PM	**Reaerosolisation of Bacterial Spores from Indoor Surfaces** Allan Bennett | *Public Health England*	**Predictive Modeling of Transport Processes at Environmental Interfaces Following Chemical or Radiological Contamination** James Hunt
4:25 PM	**Informing Response and Recovery Decisions: The Scientific Program on Reaerosolization and Exposure (SPORE), A Program Overview** Marshall Gray | *U.S. Environmental Protection Agency*	**Adsorption and Desorption of Chemical Warfare Agents on Activated Carbons: Impact of Temperature and Relative Humidity** Lukas Oudejans | *U.S. Environmental Protection Agency*
4:40 PM	**Quantitative Analysis of Resuspension** Russell Wiener | *U.S. Environmental Protection Agency*	
5:05 PM	**Experimental and Sampling Design for a Quantitative Investigation of the Resuspension of Anthrax and Surrogates under Controlled Conditions** Alfred Eisner | *ALION*	
5:30 PM	**Day 2 Adjourns**	

DAY 3: THURSDAY, November 7, 2013		
General Session 4—Low Tech/Self Help Auditorium, C-111A/B/C. Presentations and Q&A moderated by Emily Snyder and Charlie Fitzsimmons		
8:00 AM	**Assessment of RDD Contamination Removal from Laundering Soft Porous and Bulky Materials** Karen Riggs | *Battelle*	
8:25 AM	**Evaluation of Compressed Air Dusting and Vacuuming for Radiological Decontamination of Sensitive Equipment** Ryan James | *Battelle*	
8:50 AM	**Efficacy of Sporicidal Wipes on Select Surfaces** Kathryn Meyer | *Oak Ridge Institute for Science and Education*	
9:15 AM	**Inactivation of Bacillus Spores in Decontamination Wash Down Wastewater using Chlorine Bleach Solution** Vincente Gallardo | *U.S. Environmental Protection Agency*	
9:40–10:00	**Break**	
Concurrent Sessions 4		
	Biological Agent Persistence Auditorium, C-111A/B/C Presentations and Q&A moderated by Matthew Magnuson	**Chemical Agent Decontamination** C-113 Presentations and Q&A moderated by Lukas Oudejans
10:00 AM	**A Large-Scale Soil Survey of Genetic Markers Associated with *Bacillus Anthracis* and Bacillus Species Across the Contiguous United States: A Joint USGS/USEPA Project** Dale Griffin | *U.S. Geological Survey*	**Developing Decontamination Tools and Approaches to Address Indoor Pesticide Contamination from Improper Bed Bug Treatments** Dan Stout | *U.S. Environmental Protection Agency*
10:25 AM	**Persistence of Vegetative *Bacillus Anthracis* with and without Exposure to Ultraviolet Radiation to Simulate Sunlight** Thomas Kelly | *Battelle*	**Challenges in Lewisite Decontamination Studies** Harry Stone | *Battelle*
	Water and Waste Water Management	
10:50 AM	**Investigation into U.K. Capability to Manage Contaminated Water** Carmel Ramwell | *Food and Environment Research Agency, United Kingdom*	**Advanced Absorbent Wipes for Personnel and Personal Equipment Decontamination** Stuart Notman | *Defence Science & Technology Laboratories, United Kingdom*
11:15 AM	**Decontamination for the Water Sector** Marissa Lynch | *U.S. Environmental Protection Agency*	**Large Panel CWA Efficacy Testing of Hazard Mitigation Products and Processes** Adam Judd | *Battelle*
11:40 AM	**Lunch**	

Concurrent Sessions 5

	Biological Agent Decontamination Auditorium, C-111A/B/C. Presentations and Q&A moderated by Sanjiv Shah	Water and Waste Water Management C-113. Presentations and Q&A moderated by Marissa Lynch
1:00 PM	**Decontamination of Soil Contaminated with *Bacillus Anthracis* Spores** Joe Wood | *U.S. Environmental Protection Agency*	**Selected Projects of EPA's Homeland Security Research Program (HSRP) for Water and Wastewater Treatment and Decontamination** Matthew Magnuson | *U.S. Environmental Protection Agency*
1:25 PM	**Decontamination of Nursery Potting Soil with Chlorine Dioxide** Craig Ramsey | *U.S. Department of Agriculture*	**NHSRC Drinking Water Infrastructure Decontamination Overview** Jeff Szabo | *U.S. Environmental Protection Agency*
1:50 PM	**Test Method Development to Evaluate Hot, Humid Air Decontamination of Materials Contaminated with Bacillus Anthracis ΔSterne and B. Thuringiensis Al Hakam Spores** Alice Young | *Naval Surface Warfare Center, Dahlgren Division*	**Demonstration of Unit Operations for the Irreversible Wash Aid Additive for Cs-137 Contamination** Mike Kaminski | *Argonne National Laboratory*
2:15 PM	**Aerosol Delivery of Liquid Decontaminants: A Novel Approach for Decontamination of Complex Interior Spaces** Mark Tucker | *Sandia National Laboratories*	**Radiocesium, Radiostrontium and Radiocobalt Sorption/Desorption on Components of Drinking Water Distribution Systems** Irina Stepina | *RPA "Typhoon", Russia*
2:40–3:00	**Break**	

General Session 5 – Foreign Animal Disease Research

Auditorium, C-111A/B/C. Presentations and Q&A moderated by Joe Wood and Benjamin Franco

3:00 PM	**Decontamination of Agricultural Facilities Following a Bioterrorism Attack or Disease Outbreak: Learning from Outbreaks of Low Pathogenic Avian Influenza in Virginia** Gary Flory | *Virginia Department of Environmental Quality*
3:25 PM	**Animal Disease Outbreak Emergency Response** Michael Mayes | *North Carolina Department of Agriculture*
3:50 PM	**Portable Vehicle Wash Tunnel** Bob Henderson | *Integrated Solutions for Systems*
4:15 PM	**Combustion of Contaminated Livestock in a Pilot-Scale Air Curtain Burner** Paul Lemieux | *U.S. Environmental Protection Agency*
4:40 PM	**Final Remarks**
5:00 PM	**Conference Adjourns**

Appendix B

Attendance

Name	Affiliation
Nancy Adams	Self, U.S.
Bruce Akers	North Carolina Department of Agriculture & Consumer Services, U.S.
Brian Allen	Missouri Department of Natural Resources, U.S.
Linda Ang	DSO National Laboratories, Singapore
Anthony Arkell	U.K. Government Decontamination Service
Donald Bansleben	Department of Homeland Security, U.S.
Rachel Bartholomew	Pacific Northwest National Laboratory, U.S.
Charles Bass	Defense Threat Reduction Agency (DTRA), U.S.
William Batt	CTTSO/TSWG, U.S.
Nicholas Bauer	U.S. Department of Agriculture, Food Safety and Inspection Service
William Bell	TDA Research, Inc., U.S.
Allan Bennett	Public Health England (formerly Health Protection Agency)
Doris Betancourt	U.S. EPA
Nathan Birnbaum	U.S. Department of Agriculture, Animal and Plant Health Inspection Service
Timothy Boe	Oak Ridge Institute for Science and Technology, U.S. EPA
Charlena Bowling	U.S. EPA
Eletha Brady-Roberts	U.S. EPA
Carl Brown	Environment Canada

Name	Affiliation
Michael Brown	Los Alamos National Laboratory, U.S.
Kelly Brown	MRIGlobal, U.S.
Tony Buhr	Naval Surface Warfare Center Dahlgren Division, U.S.
David Burford	EPA START, U.S.
Erik Burnett	U.S. Special Operations Command (SOCOM)
Kathryn Burns	Naval Surface Warfare Center Dahlgren Division, U.S.
Joan Bursey	U.S. EPA
Kirkley Cain	U.S. EPA
Worth Calfee	U.S. EPA
Romy Campisano	U.S. EPA
Joseph Cappello	CUBRC, U.S.
Michael Carpenter	Idaho National Laboratory, U.S.
Sara Casey	U.K. Government Decontamination Service
Kevin Choe	We Green, Inc, South Korea
Matthew Clayton	ARCADIS, U.S.
Teresa Cremer	BioSAFE Engineering, U.S.
Beverly Cusworth	Naval Surface Warfare Center Dahlgren Division, U.S.
Sandra Da Silva	National Institute of Standards and Technology, U.S.
Joe Dalmasso	Yakibou, Inc.
Richard Danzig	Former Secretary of the Navy and Vice-Chair of the RAND Corporation

Name	Affiliation
Matthew Davenport	The Johns Hopkins University Applied Physics University, U.S.
Wendy Davis-Hoover	U.S. EPA
Amy Dean	JPEO-CBD, U.S.
Jeff Dellinger	North Carolina DHHS Public Health, U.S.
Brendan Doyle	U.S. EPA
John Drake	U.S. EPA
Erin Durke Davis	OptiMetrics, Inc./A DCS Corp., U.S.
Dan Dutrow	The Johns Hopkins University Applied Physics Laboratory, U.S.
Rovelyn Dytioco	Boeing, U.S.
Donna Edwards	Sandia National Laboratories, U.S.
Alfred Eisner	ALION, U.S.
Hiba Ernst	U.S. EPA
Anthony Evans	FBI, U.S.
Susan Fairchild	U.S. EPA
Sylvain Faure	Commissariat for Atomic Energy and Alternative Energies (CEA), France
Richard Fitzpatrick	CUBRC, U.S.
Charlie Fitzsimmons	U.S. EPA
Gary Flory	Virginia Department of Environmental Quality, U.S.
Francois Fontaine	National Institute of Environmental & Industrial Risks (INERIS), France
Brian France	TDA Research, Inc., U.S.
Benjamin Franco	U.S. EPA

Name	Affiliation
Vicente Gallardo	U.S. EPA
Christopher Gallo	U.S. EPA
Jerome Gilberry	RTI International, U.S.
Marshall Gray	U.S. Public Health Services - U.S. EPA
Jayson Griffin	U.S. EPA
Dale Griffin	U.S. Geological Survey
Nicole Griffin Gatchalian	ARCADIS, U.S.
Robert Henderson	Integrated Solutions for Systems, U.S.
Stephen Hibbs	DSTL Porton Down, U.K.
Art Hin	METSS Corporation
Nagahisa Hirayama	National Institute for Environmental Studies, Japan
James Hunt	Consultant, U.S.
Ryan James	Battelle, U.S.
Shalini Jayasundera	CSC, U.S.
Adam Judd	Battelle, U.S.
Peter Jutro	U.S. EPA
Lek Kadeli	U.S. EPA
Lawrence Kaelin	U.S. EPA
Michael Kaminski	Argonne National Laboratory, U.S.
Amit Kapoor	First Line Technology
Melissa Kaps	U.S. EPA
David Karaolis	National Biodefense Analysis and Countermeasures Center (NBACC), U.S.
Thomas Kelly	Battelle, U.S.
Jeff Kempter	U.S. EPA (Retired)

Name	Affiliation
Aimee Ketner	Naval Surface Warfare Center Dahlgren Division, U.S.
Sean Kinahan	The Johns Hopkins University Applied Physics Laboratory, U.S.
Robert Knowlton	Sandia National Laboratories, U.S.
Dean Komm	U.S. Department of Agriculture, Animal and Plant Health Inspection Service
Aleksei Konoplev	RPA "Typhoon", Russia
Marek Kuzma	Institute of Microbiology, Czech Republic
Shawn Lafferty	U.S. EPA
Ross Leadbetter	University of North Carolina, U.S.
Sang Don Lee	U.S. EPA
Johannes Lee	ARCADIS, U.S.
Paul Lemieux	U.S. EPA
Laurene Levy	U.S.D.A., Animal and Plant Health Inspection Service
Hoo Li Wei	Ministry of Home Affairs, Singapore
Kai Yun Lim	National Environment Agency, Singapore
Alan Lindquist	U.S. EPA
Jin Phang Jimmy Loh	DSO National Laboratories, Singapore
Marissa Lynch	U.S. EPA
Matthew Magnuson	U.S. EPA
Blair Martin	U.S. EPA (Retired)
Katerina Maslova	RPA "Typhoon", Russia
Keely Maxwell	U.S. EPA

Name	Affiliation
Michael Mayes	North Carolina Department of Agriculture & Consumer Services, U.S.
Katrina McConkey	Booz Allen Hamilton, U.S.
Tanya Medley	U.S. EPA
Kathryn Meyer	Oak Ridge Institute for Science and Technology, U.S. EPA
James Michael	U.S. EPA (Retired)
Leroy Mickelsen	U.S. EPA
David Mickunas	U.S. EPA
Lori Miller	U.S. Department of Agriculture, Department of Homeland Security
Ong Ming Kwei	Singapore National Environment Agency
Shoji Nakayama	National Institute for Environmental Studies, Japan
Tonya Nichols	U.S. EPA
Stuart Notman	DSTL, U.K.
Brian O'Donnell	Joint Project Manager for Elimination, U.S.
Jeremy OKelly	FBI, U.S.
Tim Oliver	Cooper Zietz Engineers, Inc., U.S.
Lukas Oudejans	U.S. EPA
Bruno Pagnani	Dynamac Corp., U.S.
Kurtis Palmer	14th CST (CT-ARNG), U.S
Lucas Pantaleon	Ogena Solutions, LLC, U.S.
Greg Parra	U.S.D.A.
Cayce Parrish	U.S. EPA
Brooke Pearson	Cubic, U.S.

Name	Affiliation
Karen Pongrance	Excet, Inc., U.S.
Brent Pulsipher	Pacific Northwest National Laboratory, U.S.
Craig Ramsey	U.S.D.A., Animal and Plant Health Inspection Service
Carmel Ramwell	The Food and Environment Research Agency, U.K.
Juan Reyes	U.S. EPA
Karen Riggs	Battelle, U.S.
Laura Rose	U.S. Centers for Disease Control and Prevention
Theodore Ruff	U.S. Centers for Disease Control and Prevention
Richard Rupert	U.S. EPA
Shawn Ryan	U.S. EPA
Jonathan Sabol	Aberdeen Proving Grounds, U.S.
Mike Saye	CSC, U.S.
Greg Sayles	U.S. EPA
Robin Schubauer	U.S. EPA
Landon Sego	Pacific Northwest National Laboratory, U.S.
Shannon Serre	U.S. EPA
Sanjiv Shah	U.S. EPA
John Shaw	Battelle, U.S.
Erin Silvestri	U.S. EPA
Markham Smith	Defense Threat Reduction Agency (DTRA), U.S.
Emily Snyder	U.S. EPA
Douglas Steele	U.S. EPA
Irina Stepina	RPA "Typhoon", Russia

Name	Affiliation
Harry Stone	Battelle, U.S.
Daniel Stout II	U.S. EPA
Kevin Strohmeier	Kentucky Department for Environmental Protection, U.S.
Mark Sutton	Lawrence Livermore National Laboratory, U.S.
Noriyuki Suzuki	National Institute for Environmental Studies, Japan
Jeffrey Szabo	U.S. EPA
Dennis Tabor	U.S. EPA
Calvin Terada	U.S. EPA
Eben Thoma	U.S. EPA
Jonathan Thornburg	RTI International, U.S.
Anna Tschursin	U.S. EPA
Mark Tucker	Sandia National Laboratories, U.S.
Jenia Tufts	Oak Ridge Institute for Science and Technology, U.S. EPA
Dana Tulis	U.S. EPA
Bryan Vasser	EPA START, U.S.
Howard Walls	RTI International, U.S.
Russell Wiener	U.S. EPA
Steven Wilkinson	ChemCentre, Australia
Stuart Willison	U.S. EPA
Joseph Wood	U.S. EPA
Stacey Wyke	Public Health England
Barbara Wyrzykowska-Ceradini	ARCADIS, U.S.
Jennifer Yap	National Environment Agency, Singapore

Name	Affiliation
Alice Young	Naval Surface Warfare Center Dahlgren Division, U.S.

Name	Affiliation
Cynthia Yund	U.S. EPA

Appendix C
Presentation Slides

Tuesday, November 5, 2013

General Session 1

Outcome Tabletop Exercise, Guidance, and Response

Environment Canada / Environnement Canada

Canada

The Role of the Private Sector in the Assessment and Remediation of Areas Impacted by a CBRNE Incident

C.E. Brown*, P.G. Lambert, M. Goldthorp, and K. Volchek
Environment Canada
F. Scaffidi, and K. Corriveau
Transport Canada
N. Yanofsky
Defence R&D Canada

Origins of a Private Sector Project

- Primary focus of EC's CBRNE S&T efforts to date;
  - Assessment and remediation of CBRN contamination of sites and facilities
  - Development of remediation guidelines, R&D related to new technologies or proof of concept projects to demonstrate novel technologies
  - Funding provided by Canadian Safety and Security Program (CSSP), Defence R&D Canada
- Based on a gap analysis that was undertaken, there is evidence that private sector industry and emergency response contractors have not been adequately engaged in CBRNE S&T activities

Private Sector Engagement

- Environment Canada, Transport Canada, and Defence R&D Canada's Centre for Security Science have undertaken projects to improve Canada's resilience to potential CBRNE events
- Developed and delivered table-top exercises in Hamilton, ON (2012) and Calgary, AB (2013) with another planned for Montreal, Quebec (November 2013)
- These TTXs examined the role of private industry during the response to a CBRNE event involving emergency services from all levels of government
- The exercises are part of a larger program to integrate private sector capabilities in response to CBRNE events

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Exercise Development

- Planning for the Hamilton TTX began a year in advance
- Exercise was intended to build CBRNE capability and capacity across a broad range of stakeholders including industry, municipal & provincial governments, the Chemical, Forensic and Explosive CoPs and member departments
- The goal was to target stakeholders in one geographic area who, as a whole, would benefit from participation in the larger scale CBRNE exercises
- The exercise scenario was intentionally designed to;
  - meet the specific needs of the local participants,
  - fulfill the goals of the larger private sector engagement program,
  - develop a template for future exercises throughout Canada

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TTX ~ 40 participants 20+ organizations

First Responders	• Hamilton Emergency Medical Services (EMS) • Hamilton Fire/Hazmat • Hamilton Police Services	• Calgary Emergency Medical Services (EMS) • Calgary Fire/Hazmat • Calgary Police Services • Canadian Pacific Police Service • Office of the Fire Commissioner
Industry	• Agrium Inc. • Canadian National Railway (CN Rail) • Canadian Pacific Railway (CP Rail) • I-Tech Environmental • Newalta Emergency Response • Quantum Murray LP • Railway Association of Canada (RAC) • U.S. Steel Canada	• Agrium Inc. • Canadian Fertilizer Institute (CFI) • Canadian National Railway (CN Rail) • Canadian Pacific Railway (CP Rail) • Chemistry Industry Association of Canada (CIAC) • Enviro Hazmat • Quantum Murray LP • Railway Association of Canada (RAC) • Shield Specialized Emergency Services Inc.
Municipal, Regional, Provincial, Federal, Organizations	• Environment Canada (Ontario Region) • Hamilton Emergency Management Office (EMO) • Ministry of Environment Spills Action Centre (SAC) • Public Health (PH)	• Alberta Emergency Management Agency (AEMA) • Calgary Emergency Management Agency (CEMA) • Alberta Environment • Alberta Transportation Dangerous Goods • Transport Canada (Regional Office)
Observers	• DRDC Centre for Security Science (CSS) • Emergency Response Management Consulting (ERMC) • Hamilton Emergency Management Office (EMO) • Hamilton Port Authority	• DRDC Centre for Security Science (CSS)
Planning Team and Facilitators	• Environment Canada (EC) • Transport Canada (TC) • International Safety Research Inc. (ISR)	• Canadian Safety & Security Program (CSSP) • Transport Canada (TC) • International Safety Research Inc. (ISR)

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Exercise Outline – Scenario Overview

- Consultation with the municipalities to build local capability focussing on response and consequence management stages of a CBRNE event
- Examine the roles of private sector or industry manager and response contractors
- Two separate plausible scenarios employing significant releases of toxic industrial chemicals that have an effect on city infrastructure and threaten public safety
  1. Railcar of anhydrous ammonia
  2. Transport truck carrying drums of chloropicrin
  - Both chemicals are regulated by TC and EC and are on numerous Hazmat and CBRNE threat agent lists
  - Hazardous material properties relevant to focus of the exercise
- Both scenarios lead to activation/authorization of Emergency Response Action Plan (ERAP)
  - Attacks were located in or near population centres and took place consecutively over the course of several hours
  - The timing of the simulated attacks was designed to maximize the number of casualties, public panic and economic disruption consistent with a terrorist event

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Exercise Outline – Ammonia Scenario

- Immediate assessment and response actions by the participants were the focus of the ammonia scenario
- Scenario details:
  - Weather stable wind 5-10 km/hr from 350°, 10°C, with fog
  - Freight train with 37 loaded cars, 20 empty cars, arriving
  - Transporting chlorine, propane and anhydrous ammonia (UN1005)

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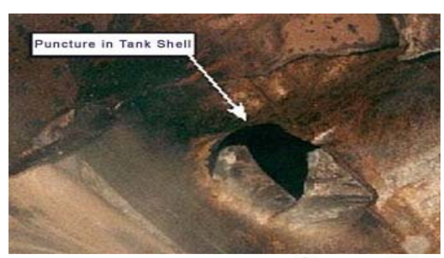
Exercise Outline – Ammonia Scenario

- Timeline of scenario was T= 0 to 8 hours
- Example of Inject Objectives:
  - To understand the role and actions of each participant at that moment in time
  - What are the responsibilities of the rail yard and how would they respond internally?
- Example of questions used to drive the exercise
  - Who would they call?
  - Are other authorities notified by the dispatched responders?
  - How the response changed when the HAZMAT event evolved to a CBRNE event



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Exercise Outline – Ammonia Scenario

- T= 6 hours
- Public Health
  - More than 500 people are self presenting at hospital
  - < 5 deaths
- T= 8 hours
- Forensic and evidence collection
  - Expectations for industry to support the crime scene investigation?
- Transitioning the site to industry for remediation

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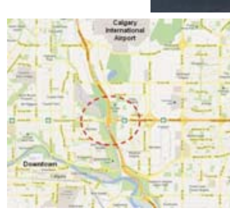
Exercise Outline – Chloropicrin Scenario

- The chloropicrin scenario targeted the study of longer term consequence management and recovery operations
- T= 12 hours, or 0500 hours next day
- 2nd event, hours before morning rush hour traffic
- Sequential with ammonia scenario versus separate events
- Public Health
  - Numerous 911 calls
  - Need to address public safety



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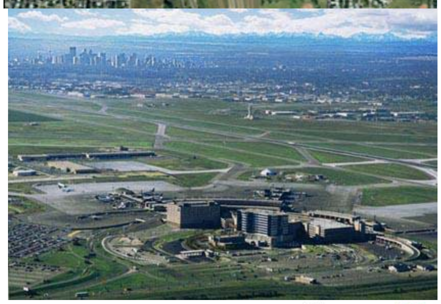
Exercise Outline – Chloropicrin Scenario

- T= 18 hours, 1100 hours next day
- Significant contamination to City's critical infrastructure
  - Primary road
  - Public transit including airport buses
- Drains into storm sewer
- T=48 hours
  - Remediation capability
- T= weeks
  - Remediation criteria and clean up standards
  - What steps are taken to restore safe operations of the City?



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Discussion - Hamilton

- Overall, the exercise achieved its intended objective to advance the role of private sector industry in CBRNE events and enhance capability of regional emergency services
- The number, diversity and positive contribution of the industry groups and regional M/P/F emergency offices greatly added to the outcomes
- Extended planning period was advantageous
  - Was essential for administrative requirements,
  - Facilitates communication with each participant to better determine the objectives of each group

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Discussion – Federal Participants

- Goals specific to respective departmental mandates
  - EC tested its environmental emergency notification and response protocols and examined the application of its regulations within the context of a CBRNE event
  - Private sector and crime scene management – The National CBRNE Response Team
  - TC's Transportation of Dangerous Goods (TDG) legislation has extend Emergency Response Assistance Plans (ERAP) to CBRNE events and sought to better understand the practical issues of a CBRNE event within its legal jurisdiction and internal response plans

Discussion – Industry

- Railway Association of Canada provided valuable insight on the impact to the concept of operations whether the railyard or rail line was federally or provincially regulated or if the railcar was on the property of a client at the time of the incident
- CN and CP provided important details on their existing Hazmat response procedures such as isolating leaking railcars

Discussion – Response Contractors

- Extensive detection and monitoring equipment inventories
- Highly trained personnel with specialized response skills required for some TIC incidents and not available elsewhere
- Performance standards for response contractors exist
- With appropriate site safety planning will potentially enter a CBRNE “hot zone”
- Work in partnership with municipal responders including law enforcement agencies and public health
- May already have response agreement with City and/or industry

Discussion – Product Specialists

- Agrium Inc. provided specialists to support any response
- Expert advice on
  - the product,
  - response options,
  - impact to the concept of operations of specific details such as who was the product owner
- In addition, the challenge of whether or not it was a known versus an unknown intentional attack was examined.

Agrium

Discussion – City of Hamilton

- Interoperability of the participating groups varied from fully successful to less defined
- The City of Hamilton Emergencies Services established a unified command with a lead agency in a timely matter
  - Their experience and results of their recent participation in the CBRNE post-blast research project and workshop was apparent
- Each of the participants have established response management systems
  - Challenge was to identify and overcome the practical issues of integrating different systems in a multi-agency response
  - Incident Command and Unified Command System were noted
  - Players were able to reconcile broad issues surrounding concept of operations
- The importance of a multi-agency concept of operations to address a CBRNE event involving first responders, all levels of government and the private sector was noted early in the planning stages of the exercise

Discussion – City of Calgary

- Allowed industry to show the first responder communities its technical expertise and capabilities
- It is likely that industry will play an important role in response to the type of scenario used in the TTX
- Demonstrated the need to get industry involved in the planning phases for response to an incident
  - Their familiarity with product behavior, means of containment was useful in assessing risks and developing response strategies
- Re-enforced existing working relationships between organizations and created some new ones

Discussion – City of Calgary

- Provided critical guidance towards developing TC CBRNE Response Framework so that it clarifies;
  - limits on costs,
  - the extent to which we can apply an ERAP to a CBRNE event, and
  - the additional equipment needed during a CBRNE event.
- Demonstrated
  - how complex a CBRNE incident can be in terms of scope,
  - requirements for decisions affecting public safety,
  - requirements for decisions with large financial implications (e.g. how far to evacuate, decontaminate – and to what extent?
- Showcased contractor-owned equipment and existing industry capabilities

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Next Steps

- Follow up work initiated or pending includes:
  - A scoping study to further review the challenges of an inter-agency concept of operations that includes the private sector was undertaken and a report prepared
  - A survey of federal departments including members of the National CBRNE Response Team and Chemical CoP to obtain additional information on the engagement of private sector contractors by federal departments in their potential support to a CBRNE event
  - A literature search and a road map to learn from the experience of other stakeholders who have addressed similar challenges related to private sector engagement. Examples are;
    - Contaminated site reclamation industry,
    - Natural disaster emergency response groups,
    - The workplace occupational health and safety sector, and
    - Building and property manager associations

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Next Steps

- Planning for future exercises
  - Montreal, QC November 19, 2013
- Incorporate lessons-learned
- Consideration of other issues, such as;
  - Liability and/or insurance,
  - Psycho-social, and
  - Casualty management
- Delivery models
  - Further advance capability in same location(s),
  - Offer in new location(s),
  - Combine with other demonstrations and exercises

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  - Mr. M. Roy, Explosives Community of Practice
  - Mr. T. Sykes, CSSP, CBRNE Section Head (retired)
  - Mr. Pervez Azmi, ESTS, Environment Canada

Public Health England

UK Recovery Guidance and Advice: The UK Recovery Handbook for Chemical Incidents

Dr Stacey Wyke

Public Health England

Contents

- Introduction
  - Acknowledgements: Nick Brooke, Antonio Pena-Fernandez, David Baker, Raquel Duarte-Davidson and Virginia Murray,
- Recovery from major chemical incidents
- The UK Recovery Handbook for Chemical Incidents
  - Scope
  - Evidence base
- What next……. Chemical and Radiation Recovery Decision Support Tool (C&R DST)

2

Public Health England

Recovery guidance and advice

Why develop recovery handbooks?

[More information](#)

[More information](#)

[More information](#)

[More information](#)

3 UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)

Public Health England

Definition of recovery

' the process of rebuilding, restoring and rehabilitating the community following an emergency'

HM Government (2005) Emergency response and recovery: Non- statutory guidance accompanying the Civil Contingencies Act 2004.

4

Public Health
England

History ….

UK Recovery handbook (Rad) v1

2005

EURANOS generic handbooks (Rad) v1 **2006/7**

European stakeholder networks e.g. FARMING

Public Health
England

EURANOS generic handbooks (Rad) v1

UK Recovery handbook (Rad) v3 (2009)

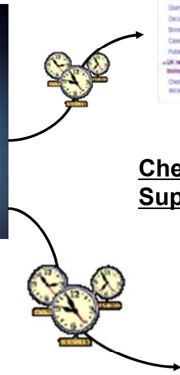
EURANOS generic handbooks (Rad) v2

'Demonstration'

Handbook Users Group

Public Health England

UK Recovery handbook (Chemicals) v1 (2012)



UK Recovery handbook (Biological) v1 (2012 - 2015)

Chemical and Radiation Recovery Decision-Support Tool (2013 – 2015)

Public Health England

Target audience

- National and local authorities
- Central government departments and agencies
- Environmental and health protection experts
- Industry
- Emergency services
- Others that may be affected by a Chemical incident

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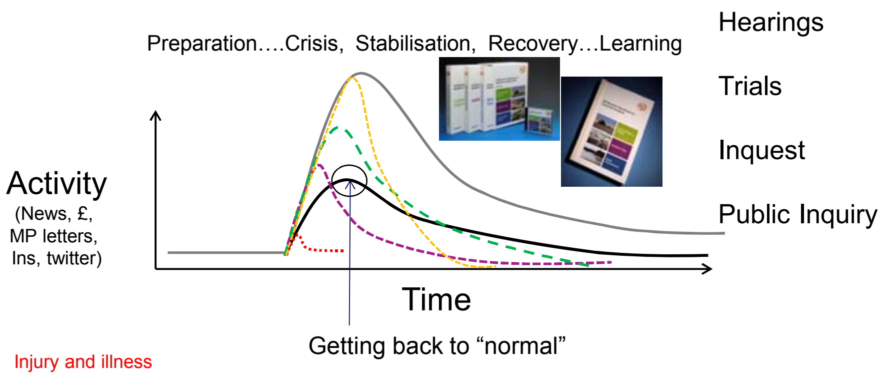

- Injury and illness
- Worry or concern
- Political
- Media

Focus on clean-up and restoration

Does not address all aspects of the recovery phase

Risk assessment protocols

Sampling or monitoring strategies

Not a substitute for specialist advice,
but will **aid decision makers** in the
Development of a recovery strategy

Public Health England

Practical application of the Handbook

Robust scientific and technical advise, presented in a simple format as checklists, decision tree's and "steps" to lead users through the stages of developing a recovery strategy.

Recovery option datasheets, provide an overview of different remediation techniques, highlighting associated issues

What are recovery options?

Definition: "An action intended t
avert the exposure of people to che
contamination"

Protection

Prohibit public access to non-residential areas
Impose restrictions on transport
Temporary relocation from residential areas

Remediation/ removal options

Reactive liquids (bleaches, detergents, foams, gels)
Vacuum cleaning
Surface removal

Evaluating the evidence base

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Step 1: Obtain information regarding the incident
Determine physicochemical properties of contaminant and identify area that has been affected

Important physiochemical properties of chemicals affecting Inhabited Areas					
Physical characteristic	**Description**	**Interpretation**		**Chemical**	
				Description/ value	**Interpretation**
Physical form (solid/liquid gas)	**Gases** and vapours spread out in the environment until they are equally distributed throughout the space available to them. **Liquids** will flow with gravity when released and therefore require safe containment to stabilise the incident and prevent further risk to persons, property and the environment. **Solids** need further assistance to move greater distances and in general are easier to contain. However, solids in the form of fibres, dusts or smoke can be quickly carried by the air and present a risk to anyone situated in the path of dispersion			[redacted]	
Vapour pressure (VP)	A measure of how easily a liquid evaporates or gives off vapours. For instance, where the vapours being given off by a liquid pose a hazard (e.g. Sulphur Mustard) fixative / strippable coating options may be considered. Higher volatility would result in a higher vapour pressure. Interpretation (Units = Pascals) $< 1.3 \times 10^{-4}$: Unlikely to volatilise Between 1.3×10^{-4} and 1.33: Increasing likelihood of volatilising >1.3 : likely to volatilise	**High VP** Likely to: Be an inhalational risk Evaporate quickly	**Low VP** Unlikely to be: An inhalational risk		
Vapour Density (D vapour)	This refers to the relative weight of a gas or vapour compared to air (or sometimes it can be compared to hydrogen gas). Air is assigned an arbitrary value of 1 and if a gas has a vapour density of <1.29 it will generally rise in air. If the vapour density is >1.29 the gas will generally sink in air. All vapours tend to be heavier than air.	**D > 1.29** Will: Stay close to the ground	**D < 1.29** Will: Rise and mix in air more easily		
Density of liquid (D Liquid)	The density (specific gravity) of a liquid is determined by comparing the weight of an equal amount of water. (Water = 1.0). If the specific gravity is less than 1.0 then it will float, if greater than 1.0 it will sink. This is likely to be an important factor following release to water where the use of certain recovery options (e.g. use of adsorbent booms/mats) could be considered for chemicals that float on water.	**D > 1** Will: Sink in water	**D < 1** Will: Form a surface film on water		
Persistence	The time that the released chemical is physically present following release and is related to physiochemical properties and is affected by environmental conditions such as humidity and temperature. This is an important factor to consider when judging when recovery options can be implemented following an incident.	**Short persistence:** Hours to days **Moderate Persistence:** Weeks to months **Long Persistence:** Months to Years			

Step 1: Obtain information regarding the incident
Determine physicochemical properties of contaminant and identify area that has been affected

Important physiochemical properties of chemicals affecting Inhabited Areas					
Physical characteristic	**Description**	**Interpretation**		**Chemical**	
				Description/ value	**Interpretation**
Absorbtion on porous surfaces	The ability of a substance to absorb to porous surfaces (e.g. concrete) is an important consideration as this may influence the effectiveness of decontamination options. In some cases (e.g. Sulphur mustard) options such as surface removal may be more appropriate	**Absorbs** Likely to be effectively removed via: Surface removal Disposal and dismantling	**Does not absorb** Likely to be : Easier to decontaminate		
Surface Tension	Chemicals with a low surface tension are more likely to seep into relatively inaccessible surfaces (e.g. between screws/ bolts) which has implications for the remediation of these surfaces. Those with a higher surface tension are more likely to accumulate on a surface without penetrating inaccessible areas. Examples, units: dynes /cm Ethanol: 22.3 (low) Water: 75.6 Mercury: 465 (high)	**High** Likely to: Accumulate on surface	**Low** Likely to: Contaminate inaccessible surfaces		
Water solubility	The ability of a material (gas, liquid or solid) to dissolve in water. Materials can be insoluble, sparingly soluble or soluble. Water soluble materials (such as acids) may be more easily dispersed in water and have a greater potential to pollute water environments (e.g. groundwater). Many water insoluble materials (e.g. petrol) may be spread by flowing water. Water based decontamination of surfaces may be more effective if a chemical is water soluble; removal options or active decontamination may be more appropriate for non-water soluble chemicals Interpretation:: Units ppm (mg/l) <10: Negligible solubility Between 10 and 1000: Increasing likelihood of solubilising >1000: Likely to solubilise	**High Solubility** Likely to be: Mobile Decontaminated by water based solutions Unlikely to be: Volatilised Persistent	**Low solubility** Likely to be: Immobilised by adsorption Persistent Unlikely to be: Mobile		

Step 1: Obtain information regarding the incident
Determine physicochemical properties of contaminant and identify area that has been affected

Important physiochemical properties of chemicals affecting Inhabited Areas

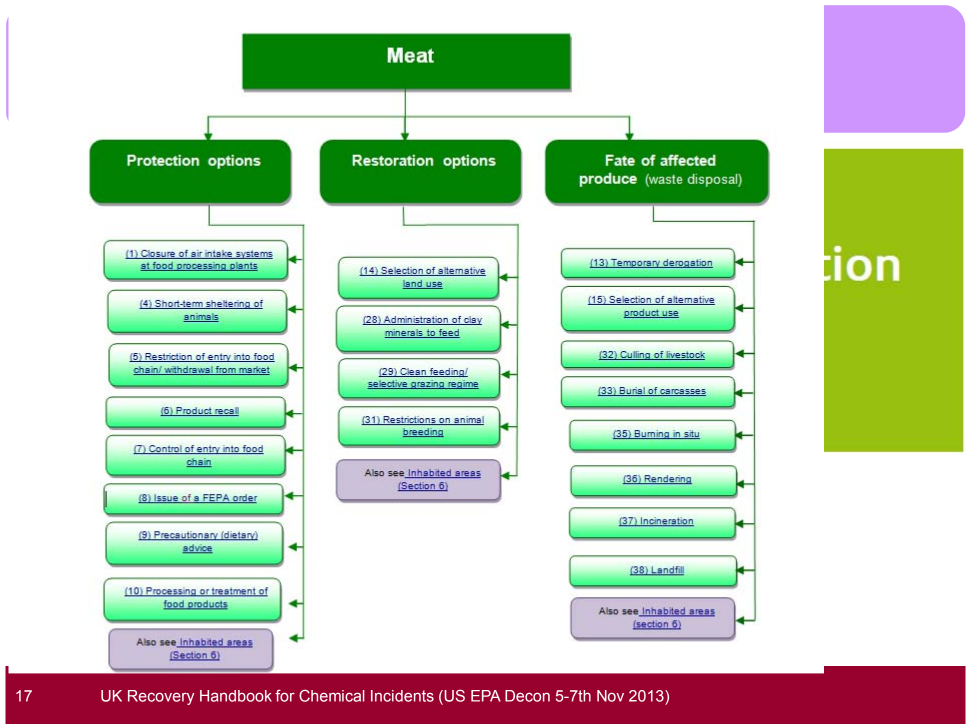
Physical characteristic	Description	Interpretation		Chemical	
				Description/ value	Interpretation
Soil sorption	Measures how readily a chemical is adsorbed to organic surfaces in the soil matrix. Some soils have very limited abilities to sorb chemicals e.g. sandy soils or ones with low clay or organic matter contents. Gives an indication of likely persistence in soil. Interpretation (Units = K_{oc}) > 10,000 : Likely to adsorb Between 1,000 and 10,000 : Increasing likelihood of adsorbing < 1,000: Unlikely to adsorb	High K_{oc} Likely to be: Adsorbed Accumulated Unlikely to be Mobile	Low K_{oc} Likely to be: Mobile Unlikely to be Adsorbed		
Partition coefficient between water and octanol (K_{ow})	This gives an indication of relative solubility of a material (compound) in water and in octanol. Chemicals that preferentially dissolve in octanol are defined as hydrophobic and have a high partition coefficient. A high value also gives an indication of potential to adsorb to soil and sediments. Interpretation (Units = K_{ow}) > 1,000 : Likely to bioaccumulate (hydrophobic)- High Between 500 and 1,000 : Increasing likelihood of bioaccumulating < 500: Unlikely to bioaccumulate (hydrophilic)- Low	High K_{ow} Likely to be Bioaccumulated: Sorbed in soil or sediments Unlikely to be: Mobile	Low K_{ow} Likely to be: Mobile Soluble Biodegraded Unlikely to be: Bio-accummulated		
Viscosity	The viscosity of a chemical determines how easily it flows within an environment. It may influence how easy it is to remove from an environment (e.g. it would be difficult to vacuum a highly viscous chemical). Viscous chemicals are also less likely to re - suspend in the environment. Examples: Units = mPa. Water: 0.894 (low) Corn syrup: 81 (high)	High: Likely to be: Difficult to decontaminate Unlikely to be: Vacuumed Resuspended Mobile	Low: Likely to be: Mobile Easier to decontaminate		
Degradation and reaction by-products	Process by which chemicals decompose to their elemental parts or form by-products on reaction with other chemicals or water. Some chemicals can be converted to more toxic products during this process.				
Toxicity	Sum of adverse effects or the degree of danger posed by a substance to living organisms. It is expressed generally as a dose response relationship involving the quantity of substance to which the organism is exposed and the route of exposure skin (absorption), mouth (ingestion), or respiratory tract (inhalation).				

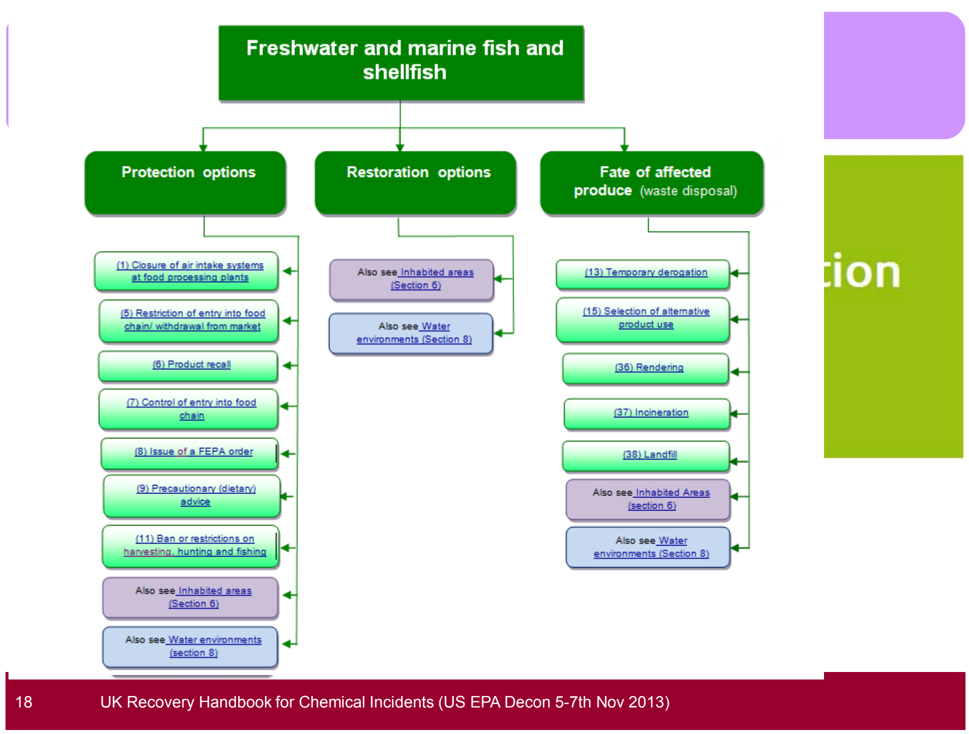
15 UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)

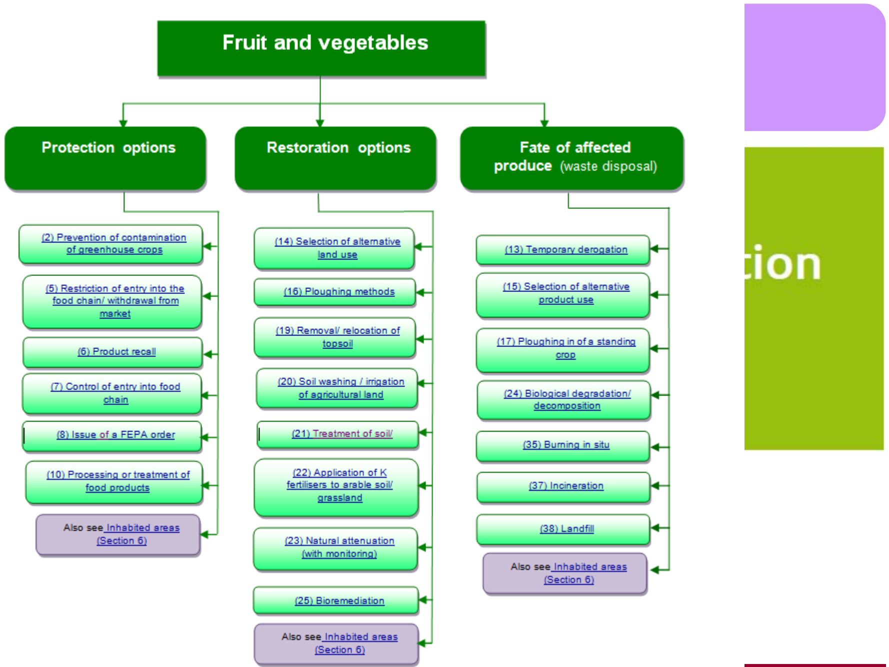
Step 2: Consult flow chart decision tree's for specific environment
Identify potentially applicable recovery options
Consult other sections of Handbook (if applicable)

Food Production Systems

16 UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)


Meat
Protection options
Restoration options
Fate of affected produce (waste disposal)
(1) Closure of air intake systems at food processing plants
(4) Short-term sheltering of animals
(5) Restriction of entry into food chain/ withdrawal from market
(6) Product recall
(7) Control of entry into food chain
(8) Issue of a FEPA order
(9) Precautionary (dietary) advice
(10) Processing or treatment of food products
Also see Inhabited areas (Section 6)
(14) Selection of alternative land use
(28) Administration of clay minerals to feed
(29) Clean feeding/ selective grazing regime
(31) Restrictions on animal breeding
Also see Inhabited areas (Section 6)
(13) Temporary derogation
(15) Selection of alternative product use
(32) Culling of livestock
(33) Burial of carcasses
(35) Burning in situ
(36) Rendering
(37) Incineration
(38) Landfill
Also see Inhabited areas (section 6)
tion
17
UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)


Freshwater and marine fish and shellfish
Protection options
Restoration options
Fate of affected produce (waste disposal)
(1) Closure of air intake systems at food processing plants
(5) Restriction of entry into food chain/ withdrawal from market
(6) Product recall
(7) Control of entry into food chain
(8) Issue of a FEPA order
(9) Precautionary (dietary) advice
(11) Ban or restrictions on harvesting, hunting and fishing
Also see Inhabited areas (Section 6)
Also see Water environments (section 8)
Also see Inhabited areas (Section 6)
Also see Water environments (Section 8)
(13) Temporary derogation
(15) Selection of alternative product use
(36) Rendering
(37) Incineration
(38) Landfill
Also see Inhabited Areas (section 6)
Also see Water environments (Section 8)
tion
18
UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)



19 UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)

Step 2: Consult flow chart decision tree's for specific environment
Identify potentially applicable recovery options
Consult other sections of Handbook (if applicable)

Inhabited Areas

20 UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)

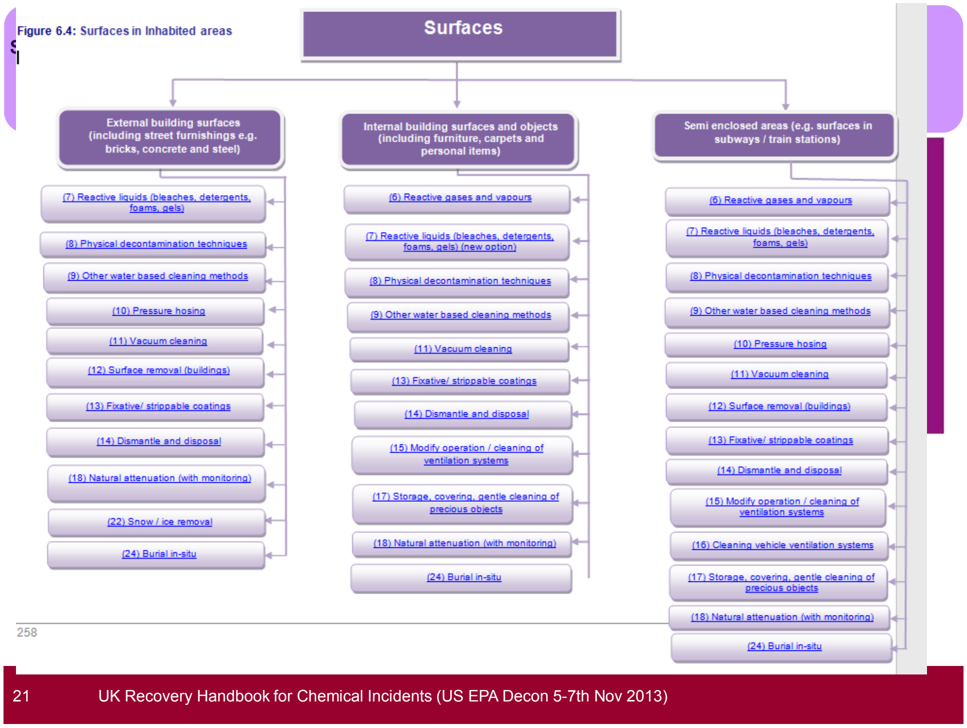
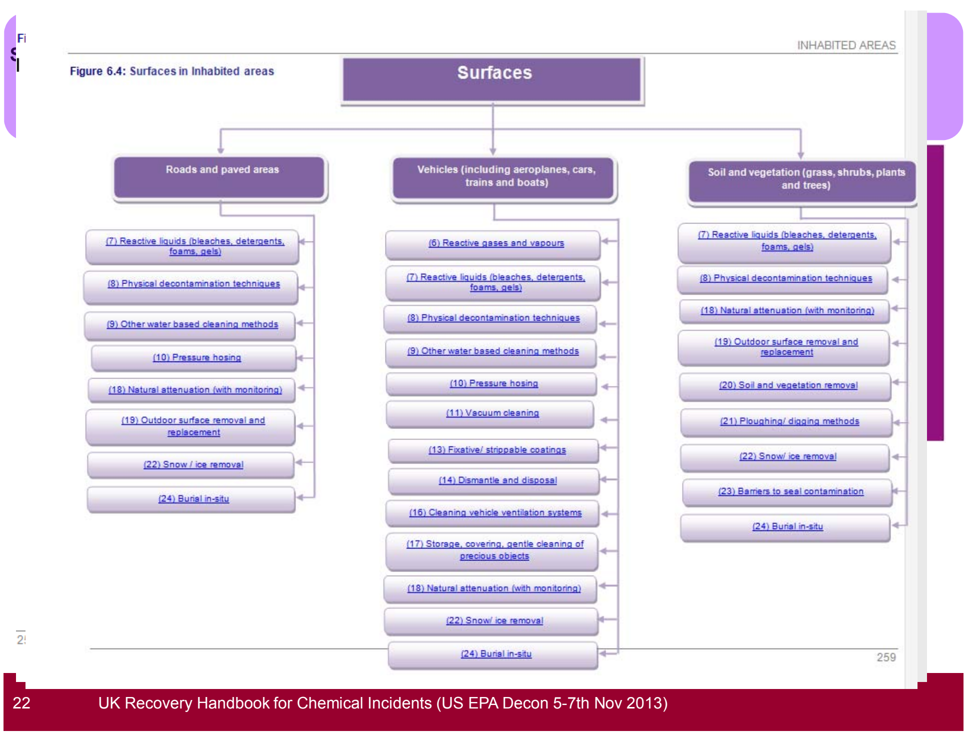


Figure 6.4: Surfaces in Inhabited areas
Surfaces
External building surfaces (including street furnishings e.g. bricks, concrete and steel)
(7) Reactive liquids (bleaches, detergents, foams, gels)
(8) Physical decontamination techniques
(9) Other water based cleaning methods
(10) Pressure hosing
(11) Vacuum cleaning
(12) Surface removal (buildings)
(13) Fixative/ strippable coatings
(14) Dismantle and disposal
(18) Natural attenuation (with monitoring)
(22) Snow / ice removal
(24) Burial in-situ
Internal building surfaces and objects (including furniture, carpets and personal items)
(6) Reactive gases and vapours
(7) Reactive liquids (bleaches, detergents, foams, gels) (new option)
(8) Physical decontamination techniques
(9) Other water based cleaning methods
(11) Vacuum cleaning
(13) Fixative/ strippable coatings
(14) Dismantle and disposal
(15) Modify operation / cleaning of ventilation systems
(17) Storage, covering, gentle cleaning of precious objects
(18) Natural attenuation (with monitoring)
(24) Burial in-situ
Semi enclosed areas (e.g. surfaces in subways / train stations)
(6) Reactive gases and vapours
(7) Reactive liquids (bleaches, detergents, foams, gels)
(8) Physical decontamination techniques
(9) Other water based cleaning methods
(10) Pressure hosing
(11) Vacuum cleaning
(12) Surface removal (buildings)
(13) Fixative/ strippable coatings
(14) Dismantle and disposal
(15) Modify operation / cleaning of ventilation systems
(16) Cleaning vehicle ventilation systems
(17) Storage, covering, gentle cleaning of precious objects
(18) Natural attenuation (with monitoring)
(24) Burial in-situ
258
21
UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)


INHABITED AREAS
Figure 6.4: Surfaces in Inhabited areas
Surfaces
Roads and paved areas
(7) Reactive liquids (bleaches, detergents, foams, gels)
(8) Physical decontamination techniques
(9) Other water based cleaning methods
(10) Pressure hosing
(18) Natural attenuation (with monitoring)
(19) Outdoor surface removal and replacement
(22) Snow / ice removal
(24) Burial in-situ
Vehicles (including aeroplanes, cars, trains and boats)
(6) Reactive gases and vapours
(7) Reactive liquids (bleaches, detergents, foams, gels)
(8) Physical decontamination techniques
(9) Other water based cleaning methods
(10) Pressure hosing
(11) Vacuum cleaning
(13) Fixative/ strippable coatings
(14) Dismantle and disposal
(16) Cleaning vehicle ventilation systems
(17) Storage, covering, gentle cleaning of precious objects
(18) Natural attenuation (with monitoring)
(22) Snow/ ice removal
(24) Burial in-situ
Soil and vegetation (grass, shrubs, plants and trees)
(7) Reactive liquids (bleaches, detergents, foams, gels)
(8) Physical decontamination techniques
(18) Natural attenuation (with monitoring)
(19) Outdoor surface removal and replacement
(20) Soil and vegetation removal
(21) Ploughing/ digging methods
(22) Snow/ ice removal
(23) Barriers to seal contamination
(24) Burial in-situ
259
22
UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)

Step 2: Consult flow chart decision tree's for specific environment
Identify potentially applicable recovery options
Consult other sections of Handbook (if applicable)

Water Environments

Public and private drinking water supplies

Marine and coastal water

Inland and underground waters (including recreational waters_

Sewage treatment

Step 3: Determine effectiveness of recovery options
A: Eliminate options based on physicochemical properties
B: Eliminate options based on surface material

Recovery Option	Efficacy for type of contamination and surface material				
	Surface Type		Contamination type		
	Robust	Sensitive	Free	Absorbed	Inaccessible
(6) Reactive gases and vapours					
(7) Reactive liquids (bleaches, detergents, foams, gels)					
(8) Physical decontamination techniques					
(9) Other water based cleaning methods (scrubbing, shampoo)					
(10) Pressure hosing					
(11) Vacuum cleaning					
(12) Surface removal (buildings)					
(13) Fixative/ strippable coatings					
(14) Dismantle and disposal of contaminated material					
(15) Modify operation/ cleaning of ventilation systems					
(16) Cleaning vehicle ventilation systems					
(17) Storage, covering, gentle cleaning of precious objects					
(18) Natural attenuation (with monitoring)					
(19) Outdoor surface removal and replacement (road, soil)					
(23) Barriers to seal land contamination					
(24) Burial in-situ					

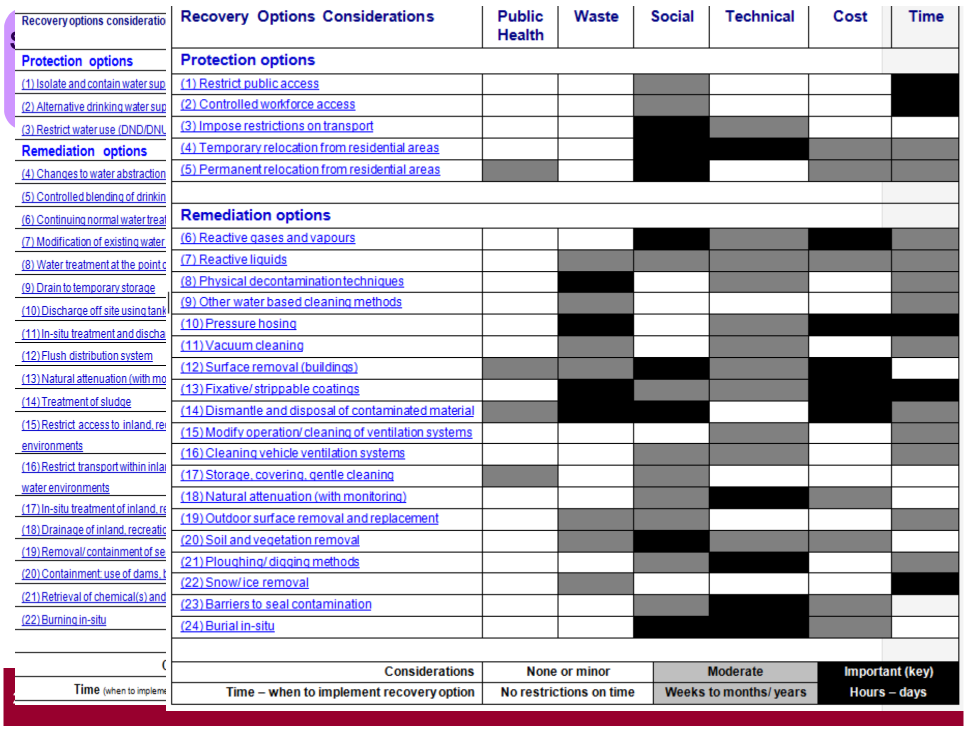
Effectiveness	Up to 100% effective	Potentially effective	Limited effectiveness

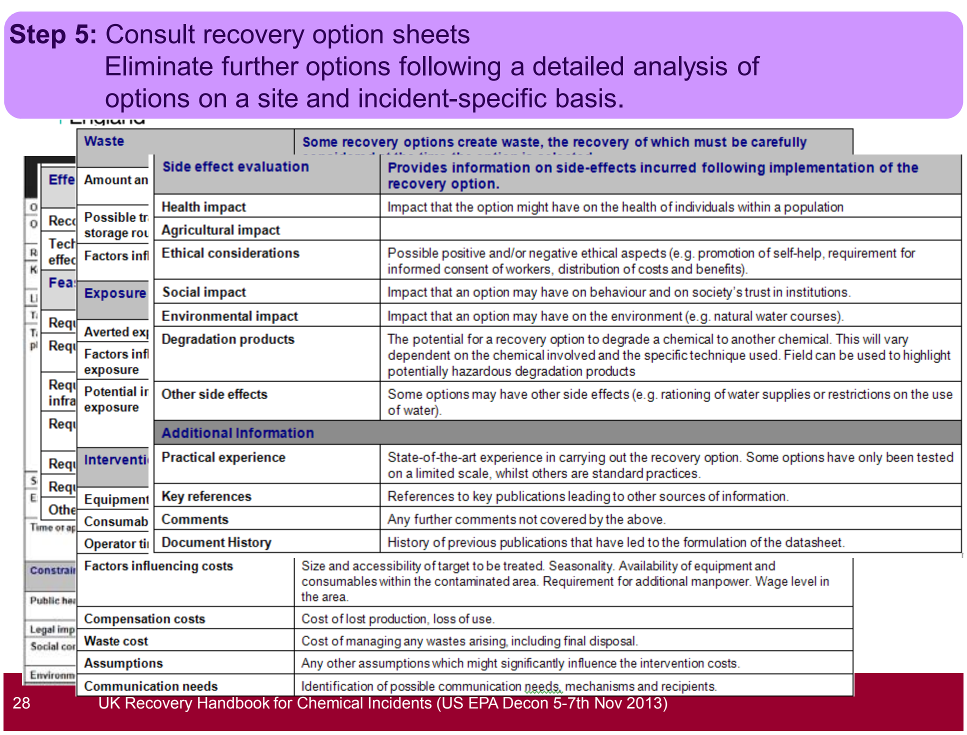
Step 4: Review key considerations and constraints
Eliminate further options according to other considerations
(public health, waste, social, technical, cost and time)

25 UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)

Recovery options considerations	Public Health	Waste	Social	Technical	Cost	Time
Protection options						
(1) Isolate and contain water supply						
(2) Alternative drinking water supply						
(3) Restrict water use (DND/DNU notices)						
Remediation options						
(4) Changes to water abstraction point or location of water source						
(5) Controlled blending of drinking water supplies						
(6) Continuing normal water treatment						
(7) Modification of existing water treatment						
(8) Water treatment at the point of use [tap]						
(9) Drain to temporary storage						
(10) Discharge off site using tankers (tankering)						
(11) In-situ treatment and discharge						
(12) Flush distribution system						
(13) Natural attenuation (with monitoring)						
(14) Treatment of sludge						
(15) Restrict access to inland, recreational or coastal (controlled) water environments						
(16) Restrict transport within inland, recreational or coastal (controlled) water environments						
(17) In-situ treatment of inland, recreational, coastal (controlled) waters						
(18) Drainage of inland, recreational, coastal (controlled) waters						
(19) Removal/ containment of sediment						
(20) Containment: use of dams, booms, absorbent materials						
(21) Retrieval of chemical(s) and containers						
(22) Burning in-situ						

Considerations	None or minor (Low)	Moderate (Medium)	Important (key)
Time (when to implement recovery option)	No restrictions on time	Weeks to months/ years	Hours – days


Recovery Options Considerations
Public Health
Waste
Social
Technical
Cost
Time
Protection options
(1) Restrict public access
(2) Controlled workforce access
(3) Impose restrictions on transport
(4) Temporary relocation from residential areas
(5) Permanent relocation from residential areas
Remediation options
(6) Reactive gases and vapours
(7) Reactive liquids
(8) Physical decontamination techniques
(9) Other water based cleaning methods
(10) Pressure hosing
(11) Vacuum cleaning
(12) Surface removal (buildings)
(13) Fixative/ strippable coatings
(14) Dismantle and disposal of contaminated material
(15) Modify operation/ cleaning of ventilation systems
(16) Cleaning vehicle ventilation systems
(17) Storage, covering, gentle cleaning
(18) Natural attenuation (with monitoring)
(19) Outdoor surface removal and replacement
(20) Soil and vegetation removal
(21) Ploughing/ digging methods
(22) Snow/ ice removal
(23) Barriers to seal contamination
(24) Burial in-situ
Considerations
None or minor
Moderate
Important (key)
Time – when to implement recovery option
No restrictions on time
Weeks to months/ years
Hours – days


Step 5: Consult recovery option sheets
Eliminate further options following a detailed analysis of options on a site and incident-specific basis.
Side effect evaluation
Provides information on side-effects incurred following implementation of the recovery option.
Health impact
Impact that the option might have on the health of individuals within a population
Agricultural impact
Ethical considerations
Possible positive and/or negative ethical aspects (e.g. promotion of self-help, requirement for informed consent of workers, distribution of costs and benefits).
Social impact
Impact that an option may have on behaviour and on society's trust in institutions.
Environmental impact
Impact that an option may have on the environment (e.g. natural water courses).
Degradation products
The potential for a recovery option to degrade a chemical to another chemical. This will vary dependent on the chemical involved and the specific technique used. Field can be used to highlight potentially hazardous degradation products
Other side effects
Some options may have other side effects (e.g. rationing of water supplies or restrictions on the use of water).
Additional Information
Practical experience
State-of-the-art experience in carrying out the recovery option. Some options have only been tested on a limited scale, whilst others are standard practices.
Key references
References to key publications leading to other sources of information.
Comments
Any further comments not covered by the above.
Document History
History of previous publications that have led to the formulation of the datasheet.
Waste
Some recovery options create waste, the recovery of which must be carefully
Factors influencing costs
Size and accessibility of target to be treated. Seasonality. Availability of equipment and consumables within the contaminated area. Requirement for additional manpower. Wage level in the area.
Compensation costs
Cost of lost production, loss of use.
Waste cost
Cost of managing any wastes arising, including final disposal.
Assumptions
Any other assumptions which might significantly influence the intervention costs.
Communication needs
Identification of possible communication needs, mechanisms and recipients.
28
UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)

Public Health England

Step 1: Obtain information regarding the incident
Determine physicochemical properties of contaminated area

Step 2: Consult flow chart decision tree's for specific environment
Identify potentially applicable recovery options
Consult other sections of Handbook (if applicable)

Step 3: Determine effectiveness of recovery options
A: Eliminate options based on physicochemical properties
B: Eliminate options based on surface material

Step 4: Review key considerations and constraints
Eliminate further options according to other considerations (public health, waste, social, technical, cost and time)

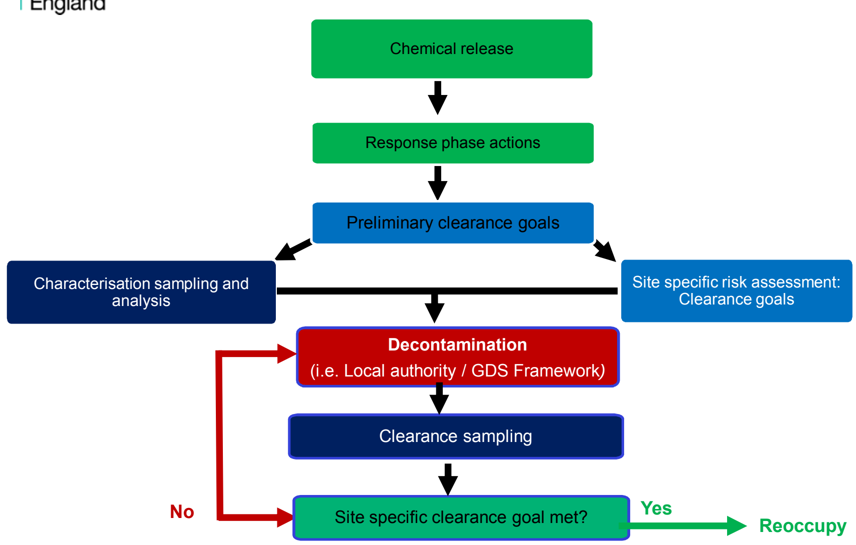
Step 5: Consult recovery option sheets
Eliminate further options following a detailed analysis of options on a site and incident-specific basis.

Step 6: Compare remaining recovery options
Based on steps 1-5, select and combine options

29 UK Recovery Handbook for Chemical Incidents (Arcopol conference, 12th Sept 2013)

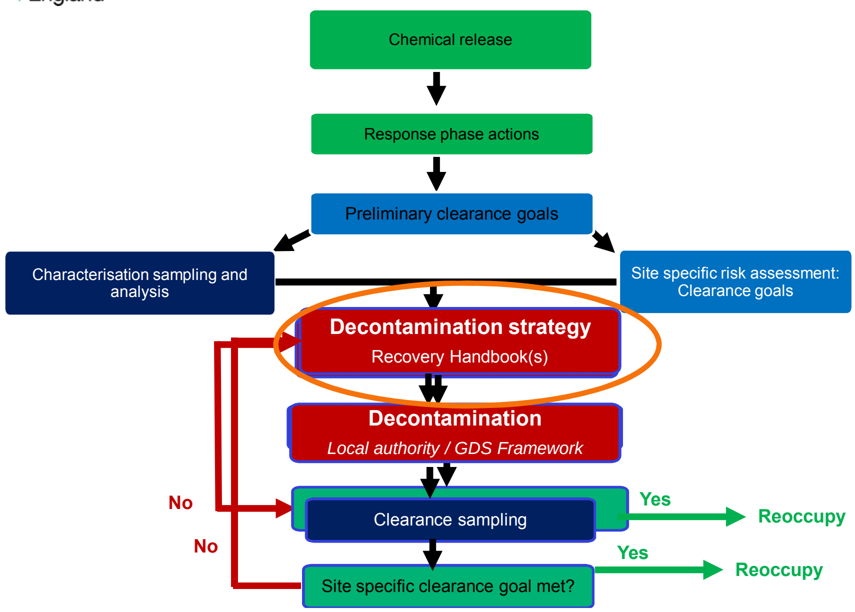
Public Health England

Overview recovery in the UK



Public Health England

Overview recovery in the UK



Public Health England

What next ?

Chemical and Radiation Recovery Decision Support Tool (2013- 2015)

- Inhabited areas pilot
- Review and update Radiation Recovery Handbook

Public Health England

Chemical Recovery Decision Support Tool

The chemical recovery decision support tool will help direct you through the steps in developing a recovery strategy.

You will also need to consult the UK Recovery Handbook for Chemical Incidents

Start

33 UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)

Inhabited Areas

Sub areas

- Residential
- Non-residential
- Recreational

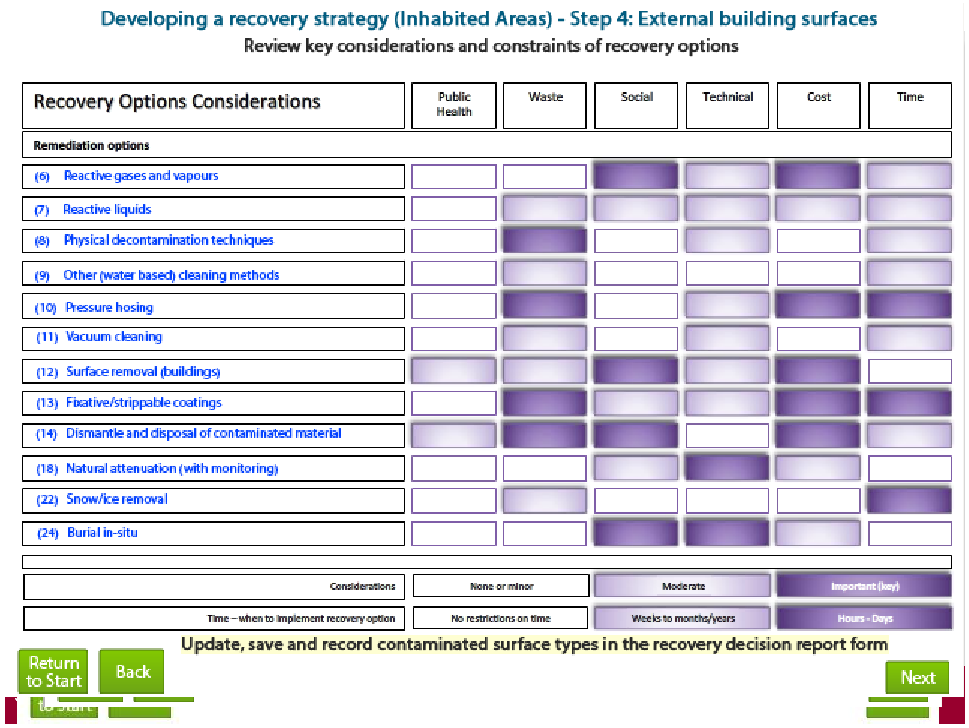
Buildings (hospitals, schools)

Transport networks

Underground spaces

Return to Start | Back | Next

34 UK Recovery Handbook for Chemical Incidents (US EPA Decon 5-7th Nov 2013)



Public Health England

PHE are committed to;

- Maintain and update the Recovery Handbooks
- Take forwards areas of research to improve and further develop guidance for the recovery and remediation of the environment following an incident
- Continue to build the evidence base of recovery options recommended within the handbooks (biological incident review; chemical incident review)

Contact details:

For more information on the recovery handbooks and projects, to attend workshops, or participate in the retrospective reviews of chemical, biological and radiation incidents, please email;

Stacey.wyke@phe.gov.uk; Antonio.pena-fernandez@phe.gov.uk

Biological.Recovery@phe.gov.uk

Public Health England

Cleaning Up Afterwards. Towards a UK Recovery Handbook for Biological Incidents

Allan Bennett, Stacey Wyke, Thomas Pottage Sara Speight & Emma Goode

Public Health England

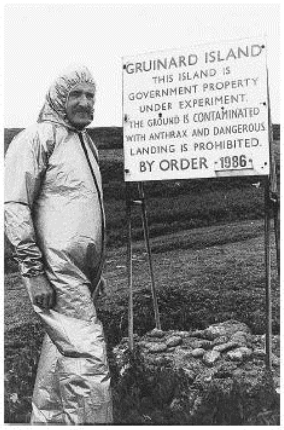
Contents

- Introduction
- Recovery from Anthrax Incidents in the UK (and Sweden)
- The UK Recovery Handbook for Biological Incidents
- Persistence Database
- Disinfection Database

2

Public Health
England

Gruinard Island (1986)



- Formalin and sea water
- Topsoil removal

Public Health
England

Remediating Anthrax Graveyard (1990s)

- Site intended for housing
- Sampling showed >2000 spores/g
- Decontaminated with formalin
- Unsuccessful
- Ground capped with concrete

Public Health England

Two UK Anthrax Cases

- The first fatal human case of anthrax in the UK for over 32 years
- Cause not identified for a month
- Samples sent to PHE Porton and identification made

Lived near Hawick (Scottish Borders)

- Skilled craftsman and carver
- Recently joined a local drumming group

Past medical history

- Acute myeloid leukaemia in remission

- In October 2008 a man contracted anthrax and died after weeks in intensive care
- Diagnosed rapidly by PHE Porton
- Treated with immunoglobulin

Lived in East London

- Drum Maker, Teacher and Player
- Lived in bedsitter and workshop on busy road

Past medical history

- Tuberculosis

Public Health England

Anthrax Positive Sites From Scottish Case

- **Belford – England**
  - Home of couple who run a drumming workshop, authentic African drums stored here, as well as skins/hides for additional drums
- **Smailholm – Scotland**
  - Garage was used to prepare hides
- **Smailholm Village Hall**
  - Venue for a drumming workshop attended by the deceased
- All premises culture and PCR positive. Only small numbers found

Public Health England

Dalston Lane, London


Hackney Gazette
SELL YOUR CAR FROM ONLY £10
FUN FIREWORKS DISPLAY
DRUM AND BASE
Bio-hazard team investigates as anthrax victim loses fight for life
HOUSING NEEDS

- Single room basement flat with shared entrance to three other premises located on busy thoroughfare
- Cupboard under stairs reputed to contain skins
- Resident cat
- Anthrax positive drum found
- Anthrax skins in cupboard



Public Health England

Scottish Decontaminations

- International experts consulted on appropriate course of action. No consensus gained
- Belford Home and Smailholm Garage decontaminated using Hydrogen Peroxide
- Village Hall decontaminated using SABRE Chlorine Dioxide



VILLAGERS' FURY AT ANTHRAX CLEAN-UP

8 Gaseous Decontamination

London Decontamination

- *B.anthracis* found on one of the drums and on a skin from under the stairs
- Items removed from two other sites found to be negative
- Contaminated items removed and destroyed
- Local decontamination with 10% sodium hypochlorite on areas surrounding the contaminated items

Public Health England

Swedish Anthrax Cases

- In 2008 a single cow from a beef cattle herd suddenly died without any observed previous symptoms. The carcass was sent for routine destruction.
- Within the next thirteen days, ten more animals from the same herd had died. Three carcasses were sent to a regional laboratory for investigation and on the 12th December, the cause of death was confirmed as *Bacillus anthracis* by culture and PCR methods.. Environmental samples of the farm were taken and only two samples returned positive for anthrax from the courtyard where the infected carcasses were stored. The most likely source was thought to be contaminated roughage, but couldn't be proved by laboratory analysis.
- "Decontamination of the farm has been extensive and it has been one of the most expensive single sanitizing procedures in Swedish history." Knuttson R, 2012 The entire decontamination process cost approximately 60 million SEK (£5.8 million).
- It included a mobile incinerator and liquid disinfection of farm

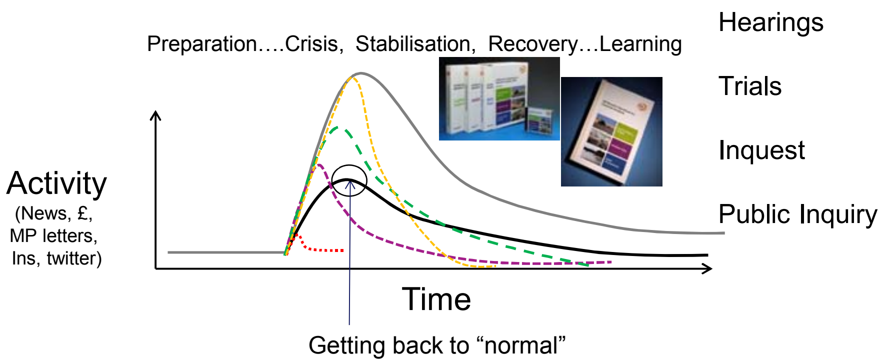
Public Health
England

Different Scenarios, Different Recovery Options

- No one size fits all option
- In many of the cases there was no complete record of how and why decisions had been taken
- Options used varied widely in cost, time-scale and amount of disruption

11 Gaseous Decontamination

Public Health
England

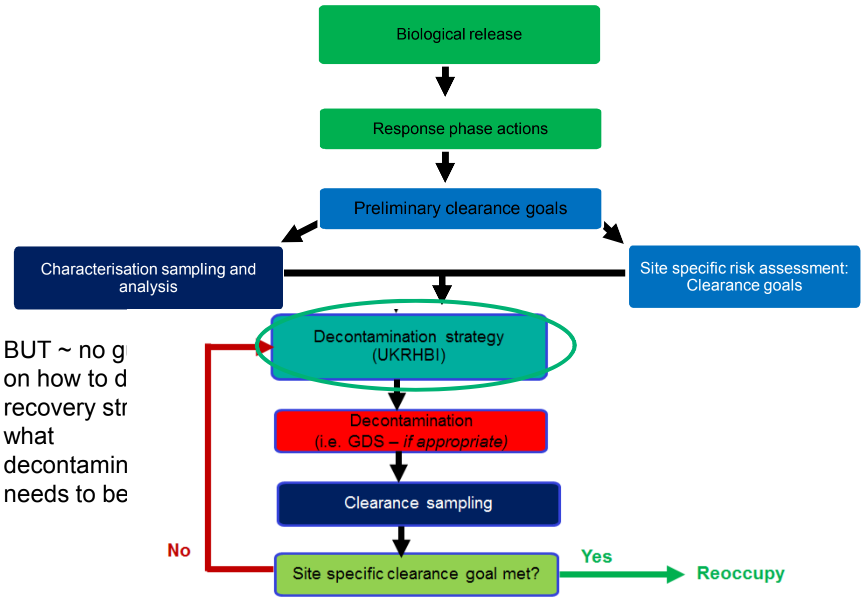


- Injury and illness
- Worry or concern
- Political
- Media

12 UK Recovery Handbook for Chemical Incidents (Arcopol conference, 12th Sept 2013)

Public Health England

Overview of Recovery in the UK



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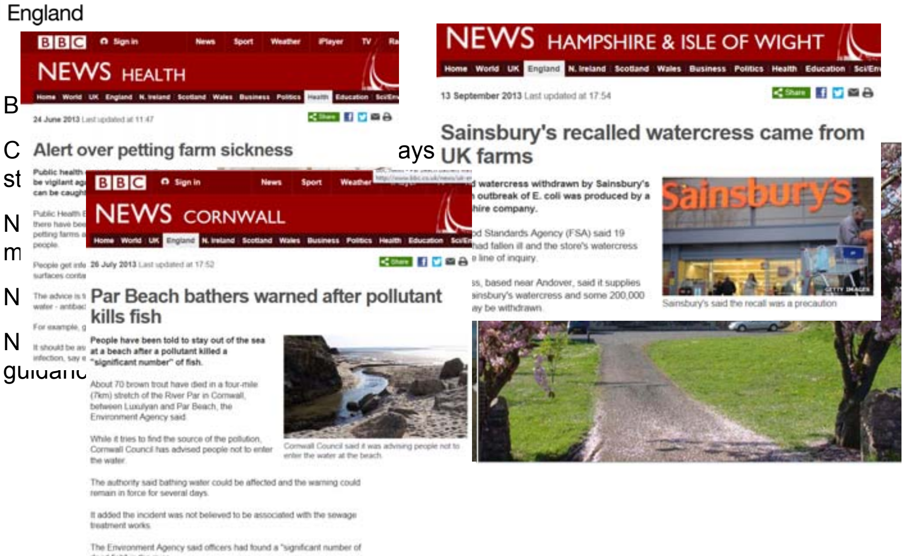
Public Health England

Why do we need a Biological handbook?



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14

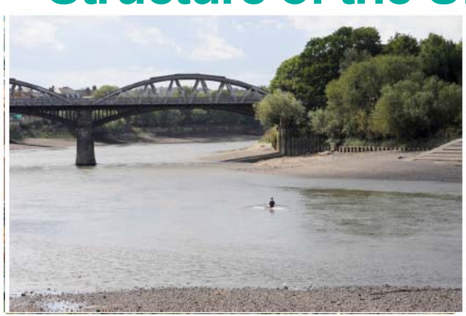
Scope

- Focus on clean up and restoration.
- Does not address all aspects of the recovery phase
    - Risk assessment protocols
    - Sampling or monitoring strategies
- **Not** a substitute for specialist advice but will **aid** decision makers in the development of a recovery strategy

- **Aim: reduce exposure and return to 'normality'**

15 UK Recovery Handbook for Biological Incidents

Structure of the UKRHBI



Water Environments

Public Health England

Who will use the Handbook?

- National and local authorities
- Central government departments and agencies
- Environmental and health protection experts
- Industry
- Emergency services
- Others that may be affected by a biological incident

Public Health England

Difference from Chemical handbook

- Differences in the decision making frameworks caused by microbiological factors
  - Ability to divide and grow
  - Difficulties in rapid detection
  - Epidemiology
  - Persistence differences
  - Lack of data on effectiveness of recovery options
- List of representative agents agreed
- Persistence Database developed
- Disinfection Database in development

Public Health England

Agent prioritisation list

Agent / scenario	Environment	Inclusion criteria
Aspergillus spp. and other environmental Fungi	Inhabited Areas	Causes Aspergillosis infecting humans and birds, can cause sensitisation
Bacillus anthracis	Food Production systems / Inhabited Areas	Rare but high impact due to persistence / resistance of spore
Bacillus cereus	Food Production Systems	Cause of diarrhoea from food poisoning
Brucella abortus	Food Production Systems	Rare but high impact
Campylobacter	Food Production Systems	Common causative agent of food-poisoning outbreaks
Clostridium botulinum	Food Production Systems	Rare but high impact, toxins released can cause serious harm
Clostridium difficile	Inhabited Areas	Large numbers of infections annually
Clostridium perfringens	Food Production Systems	Causes many cases of food poisoning. Large number thought to be underreported.
Coxiella burnetii	Food Production Systems / Inhabited Areas	High impact due to resistance of agent
Cryptosporidiosis	Water environments / Food Production Systems	Common cause of waterborne disease outbreaks
Cyanobacteria	Water environments	Toxins released can cause harm
Dampness in buildings	Inhabited Areas	Common generic problem
Escherichia coli 0157 & other VTEC Serogroups	Inhabited Areas / Food Production Systems	Seen in food outbreaks, and also in farms / petting zoos

Top 20 organism		Limited persistence - <7 days
Relevant to inhabited areas		Intermediate persistence - 8-100 days
Non-top 20 organism		Persistent - >101 days

* Some papers just say surfaces or fomites and are not specific

	Persistance in inhabited areas								
Pathogen	**Surfaces/fomites***	**s/steel (metal**	**glass/ceramics**	**carpet**	**wood**	**plastics and/or vinyl flooring**	**soft furnishings/fabrics**	**beach sand**	**faeces/pest faeces/pests/dus**
Aspergillus	>30					>30	>30		
Avian influenza/ influenza	1-2	1-13	7-66		3	1-2	1-160		
Bacillus spp							>3650		
Clostridium spp	150	> 7							
Coxiella burnetii									
E. coli 0157	30-480	> 60	1-3		7-294			5-15	
Legionella pneumophila									
MRSA	7-210		< 2 -18		90-140	60-140	7- (>) 30		
Mycobacterium tuberculosis	1 - 120			19 days	> 88		45		56-120
Norovirus	<1-19	7- >42	7->42		16-28	> 42			
Viral haemorrhagic fevers	4-5	6	6-50			6-26			
Brucella abortus		>56	>56		28 - 56				
Campylobacter	1-6							4-12	
Cryptosporidium	< 1								
Cyanobacteria									
Giardia									
Listeria monocytogenes	1- > 30	> 28							
Salmonella spp	1-1500	14-336				< 1		20-30	21 -32
Toxoplasma gondii									46-357
Acinetobacter	3-150		3-60						
Adenovirus	7-90	21-56	21-56			35-49			
Bordatella pertussis	3-5		6				5		
Candida	1-150	3->14	3- >14			3-30	1-30		
Chlamydia spp	1-15								
Coronavirus	<1								
Corynebacterium spp	1-180								
Enterococcus	5-120							>30	
Foot and mouth virus									
Francisella tularensis									
Haemophilus influenzae	12					< 1			
Helicobacter pylori	<1								
Hepatitis A	<1 -60	>7	30		17	> 30	30-60		> 30
Klebsiella spp	<1-900								
Neisseria gonorrhoeae	1-3								
Parvovirus	> 365								
Proteus vulgaris	1-2								
Pseudomonas aeruginosa	1-480								
Rotavirus	60	<10	10-35			< 10			
Serratia marcescens	3-60		10-18						
Shigella	2-150	2-28							20-24
Streptococcus spp	1-195								
Vibrio cholera	1-7								

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Public Health England

The disinfection database

	Decon method	Aspergillus	Bacillus spp	B. abortus	Campylobacter	Clostridium spp	C. burnetii	Cryptosporidium	Cyanobacteria	E. coli VTEC
Gaseous	Steris VHP									
	Bioquell HPV					*				
	Sterinis aHP									
	Chlorine dioxide		*							
	Ozone									
	Ethylene Oxide									
	Formaldehyde		*							
Energy	Dry Heat									
	Boiling (liquids)									
	Moist Heat									
	UV									*
	Gamma									
Liquid	FAC (i.e. Bleach)		*			*				*
	Hydrogen Peroxide									
	Chlorine dioxide (aq)		*							
	Alcohol	*								
	Ammonium compounds									

	Decon method	Giardia	Influenza	L. pneumophila	L. monocytogenes	MRSA	M. tuberculosis	Norovirus	Salmonella spp	T. gondii	VHF
Gaseous	Steris VHP						*				
	Bioquell HPV										
	Sterinis aHP						*				
	Chlorine dioxide										
	Ozone										
	Ethylene Oxide										*
	Formaldehyde										*
Energy	Dry Heat										
	Boiling										
	Moist Heat										
	UV										
	Gamma										
Liquid	FAC (i.e. Bleach)								*		*
	Hydrogen Peroxide								*		
	Chlorine dioxide (aq)										
	Alcohol							*			
	Ammonium compounds										

No information
very effective (>4 log kill)
some effectiveness (2-4 log kill)
lim ed ef ect veness (<2 log k ll)
* contradicting data available

21

Public Health England

Retrospective Study

- Project team is inviting stakeholders and other interested parties to participate in a retrospective study of biological incidents and recovery options used (successful or unsuccessful)
- Initially short online questionnaire
- https://www.hpa-surveys.org.uk/TakeSurvey.aspx?PageNumber=1&SurveyID=8lKJ76lM&Preview=true
- Followed by telephone interview / meeting
- Contact the project team if you are interested in participating; biological.recovery@phe.gov.uk

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Public Health England

Acknowledgements

There are a wide range of stakeholders and PHE steering group members to help steer the knowledge base and direction of the Handbook

Public Health England
HSC Public Health Agency
The Scottish Government
Home Office
defra Department for Environment Food and Rural Affairs
Food Standards Agency
Department of Health, Social Services and Public Safety

November, 2013

Research activities on environmental contamination of radioactive substances at National Institute for Environmental Study

1. Behavior of radionuclides in the environment
2. Appropriate treatment and disposal technologies for radioactively contaminated waste

Principal Investigator Toshimasa Ohara and Masahiro Osako

Project Members Seiji Hayashi, **Noriyuki Suzuki**, Masanori Tamaoki, **Shoji F. Nakayama**, Yasuyuki Shibata, Motoyuki Mizuochi, Masato Yamada, Hidetoshi Kuramochi, Hidetaka Takigami, **Nagahisa Hirayama**, Yuji Matsuzaki

1

Introduction

- Due to nuclear accident at the Fukushima Daiichi nuclear power plant (FDNPP), enormous amounts of radionuclides were emitted into the atmosphere and the ocean.
- Radioactive materials may affect human health through the contamination of air, water, soil, waste, and food.
- Research projects on beharior and disposal technologies are now underway
  - Behavior of the radionuclides in the environment
  - Appropriate treatment and disposal technologies for radioactively contaminated waste

2 2

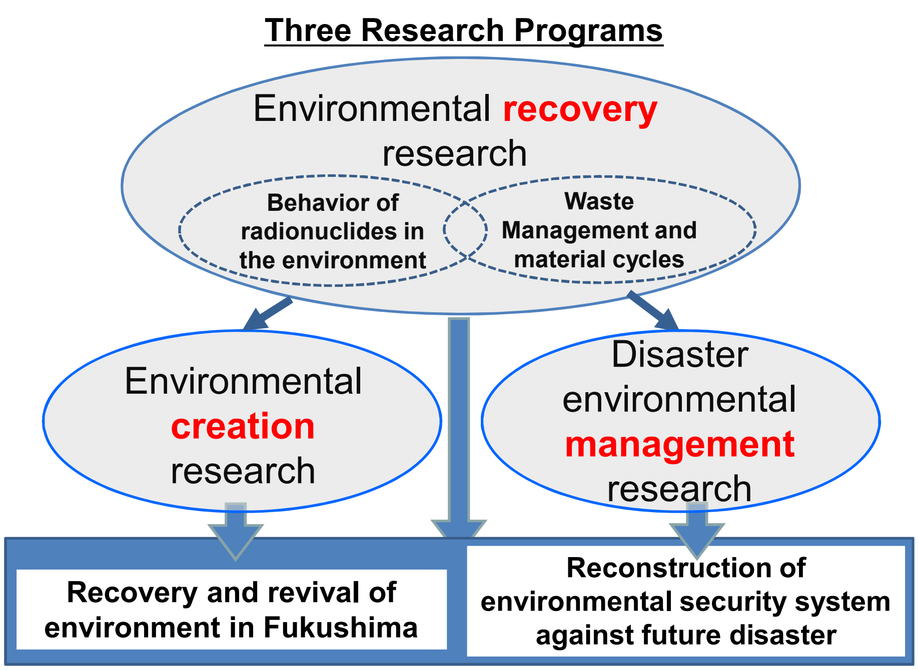
Aims of the two projects

- Behavior of the radionuclides in the environment
  - Predict long-term distribution of radioactive nuclides in the terrestrial and aquatic environment as well as in living organisms
  - Build a model to estimate long-term human exposure to radiation
  - Contribute to better understanding of the impacts on human, wildlife and ecosystem health
- Appropriate treatment and disposal technologies for radioactively contaminated waste
  - Accumulate the know-how for treatment and disposal and establish the systems
  - Reflect and use in technical standards and indicators
  - Advance safe and effective waste treatment based on scientific evidence

3

3

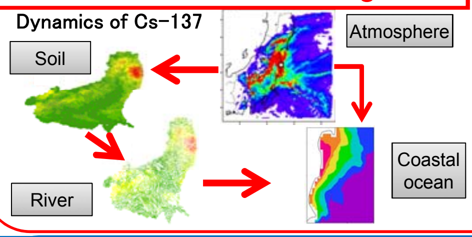
NIES's plan in Fukushima-ken Environmental Creation Center



4

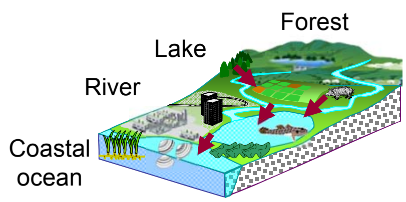
Outline of study on “Behavior of radionuclides in the environment”

Multimedia Modeling



- ✓Developing a multimedia fate model by coupling models for atmospheric, oceanic, and terrestrial environments.
- ✓Analyzing and predicting the dynamics of Cs-137 in the air, soil, river/lake, and coastal ocean.

Field Measurements

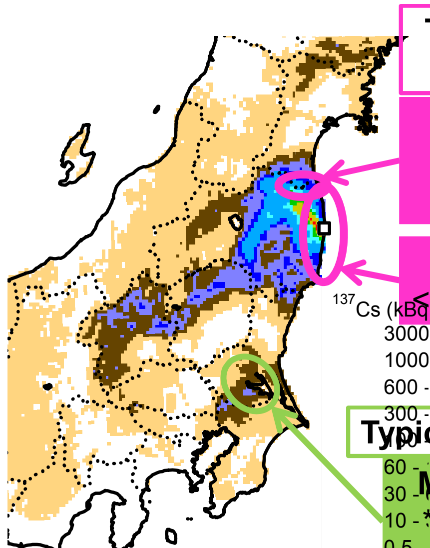


Field survey in the eastern area of Fukushima prefecture and Mt. Tsukuba/Lake Kasumigaura

- ✓ Monitoring radionuclides in the atmosphere.
- ✓ Measuring radioactive Cs in forest, lake, river, and coastal ocean.
- ✓ Improving the analytical method of I-129, radioactive Sr, and Cs in the water.

5

Targeted area of field study in our project



Cs-137 deposition map by airborne monitoring

Typical high contamination area around FDNPP

Udagawa river
＊Typical watershed in Fukushima (Forest, lake, river, creek)

FDNPP surrounding area
<Biological and ecosystem impacts>

Typical moderate contamination area

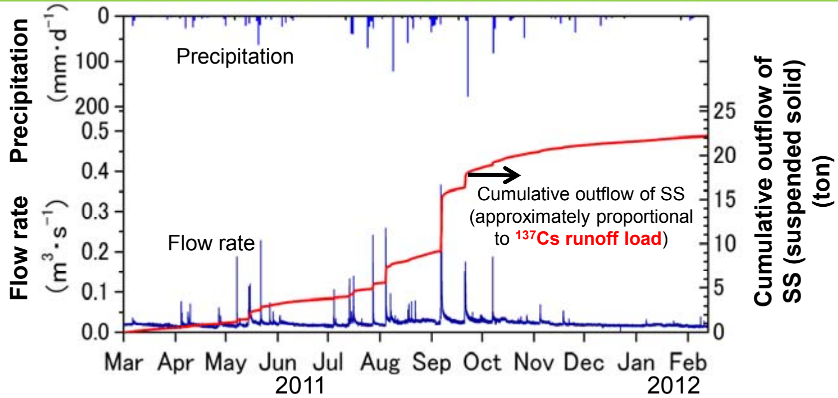
Mt. Tsukuba, Lake Kasumigaura
* Typical watershed in Kanto area (Forest, river, lake)

6

Runoff characteristics of radiocesium from a forest catchment (Mt. Tsukuba)

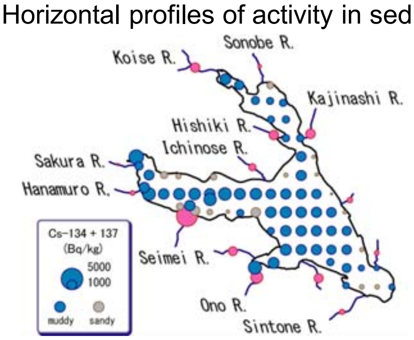
- Continuous hydrological observations started immediately after the accident and stream water sampling during the rain events at a forested catchment
- Estimated ^{137}Cs annual runoff load was 0.04 kBq/m^2 for one year, corresponding to only 0.3% of the total amount deposition in the catchment.
- Very little contribution of forested area as a source of ^{137}Cs at present

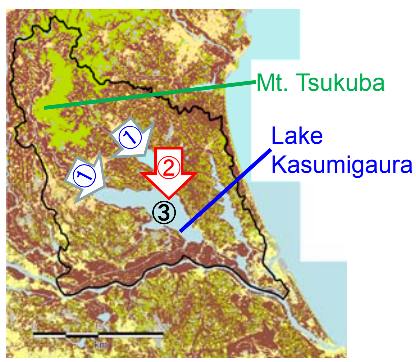
^{137}Cs runoff = [^{137}Cs concentration in SS (900 Bq/kg-SS)] x (runoff volume of SS)



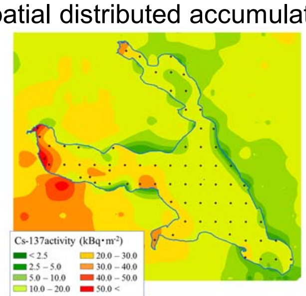
Stock and flow of Cs-137 (Lake Kasumigaura)

Horizontal profiles of activity in sediment





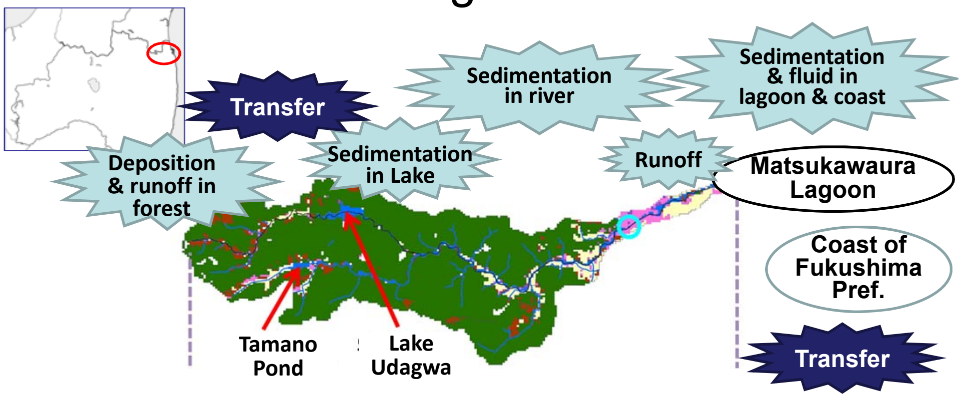
Spatial distributed accumulation



Budget of Cs-137 in Lake

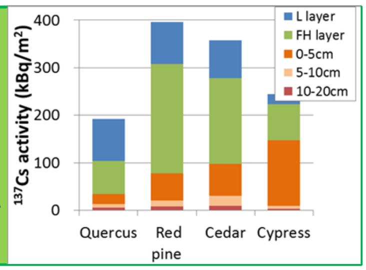
① Inflow via river 0.2 TBq
(runoff ratio from entire land to lake = 0.5 %)
② Deposition from air to lake 2.7 TBq
(= ③ - ①)
③ Stock into the lake sediment 2.9 TBq
(estimation based on the measurements)

Observation in Udagawa River catchment



Deposition in forest soil (Sep. 2012)

Ave. deposition
330kBq/m²



Runoff from forest area (Jul. 2012 to Feb. 2013)

- ^{137}Cs runoff amount per unit area
  0.04 ~ 0.07 kBq/m²
- Runoff ratio to deposition
  0.02 ~ 0.03%

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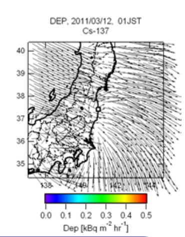
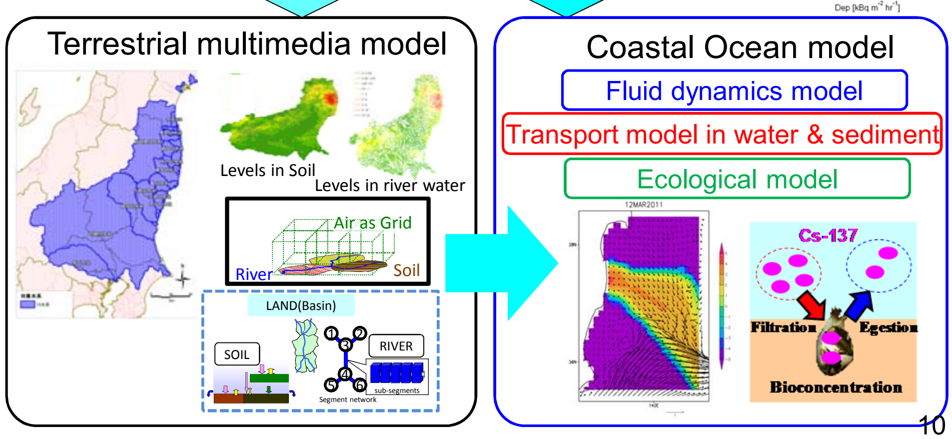
Outline of multimedia fate modeling

To establish simulation model to estimate the long-term (up to several tenth years) fate of radioactive substances, combining existing atmospheric, multimedia and ocean fate models





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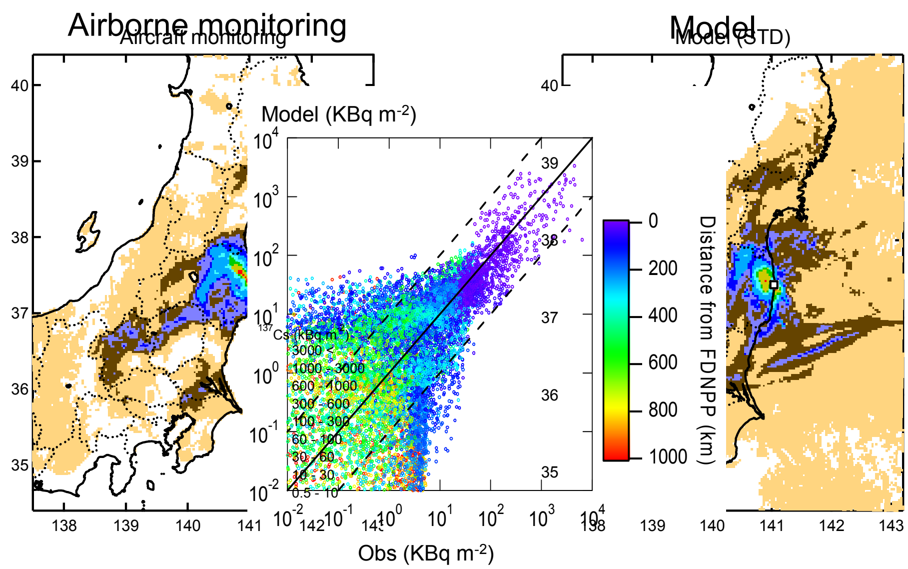
Observed and modeled Cs-137 deposition map



Bias = -14 %; Error = 78 %; r = 0.67

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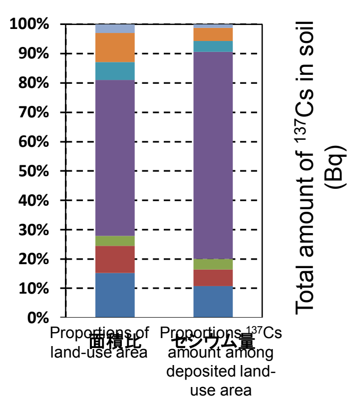
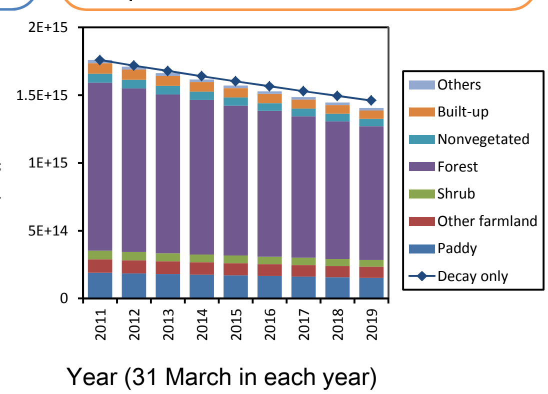
Simulated trend of ^{137}Cs in soil

- Most part of ^{137}Cs were mainly deposited to forest area
  - Contaminated plume passed above forest area

- Decreasing trend of ^{137}Cs in soil
  - Simulated to slightly faster than radioactive decay, by runoff processes





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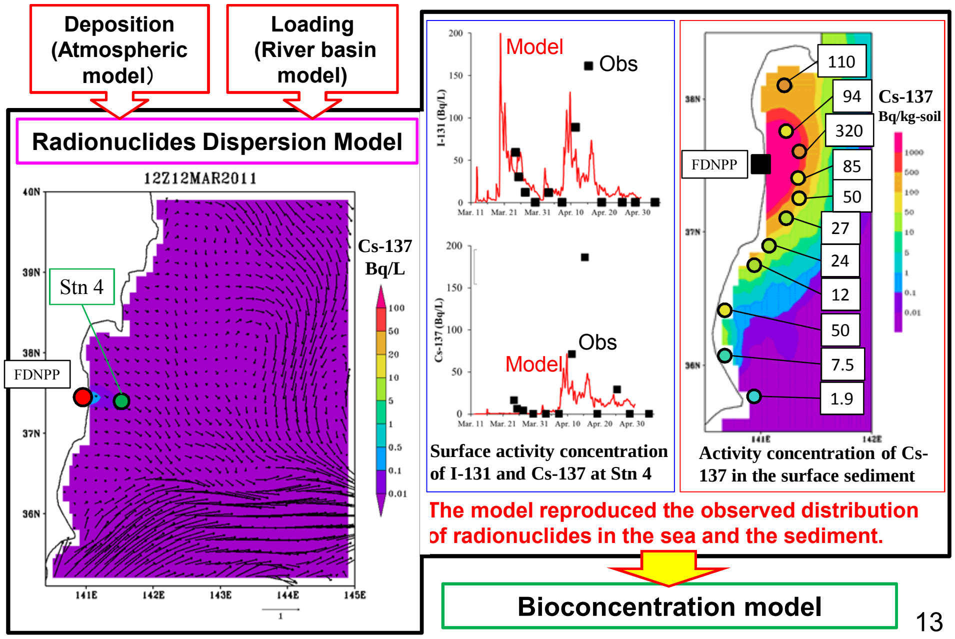
Coastal Ocean Model (Dispersion and Sedimentation)



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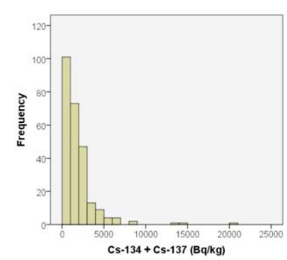
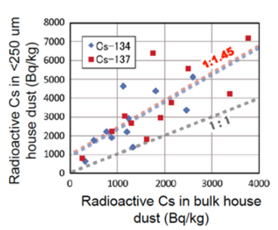
Exposure monitoring

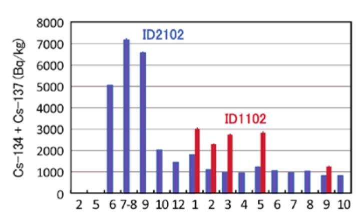
- Vacuum cleaner dust measurement
  - The most radioactive material in the indoor environment
  - Log-normal distribution
  - Decreased in the first several months but reached the plateau after that
  - Distribution in ingestible size (< 250 μm)
  - Provided a model with parameters



Radioactive Cs in bulk house dust (n=254, April, 2012)



Estimation of the enrichment factor



Temporal change of radioactive Cs in house dust

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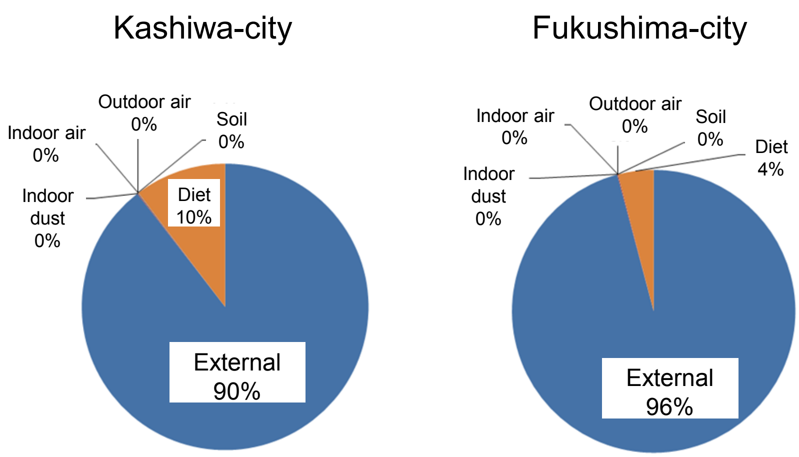
Exposure route



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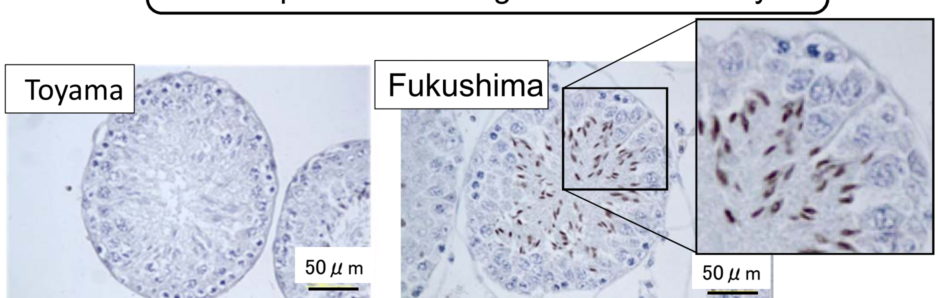
Ecosystem evaluation

(1) Effect for Wild animals

Wild mouse, *Apodemus speciosus*, were captured at high-gamma-dose area in Fukushima and low-gamma-dose area (Aomori and Toyama).

Check DNA oxidization by gamma irradiation at sperm cells using 8-OHdG antibody

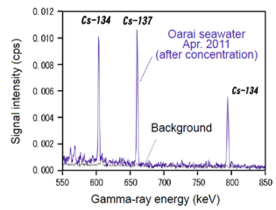


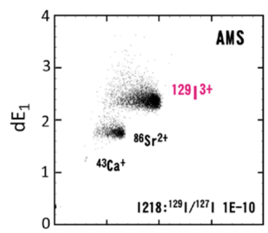
DNA oxidization in sperm cells was remarkable in Fukushima

16

Analytical method development

- Dissolved radioactive ceasium
  - Rapid and trace measurement of dissolved Cs in water using Cs selective disc
- Radioactive strontium
  - An effective solid phase extraction method developed using crown ether resin
- Iodine 129
  - Ultra trace determination of ^{129}I by an accelerator MS
  - Reconstruction of short-lived ^{131}I distribution
- Imaging plate
  - Disposition in organisms, house dust and wastes





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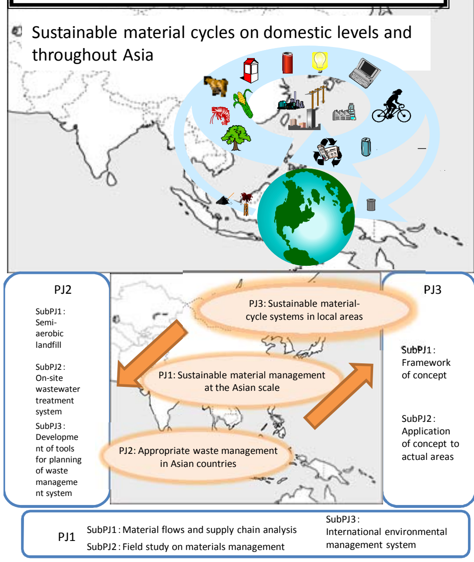
Center for Material Cycles and Waste Management Research

Contributing solutions for sustainable usage of resources and the reduction of the environmental waste which accompanies that use

1.Sustainable Material Cycles Research Program

Sustainable material cycles on domestic levels and throughout Asia



2.Policy-driven research on waste management

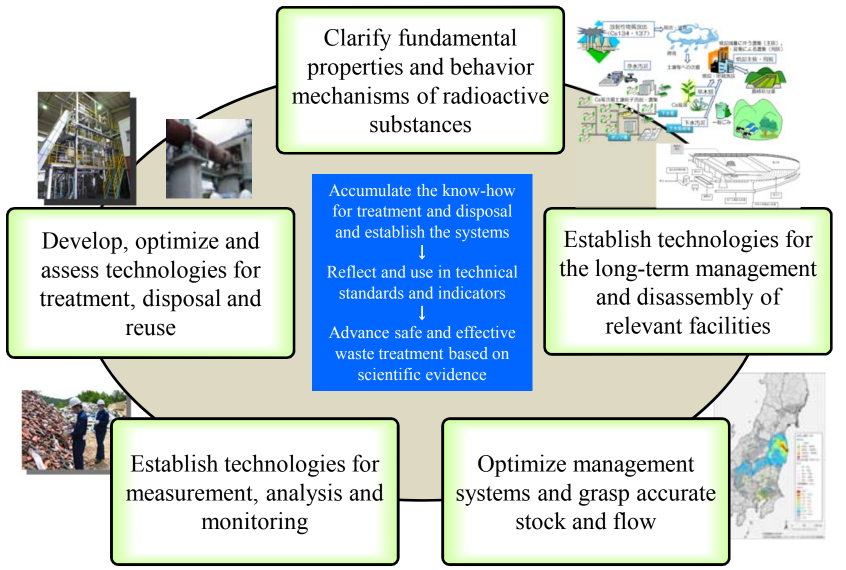
Reliable support for policy needs in the short and long term

- Evaluation of waste incineration system and development of energy recovery technology
- Development of quality control engineering system for wastes towards an advanced sound material-cycle society
- Establishment of appropriate countermeasures for domestic liquid-waste and greenhouse gas emissions
- Development and evaluation of treatment technologies and analytical methods for the countermeasures toward legacy wastes and materials with recycling difficulties
- Development, standardization and application of testing methods for the evaluation of recycled products on the environmentally sound quality of chemicals

3.Seed and foundation research

Study of fundamental technologies

Appropriate treatment and disposal technologies for radioactively contaminated waste



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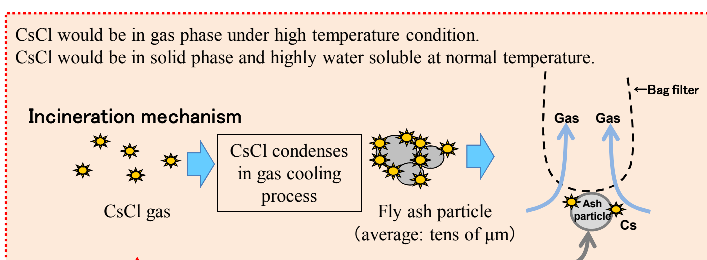
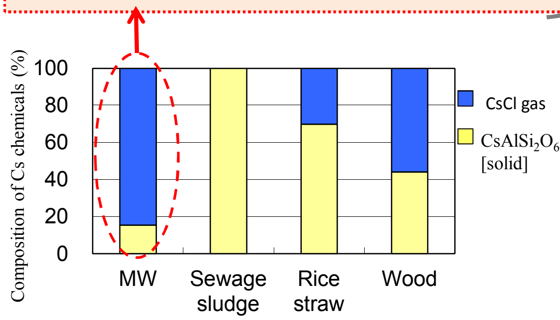
Behavior mechanisms of radioactive cesium during waste incineration



It is very important to take measures to avoid leaching from waste to surrounding water system.



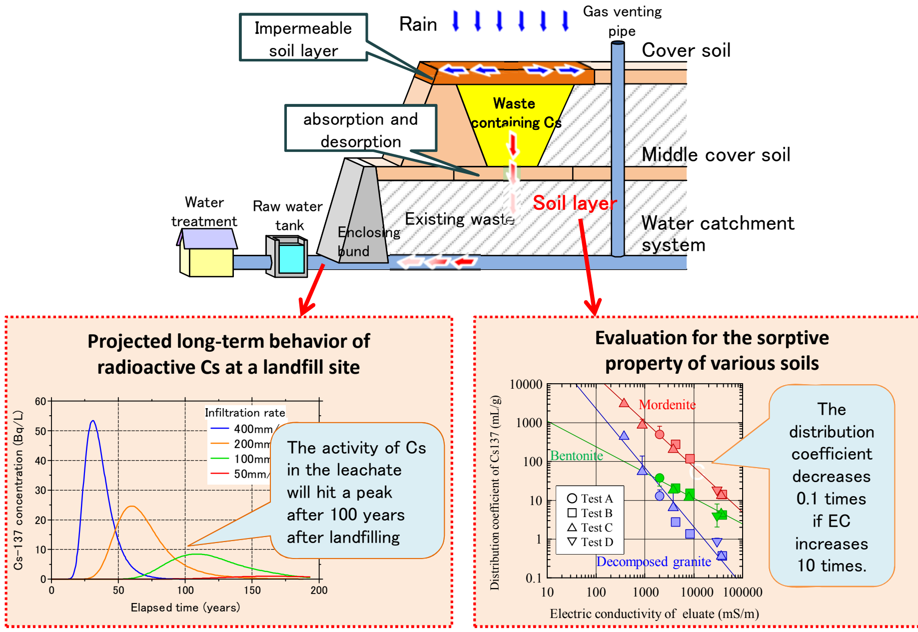
Equilibrium composition of Cs chemicals during waste combustion at 850℃

■CsCl condenses and trapped in fly ash particles during gas cooling process

■$CsAlSi_2O_6$ remains in the bottom ash

Calculation results by thermodynamic equilibrium model can successfully explained Cs concentration mechanism of fly ash and bottom ash. We also discovered that the compositions of CsCl and $CsAlSi_2O_6$ were different depending on incineration contents.

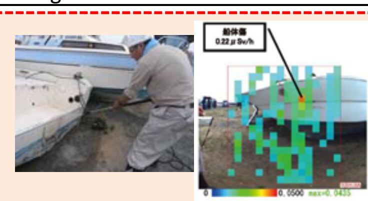
Landfill and storage technology for contaminated wastes and soil



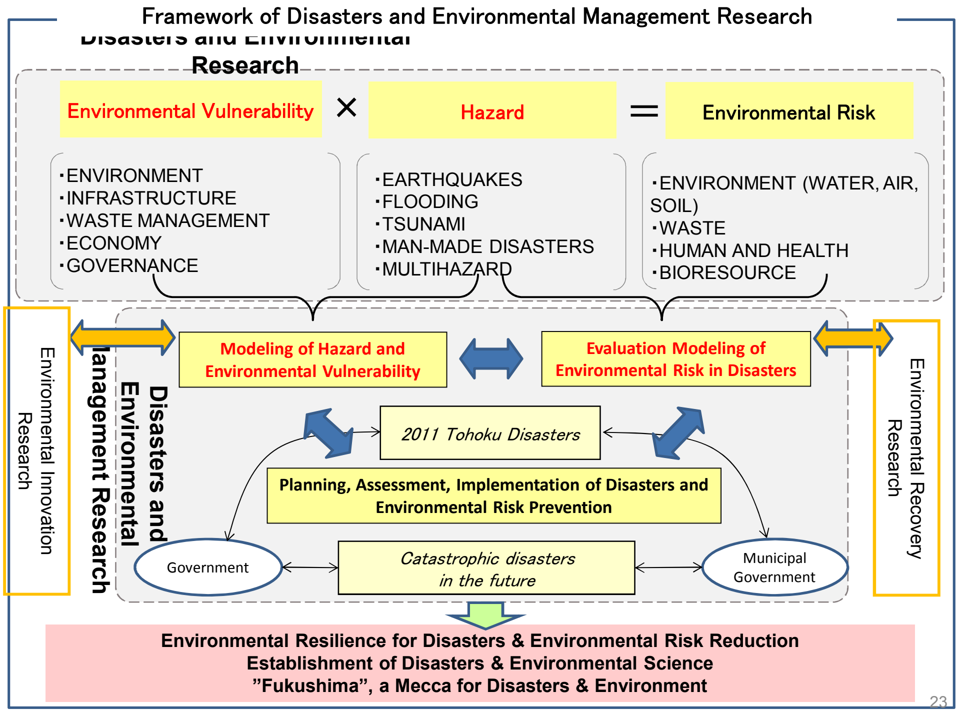
Establishment of monitoring technologies for radioactivity and application to waste management

Research challenge

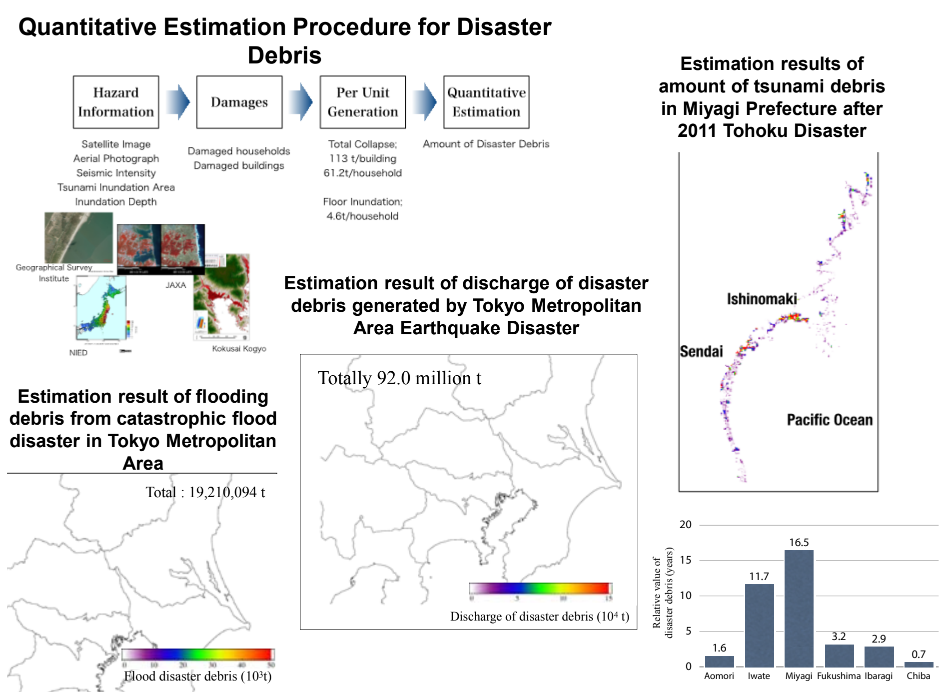
- **Advance inquest** — Screening survey Ì (ex: vegetation, shipping, compost) Ï
- **Field survey**
- **Sampling** — Research for sampling method of Cs in incineration gas
- **Sample preparation** — Research for increment sampling number of waste lot
- **Measurement and analysis** — Research for the fraction and existence form of Cs in waste water
- **Accuracy management** — Cross check measurement using common sample (ex. Incineration ash, soil)
- **Feedback** — Development of the decontamination manual for waste shipping
- **Knowledge review** — Contribution to revision of the measurement guideline by MOE; Development of the interim measurement manual for waste contaminated by radioactive Cs



Application of radiation-sensing camera to visualize the dose rate distribution within the area
(the case of contaminated waste shipping)



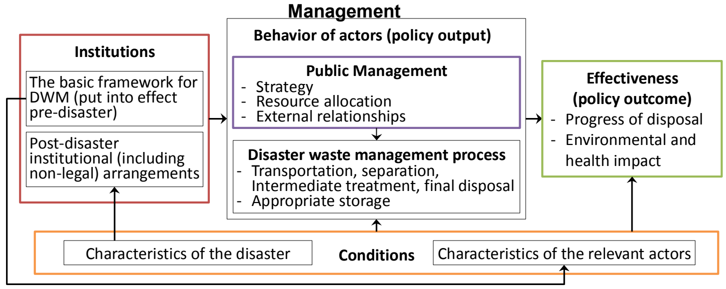
Framework of Disasters and Environmental Management Research
Environmental Vulnerability
×
Hazard
=
Environmental Risk
・ENVIRONMENT
・INFRASTRUCTURE
・WASTE MANAGEMENT
・ECONOMY
・GOVERNANCE
・EARTHQUAKES
・FLOODING
・TSUNAMI
・MAN-MADE DISASTERS
・MULTIHAZARD
・ENVIRONMENT (WATER, AIR, SOIL)
・WASTE
・HUMAN AND HEALTH
・BIORESOURCE
Environmental Innovation Research
Disasters and Environmental Management Research
Modeling of Hazard and Environmental Vulnerability
Evaluation Modeling of Environmental Risk in Disasters
2011 Tohoku Disasters
Planning, Assessment, Implementation of Disasters and Environmental Risk Prevention
Government
Catastrophic disasters in the future
Municipal Government
Environmental Recovery Research
Environmental Resilience for Disasters & Environmental Risk Reduction
Establishment of Disasters & Environmental Science
"Fukushima", a Mecca for Disasters & Environment
23



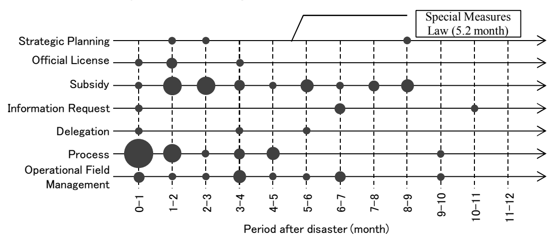
Quantitative Estimation Procedure for Disaster Debris
Hazard Information
Damages
Per Unit Generation
Quantitative Estimation
Satellite Image
Aerial Photograph
Seismic Intensity
Tsunami Inundation Area
Inundation Depth
Damaged households
Damaged buildings
Total Collapse;
113 t/building
61.2t/household
Floor Inundation;
4.6t/household
Amount of Disaster Debris
Geographical Survey Institute
JAXA
NIED
Kokusai Kogyo
Estimation results of amount of tsunami debris in Miyagi Prefecture after 2011 Tohoku Disaster
Ishinomaki
Sendai
Pacific Ocean
Estimation result of discharge of disaster debris generated by Tokyo Metropolitan Area Earthquake Disaster
Totally 92.0 million t
Discharge of disaster debris (10^4 t)
Estimation result of flooding debris from catastrophic flood disaster in Tokyo Metropolitan Area
Total : 19,210,094 t
Flood disaster debris (10^3t)
Relative value of disaster debris (years)
1.6
11.7
16.5
3.2
2.9
0.7
Aomori
Iwate
Miyagi
Fukushima
Ibaragi
Chiba

Establishment of Disaster Waste Management

Policy Implementation Process within the Context of Disaster Waste Management

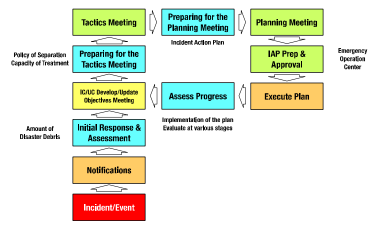


A result of system management for disaster waste treatment



Change of the number of the system correspondence by the administration provisions pertaining to the disaster waste treatment that the Government of Japan carried out after the 2011 Tohoku Disaster

Operational Planning P System for Disaster Debris Management



Future work

- On-going research activities
  - More advanced understanding and modeling of the dynamics of radionuclides in environment and impacts
    - Extensive monitoring, model development, exposure and impacts on wildlife
  - Continuing development of waste disposal technologies
    - Incineration, landfill and storage, monitoring and management
- Relation to future Fukushima environmental creation center
  - Environmental recovery research
    - Following the activities of first half
  - Environmental creation research – not presented today
  - Disaster environmental management research
    - Following the activities of second half, and relating to our visit today

UK Government Decontamination Service

The UK Government Decontamination Service

Sara Casey – Biological Hazards Adviser

EPA International Decontamination Research and Development Conference November 2013

Part of the Food and Environment Research Agency

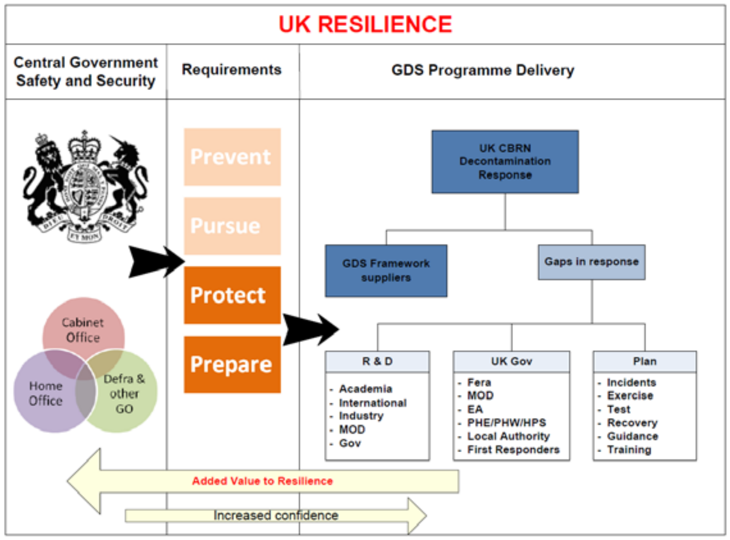
UK Government Decontamination Service

Summary

- Who are GDS
- UK Government
- GDS Framework Suppliers
- Research and Projects
- Future work

UK Policy Driver

UK Government
Decontamination
Service



GDS Remit

UK Government
Decontamination
Service

- Assist in the recovery from a CBRN event
- Maintain a framework of private sector contractors
- Run a development programme for CBRN remediation
- Capability Development

Capability Development

UK Government Decontamination Service

- Direct link to policy owners
- Capability gaps from scenarios based upon National Risk Assessment
- Management of CBR R&D projects for the Home Office
- Exploitation of research and development projects
- International research collaboration

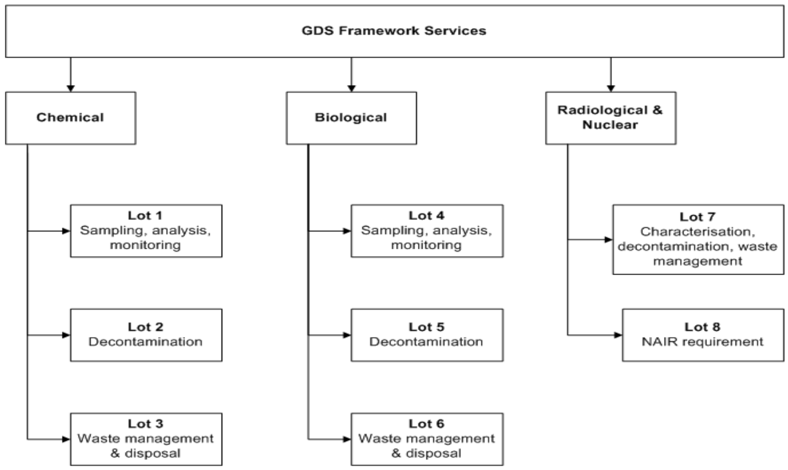
GDS Operational Capability

UK Government Decontamination Service

- Facilitate the rapid decontamination of CBRN releases using private-sector capability
- On call 24/7 to provide rapid access to GDS expertise and Framework service
- GDS Emergency Operations Centre (EOC) that can be activated in minutes
- Provide expert scientific and technical advice to relevant groups, on the most appropriate decontamination methods

UK Government
Decontamination
Service

GDS Framework Lots



UK Government
Decontamination
Service

GDS Supplier Roles

- Sampling and monitoring to determine the extent of the contamination and effectiveness of decontamination
- Prioritising the appropriate resources and equipment for decontamination
- Decontamination of the built and open environment, transport assets
- Waste disposal

Framework Assurance

UK Government Decontamination Service

Exercises, Evaluations, Case Studies

UK Government Decontamination Service

Exercise RED EAGLE
Site Sampling Plan

UK Government
Decontamination
Service

- Exercising of a wide area biological sampling standard operating procedure (SOP)
- The requirement came from a national risk assessment driver
- The suitability of organisations with sampling and PPE capability was assessed

Types of PPE worn by sampling teams

UK Government
Decontamination
Service

Practical Testing of a Formaldehyde SOP

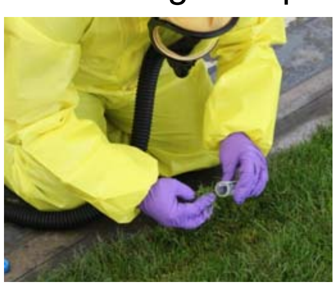
UK Government Decontamination Service

- Development of a standard operating procedure (SOP) for a decontamination process using formaldehyde
- To test a GDS supplier using the formaldehyde SOP
- To validate the efficacy of the SOP in the hands of a GDS supplier

Framework Assurance (biological)

UK Government Decontamination Service

- Building contaminated with *Bacillus atropheus* (10^9/ml)
- Suppliers were asked to sample the site to verify presence and determine distribution.
- Suppliers were asked to remediate the area using their preferred technique



Since 2006

UK Government Decontamination Service

- Tolerability of residual hazard (ToRH)
- Wide area sampling and analysis (WASA)
- VSP development
- Development of methods to test suppliers
- Background levels study
- Novel biological decontamination technologies
- SOP development and testing

Future Work

UK Government Decontamination Service

- Rolling programme of framework assurance work for biological framework suppliers
- Operationalise research and development
- Research collaboration
- Multi-agency response and recovery evaluation
- Redevelopment of the ToRH biological guidance
- Revision of wide area sampling and analysis SOPs
- Biology of *Bacillus anthracis* conference

UK Government Decontamination Service

Questions ?

sara.casey@gds.gsi.gov.uk

BIOLOGICAL RESPONSE AND RECOVERY SCIENCE AND TECHNOLOGY ROADMAP

Brooke Pearson
Executive Secretary
(Contract Support to DHS S&T)
Biological Response and Recovery Science and Technology Working Group

Biological Response and Recovery

- A catastrophic biological incident could threaten the Nation's human, animal, plant, environmental, and economic health, as well as America's national security.
- Such an event would demand swift and effective responses in order to minimize loss of life and other adverse consequences or, in the case of suspected criminal activity or terrorism, to prevent additional attacks.
- Standing ready to respond to a biological incident requires ongoing data and information collection, data integration and scientific analysis, evidence-based review, strategic decision making, and continuous coordination across government and with nongovernmental partners.
- In addition, an effective response and recovery process requires the coordination of data and capabilities from several sectors—such as public health, law enforcement, waste management, infrastructure management, transportation, and more.

2

The Office of Science and Technology Policy (OSTP)

- Congress established the Office of Science and Technology Policy in 1976 with a broad mandate to advise the President and others within the Executive Office of the President on the effects of science and technology on domestic and international affairs.
- Strategic Goals and Objectives
  - **Ensure that Federal investments in science and technology are making the greatest possible contribution to economic prosperity, public health, environmental quality, and national security**
  - Energize and nurture the processes by which government programs in science and technology are resourced, evaluated, and coordinated
  - Sustain the core professional and scientific relationships with government officials, academics, and industry representatives that are required to understand the depth and breadth of the Nation's scientific and technical enterprise, evaluate scientific advances, and identify potential policy proposals
  - Generate a core workforce of world-class expertise capable of providing policy-relevant advice, analysis, and judgment for the President and his senior staff regarding the scientific and technical aspects of the major policies, plans, and programs of the Federal government

3

R&D Budgets

- The Office of Science and Technology Policy (OSTP) has responsibility, in partnership with the Office of Management and Budget (OMB), for advising the President on the Federal Research and Development (R&D) budget and shaping R&D priorities across those Federal agencies that have significant portfolios in science and technology.
- OSTP also has responsibility—with the help of the National Science and Technology Council (NSTC), which is administered out of OSTP—for coordinating interagency research initiatives. It is OSTP's mission to help develop and implement sound science and technology policies and budgets that reflect Administration priorities and make coordinated progress toward important national policy goals.

4

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL (NSTC)

- The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the Federal research and development enterprise.
- A primary objective of the NSTC is establishing clear national goals for Federal science and technology investments.

COMMITTEE ON HOMELAND & NATIONAL SECURITY (CHNS) Zach Lemnois (DoD), Tara O Toole (DHS), Arun Seraphin (OTSP)		
BDRD: Biological Defense Research & Development (SC)	HFHNS: Human Factors for Homeland and National Security (SC)	SOS-CBRNE Standards (SC)
CDRD: Chemical Defense Research and Development (SC)	ISC: Infrastructure (SC)	D-IED: Domestic IEDs (SC)
	NDRD: Nuclear Defense Research & Development (SC)	

5

Biological Response and Recovery Science and Technology Working Group (BRRST WG)

Co-Chair
Jayne B. Morrow
National Institute of Standards and Technology
Department of Commerce

Co-Chair
John F. Koerner
Assistant Secretary of Preparedness and Response
Department of Health and Human Services

Staff
Brooke Pearson
Executive Secretary

- Dave Adams, Department of Homeland Security–Office of Health Affairs
- Matthew Arduino, Department of Health and Human Services–Centers for Disease Control and Prevention
- Mark Beall, Department of Defense–Office of the Assistant Secretary of Defense for Homeland Defense
- Erica Canzler, Environmental Protection Agency–Office of Emergency Management
- Lisa Delaney, Department of Health and Human Services–Centers for Disease Control and Prevention
- Aaron Firoved, Department of Homeland Security–Office of Health Affairs
- Sonia Hunt, Department of Justice–Federal Bureau of Investigation
- George Korch, Department of Health and Human Services–Office of the Assistant Secretary for Preparedness and Response
- James Lawler, Department of Health and Human Services–National Institutes of Health
- Helen Lawrence, Department of Justice–Federal Bureau of Investigation
- Ryan Madden, Department of Defense–Defense Threat Reduction Agency
- Tyler McAlpin, U.S. Department of Agriculture–Animal and Plant Health Inspection Service
- Lori Miller, Department of Homeland Security–Science and Technology
- Stephen Morse, Department of Health and Human Services–Centers for Disease Control and Prevention
- Shawn Ryan, Environmental Protection Agency–National Homeland Security Research Center
- Jill Sheets, Department of Justice–Federal Bureau of Investigation
- Lynn Slepski, Department of Transportation
- Theresa Smith, Executive Office of the President–National Security Staff
- Margaret Sobey, Department of Defense–Joint Program Executive Office for Chemical and Biological Defense
- Angela Weber, Department of Health and Human Services–Centers for Disease Control and Prevention

6

The Road to the Roadmap

- The BRRST WG developed a working document that described the **decisions that first responders or government officials would need to make** following a biological incident, what questions the decision maker might ask, and, of those questions, which could be addressed with scientific information or technological capabilities.
- The BRRST WG developed a **list of major (high-impact) decisions** that would need to be made during each phase of response and recovery.
- The resultant working document was used to guide discussions and to **collect Federal department and agency information on current and planned programmatic activity** with the potential to address the questions answerable by S&T.
- Review of submitted information on Federal activities drove the development of **S&T capability goals and objectives.**
- Those goals and objectives constitute the heart of this Roadmap and comprise a guide for future Federal, academic, and industrial S&T efforts and for international collaborations.

7

Key Response and Recovery Decisions

Response and Recovery					
Crisis Management		Consequence Management			
		Remediation/Cleanup			
Notification	First Response	Characterization	Decontamination	Clearance	Restoration/ Re-occupancy
Initiate first response activities, including notification of proper authorities Develop a public-engagement campaign Evaluate Threat Credibility	Operational Coordination Law enforcement, intelligence, and investigative response When and how to distribute medical countermeasures Recommend staying-in-place or evacuation Recommend quarantine/isolation/social distancing Implement transportation restrictions Provide safety and health guidance and protections to impacted first responders and citizens Issue guidance on personal hygiene or decontamination Provide support for mass casualty Establish mass medical treatment facilities Implement modified standards of care	Develop/ implement strategies for characterization in facilities and the outdoors Implement strategies and procedures to identify, stabilize, and maintain infrastructure and property Determine requirements and methods to protect natural and cultural resources Implement strategies and means to contain and mitigate the spread of contamination and eliminate sources of further distribution (e.g., insecticides for flies)	Decontaminate outdoor areas and/or buildings Decontaminate wide areas Implement required capabilities for sustained environmental decontamination operations Implement decontamination waste handling requirements Decontaminate critical infrastructure	Provide guidance for determination of effectiveness of decontamination	Provide guidance for re-occupancy and reuse criteria and goals Provide guidance for controls to implement, reduce, mitigate any potential exposures or future incidents after re-occupancy Implement public messaging to instill confidence in the public and workforce that re-occupancy is safe Implement measures to retain, maintain and improve the economic vitality of a region Implement long term health treatment, intervention and surveillance strategy

8

Findings

Key near-term R&D priorities and objectives outlined in the Roadmap include:

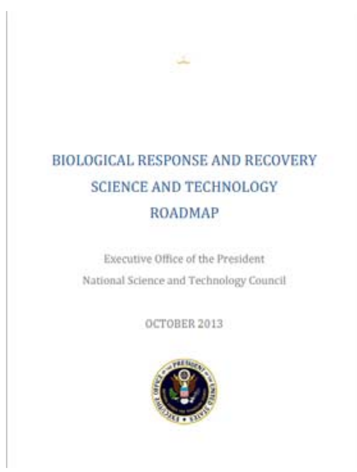
- Develop reliable estimates of risk of exposure for a multitude of environments, matrices, and conditions associated with wide-area release scenarios;
- Develop reliable estimates of risk to humans, animals, and plants through various exposure and transmission routes;
- Evaluate population infection prevention measures (e.g., quarantine, isolation, and social distancing) used to reduce incident impact and develop a strong scientific basis for recommending these measures; and
- Apply insights from risk-communication research to guide dissemination of appropriate messages to decision makers, first responders, and others.

9

The BRRST Roadmap

The *Roadmap* aims to:

- Categorize key scientific gaps,
- Identify specific technological solutions
- Prioritize research activities to enable government—at all levels—to make decisions more effectively


BIOLOGICAL RESPONSE AND RECOVERY
SCIENCE AND TECHNOLOGY
ROADMAP

Executive Office of the President
National Science and Technology Council

OCTOBER 2013

http://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/brrst_roadmap_2013.pdf 10

Questions?

Jayne B. Morrow
BRRST Co-Chair /
Executive Director
National Science and Technology Council
Jayne_B_Morrow@ostp.eop.gov

John F. Koerner
BRRST WG Co-Chair
Assistant Secretary of Preparedness and Response
Department of Health and Human Services
john.koerner@hhs.gov

Brooke Pearson
BRRST WG Executive Secretary
(Contract support to DHS S&T)
brooke.pearson@cubic.com

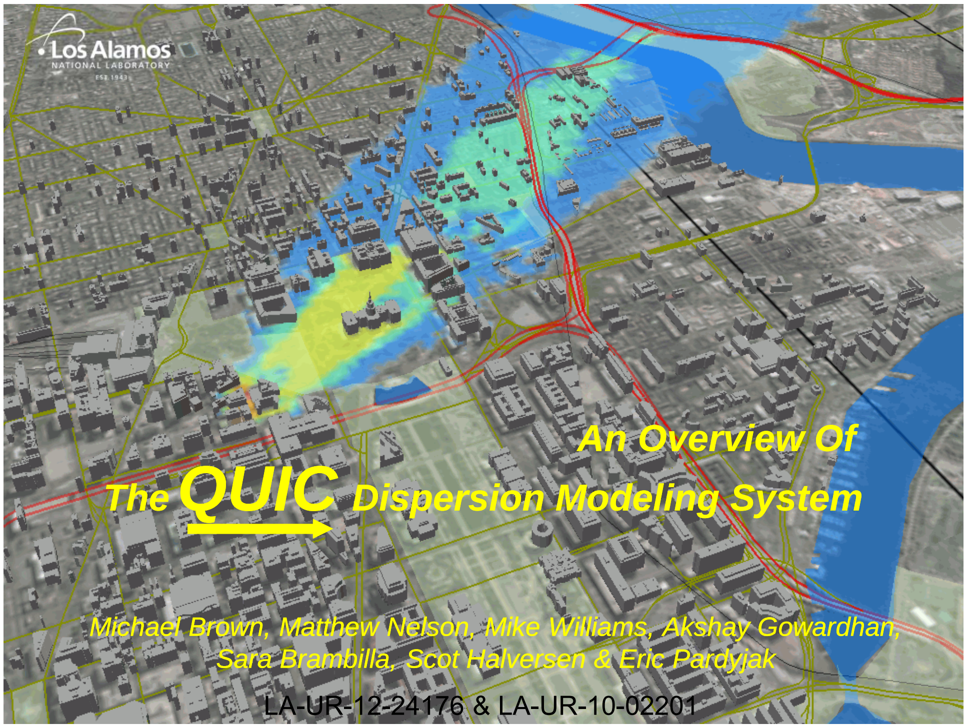
Andrew Hebbeler
Senior Policy Analyst
National Security & International Affairs Division
Andrew_M_Hebbeler@ostp.eop.gov

11

Tuesday, November 5, 2013

General Session 2

Decision Support Tools



Outline

- QUIC Model Components
- QUIC Urban Capabilities
- QUIC CBR Capabilities
- Applications
- Validation

Unclassified LA-UR-12-24176 & LA-UR-10-02201

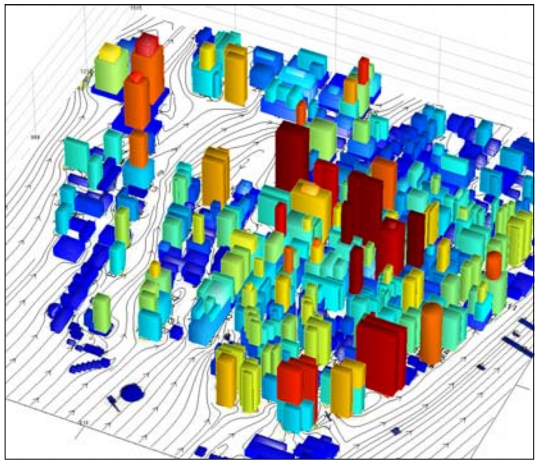
What is QUIC?

Quick Urban & Industrial Complex dispersion modeling system

*** QUIC-URB**

rapidly produces 3D wind field around buildings using an empirical/diagnostic model based on Röckle (1990)

Pardyjak and Brown (2001)



Lower Manhattan

What is QUIC?

Quick Urban & Industrial Complex dispersion modeling system

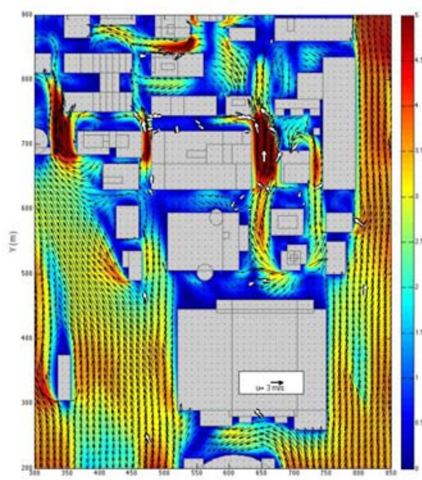
*** QUIC-CFD**

- solves incompressible RANS equations for steady-state solution relatively quickly compared to other CFD models.

- based on artificial compressibility method (Chorin, 1967)

- uses simplified algebraic turbulence model based on Prandtl's mixing-length theory

Gowardhan et al (2011)



Oklahoma City

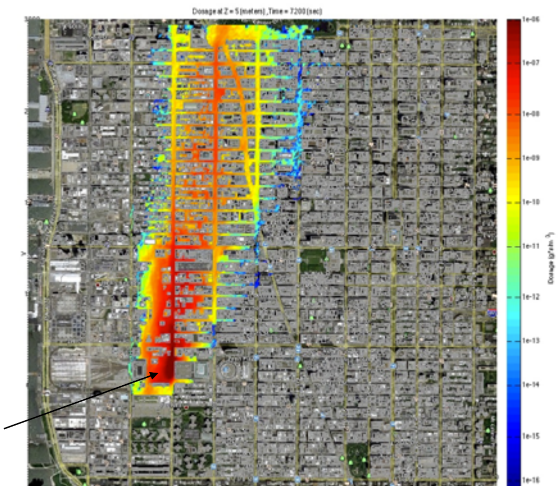
What is QUIC?

Quick Urban & Industrial Complex dispersion modeling system

*** QUIC-PLUME**

- "urbanized" Lagrangian random-walk dispersion model
- local, non-local, and vortex turbulent mixing schemes
- drift terms to account for inhomogeneous turbulence
- CBR capabilities

Williams et al (2004)



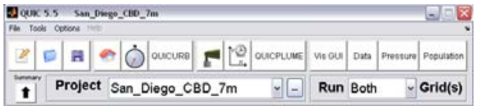
Penn Station Release, Midtown Manhattan

What is QUIC?

Quick Urban & Industrial Complex dispersion modeling system

*** QUIC-GUI**

graphical user interface for set-up, running, and visualization



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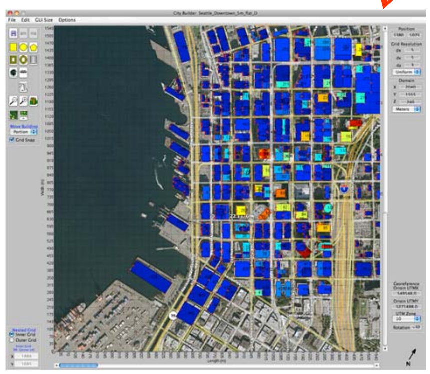

Los Alamos

Unclassified

LA-UR-12-24176 & LA-UR-10-02201

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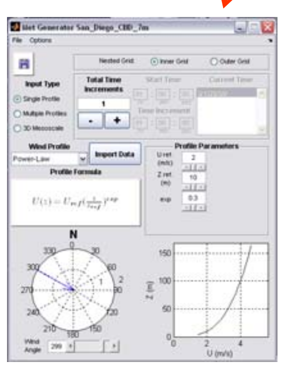

Los Alamos

Unclassified

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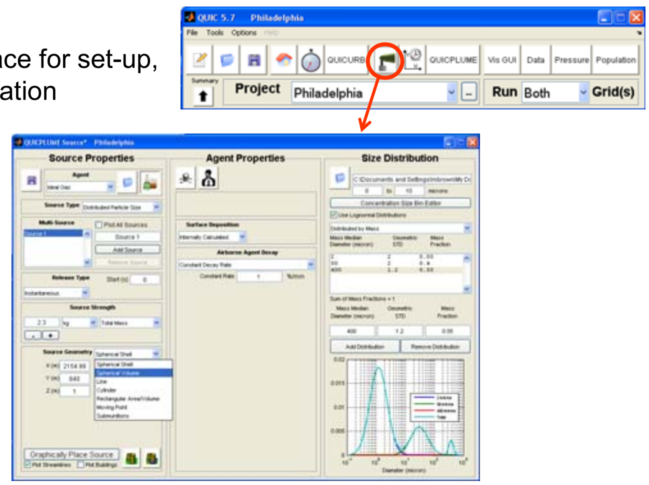

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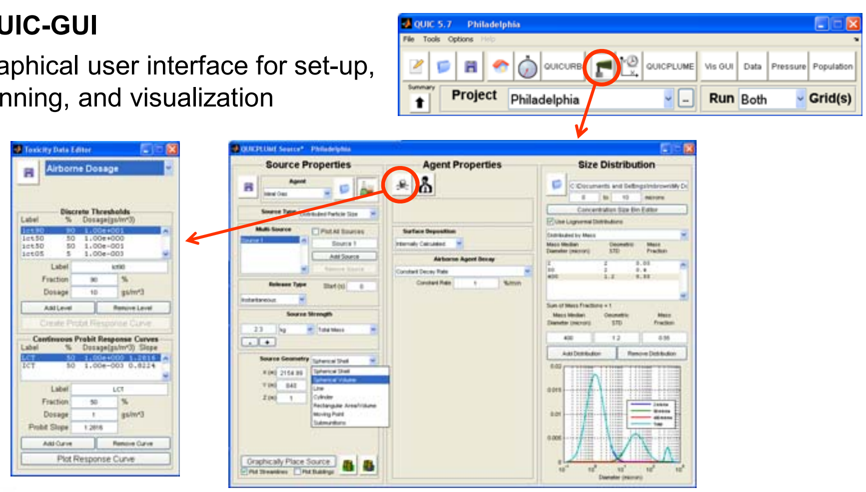

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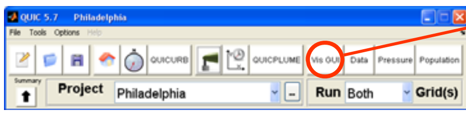
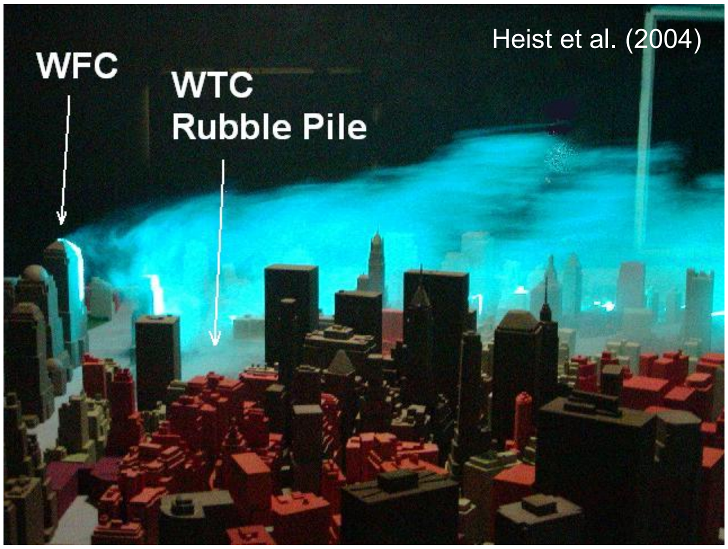


QUIC's Niche

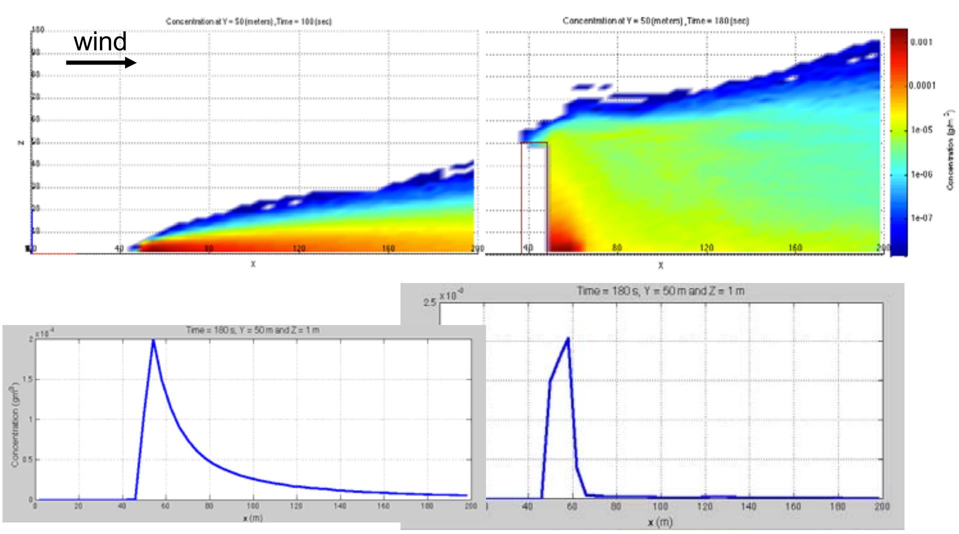
1. **Urban dispersion with buildings**

Impact of Buildings on T&D



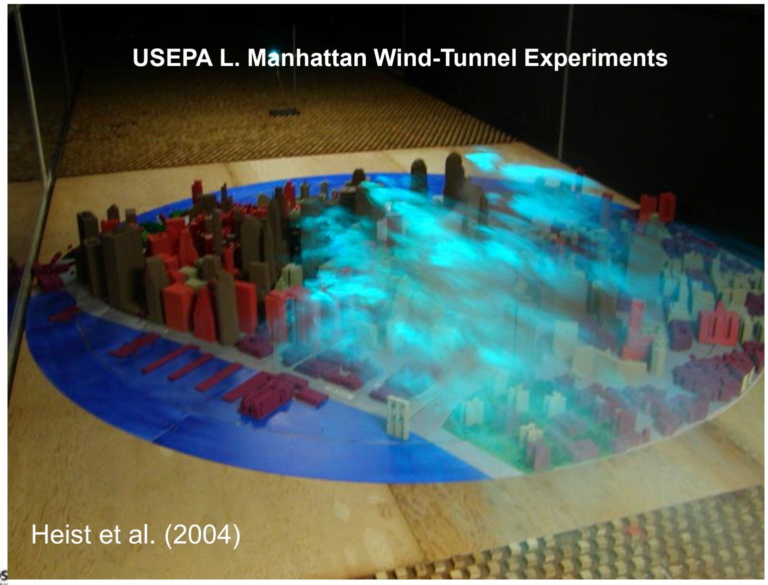
USEPA wind-tunnel experiments of L. Manhattan

Impact of Buildings on T&D

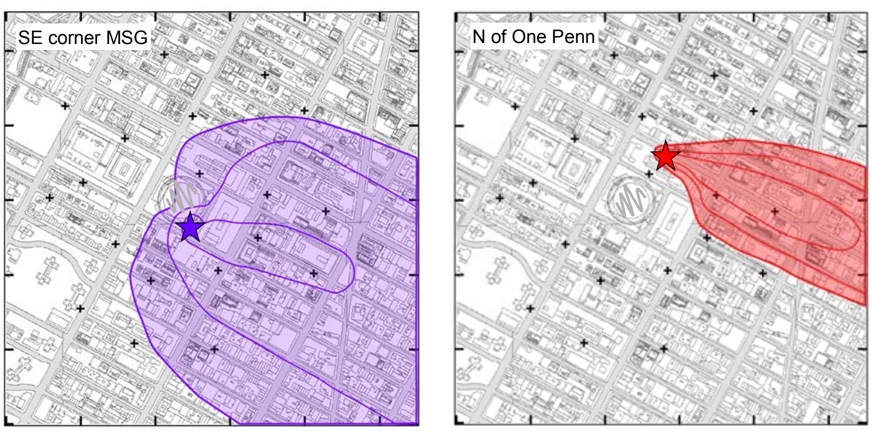


Enhanced Dilution for Source Immediately Downwind of Building

Impact of Buildings on T&D



Impact of Buildings on T&D

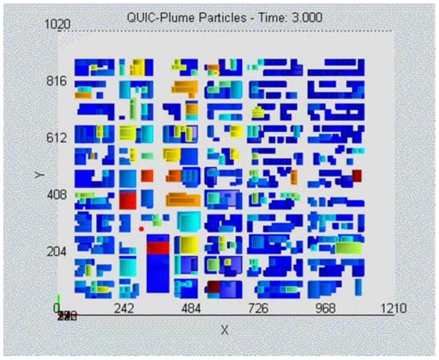


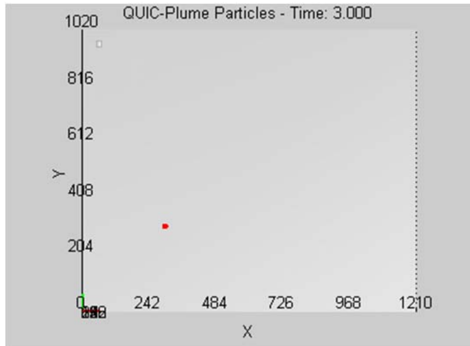
DTRA/DHS NYC Madison Square Garden Tracer Experiment
(PNNL - Allwine et al, 2006)

Impact of Buildings on T&D

Impact of buildings on retention and timing

Midtown @ Grand Central Station – Particle dispersion animation

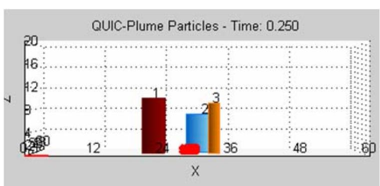


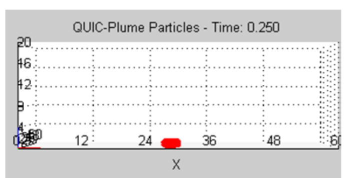


QUIC model w/ buildings **QUIC model w/out buildings**

Impact of Buildings on T&D

Impact of buildings on Dense Gas dispersion



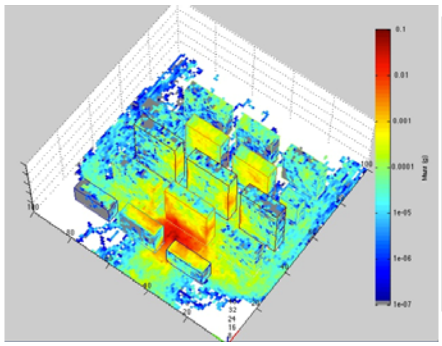


Particle animation showing enhanced vertical mixing of the dense gas cloud by buildings (ρ=3 kg/m^2).

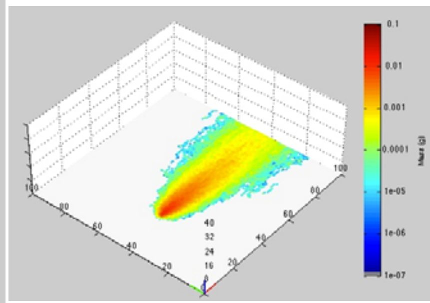
QUIC model w/ buildings **QUIC model w/out buildings**

Impact of Buildings on T&D

Impact of buildings on Particle Deposition patterns



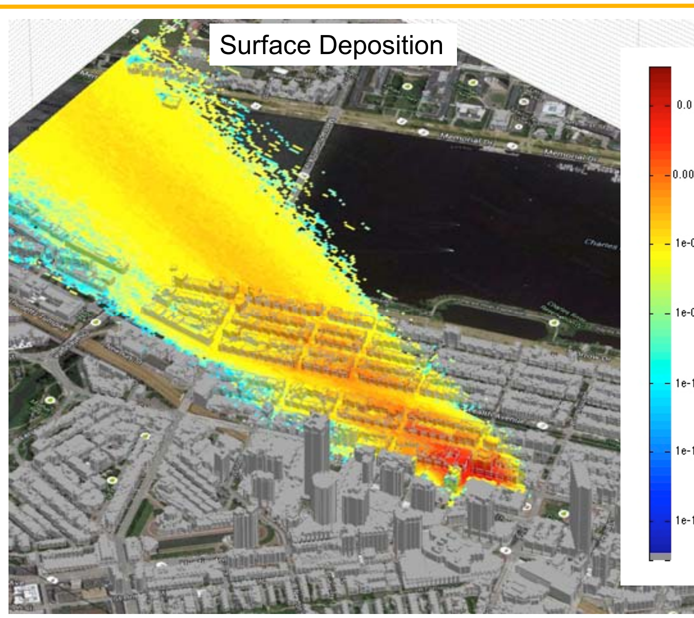
QUIC model w/ buildings



QUIC model w/out buildings (similar to Gaussian solution)

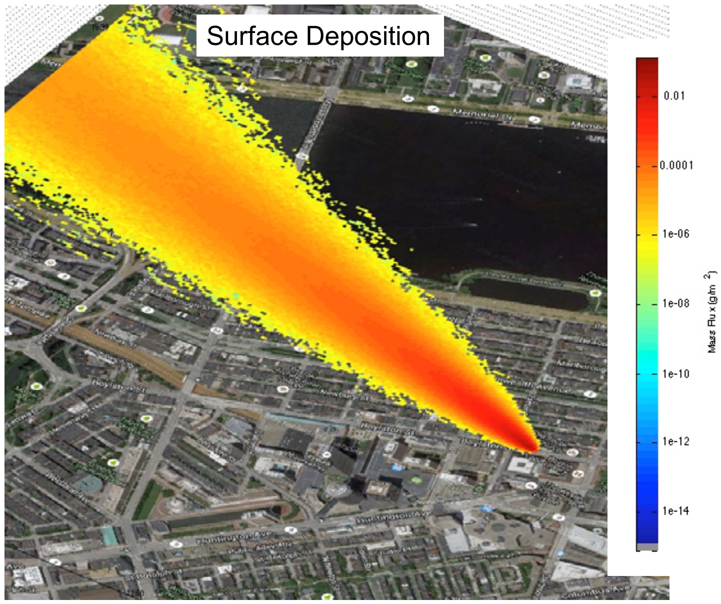
Impact of Buildings on T&D

QUIC model w/ Boston buildings



Impact of Buildings on T&D

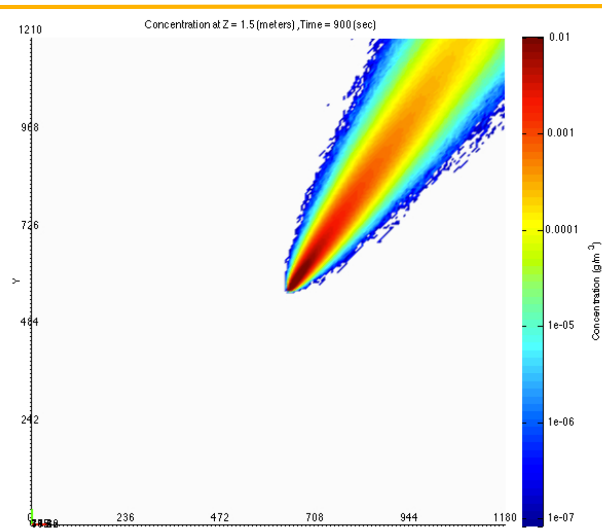
QUIC model w/out buildings



Quantifying Impact of Buildings on T&D

Ran QUIC without buildings using

Oklahoma City Joint Urban 2003 IOP 2, Release 1 Inflow Conditions



OKC Joint Urban 2003 domain w/out buildings

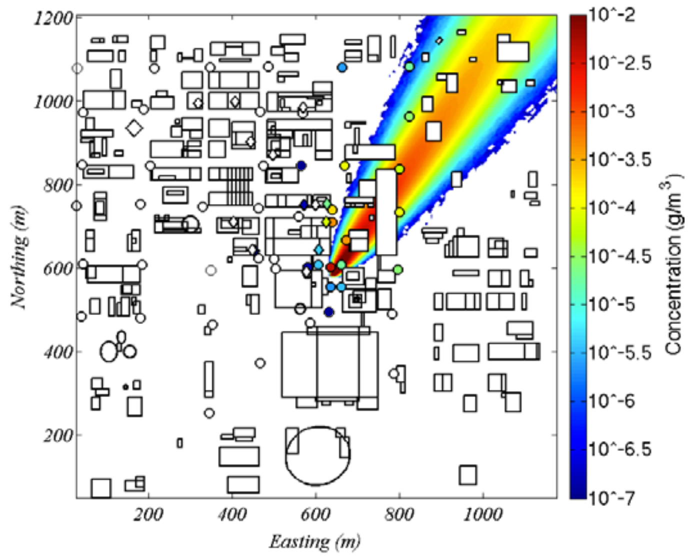
Quantifying Impact of Buildings on T&D

Ran QUIC without buildings using

IOP 2, Release 1 Inflow Conditions

30-min conc. measurements

< 10^{-7} **conc.**



OKC Joint Urban 2003 domain w/ buildings

Los Alamos NATIONAL LABORATORY

Operated by Los Alamos National Security, LLC for NNSA

UNCLASSIFIED

NNSA

Quantifying Impact of Buildings on T&D

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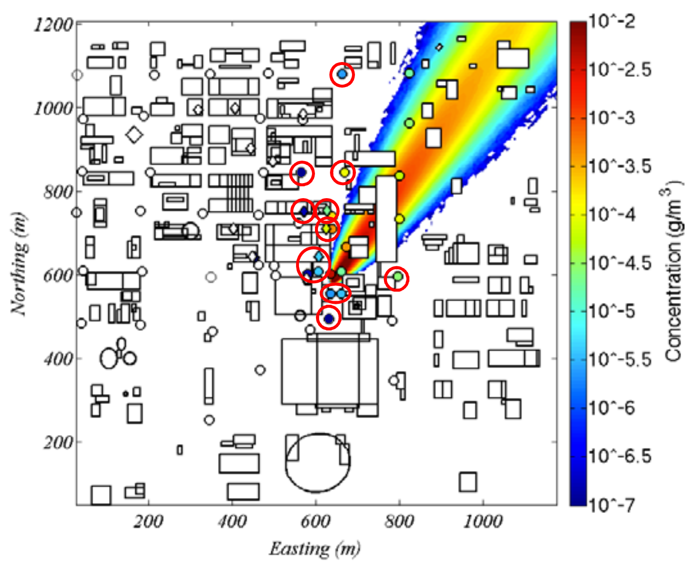

OKC Joint Urban 2003 domain w/ buildings

Los Alamos NATIONAL LABORATORY

Operated by Los Alamos National Security, LLC for NNSA

UNCLASSIFIED

NNSA

Quantifying Impact of Buildings on T&D

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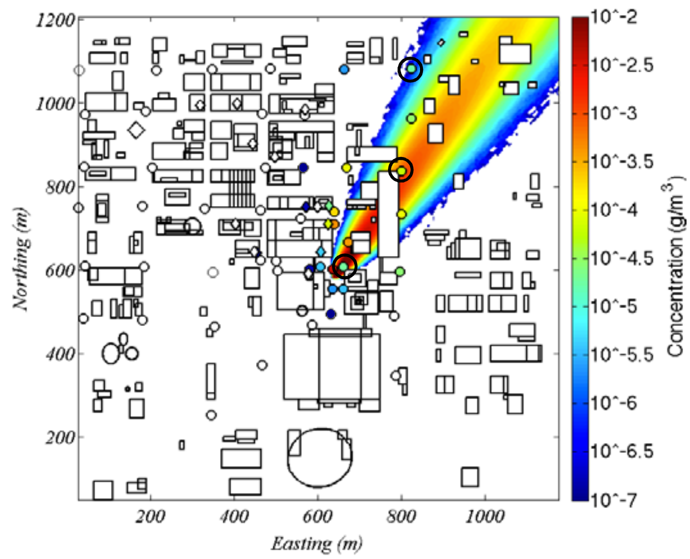

OKC Joint Urban 2003 domain w/ buildings

Operated by Los Alamos National Security, LLC for NNSA

UNCLASSIFIED

Quantifying Impact of Buildings on T&D

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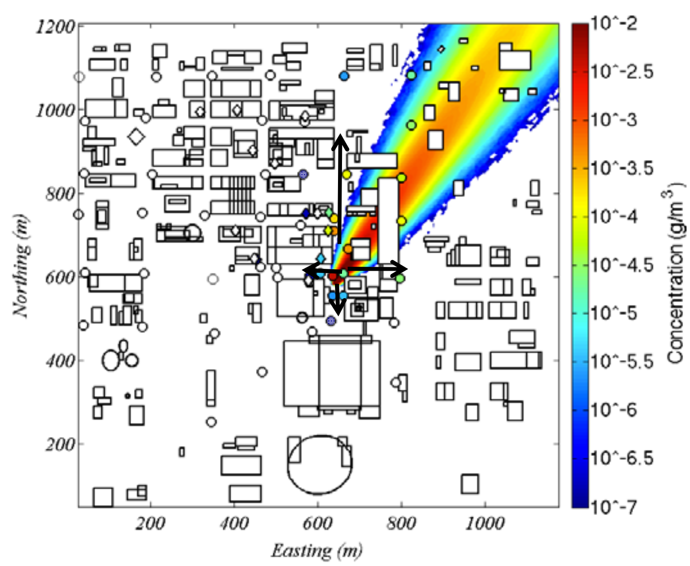
30-min conc. measurements

< 10^{-7} **conc.**



OKC Joint Urban 2003 domain w/ buildings

Operated by Los Alamos National Security, LLC for NNSA

UNCLASSIFIED

Quantifying Impact of Buildings on T&D

Ran QUIC with buildings using

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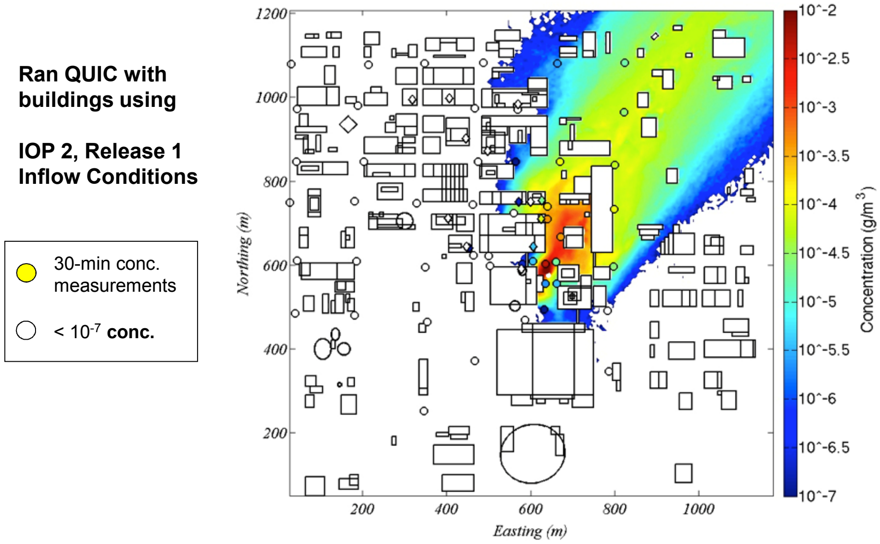
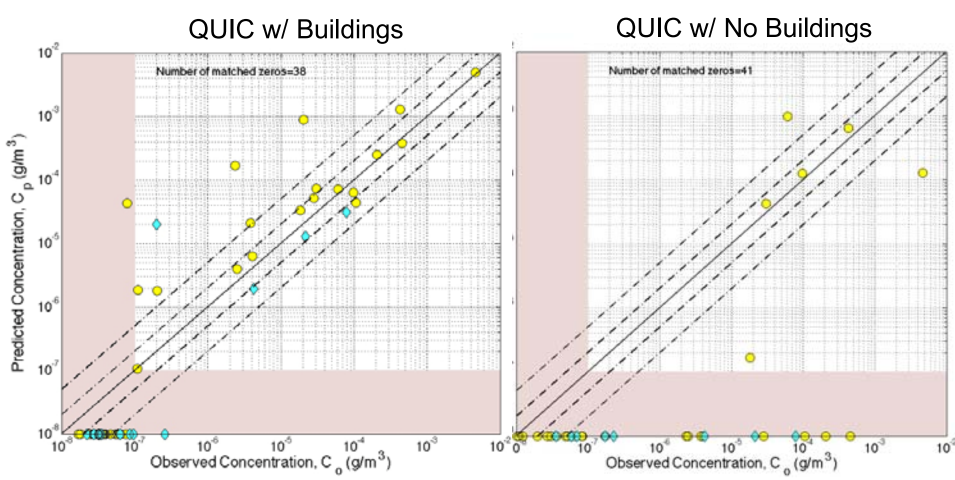
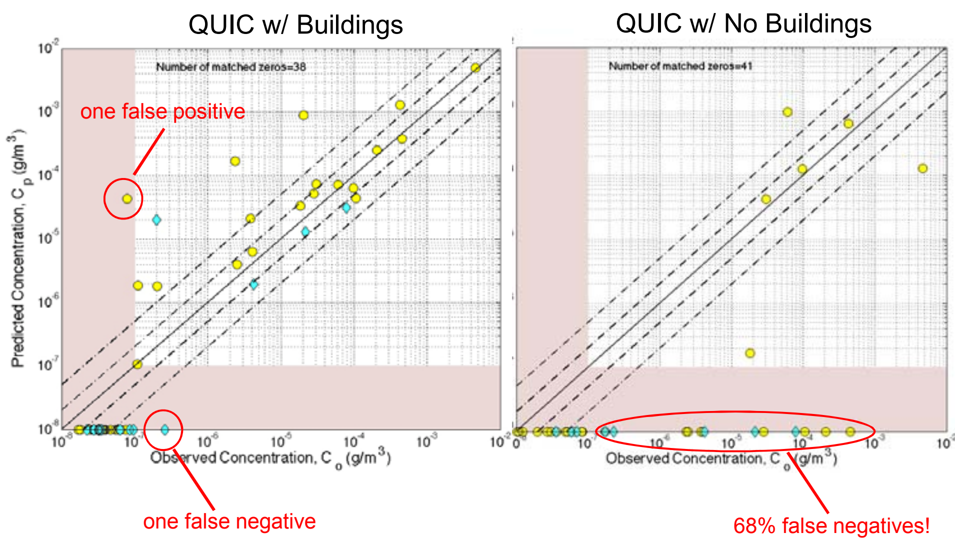


Figure 6. Comparison of 30-min-averaged model-computed concentrations and measurements

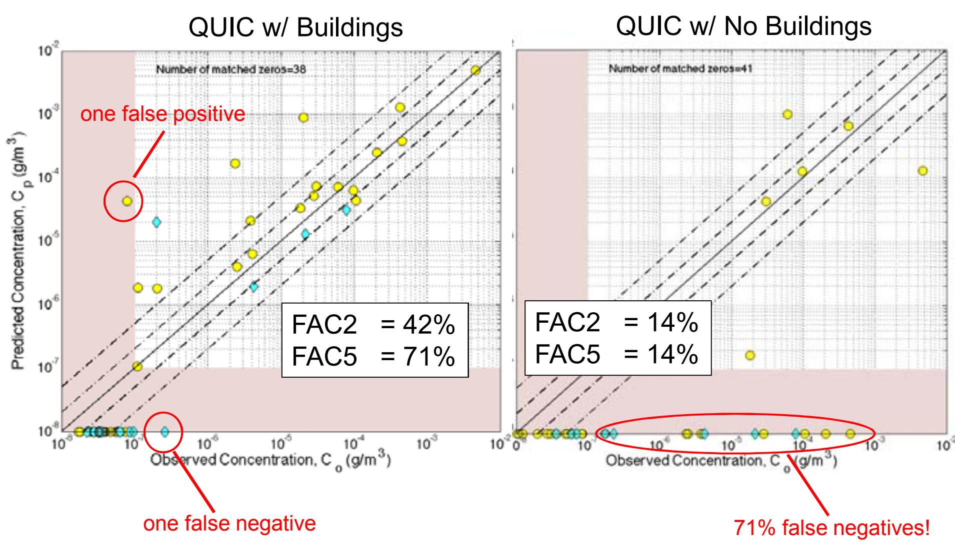
Quantifying Impact of Buildings on T&D



Quantifying Impact of Buildings on T&D



Quantifying Impact of Buildings on T&D

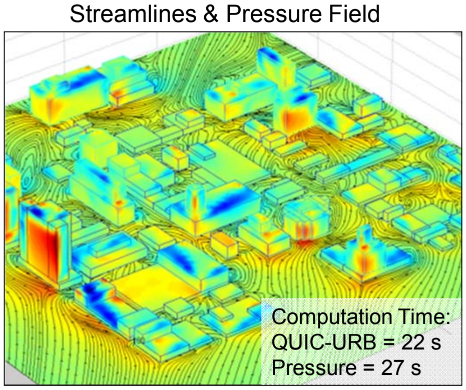


QUIC’s Niche

1. **Urban dispersion with buildings**
2. **Relatively fast**

QUIC Wind Solver Run Time

Streamlines & Pressure Field



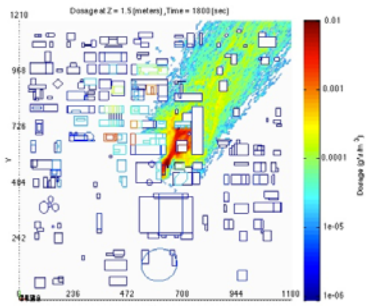
3.7 million grid cells

5.4 million grid cells

QUIC v. 6.01
2010 Macbook Pro 2.66 GHz Laptop – 1 processor

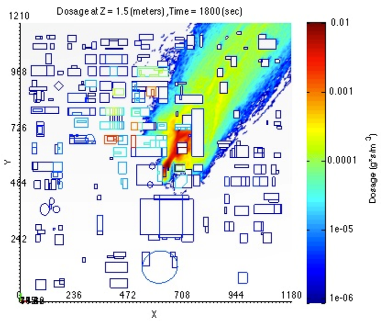
QUIC-URB Wind Solver

QUIC T&D Solver Run Time



10,000 particles

Computation Time = 33 s



100,000 particles

Computation Time = 215 s

= 134 s (2 processors; 1.6x speedup)

Simulation Parameters:

- Oklahoma City Central Business District
- Instantaneous near-sfc. release
- 1.2 x 1.1 km domain
- 4 m/s wind speed
- Δt =2 s
- <15 minute particle clearance time
- 15 minute simulation
- dx=dy=5 m, dz=3 m

QUIC v. 6.01
2010 Macbook Pro 2.66 GHz Laptop

QUIC's Niche

1. **Urban dispersion with buildings**
2. **Relatively fast**
3. **Chemical, biological, and radiological agents**

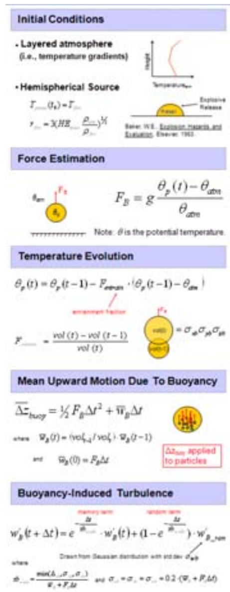
Release Type

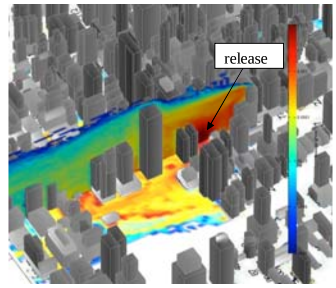
Radiological Dispersal Devices

QUIC scheme based on:

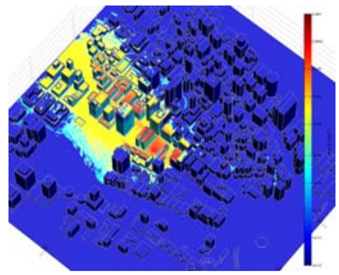
Boughton, B. A. and J. M. DeLaurentis, "An Integral Model of Plume Rise from High Explosive Detonations," SAND-86-2553C.

- inputs: HE mass, particle size distribution, & air temp vs. ht
- super-position of buoyant rise, building-induced updrafts and downdrafts, and particle gravitational settling





Airborne Dosage

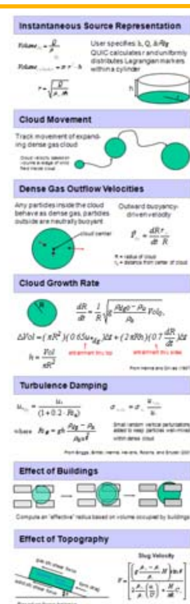


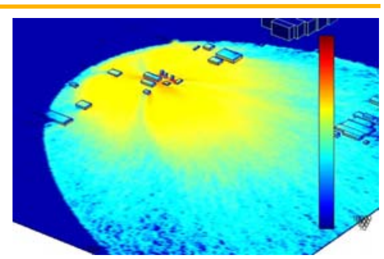
Deposition

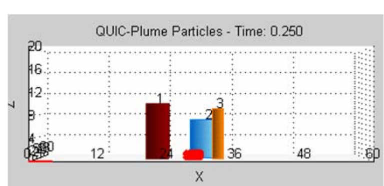
Release Type

Dense Gas Releases

- dense gas w/ buildings
- dense gas w/ terrain
- shallow-water liquid pool
- flashed release
- 2-phase thermodynamics
- water vapor thermodynamics



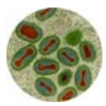


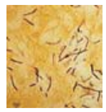


Dense gas (ρ=3 kg/m^2)

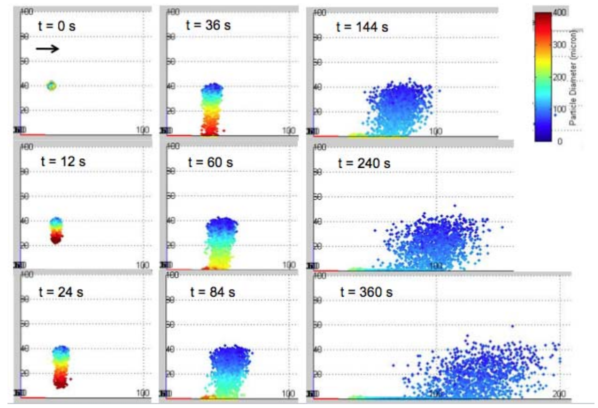
Release Type

Biological Agent Releases





- multiple particle sizes
- gravitational settling
- UV decay
- dry powders
- bio-slurry w/ droplet evaporation



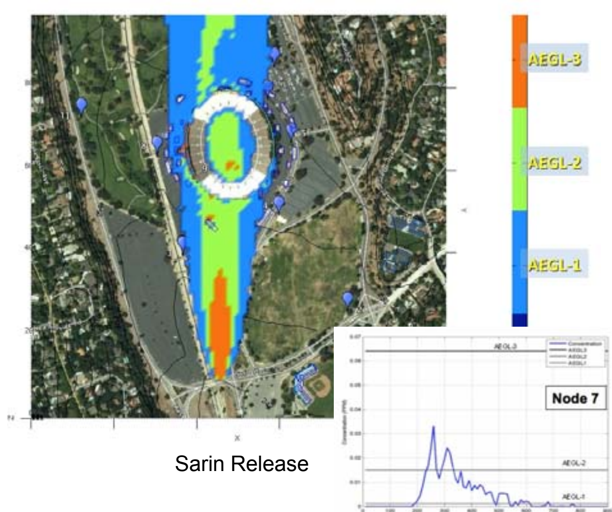
Bio slurry release at 40 m agl.

Zajic, D., M. Nelson, M. Williams, and M. Brown, 2010: Description and Evaluation of the QUIC Droplet Spray Scheme - Droplet Evaporation and Surface Deposition, 16th AMS Conf. Appl. Air Poll. Met., Atlanta.

Release Type

Chemical Agent Releases

- two-phase flow capable, i.e., QUIC tracks both the liquid droplet and the evaporated gas
- multiple droplet sizes
- secondary evaporation porous & non-porous sfc



Sarin Release

Williams, M., M. Nelson, and M. Brown, 2009: QUIC-PLUME Theory Guide, Draft, 45 pp.

QUIC’s Niche

1. Urban dispersion with buildings
2. Relatively fast
3. Chemical, biological, and radiological agents
4. Advanced users

QUIC’s Niche

1. Urban dispersion with buildings
2. Relatively fast
3. Chemical, biological, and radiological agents
4. Advanced users
5. Applications where many simulations must be performed and/or rapid feedback is required

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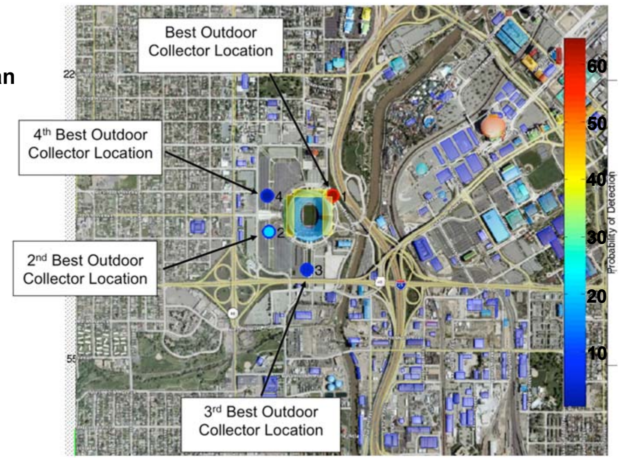
CBR Sensor Siting

Goal: Optimally Site Bio Collectors to Enhance the Probability of Detecting a Bio Attack on High-Profile Facilities & Special Events

The automated tool has been used for, e.g.,

- Democratic and Republican National Conventions
- The Superbowl
- The World Series
- G-8 Summit Meetings
- A Financial District
- The Rose Bowl
- The Rose Bowl Parade
- NYC WTC Complex

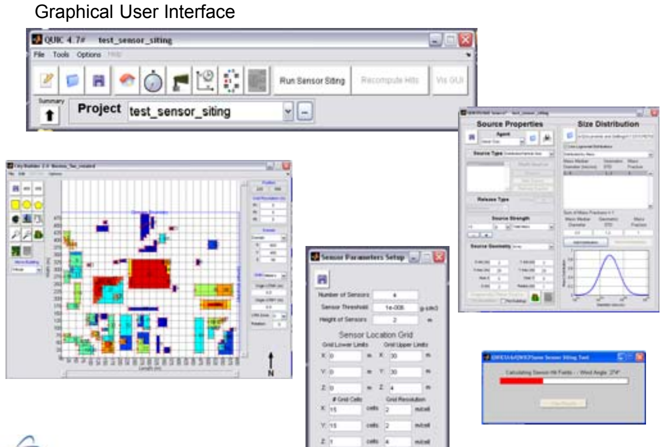


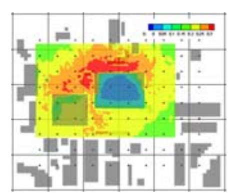
Example of Delivered Final Product

QUIC Collector Siting Tool GUI

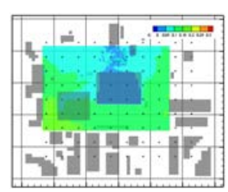
- **The model is completely automated and allows for batch processing on multi-processor platforms**

Graphical User Interface





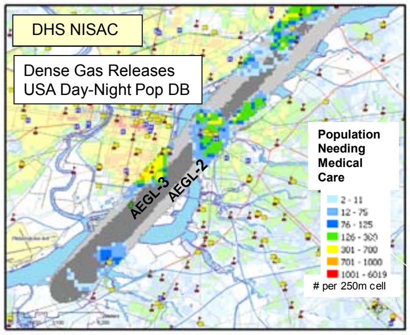
Hit probability map for 1st collector



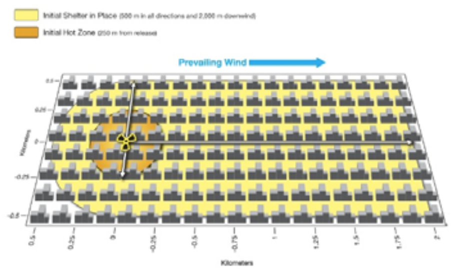
Hit probability map for 2nd collector

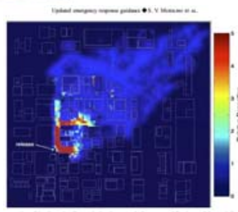
Assessments & Response Guidance

Chemical Facility Vulnerability Assessments



Emergency Response Guidance





Musolino, S., Buddemeier, B., Brown, M., Harper, F.T. and Schlueck, R. (2013) ‘Updated emergency response guidance for the first 48 h after the outdoor detonation of an explosive radiological dispersal device’, *Health Physics*, Vol. 105, No. 1, pp.65–73.

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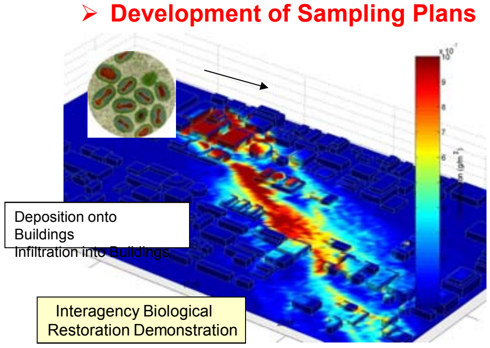
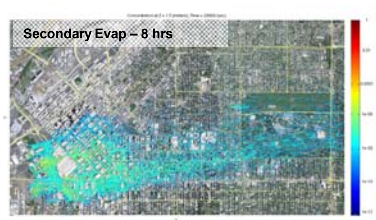
Clean-up & Restoration Studies

- **Development of Sampling Plans**

DHS S&T
WARRP Study





CWA Secondary Evaporation

Van Cuyk, S., Deshpande, A., Hollander, A., Franco, D. Teclemariam, N., J. Layshock, L. Ticknor, M. Brown, and K. Omberg, 2012: Transport of Bacillus thuringiensis var. kurstaki from an outdoor release into buildings: pathways of infiltration and a rapid method to identify contaminated buildings, Biosecurity & Bioterrorism: Biodefense Strategy, Practice, and Science, v 10, No. 2, 215-227.

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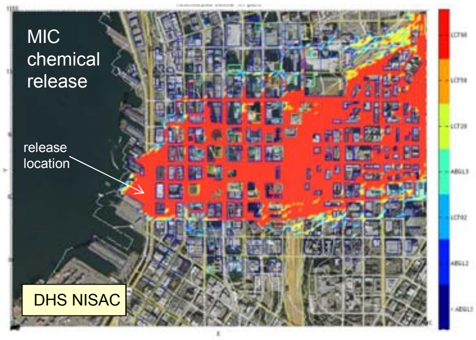
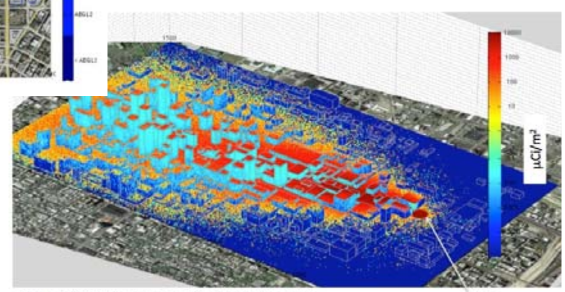
Training and Exercise

National Level Exercise Support



Liberty RadEx



Case 1: 3000 lb HE, 3 m/s wind, 700 m BL depth, B stability

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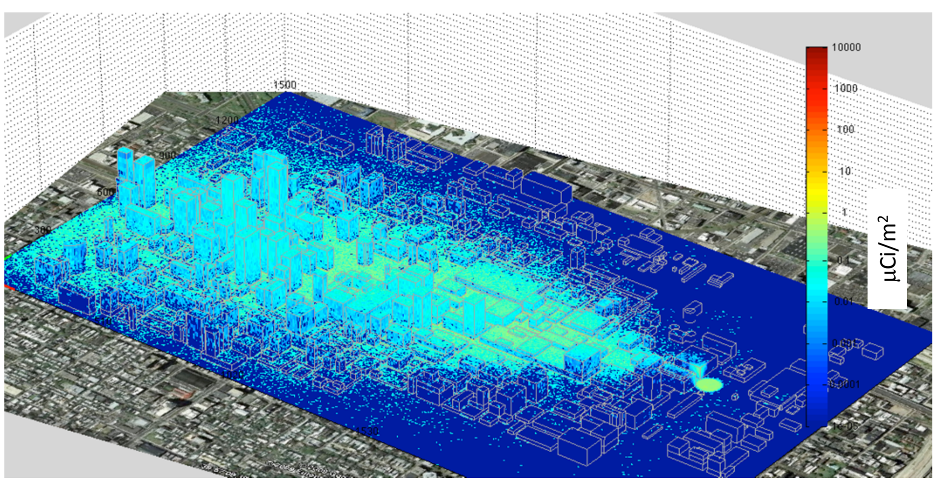
Deposition – 0-5 micron particles



The 0-5 micron particles get lofted high into the air and slowly settle out. They are the major contributors to the deposition on the upper walls of tall buildings.

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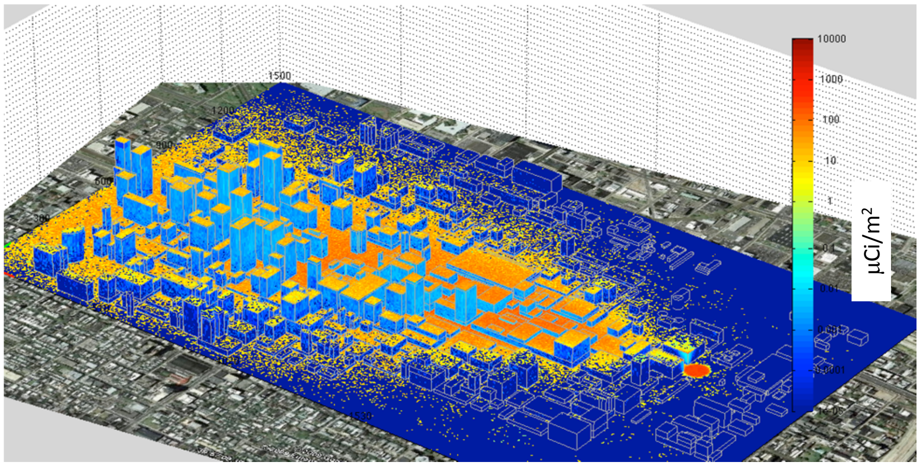
Unclassified

UNCLASSIFIED

NNSA

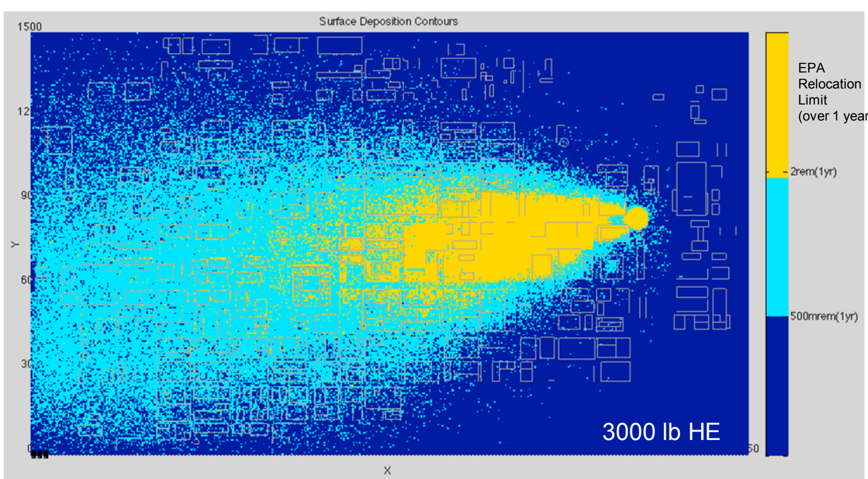
Deposition – 25-100 micron particles



The 25-100 micron particles get lofted fairly high into the air and settle out fairly rapidly. They are a major contributor to the deposition on building roofs and the ground.

Protective Action Guidelines

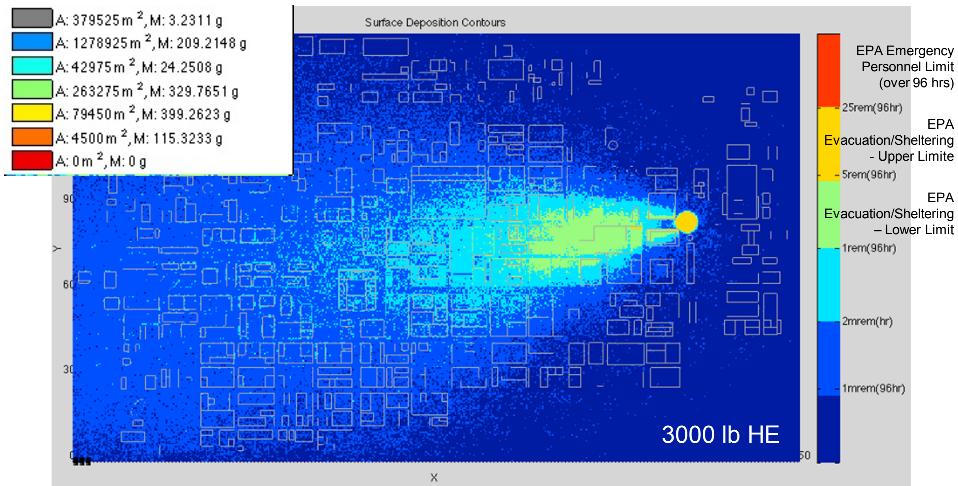
Public Evacuation Guidelines



Case 1: 3000 lb HE, 3.6 m/s wind, 700 m BL depth, B stability

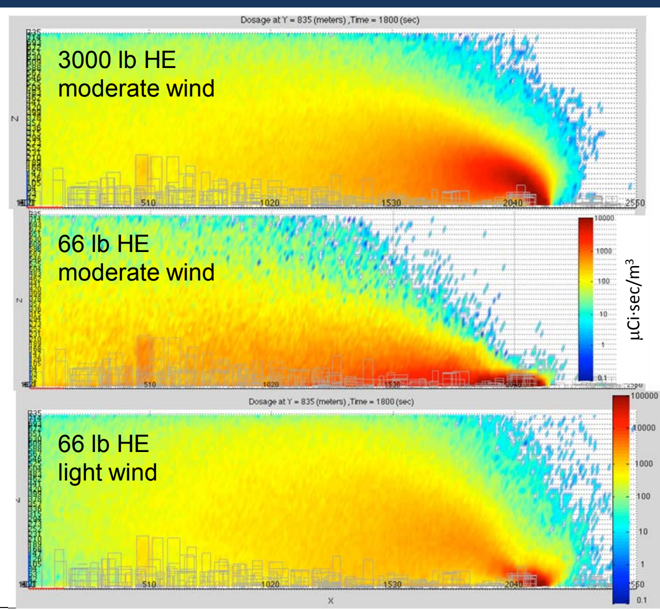
Protective Action Guidelines

Emergency Responder Guidelines



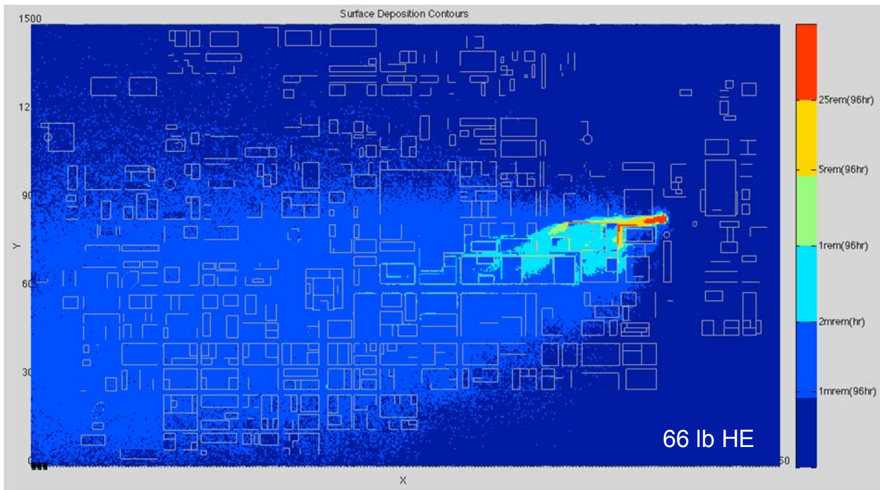
Case 1: 3000 lb HE, 3.6 m/s wind, 700 m BL depth, B stability

Sensitivity Analyses



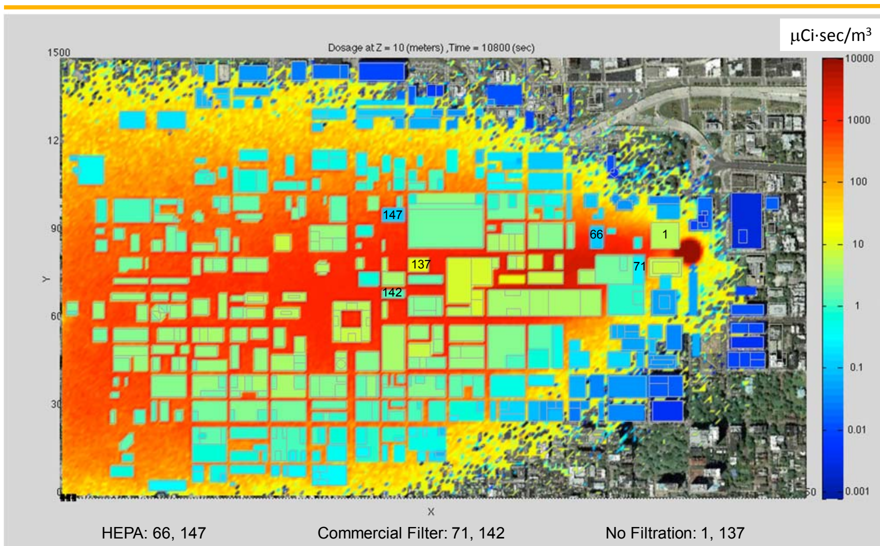
Protective Action Guidelines

Emergency Responder Guidelines



Case 2: 66 lb HE, 3.6 m/s wind, 700 m BL depth, B stability

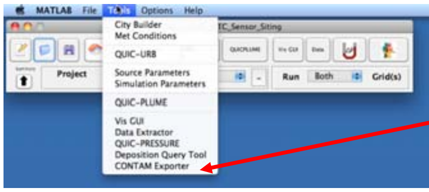
QUIC Building Infiltration Capability



Note: majority of building infiltration properties set to default (old office with commercial filter and closed windows)

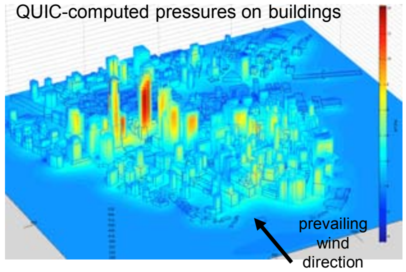
Linkage with NIST CONTAM Model

➤ **Outdoor-to-Indoor Infiltration**



CONTAM Exporter Tool

QUIC-computed pressures on buildings



prevailing wind direction

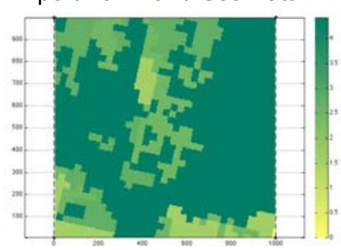
CONTAM inlet locations

QUIC Provides Concentrations and Pressures at Building Inlets

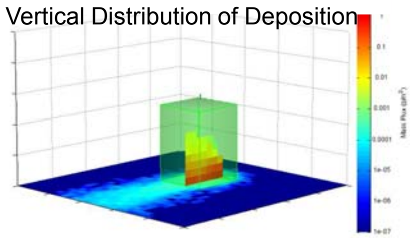
Urban Forests

Drag & Deposition

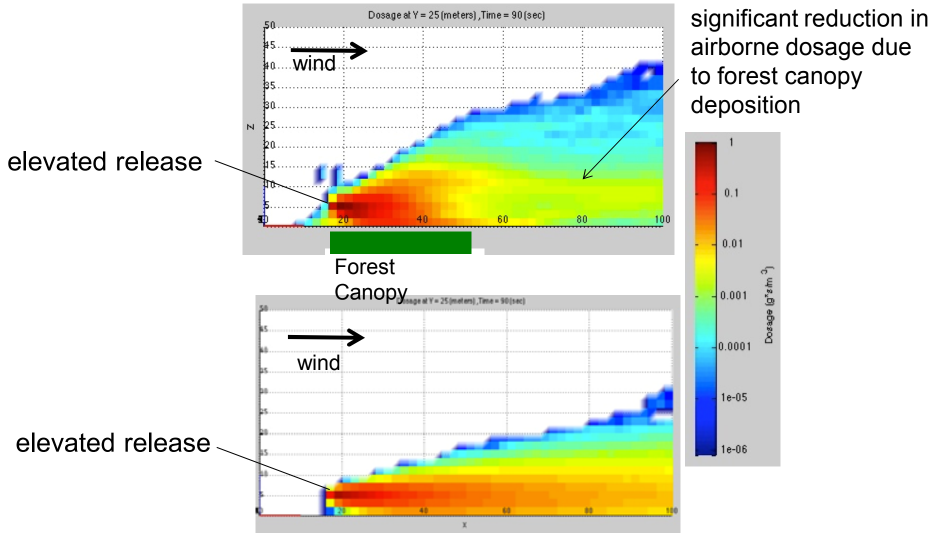
Automatic Vegetation & Urban Canopy Import from Land Use Data



Vertical Distribution of Deposition



Forest Canopies act as Particle Filters



NO Forest Canopy

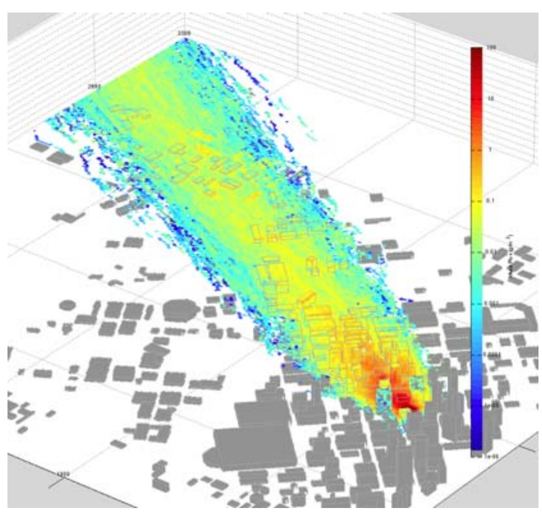
Particle Resuspension

After an initial bio or rad attack, could the hazard and clean-up zones increase over time due to resuspension of particle agent?

Radiological Dirty Bomb

Wet Slurry Bio Release

Improvised Nuclear Device



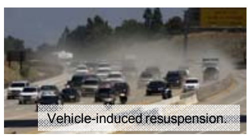
Deposition field in downtown Denver from a bio agent release.

Wind- & Mechanically-Driven Resuspension

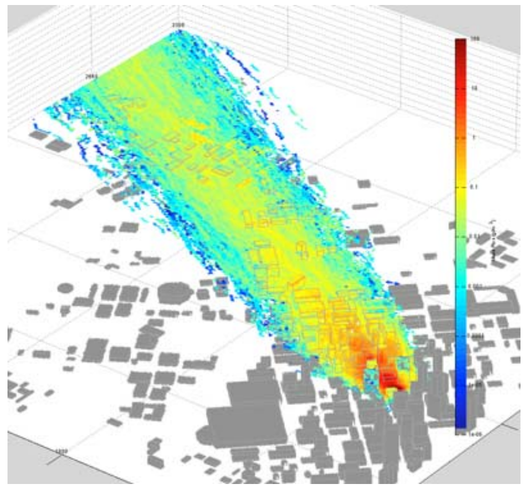
Wind gusts can loft the deposited particles from the ground, trees, and buildings up into the air again.

Dust lofted by a turbulent eddy.

Pollen cloud resulting from wind gusts.



Vehicle-induced resuspension.



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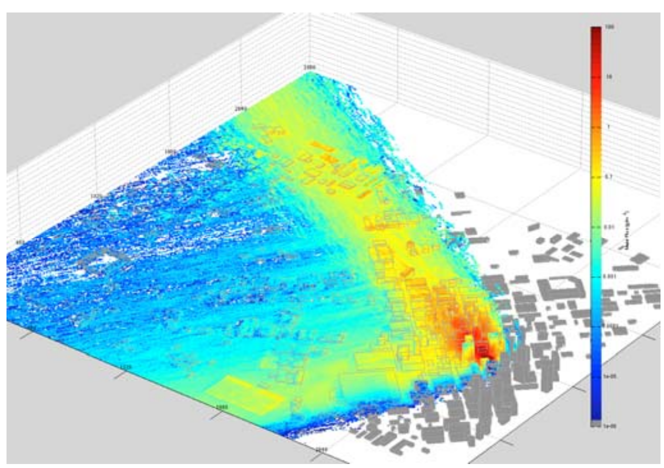

A 60 second 10 m/s wind gust from the northeast.

Wind- & Mechanically-Driven Resuspension

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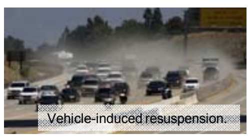
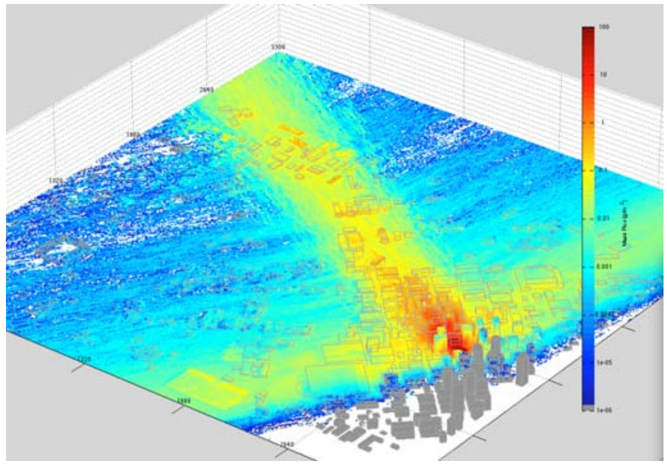
Dust lofted by a turbulent eddy.

Pollen cloud resulting from wind gusts.

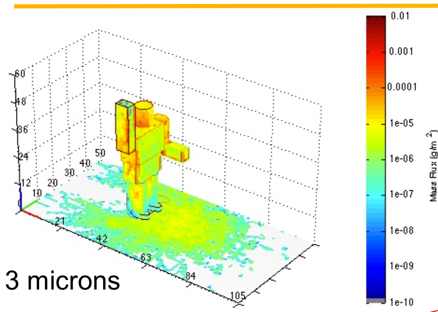


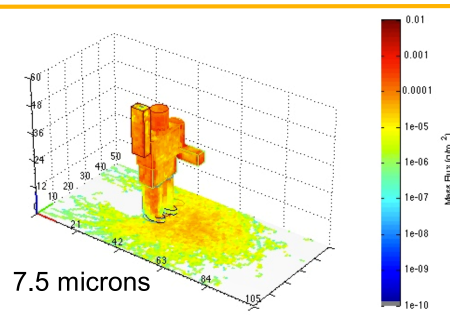
Vehicle-induced resuspension.



A 30 second 12 m/s wind gust from the south.

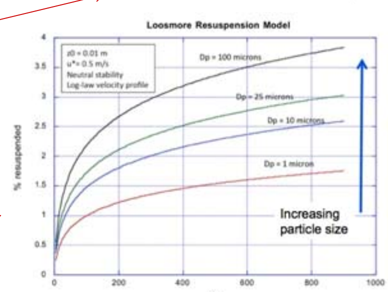
Impact of Spore Agglomerate Size



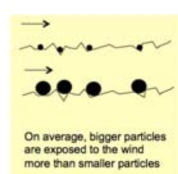


Deposition increases with particle size

Resuspension increases with particle size



$$\Lambda[s^{-1}] = 0.42\frac{u_*^{2.13}d_p^{0.17}}{t^{0.92}z_0^{0.32}\rho_p^{0.76}}$$



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Clark, J. and P. Klein, 2006: Implementation of a traffic-produced turbulence scheme into the fast-response model QUIC, *6th AMS Urb. Env. Symp*., 7 pp.

Nelson, M., M. Brown, M. Williams, 2006: Integration of the Pentagon building into the QUIC dispersion modeling system and testing against wind-tunnel data, Official Use Only, 59 pp.

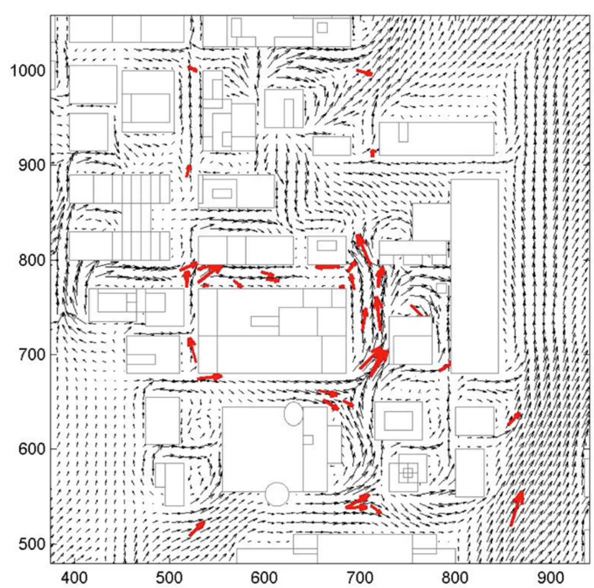
Pardyjak, E. and M. Brown, 2001: Evaluation of a fast-response urban wind model – comparison to single-building wind-tunnel data, *Int. Soc. Environ. Hydraulics*, 6 pp.

QUIC Model Evaluation – OKC Joint Urban 2003

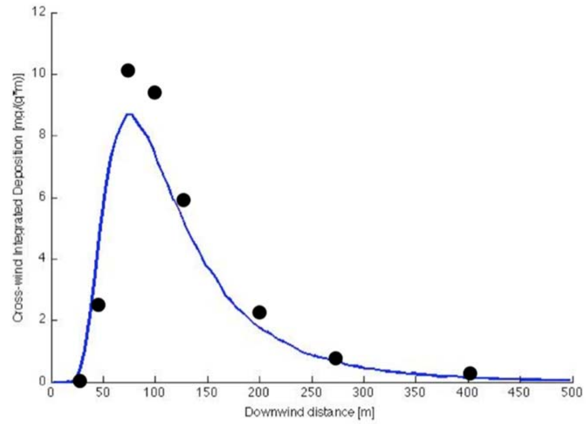
QUIC-CFD vs. OKC Joint Urban 2003 wind measurements

30 minute average winds (plan view)

Neophytou M., A. Gowardhan, and M. Brown, 2011. An inter-comparison of three urban wind models using the Oklahoma City Joint Urban 2003 wind field measurements. Int. J. Wind Eng. & Indust. Aero., Volume 99, Issue 4, Pages 357-368.

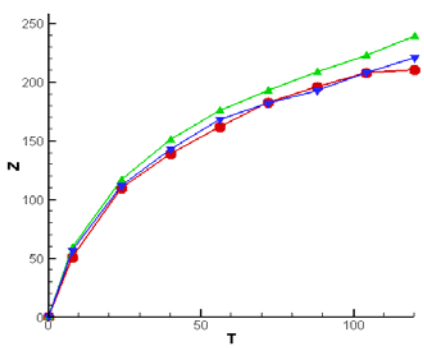


QUIC Model Validation – Particle Deposition

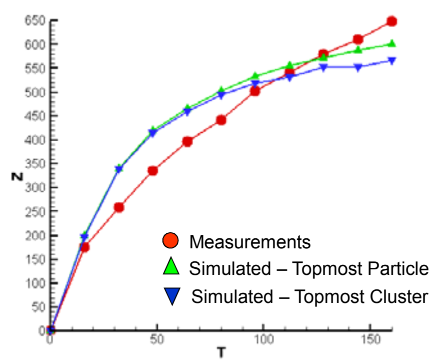


A comparison of the crosswind integrated deposition versus downwind distance measured by Walker (1965) and computed by QUIC for glass spheres of **56 micron** mass median diameter during Trial I.

QUIC Model Validation – Explosive Rise



Doubletracks 48 kg HE Outdoor Expt



Clean Slate 428 kg HE Outdoor Expt

Validation of the QUIC rise scheme using outdoor buoyant rise field experiments. The top of the model-computed buoyant puffs are close to the measurements.

Boughton, B. A. and J. M. DeLaurentis, "An Integral Model of Plume Rise from High Explosive Detonations," SAND-86-2553C.

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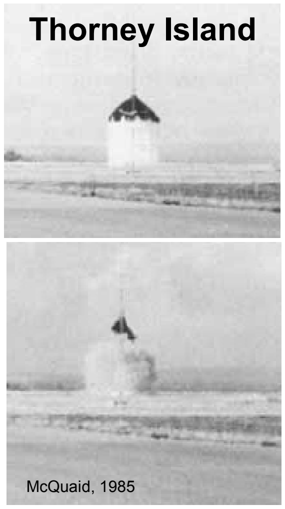
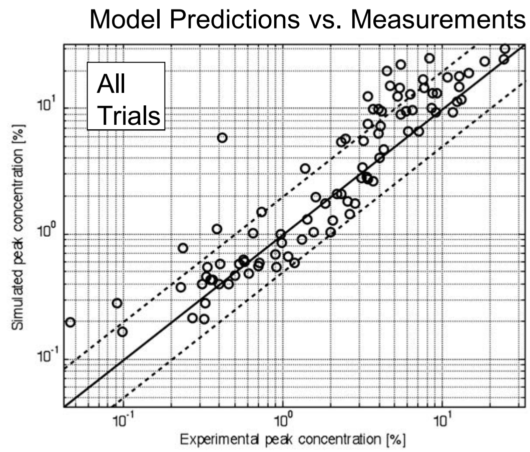
Dense Gas Validation



Heavy gas cloud after dropping the curtain



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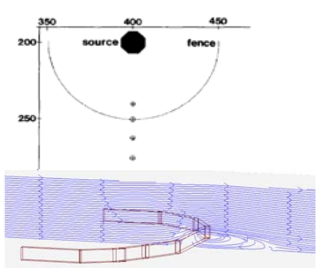
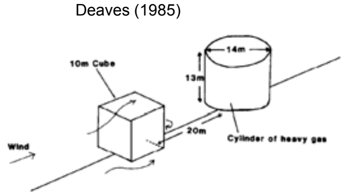
Dense Gas Validation

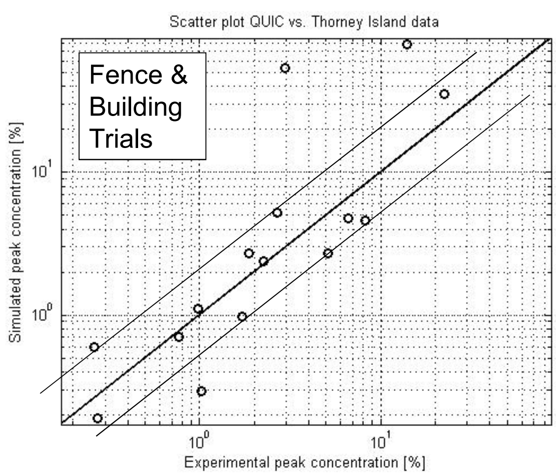
Thorney Island

Knudsen and Krogstad (1987)



Deaves (1985)





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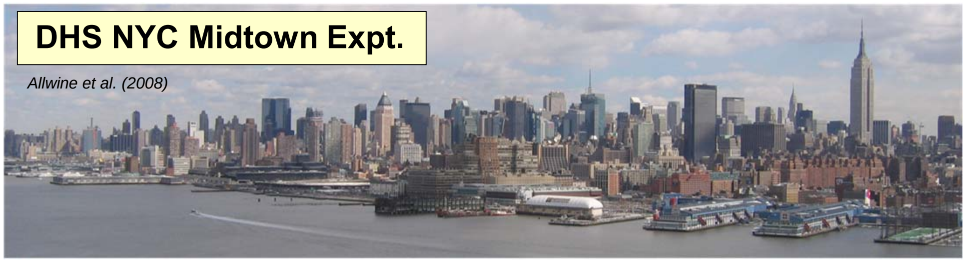
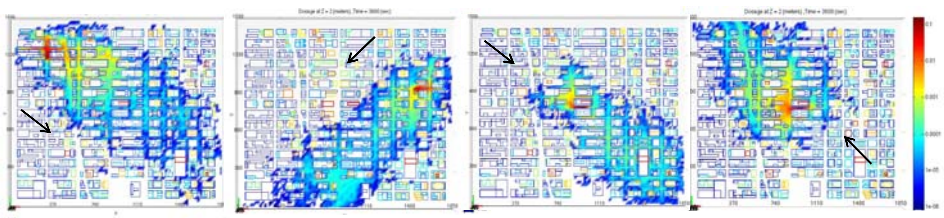
QUIC Evaluation – NYC Midtown Tracer Expt

DHS NYC Midtown Expt.

Allwine et al. (2008)





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QUIC Evaluation – NYC Midtown Tracer Expt

DHS NYC Midtown Expt.

Allwine et al. (2008)

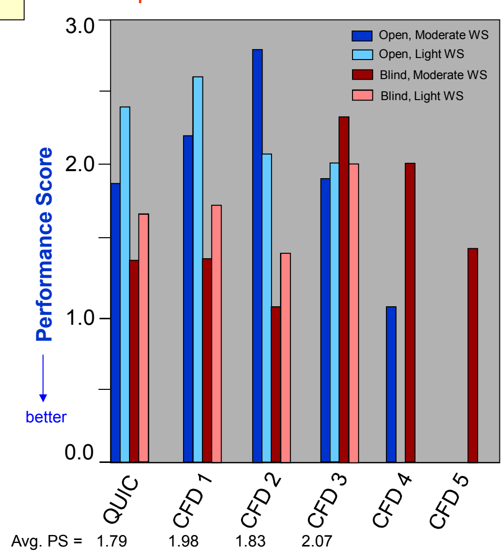
Aggregate performance score (PS) based on:

- Fraction above threshold
- Fraction within factor of 10
- Fractional bias
- Geometric mean
- Root Mean Square Error
- Geometric RMSE

PS = 0 is perfect model

1.1 < PS < 2.8

QUIC performed as well as CFD codes!



Slide 68

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QUIC Evaluation – NYC Midtown Tracer Expt

DHS NYC Midtown Expt.

Allwine et al. (2008)

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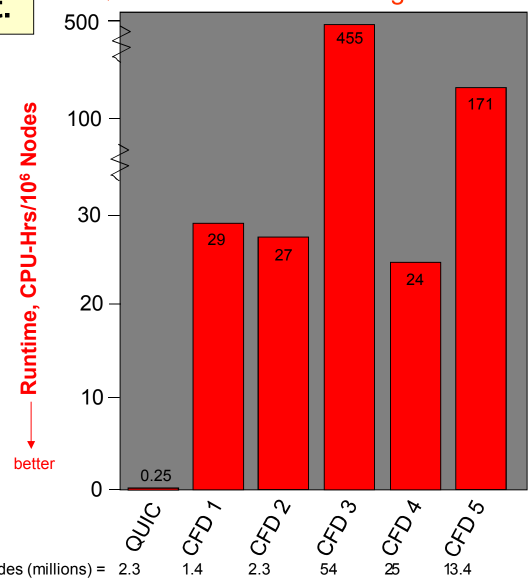
- Fractional bias
- Geometric mean
- Root Mean Square Error
- Geometric RMSE

PS = 0 is perfect model

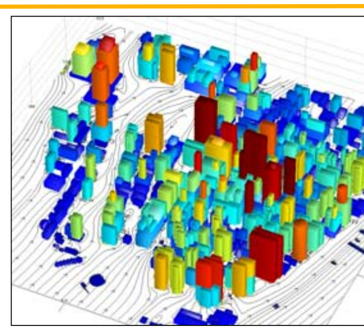
1.1 < PS < 2.8

QUIC was 2 orders of magnitude faster!



QUIC CBR Dispersion Modeling System

- **Fast running code with graphical user interface**
- **Produces 3D winds around buildings using empirical/diagnostic approach**
- **“Urbanized” random-walk plume dispersion model**
- **Algorithms for chemical, biological, and radiological source terms**
- **Infiltration into buildings**
- **In independent urban tracer expt. evaluation studies, has been shown to work as well as CFD codes, but runs hundreds of times faster (Allwine et al, 2008, PNNL).**
- **Used by several hundred groups in the US and around the world**
- **Free for research purposes**



Joint Urban 2003 – Oklahoma City

Joint Urban 2003

Held in downtown OKC

30 min SF6 release

3 release locations

IOP3 – IOP10 = 24 trials

½ day, ½ night

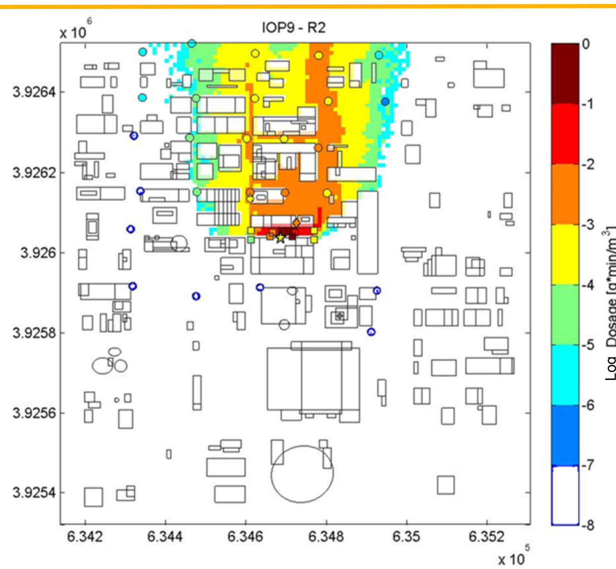
QUIC Model Evaluation – JU03 OKC

Joint Urban 2003

Street-level samplers in central business district

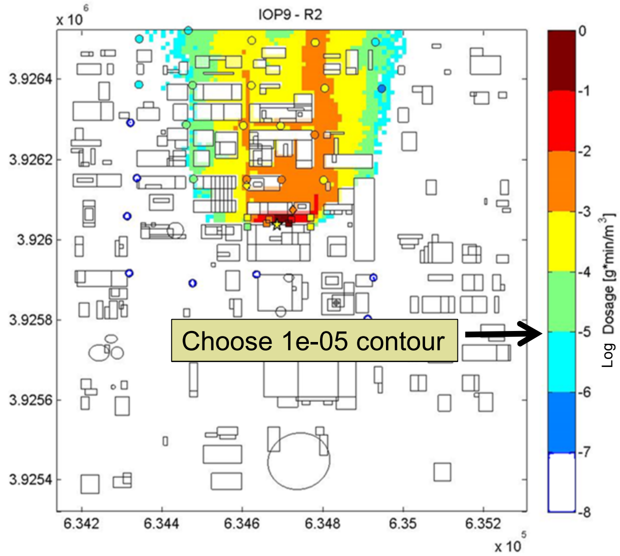
Winds predominately from the south

Wind input from Post Office PWID 15



30 min avg. plume dosage

QUIC Model Evaluation – JU03 OKC



30 min avg. plume dosage

Joint Urban 2003

Street-level samplers in central business district

Winds predominately from the south

Wind input from Post Office PWID 15

QUIC Model Evaluation – JU03 OKC

Measurements

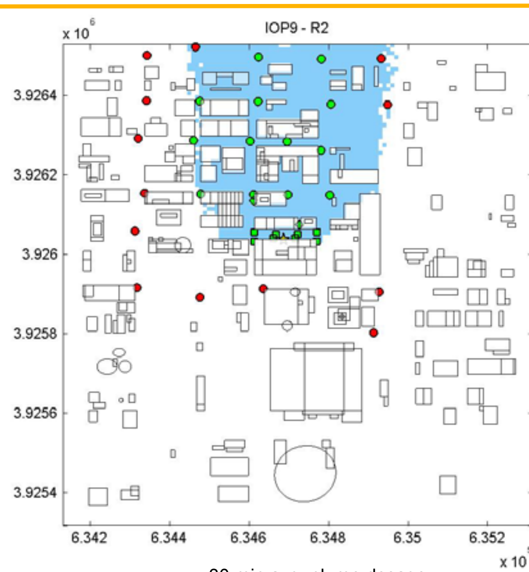
Above threshold

Below threshold

Model Computation

Above threshold

Below threshold



30 min avg. plume dosage

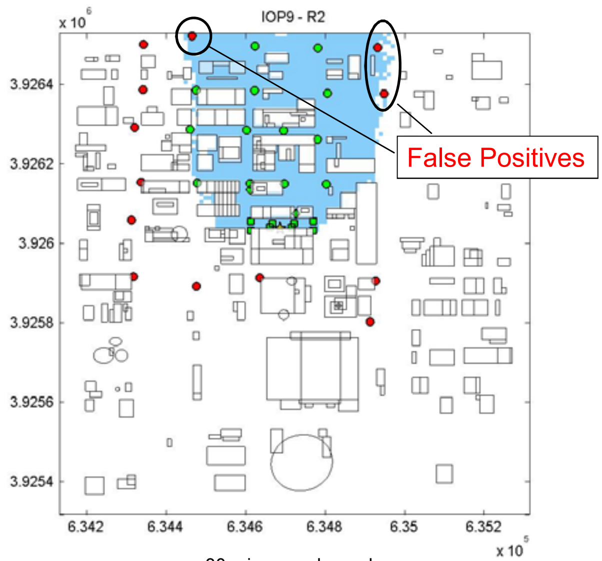
QUIC Model Evaluation – JU03 OKC

Measurements

- Above threshold
- Below threshold

Model Computation

- Above threshold
- Below threshold



30 min avg. plume dosage

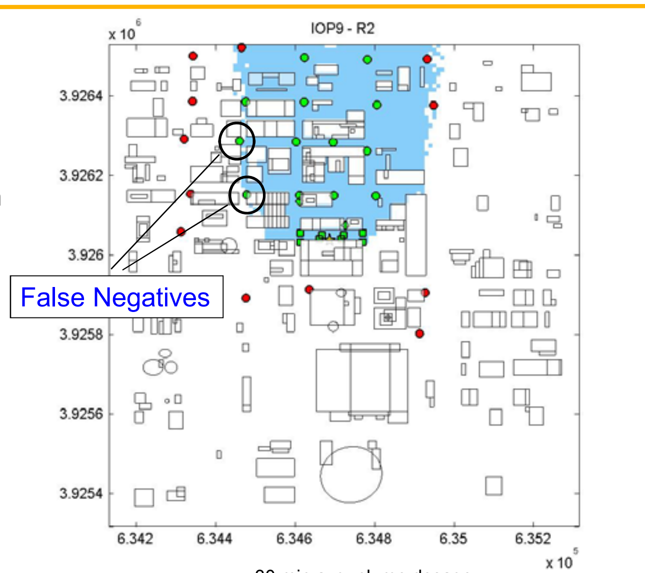
QUIC Model Evaluation – JU03 OKC

Measurements

- Above threshold
- Below threshold

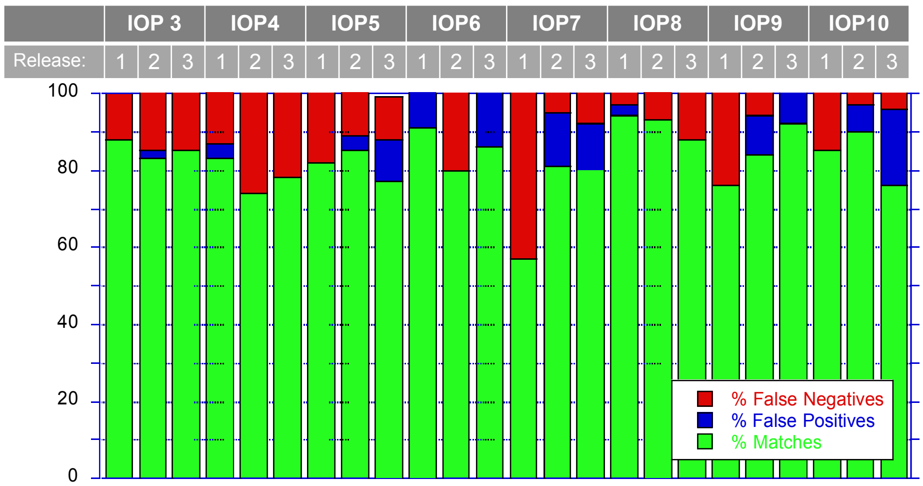
Model Computation

- Above threshold
- Below threshold



30 min avg. plume dosage

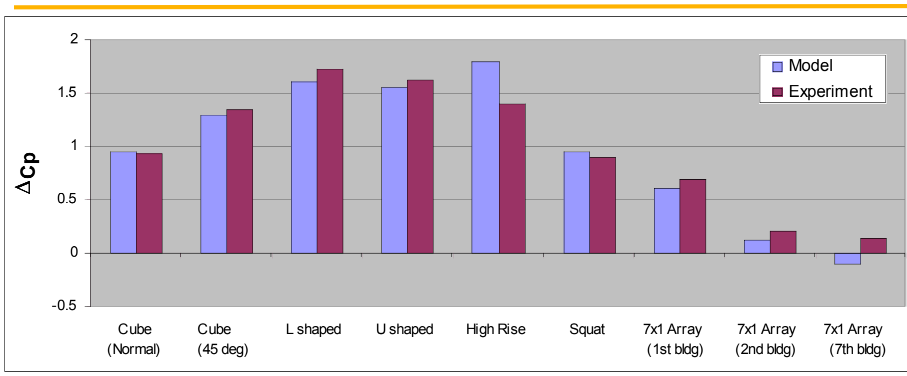
QUIC Model Evaluation – JU03 OKC



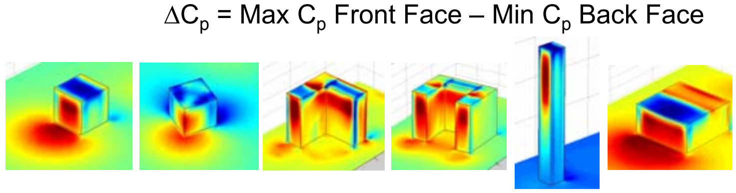
% False Negatives, False Positives, and Plume Hits

30 min avg. plume concentrations

QUIC Model Validation – Pressures



ΔC_p = Max C_p Front Face – Min C_p Back Face



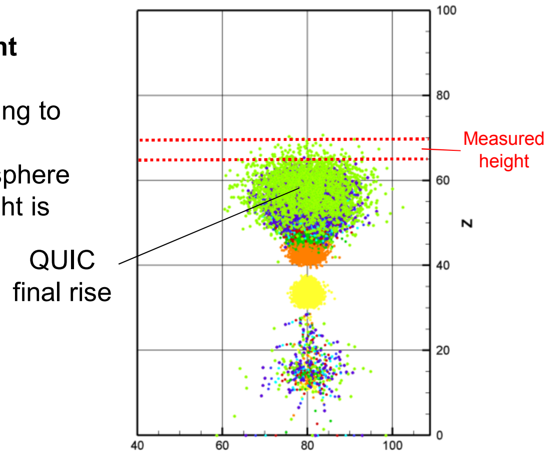
$$C_p = \frac{\overline{P} - \overline{P_o}}{\left(\frac{1}{2}\rho V_o^2\right)}$$

Brown, M., A. Gowardhan, E.R. Pardyjak, 2007: Evaluation of a fast-response pressure solver for a variety of building shapes and layouts, AMS 7th Symp. Urban Env., San Diego, CA, paper 12.6, 4 pp.

QUIC Model Validation – Buoyant Rise

Saltwater Bubble Experiment

A buoyant bubble corresponding to a 1 pound explosion of high explosive in a standard atmosphere lapse rate: the measured height is 65 to 70 meters



Morton et al, 1956: Turbulent gravitational convection from maintained and instantaneous sources, Proceedings of The Royal Society of London, **233,** pp 1-23.

Upwind view

Cloud Rise vs HE mass

Church (1969)

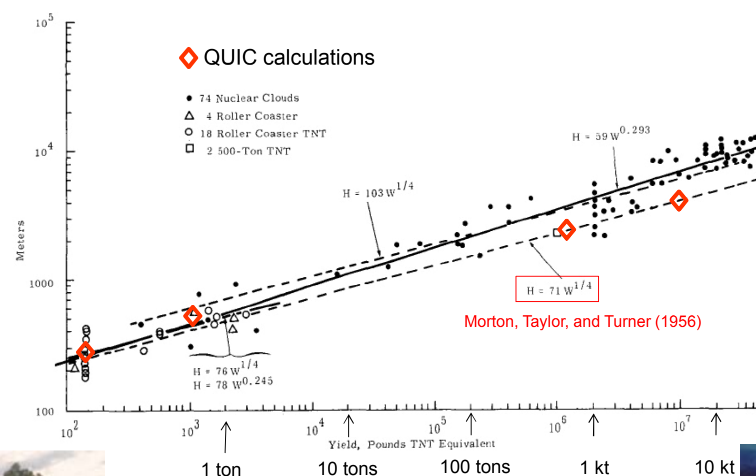
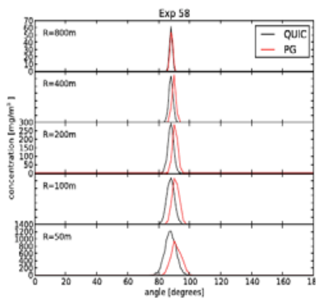


Figure 3. Two-Minute Cloud Top Height Versus Yield

QUIC Model Validation – Project Prairie Grass

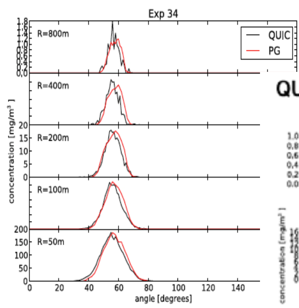
IDA Study
Heagy & Fregeau, 2011

QUIC vs. PG: Stable Case (Nighttime)



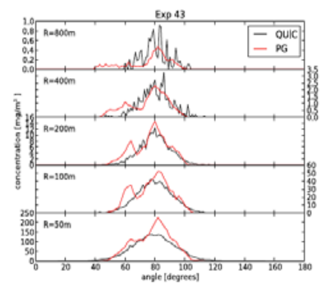
Excellent overall agreement; QUIC slightly overpredicts PG at short range

QUIC vs. PG: Neutral Case



Excellent overall agreement

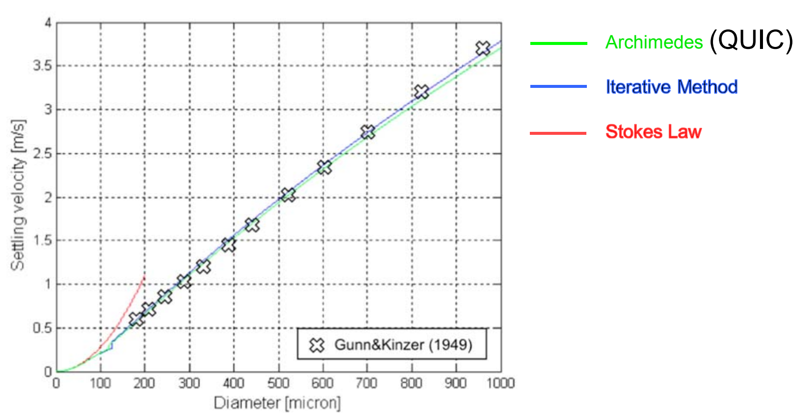
QUIC vs. PG: Unstable Case (Daytime)



Good overall agreement; QUIC appears to underpredict PG at long range

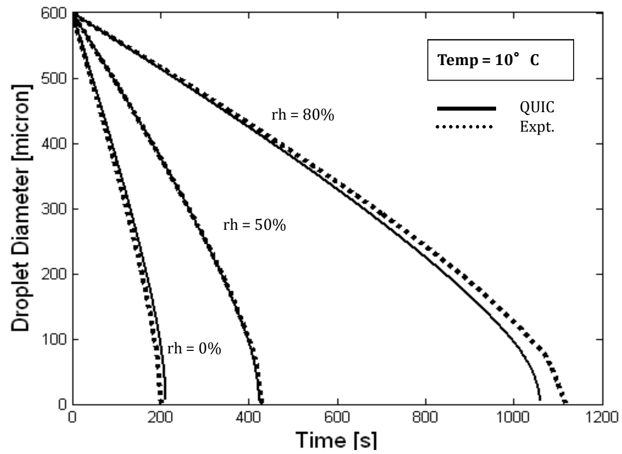
PPG: point source release over flat terrain. C measured on 5 downwind arcs.

Terminal Fall Velocity vs. Diameter



Gunn, R. and G.D. Kinzer, 1949: The terminal velocity of fall for water droplets in stagnant air, J. Meteor., 6: 243-248.

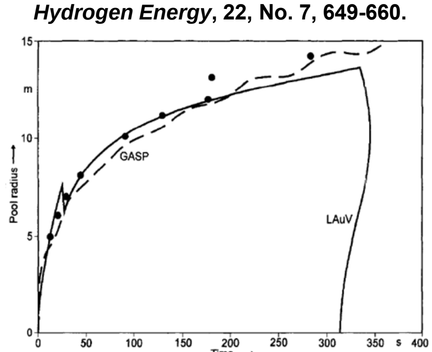
Evaporation of Falling Drops



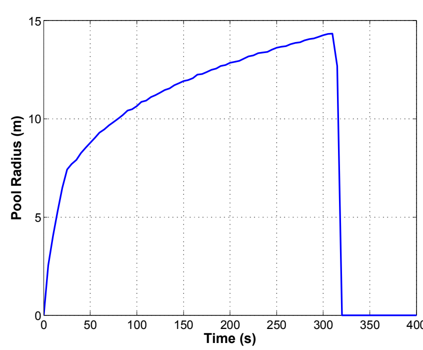
Beard, K. V. and H. R. Pruppacher, 1971: A wind tunnel investigation of the rate of evaporation of small water drops falling at terminal velocity in air, J. Atmos. Sci., 28, 1455-1464.

Liquid Pool Spreading Validation

Verfondern & Dienhart 1997: Experimental and theoretical investigation of liquid hydrogen pool spreading and vaporization. *Int. J. Hydrogen Energy*, 22, No. 7, 649-660.



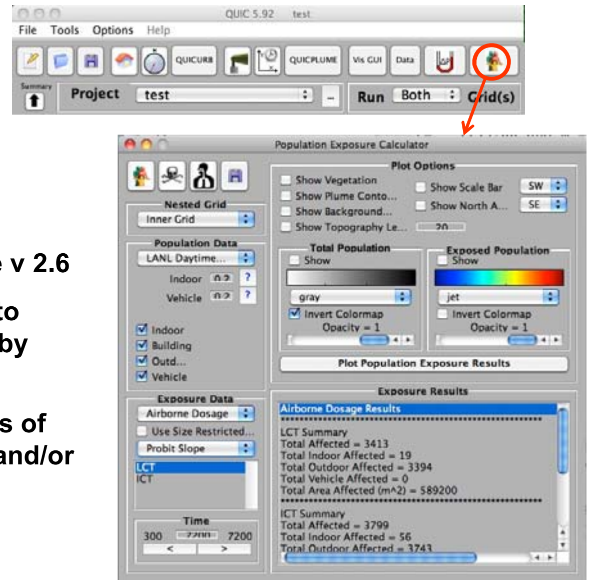
QUIC



12.5 m^3 of LNG released continuously over 300 s on concrete.

Other Unique Features

Population Exposure Calculator



- Uses LANL's Daytime/Nighttime Population Database v 2.6
- Assigns population to individual buildings by building volume
- Calculates the effects of discrete thresholds and/or probit-slope dose-response curves

Exceptional service in the national interest

Sandia National Laboratories

A Comprehensive Decision Support Tool for Agricultural Security

Robert Knowlton, Mark Tucker, Mark Kinnan, Brad Melton, Jim Davies

Sandia National Laboratories

and Lori Miller

Department of Homeland Security

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

1

An outbreak of Foot and Mouth Disease (FMD) in livestock would be devastating

- **Historical outbreaks of livestock diseases have had significant impacts:**
  - In 2001, the UK had an FMD outbreak that resulted in the slaughter of over 4M livestock and caused over $6B in agricultural and food chain losses.
  - An FMD outbreak in Korea in 2010-2011 resulted in the slaughter of over 3M livestock and $2B in financial losses.
  - The occurrence of bovine spongiform encephalopathy (BSE) in a dairy cow in the US in 2003 resulted in over $3B in lost revenue due to export restrictions.
- **Following an FMD outbreak there will be tough decisions:**
  - Should vaccination be considered?
  - Should depopulation occur both in the infected zone and a buffer zone?
  - Several options exist for disposing of carcasses, which option, or options, are best, given time and resource constraints?

2

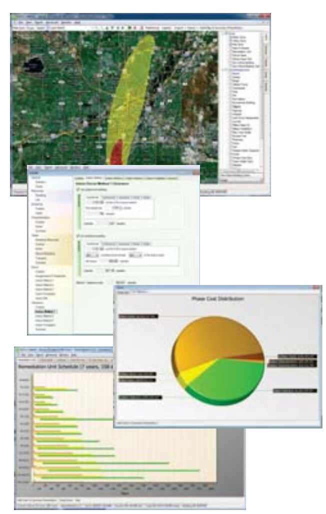
A Comprehensive Decision Support Tool

- A comprehensive decision support tool is needed to address the complex interdependencies associated with options for recovery from an FMD outbreak
- SNL had previously developed a comprehensive tool for restoration and recovery analyses following wide-area chem-bio-rad releases, called:
  - Prioritization Analysis Tool for All-Hazards/Analyzer for Wide-Area Restoration Effectiveness (PATH/AWARE)
- PATH/AWARE was developed with funding from the Department of Homeland Security (DHS) Science and Technology (S&T) Directorate and the Defense Threat Reduction Agency (DTRA)
- PATH/AWARE has been used on several projects to assess recovery costs, timelines, resource allocations, and gaps in needs
- With funding from the DHS Agricultural Defense Branch, a module that addresses agricultural security (AgSec) is being added to PATH/AWARE

3

Key Elements of the PATH/AWARE System

- A built-in Geographical Information System (GIS) that provides geospatial situational awareness
- A database that stores large datasets for critical infrastructure and building information
- Complex algorithms that implement decision rules and interdependencies in order to calculate costs and time based on user inputs for resources and parameters
- A prioritization algorithm that allows the users to weight the measures for critical infrastructure needs resulting in a prioritized list of critical assets to restore



4

AgSec Module Development

- Information on FMD recovery was obtained from a variety of sources, including the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) publication "*Foot-and-Mouth Disease Response Plan - The Red Book*"
- A set of requirements for the software were developed
- A spreadsheet application was developed that implements most of the logic for the tool to aid with the tool development and with code testing
- Reference data (e.g., cost of equipment rental, manpower rates, etc.) from the literature and the web have been documented for inclusion in the spreadsheet application and the AgSec module of PATH/AWARE
- The AgSec module within PATH/AWARE will also have:
  - GIS spatial analysis capability
  - A database of locations for rendering facilities, incinerators, and landfills (largely taken from EPA's iWASTE tool)
  - Report generation

5

Key Components of the AgSec Module

- The modules that have been defined for the tool are:
  - Vaccination
  - Depopulation (including multiple options for euthanizing livestock such as captive bolt, gunshot, and injection)
  - Composting (including carbon source estimation)
  - Rendering (including transportation)

Captive Bolt

Composting

Carcass grinding

6

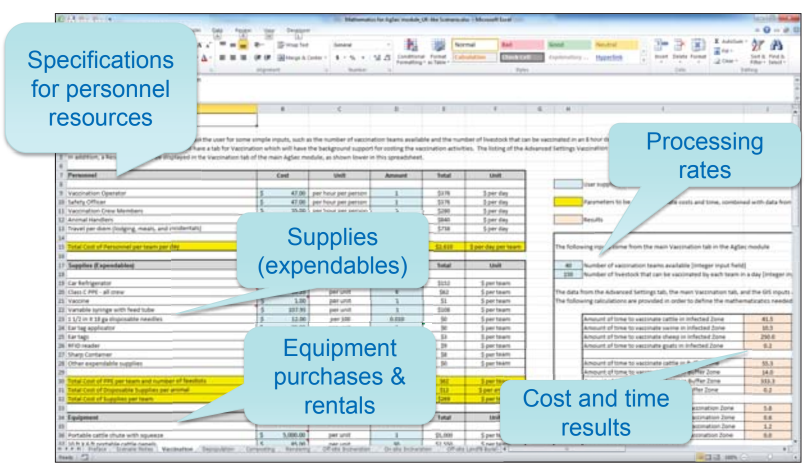
Key Components of the AgSec Module (continued)

- The modules that have been defined for the tool are:
  - Off-site Incineration (including transportation)
  - On-site Incineration (with portable air-curtain incinerators)
  - Off-site landfill burial (including transportation)
  - On-site trench burial
  - Mobile treatment technologies
- In addition, the AgSec module will have a Disposal Decision Tree and check list, as well as a Decision Options Matrix to aid the decision maker

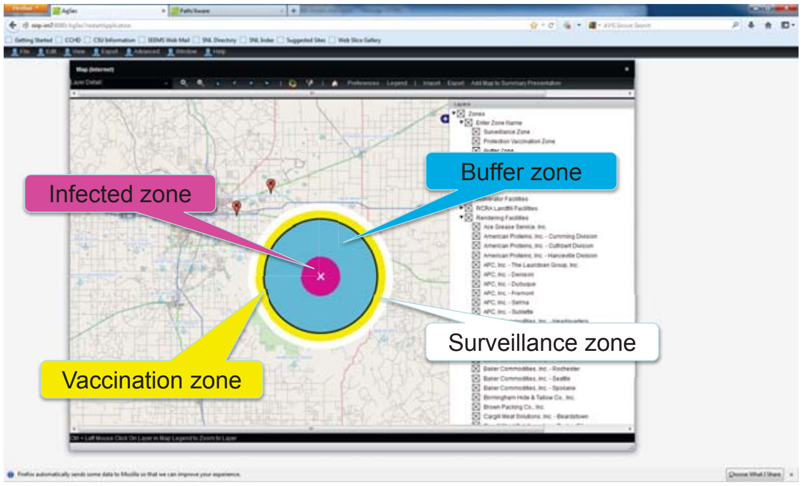
Commercial incinerator

Air curtain incinerator

The Spreadsheet Model

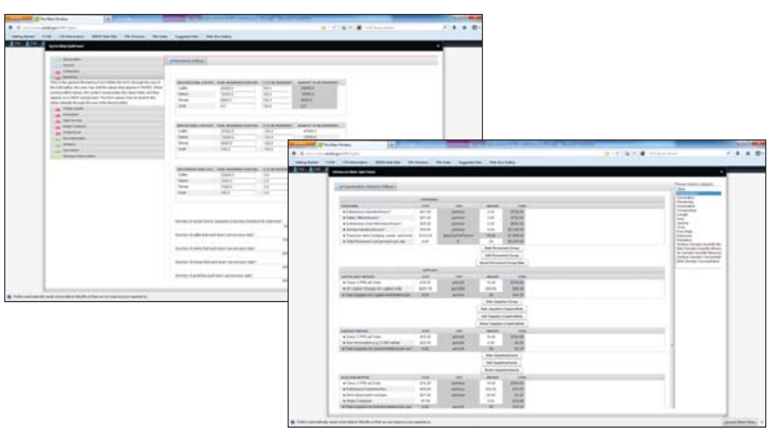


Zone Concepts in AgSec Module



Prototype Software for the AgSec Module

- The AgSec Module has been developed as a web-based software package using mostly freeware for the portal and GIS functionalities
- The software is still under development



Conclusions

- An FMD outbreak would be costly to the nation
- Options for Disinfection, Depopulation, and Disposal (3D) are complicated, so a decision support tool is desired to evaluate alternatives
- The AgSec spreadsheet model provides a basis for estimating costs and time for 3D options, as well as a specification for the coded version of the application
- The prototype AgSec Module for PATH/AWARE will be a useful web-based tool to aid decision makers and to evaluate gaps/needs

11

Pacific Northwest NATIONAL LABORATORY
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Toward Feasible Sampling Plans

EPA International Decontamination Research and Development Conference
Research Triangle Park, NC
5 November 2013

LANDON SEGO, BRENT PULSIPHER

Pacific Northwest National Laboratory
Richland, WA

PNNL-SA-99210

The challenge

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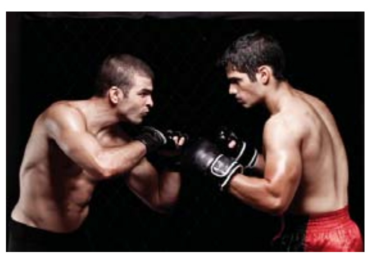
- Sampling is resource intensive!
- Laboratory capacity is a limiting factor
- Costly
- Time intensive
- Taking millions of samples is not feasible

VSP Visual Sample Plan

Strategies for feasible sampling plans

- Judgmental sampling
- Lines of Evidence
- Composite sampling
- Sampling that supports multiple objectives
- Managing risk

Judgmental sampling



Judgmental Probabilistic

- GAO:

  "Probability sampling would have allowed agencies to determine, with some defined level of confidence, when all results are negative, whether a building is contaminated."
- **The need to measure confidence** was the motivation for probabilistic sampling
- However, judgmental samples **can be used** in probabilistic models!

Lines of Evidence

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Sampling Judgmental and/or random	Evidence	Results
+	• Proven effectiveness of decontamination process	
+	• Results from indicators like spore strips • Demonstrated decontamination process control • Qualitative screening measures	
+	• Building material similarities • Spatial proximity to contaminated areas • Contamination transport model results • Observed mortality/sickness spatial patterns • Qualitative/quantitative authoritative measurements (sample results)	

Composite sampling

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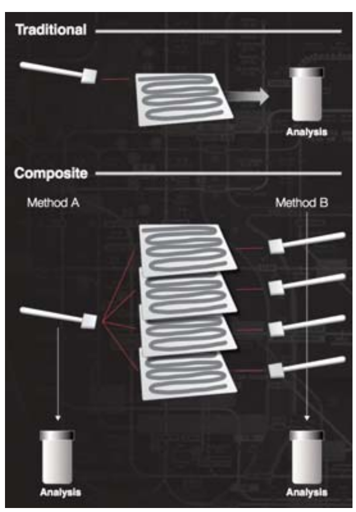
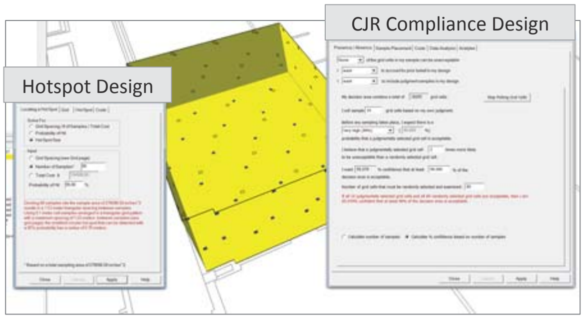


Image courtesy of MIT Lincoln Labs

- Very useful when local spatial resolution is not required
- Can reduce sampling time (less media to handle)
- Can reduce the number of samples to analyze by a factor of 4, 8, 12, or more
- Subway scenario:
  - In a RESTORe simulation by Sandia National Laboratories, we saw a 42% reduction in the cleanup timeline using 4x composites
- Must consider the potential for a “dilution effect”

VSP Visual Sample Plan

Sampling that supports multiple objectives



Population Size: 18,265

Sample footprint: 100 cm^2

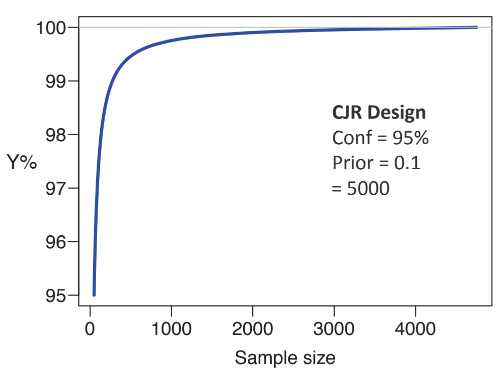
Judgmental samples: 10

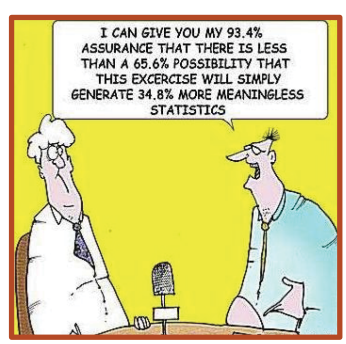
Random Samples: 80

Hotspot	Discovery	Compliance
95% chance of detecting a hotspot with at least 80cm radius if ▪ such a hotspot exists	95% chance of finding contamination if ▪ 2% of area is contaminated ▪ Judgmental sample 8x more likely to find contamination than random sample	95% probability that at least 99% of area is clean, if ▪ o samples are dirty ▪ Prior expectation that 99% of high risk area is clean ▪ High risk cells twice as likely to be contaminated as low risk

Managing risk

- X% / Y% confidence statements
  - "I'm 95% confident that at least 99% of the decision area is acceptable"
- Can we make more risk-based confidence statements?
  - Accounting for health-based exposure levels, likelihood of exposure





Visual Sample Plan

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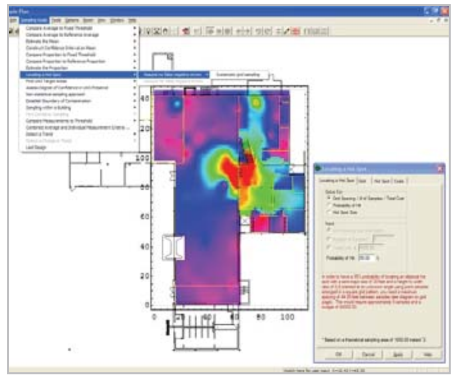
- VSP is systematic planning software for environmental sampling
- VSP helps answer:
  - How many samples do we need?
  - Where should we take samples?
  - What decisions do the data support?
  - What confidence can I have in those decisions?



- **Free VSP Download**:
  vsp.pnnl.gov

VSP Visual Sample Plan

VSP sampling strategies

Pacific Northwest NATIONAL LABORATORY
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Existing capabilities

- **Compliance sampling**
  - Given I've found nothing, what can I say about the rest of the area?
  - Can include judgmental samples
- **Discovery sampling**
  - If contamination is present, I want to find it with high probability
- **Characterization sampling**
  - I want to be assured of detecting a hotspot of a certain shape and size

In development

- **Compliance sampling**
  - Lines of evidence model
  - Account for the effect of false negatives
  - Account for areas with different levels of risk
  - Composite sampling
- **Discovery sampling**
  - Include judgmental sampling
  - Composite sampling

VSP Visual Sample Plan

Acknowledgements

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This work was funded by DHS S&T:

- Randall Long
- Don Bansleban
- Lance Brooks
- Chris Russell

and CDC/NIOSH

Contact Information:

- Landon Sego Landon.Sego@pnnl.gov
- Brent Pulsipher Brent.Pulsipher@pnnl.gov

Come see our DEMO!

VSP
Visual Sample Plan

Decision Support Toolset for Weapons of Mass Destruction (WMD) Crisis Management

Dr. Brooke Pearson on behalf of:

Mr. Ryan Madden

U.S. Department of Defense
Defense Threat Reduction Agency
Joint Science and Technology Office
ryan.madden@dtra.mil

November, 2013

Biological Resiliency Activities

BIOLOGICAL RESILIENCY					
Event Continuous	**Preparedness**	**Response**			**Recovery**
		Pre-incident	**Pan-incident**	**Post-incident**	
Routine public health monitoring Routine environmental monitoring Force protection Established communications	Research verifying best science Trained medical staff and responders Develop plans Conduct exercises Hardened infrastructure Asset and Capability Awareness	Increased exercising of response plans Increased environmental sampling Increased clinical sampling Therapeutic pre-positioning Social distancing	Notification Identify agent Deploy medication Forensic investigation Monitor exposure statistics of affected population Initial characterization	Optimize characterization Prioritize recovery Decontamination Clearance	Reoccupation decisions Long-term public health monitoring Long-term environmental monitoring Renovation

Highlighted activities are informed by the TaCBRD program decision support toolset

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Transatlantic Collaborative Biological Resiliency Demonstration (TaCBRD)

Threat Activity Sensing and Reporting

For wide area contagious biological threats, mitigate morbidity through rapid detection and containment:

- Novel use of environmental indicators
- Correlating threat probability to response actions
- Recommend response actions to prevent or mitigate catastrophic incident

Rapid Response and Recovery

For wide area persistent biological threats, compress the timeline for recovery

- Tools to inform decisions on asset prioritization, sampling/decon strategy, tradeoff analysis
- Whole-of-government and international coordination for capability development
- Recommend response actions to recover from catastrophic incident

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Biological Incident Decision Support

- "TaCBoaRD" is the group of decision support tools developed in this program
- The "TaCBoaRD" portal is accessed online

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TaCBoaRD Toolset

Mapping Portlet

- Supports geospatial data sets from Google, the Open Source Geospatial Foundation (OSGeo), and the Homeland Security Infrastructure Program (HSIP)
- Renders mapping files produced by TaCBoaRD tools
- Consolidates toolset views into common picture for situational awareness
- Incorporates Internet weather streams and GeoRSS feeds

Suite for Automated Global Electronic Surveillance (SAGES)

- Suite of tools for temporal and geospatial surveillance
- Includes disease & syndromic surveillance
- Includes web and desktop tools for:
    - Data collection
    - Analysis and visualization
    - Modeling and simulation
    - Evaluation
    - Communications
- Web portion of the suite ("OpenESSENCE") is used in TaCBRD

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TaCBoaRD Toolset

Threat Probability to Action Tool (TPAT)

- Organize and present bioterrorism and public health information
- Provide situational awareness, event characterization, response options and response guidance
- Assist responders with:
    - Selecting public health and environmental response strategies for the unfolding biological incident
    - Determine what additional information can help improve confidence levels and support better response decisions
    - Reduce downstream consequences for public health, wide-area restoration, and community recovery

Tactical Dynamic Operational Guided Sampling (TacDOGS)

- Predictive, dynamic software application
- Utilizes a physics-based approach to guide sample collection in response to an outdoor wide area biological agent release
- Significantly reduces the time, effort, and costs associated with the collection of numerous samples
- Provides confidence in making informative decisions regarding sampling approaches after a biological attack

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TaCBoaRD Toolset

Prioritization Analysis Tool for all Hazards analyzer (PATH)

- Allows for the rapid identification of key infrastructure likely to be impacted during a WMD event
- Allows users to identify restoration objectives
- Produces a prioritized list of impacted key infrastructure for recovery operations.

Analyzer for Wide Area Restoration Effectiveness (AWARE)

- Allows the user to input one or more WMD contamination scenarios
- User provides input on estimates of resources available to conduct recovery
- The prioritized list derived in the PATH tool (above) is passed to AWARE tool
  - Calculates recovery timelines
  - Estimates the cost of recovery for the key infrastructure list

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TaCBoaRD Toolset

Decontamination Selection Tool (DeconST)

- Provides cost-benefit comparisons of decontamination technology options
- Options provided for specific facilities based on:
  - Facility type
  - Construction
  - Building contents.

Capability Request Tool (CaRT)

- Standardizes foreign consequence management requests for assistance

Web Remote Message Center (Web RMC)

- Web-based version of the message center from the U.S. Joint Warning and Reporting Network (JWARN) program
- Capable of passing standard Nuclear, Biological and Chemical (NBC) and Common Alert Protocol (CAP) messages between organizations
- Capable of passing the results of the U.S. Joint Effects Model (JEM) program for display on a Google Map

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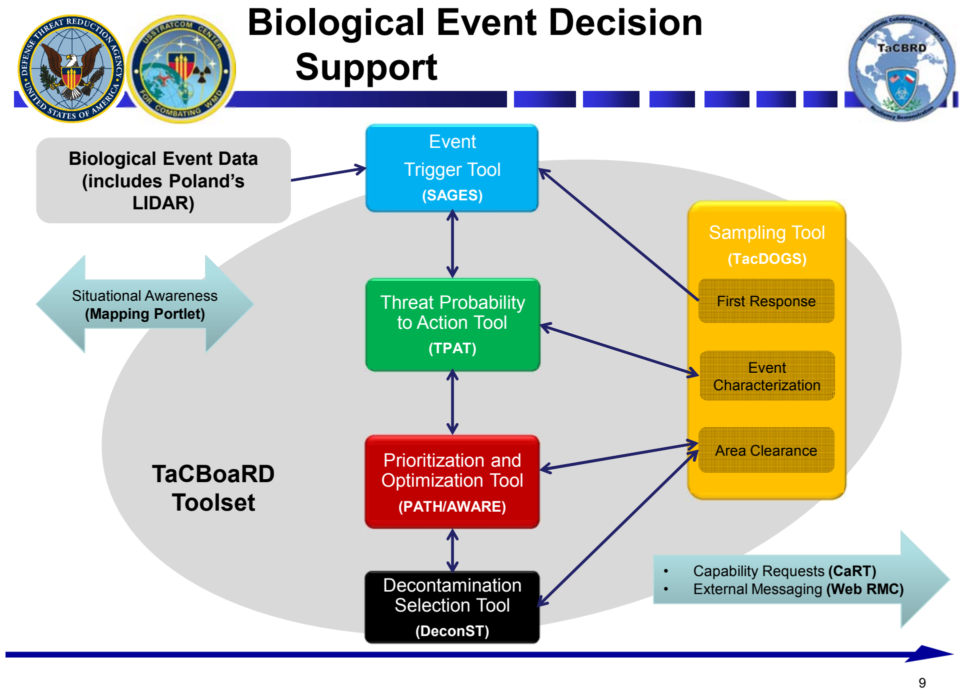
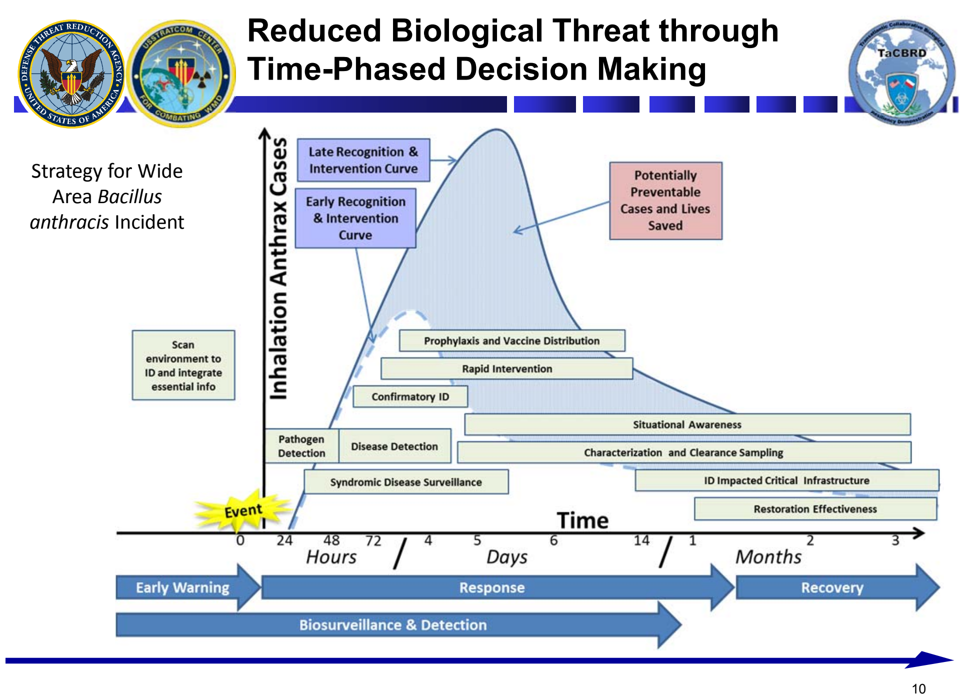

Biological Event Decision Support
TaCBRD
Biological Event Data (includes Poland's LIDAR)
Event Trigger Tool (SAGES)
Situational Awareness (Mapping Portlet)
Threat Probability to Action Tool (TPAT)
Sampling Tool (TacDOGS)
First Response
Event Characterization
Area Clearance
TaCBoaRD Toolset
Prioritization and Optimization Tool (PATH/AWARE)
Decontamination Selection Tool (DeconST)
Capability Requests (CaRT)
External Messaging (Web RMC)
9


Reduced Biological Threat through Time-Phased Decision Making
TaCBRD
Strategy for Wide Area *Bacillus anthracis* Incident
Inhalation Anthrax Cases
Late Recognition & Intervention Curve
Early Recognition & Intervention Curve
Potentially Preventable Cases and Lives Saved
Scan environment to ID and integrate essential info
Prophylaxis and Vaccine Distribution
Rapid Intervention
Confirmatory ID
Situational Awareness
Pathogen Detection
Disease Detection
Characterization and Clearance Sampling
Syndromic Disease Surveillance
ID Impacted Critical Infrastructure
Restoration Effectiveness
Event
Time
0 24 48 72 4 5 6 14 1 2 3
Hours
Days
Months
Early Warning
Response
Recovery
Biosurveillance & Detection
10

Questions?

Toolset Development Team:

Ryan Madden
TaCBRD Program Manager
Defense Threat Reduction Agency (DTRA)
Ryan.Madden@dtra.mil

William Ginley
TaCBRD Technical Manager
U.S. Army Edgewood Chemical Biological Center (ECBC)
William.J.Ginley6.civ@us.army.mil

Joe Fagan
TaCBRD Operational Manager
U.S. European Command (EUCOM)
Joe.E.Fagan.civ@mail.mil

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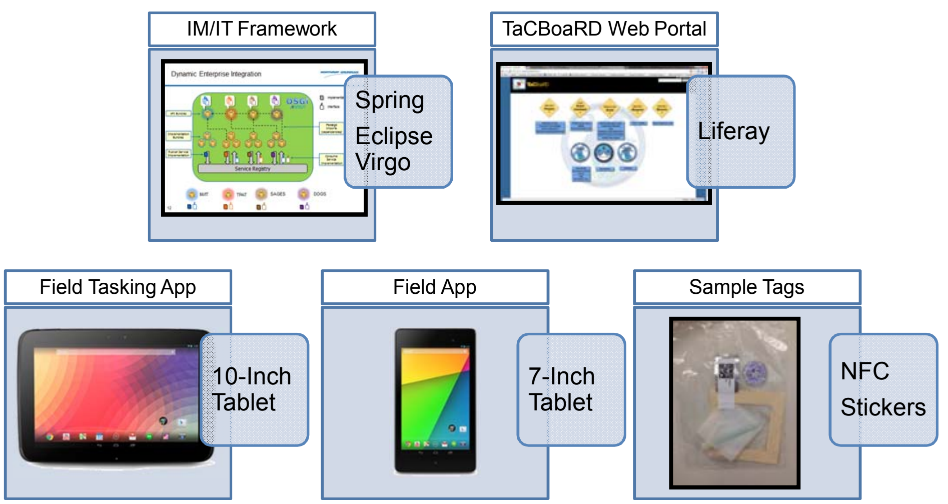
Tactical Dynamic Operational Guided Sampling Tool (TacDOGS)

Daniel Dutrow, Scott Stanchfield, Suma Subbarao, Phillip Koshute, Sean Kinahan and Alex Proescher

2013 U.S. EPA International Decontamination Research and Development Conference: Decision Support Tool Session (11/5/2013)

JOHNS HOPKINS UNIVERSITY
Applied Physics Laboratory

System Architecture



TacDOGS Overall CONOPS/Storyboard

Step 1: JTF/IC Identifies Sampling Region and Response Assets

Step 2: JTF/IC Assigns Response Assets to Localized Areas

Step 3: Response Team Commander sends R&S Team to Assess Area

Step 4: Response Team Commander Constructs Sampling Plan

Step 5: Provide Response Team with "Best Practices" for each Sampling Location

Step 6: Response Team Executes Plan

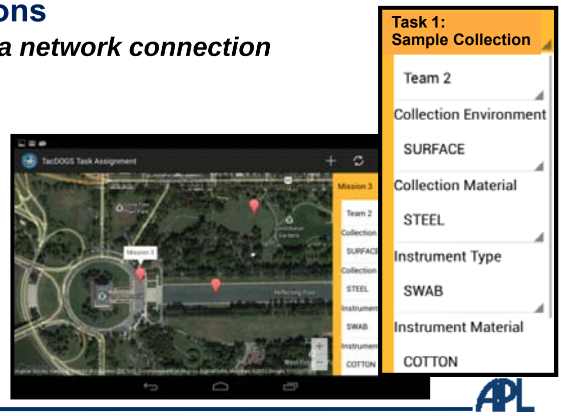
Step 7: Analyze Sample Results with Quality Value

Capabilities under development

- ***Web Portlets***
  - Asset Registration, Asset Coordination, Sampling Research
- ***Sampling Efficiency Derivation***
  - From published research → efficiency of instrument vs. surface
- ***Algorithms***
  - Assign assets to missions based on known capabilities
- ***Best Practices***
  - Given the task → suggest how best to accomplish objective
- ***Field Tasking App***
  - Identify sampling locations
- ***Field Sample Collection App***
  - Collect sampling data, record to NFC tag attached to bag

Field Tasking Application

- **Coordinate and assign a variety of tasks to specific locations**
  - *Sampling locations, points of interest*
  - *Pre-survey to record photos and notes about the locations*
- **Robust communications**
  - *Transfers data through a network connection or NFC "taps" or tags*
- **Configurable**
  - *Currently configured for outdoor biological samples*
- **Current work**
  - *Map layer import*
  - *On screen sketching*



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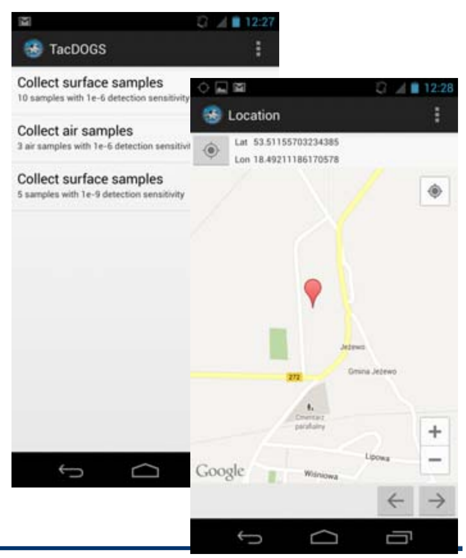
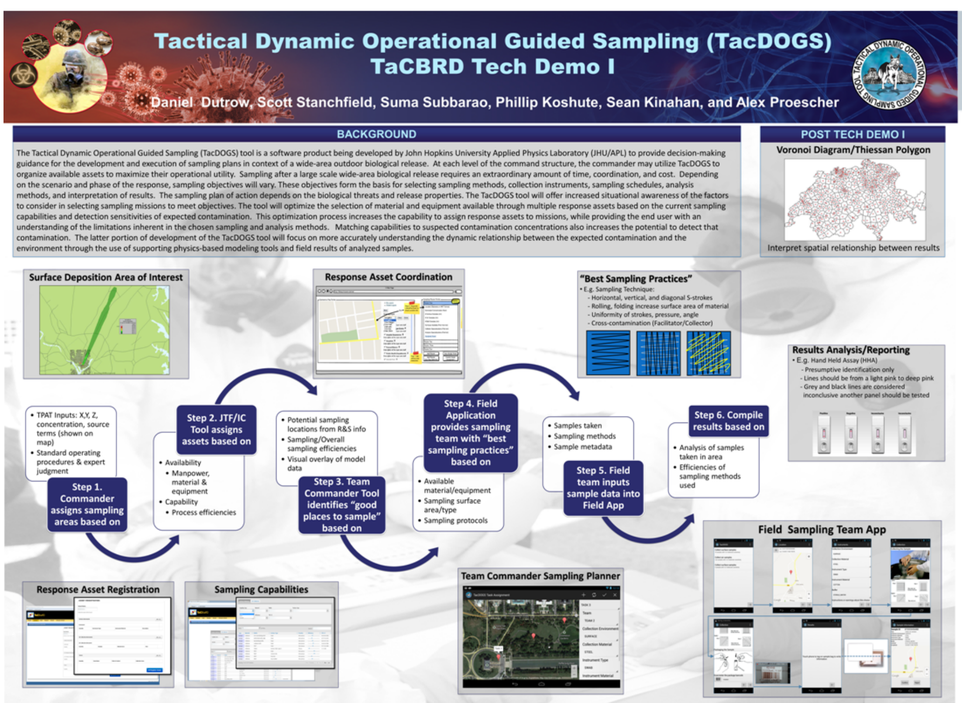
Field Sample Collection Application

- **Field Apps**
  - *Capture and track information about what, when, where, and how samples were collected*
  - *Sample collection data tracking*
    - ➢ Transferred to server
    - ➢ Transferred to NFC tag
  - *May input field analysis data (presumptive field results)*



6 11/20/2013

Questions?


Tactical Dynamic Operational Guided Sampling (TacDOGS)
TaCBRD Tech Demo I
Daniel Dutrow, Scott Stanchfield, Suma Subbarao, Phillip Koshute, Sean Kinahan, and Alex Proescher
BACKGROUND
The Tactical Dynamic Operational Guided Sampling (TacDOGS) tool is a software product being developed by John Hopkins University Applied Physics Laboratory (JHU/APL) to provide decision-making guidance for the development and execution of sampling plans in context of a wide-area outdoor biological release. At each level of the command structure, the commander may utilize TacDOGS to organize available assets to maximize their operational utility. Sampling after a large scale wide-area biological release requires an extraordinary amount of time, coordination, and cost. Depending on the scenario and phase of the response, sampling objectives will vary. These objectives form the basis for selecting sampling methods, collection instruments, sampling schedules, analysis methods, and interpretation of results. The sampling plan of action depends on the biological threats and release properties. The TacDOGS tool will offer increased situational awareness of the factors to consider in selecting sampling missions to meet objectives. The tool will optimize the selection of material and equipment available through multiple response assets based on the current sampling capabilities and detection sensitivities of expected contamination. This optimization process increases the capability to assign response assets to missions, while providing the end user with an understanding of the limitations inherent in the chosen sampling and analysis methods. Matching capabilities to suspected contamination concentrations also increases the potential to detect that contamination. The latter portion of development of the TacDOGS tool will focus on more accurately understanding the dynamic relationship between the expected contamination and the environment through the use of supporting physics-based modeling tools and field results of analyzed samples.
POST TECH DEMO I
Voronoi Diagram/Thiessan Polygon
Interpret spatial relationship between results
Surface Deposition Area of Interest
Response Asset Coordination
"Best Sampling Practices"
• E.g. Sampling Technique:
- Horizontal, vertical, and diagonal S-strokes
- Rolling, folding increase surface area of material
- Uniformity of strokes, pressure, angle
- Cross-contamination (Facilitator/Collector)
Results Analysis/Reporting
• E.g. Hand Held Assay (HHA)
- Presumptive identification only
- Lines should be from a light pink to deep pink
- Grey and black lines are considered inconclusive another panel should be tested
• TPAT Inputs: X,Y, Z, concentration, source terms (shown on map)
• Standard operating procedures & expert judgment
Step 1. Commander assigns sampling areas based on
Step 2. JTF/IC Tool assigns assets based on
• Availability
• Manpower, material & equipment
• Capability
• Process efficiencies
• Potential sampling locations from R&S info
• Sampling/Overall sampling efficiencies
• Visual overlay of model data
Step 3. Team Commander Tool identifies "good places to sample" based on
Step 4. Field Application provides sampling team with "best sampling practices" based on
• Available material/equipment
• Sampling surface area/type
• Sampling protocols
• Samples taken
• Sampling methods
• Sample metadata
Step 5. Field team inputs sample data into Field App
Step 6. Compile results based on
• Analysis of samples taken in area
• Efficiencies of sampling methods used
Field Sampling Team App
Response Asset Registration
Sampling Capabilities
Team Commander Sampling Planner

Decontamination Strategy and Technology Selection Tool (DeconST)

Donna Edwards, Tim Sa, Stephen Mueller,
Paula Krauter (retired), Julie Fruetel,
Lynn Yang, Mark Tucker
Sandia National Laboratories

Shawn Ryan, Paul Lemieux,
Leroy Mickelsen, Mario Ierardi
U.S. Environmental Protection Agency

2013 U.S. Environmental Protection Agency (EPA)
International Decontamination Research and Development Conference
November 5-7, 2013

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Sandia National Laboratories

SAND#2013-9452C

Motivation: Decontamination of a complex facility requires many considerations

- **Potential decontamination methods**
  - environmental conditions
  - application requirements
  - site-specific inputs
- **Cleaning and removal of potentially contaminated items or material**
  - off-site treatment
  - source reduction
  - waste management

…**all with associated costs and benefits**

Problem is exacerbated in wide-area incident with potentially hundreds to thousands of contaminated facilities and limited availability of resources.

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DeconST: a Decision-Support Tool for Single-Facility Remediation

- **Features**
  - Facility-specific, effective remediation approaches
  - Comparison of decontamination technologies for the facility
  - Flexible, data-rich framework

RESULTS SUMMARY	Decontamination Technologies					
	Volumetric Decontamination			Surface Decontamination		
	Chlorine Dioxide Gas	Methyl Bromide	Vaporous Hydrogen Peroxide®	Aqueous Chlorine Dioxide	Bleach Immersion	Hydrogen Peroxide PAA, Oxonia Active
% of Materials Decontaminated	90%	90%	10%	0%	90%	100%
Total Cost, $M	$5.6	$5.0	$5.6	$8.3	$8.3	$8.2
Material Removal/Replacement Time (person hours)	66,500	53,500	71,200	86,900	86,700	84,000
Total Waste Generated (tons)	300	200	300	400	400	400

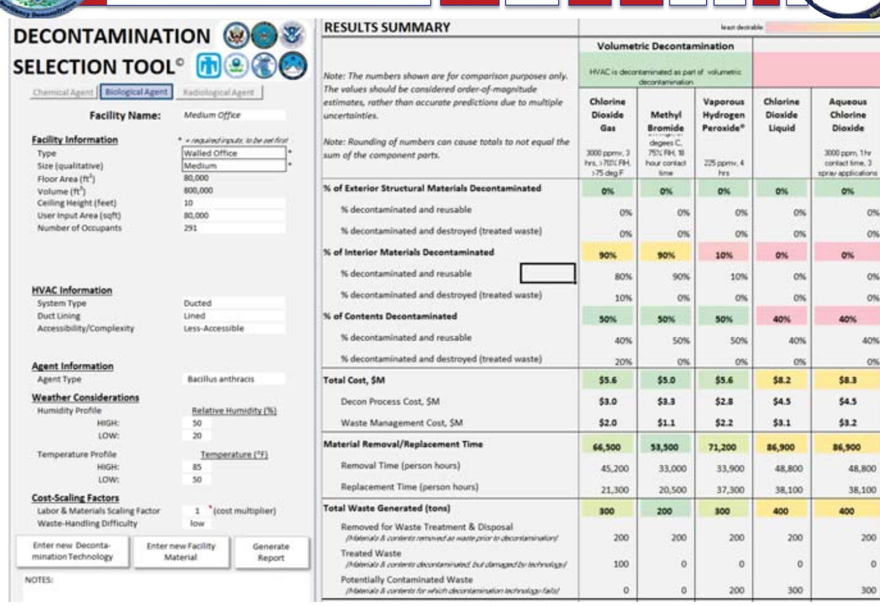
least desirable: :most desirable

- **Intended User**
  - Technical Working Group (TWG) functioning under a Unified Command (UC) providing recommendations to the Incident Commander (IC) remediating a facility

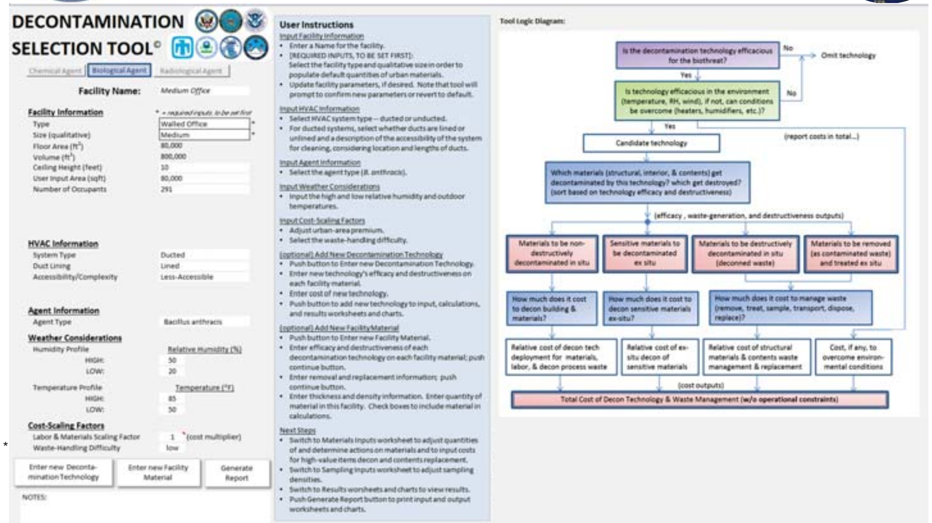
3

Source: WARRP Decontamination Strategy and Technology Selection Tool: User Manual and Report

Tool Overview



User Input: Facility Information



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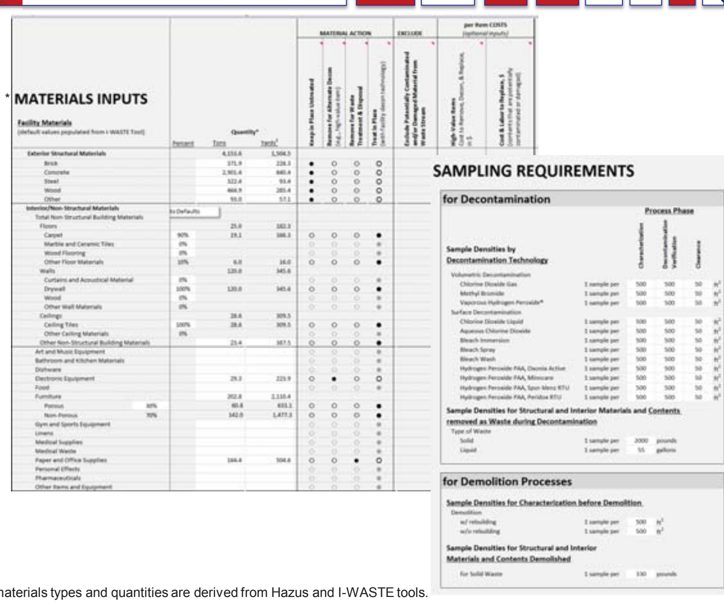
*Note: The EPA's BOTE experiment is the source for the concept of "waste handling difficulty."

User Input: Materials & Sampling Information



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*Facility-specific materials types and quantities are derived from Hazus and I-WASTE tools.

Results Summary

RESULTS SUMMARY	least desirable — most desirable						
	Volumetric Decontamination			Surface Decontamination			
	HVAC is decontaminated as part of volumetric decontamination			HVAC will be very difficult to access and decontaminate			
Note: The numbers shown are for comparison purposes only. The values should be considered order-of-magnitude estimates, rather than accurate predictions due to multiple uncertainties. *Note: Rounding of numbers can cause totals to not equal the sum of the component parts.*	**Chlorine Dioxide Gas** 3000 ppmv, 3 hrs, >70% RH, >75 deg F	**Methyl Bromide** 211 mg/L, 37 degrees C, 75% RH, 18 hour contact time	**Vaporous Hydrogen Peroxide®** 225 ppmv, 4 hrs	**Chlorine Dioxide Liquid**	**Aqueous Chlorine Dioxide** 3000 ppm, 1 hr contact time, 3 spray applications	**Bleach Immersion** Bleach: Dilute to 0.6% NaOCl by weight. Add acetic acid to pH (6.8). Immersion 30-min. STS neutralized then extracted	**Bleach Spray** Bleach: Dilute to 0.6% NaOCl by weight. Add acetic acid to pH (6.8). Spray 60-min contact. STS neutralized at end of contact time
% of Exterior Structural Materials Decontaminated	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
% decontaminated and reusable	0%	0%	0%	0%	0%	0%	0%
% decontaminated and destroyed (treated waste)	0%	0%	0%	0%	0%	0%	0%
% of Interior Materials Decontaminated	**90%**	**90%**	**10%**	**0%**	**0%**	**90%**	**90%**
% decontaminated and reusable	80%	90%	10%	0%	0%	0%	0%
% decontaminated and destroyed (treated waste)	10%	0%	0%	0%	0%	90%	90%
% of Contents Decontaminated	**50%**	**50%**	**50%**	**40%**	**40%**	**40%**	**40%**
% decontaminated and reusable	40%	50%	50%	40%	40%	40%	40%
% decontaminated and destroyed (treated waste)	20%	0%	0%	0%	0%	0%	0%
Total Cost, $M	**$5.6**	**$5.0**	**$5.6**	**$8.2**	**$8.3**	**$8.3**	**$8.3**
Decon Process Cost, $M	$3.0	$3.3	$2.8	$4.5	$4.5	$4.5	$4.5
Waste Management Cost, $M	$2.0	$1.1	$2.2	$3.1	$3.2	$3.2	$3.2
Material Removal/Replacement Time	**66,500**	**53,500**	**71,200**	**86,900**	**86,900**	**86,700**	**86,700**
Removal Time (person hours)	45,200	33,000	33,900	48,800	48,800	48,700	48,700
Replacement Time (person hours)	21,300	20,500	37,300	38,100	38,100	38,100	38,100
Total Waste Generated (tons)	**300**	**200**	**300**	**400**	**400**	**400**	**400**
Removed for Waste Treatment & Disposal *(Materials & contents removed as waste prior to decontamination)*	200	200	200	200	200	200	200
Treated Waste *(Materials & contents decontaminated but damaged by technology)*	100	0	0	0	0	200	200
Potentially Contaminated Waste *(Materials & contents for which decontamination technology fails)*	0	0	200	300	300	100	100

7

Results Summary

RESULTS SUMMARY	least desirable — most desirable						
	Volumetric Decontamination			Surface Decontamination			
	HVAC is decontaminated as part of volumetric decontamination			HVAC will be very difficult to access and decontaminate			
Note: The numbers shown are for comparison purposes only. The values should be considered order-of-magnitude estimates, rather than accurate predictions due to multiple uncertainties. *Note: Rounding of numbers can cause totals to not equal the sum of the component parts.*	**Chlorine Dioxide Gas**	**Methyl Bromide**	**Vaporous Hydrogen Peroxide®**	**Chlorine Dioxide Liquid**	**Aqueous Chlorine Dioxide**	**Bleach Immersion**	**Bleach Spray** Bleach: Dilute to 0.6% NaOCl by weight. Add acetic acid to pH (6.8). Spray 60-min contact. STS neutralized at end of contact time
% of Exterior Structural Materials Decontamina						**0%**	**0%**
% decontaminated and reusable						0%	0%
% decontaminated and destroyed (treated						0%	0%
% of Interior Materials Decontaminated						**90%**	**90%**
% decontaminated and reusable						0%	0%
% decontaminated and destroyed (treated						90%	90%
% of Contents Decontaminated						**40%**	**40%**
% decontaminated and reusable						40%	40%
% decontaminated and destroyed (treated						0%	0%
Total Cost, $M						**$8.3**	**$8.3**
Decon Process Cost, $M	$3.0	$3.3	$2.8	$4.5	$4.5	$4.5	$4.5
Waste Management Cost, $M	$2.0	$1.1	$2.2	$3.1	$3.2	$3.2	$3.2
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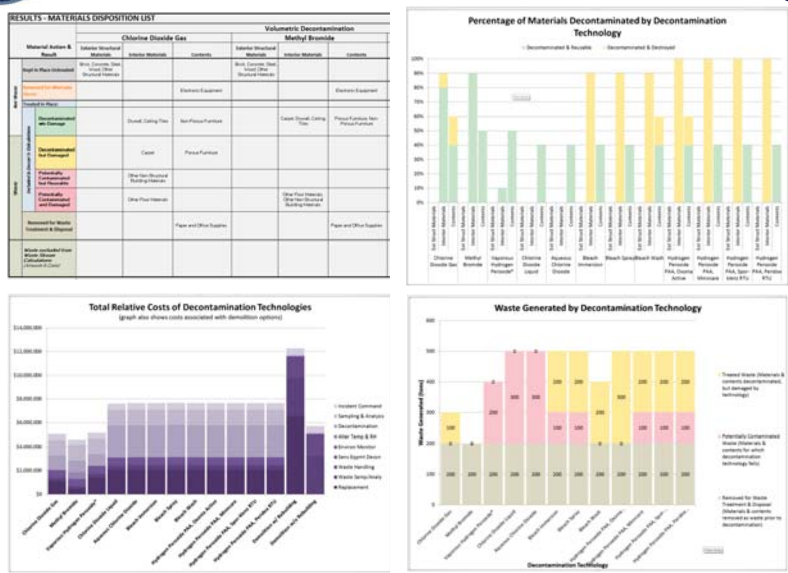
Total Waste Generated (tons)	**300**	**200**	**300**	**400**	**400**	**400**	**400**
Removed for Waste Treatment & Disposal *(Materials & contents removed as waste prior to decontamination)*	200	200	200	200	200	200	200
Treated Waste *(Materials & contents decontaminated but damaged by technology)*	100	0	0	0	0	200	200
Potentially Contaminated Waste *(Materials & contents for which decontamination technology fails)*	0	0	200	300	300	100	100

Caveat: Numbers are intended for comparison purposes rather than indicators of actual costs!

8

Output Screens



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DeconST: Impact

- **EPA's On-Scene Commander "BioGuide"**
  - Incorporated into Decontamination Technologies Chapter
- **DoD/DTRA's Transatlantic Collaborative Biological Resiliency Demonstration (TaCBRD)**
  - Demonstrated at Technical Demonstration 1
  - Integration into TaCBoaRD tool

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Contact Information

Donna Edwards

edwards@sandia.gov

925-294-2253

Carcass Management Decision Support Tools

ꕤ ꕤ

Brooke Pearson, Wayne Einfeld, Stacey Tyler, and Emilie Hill

FMD

- UK 2001
  - From February through Octobers 2001, there were 2,000 cases of the disease. Over 10 million sheep and cattle were killed
- Korea 2011
  - From late November 2010 through mid-April 2011, an estimated 3.5 million pigs and cattle in South Korea were killed




Blizzard of October 2013

- Up to 4ft of snow fell during storms in Northern Nebraska and southern South Dakota
- Animals suffocated as the snow built up, others suffered from hypothermia, fell off rocky ledges or were hit by vehicles as they wandered on to roads
- Killed between 15,000 and 30,000 head of cattle in South Dakota, and ~1,000 in Nebraska

Disposal

- UK – burning, landfill, rendering and mass burial
  - Burial: A total of seven sites were used. In total, some 1.3 million carcasses (about 20% of the total 6 million) were disposed in mass burial sites
  - Rendering: only 15,000 tons per week capacity
  - Landfill: 69,000 tons in Cumbria, but there were concerns about spread of BSE
- Korea - mass burial
  - Approximately 3.48 million animals (151,425 cattle, 3,318,299 pigs, 8,071 goats, and 2,728 deer) were buried at 4,583 burial sites
- South Dakota – mass burial
  - Two giant pits dug in the eastern part of Pennington County, SD and ranchers are being encouraged to bring carcasses to them for disposal.
- Nebraska - landfill
  - The Solid Waste Agency of Northwest Nebraska was granted a permit by the Nebraska Department of Environmental Quality to operate an Emergency Carcass Disposal Area at a landfill.

4

How can we aid in determining the disposal option for the scenario?

- What is the best option?
- What materials do I need?
- What training do I need?
- What permits do I need?
- How much land do I need?
- How long will it take?
- How much will it cost?

5

Disposal Matrix

	Onsite Composting	Rendering	Permitted Landfill	Regional Composting Facility*	Fixed Incineration	Open Burning	Unlined Burial	Mobile Technologies**
Public health risk (1)	3	3	3	3	3	2	1	?
Need to transport carcasses offsite (2)	3	1	1	1	1	3	3	3
Byproducts (3)	3	3	2	3	3	1	1	?
Biosecurity (4)	2	3	2	2	2	1	1	?
Pathogen inactivation (5)	3	3	1	3	3	2	1	?
Cost effectiveness (6)	3	2	3	3	1	1	3	?
Environmentally sustainable (7)	3	3	2	3	2	1	1	?
Volume reduction (8)	2	3	2	2	3	3	2	?
Capacity (9)	2	2	3	2	1	2	3	1
Throughput (10)	2	3	3	2	1	2	2	1
Availability (11)	2	2	3	2	1	3	1	1
Speed to implement (12)	2	2	3	2	2	1	1	?
Public acceptance (13)	3	2	3	3	2	1	1	?
Efficiency (14)	2	3	2	2	2	1	2	?
Operability (15)	2	2	2	2	2	2	3	1
Total Points	37	37	35	35	29	26	26	7
Average Score	2.5	2.5	2.3	2.3	1.9	1.7	1.7	1.4

Scores for each measure were added up and then assigned and average score

nt

- Started with Draft FAD PReP SOP for Disposal matrix in
- Reviewed by interagency 3D IPT and revised
- This is a subjective scoring system based on the expert opinions of subject matter experts
- Is a one-size fits all scenarios view

Color Key

- Ideal
- Not Ideal
- Not Suitable

6

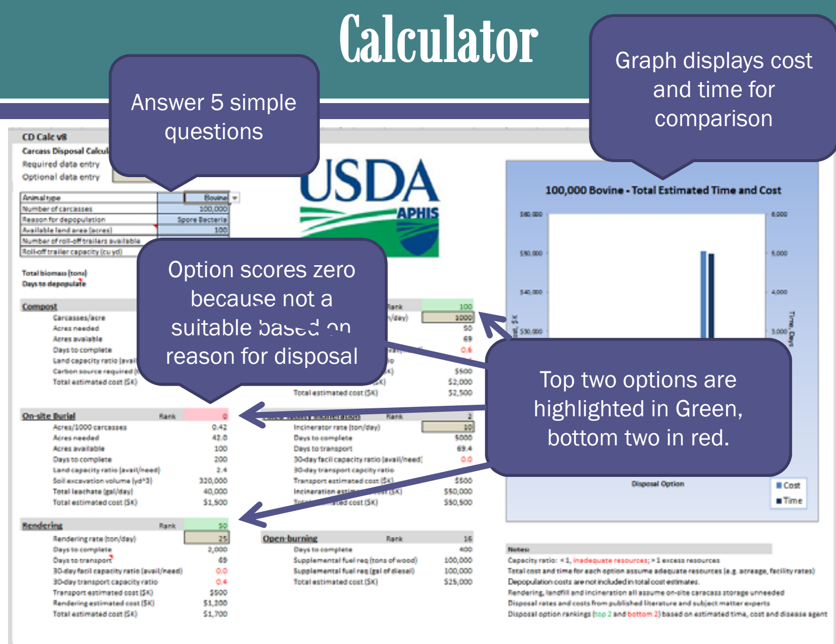
Agent Based Disposal Matrix

Disposal Option	Virus	Prion	Bacteria	Spore Bacteria	Chem[a]	Rad[b]
Unlined Burial	Possible[1]	Possible[2]	Possible[3]	Possible[4]	No[5]	No[6]
Engr. Landfill	Yes[7]	Yes[8]	Yes[9]	Possible[10]	Possible[11]	Possible[12]
Incineration	Yes[13]	Yes[14]	Yes[15]	Possible[16]	Possible[17]	Possible[18]
Open burn	Possible[19]	No[20]	Possible[21]	Possible[22]	No[23]	No[24]
Rendering	Yes[25]	Possible[26]	Yes[27]	Yes[28]	No[29]	No[30]
Compost	Yes[31]	No[32]	Yes[33]	No[34]	No[35]	Possible[36]

- Built a new matrix based upon the suitability of the disposal option and the reason for disposal
- Justification based on experimental evidence and regulations
- Primary literature and reports cited

7

Calculator



8

Tool Calculates:

Compost	Rank	0
	Carcasses/acre	230
	Acres needed	434.8
	Acres avaiable	100
	Days to complete	400
	Land capacity ratio (avail/need)	0.2
	Carbon source required (tons)	150,000
	Total estimated cost ($K)	$3,750

On-site Burial	Rank	0
	Acres/1000 carcasses	0.42
	Acres needed	42.0
	Acres available	100
	Days to complete	200
	Land capacity ratio (avail/need)	2.4
	Soil excavation volume (yd^3)	320,000
	Total leachate (gal/day)	40,000
	Total estimated cost ($K)	$1,500

Rendering	Rank	50
	Rendering rate (ton/day)	25
	Days to complete	2,000
	Days to transport	69
	30-day facil capacity ratio (avail/need)	0.0
	30-day transport capacity ratio	0.4
	Transport estimated cost ($K)	$500
	Rendering estimated cost ($K)	$1,200
	Total estimated cost ($K)	$1,700

Engineered Landfill	Rank	100
	Landfill acceptance rate (ton/day)	1000
	Days to complete	50
	Days to transport	69
	30-day facil capacity ratio (avail/need)	0.6
	30-day transport capcity ratio	0.4
	Transport estimated cost ($K)	$500
	Landfill estimated cost ($K)	$2,000
	Total estimated cost ($K)	$2,500

Fixed-facility Incineration	Rank	2
	Incinerator rate (ton/day)	10
	Days to complete	5000
	Days to transport	69.4
	30-day facil capacity ratio (avail/need)	0.0
	30-day transport capcity ratio	0.4
	Transport estimated cost ($K)	$500
	Incineration estimated cost ($K)	$50,000
	Total estimated cost ($K)	$50,500

Open-burning	Rank	16
	Days to complete	400
	Supplemental fuel req (tons of wood)	100,000
	Supplemental fuel req (gal of diesel)	100,000
	Total estimated cost ($K)	$25,000

- The time to depopulate
- The resource capacity ratio (e.g., adequacy of land and transport)
- The estimated time to complete disposal
- The estimated cost for the entire disposal operation

The results of these calculations allow users to quickly narrow the number of suitable disposal options.

9

Checklist and Training


Carcass Management Options Checklist

First Option - Can Animal be used for its intended purpose?

Second Option - Can off-site permitted landfill be used?

Checklists for suitability

On-line training for more planning information

10

Questions?

The epidemic health control officer gave us a few guidelines. “No one can leave here until after all the work is done and the sterilizing truck has come and disinfected everyone. We will begin the live burial of bigger pigs first, and then move on to the smaller pigs.” Even the mayor, who had to volunteer like the rest of us due to lack of personnel, had to follow these orders.

— Yoon Hu-Duk, a politician who is also a volunteer with his local disease-prevention authority in Paju—a city at the northern border of South Korea commenting on Korea’s FMD disposal activities

11

WASTE ESTIMATION SUPPORT TOOL: AN OVERVIEW, UPDATES, AND DEMONSTRATION

Tim Boe
Oak Ridge Institute for Science and Education

Paul Lemieux
US EPA, Office of Research and Development

Colin Hayes
Eastern Research Group

2013 EPA International Decontamination Research and Development Conference RTP, NC November 5-7, 2013

EPA United States Environmental Protection Agency

EPA United States Environmental Protection Agency

Purpose

- **GIS-based tool that can assist in planning/preparedness activities**
  - Radiological incident waste management issues linked with decontamination and restoration timeline
  - Waste management decisions need to be made early
- **Waste Estimation Support Tool (WEST) Facilitates**
  - First-order estimate of waste quantity and activity
  - Pre-selection of waste management options
  - ID of potential triage/staging/temporary storage areas
  - Assessment of impact of decontamination/waste management strategies on waste generation and vice-versa
  - Identify starting points for policy discussions

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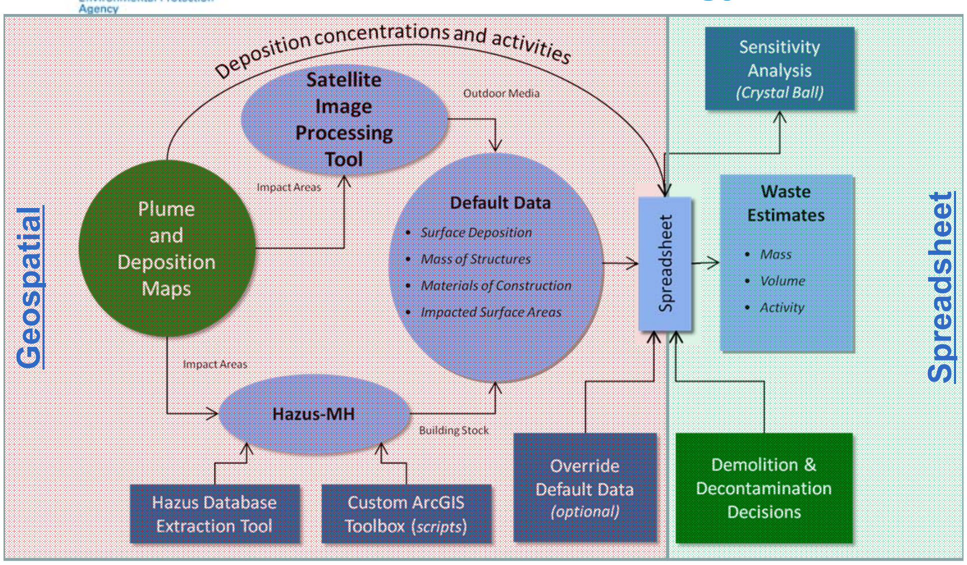
Conceptual Methodology



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Potential Scope of Problem

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Wide Area Recovery and Resiliency Program (Denver Metro Area)

Adjustable Parameters

- **Demolition/decontamination decisions**
  - –Default % for all buildings within each zone
  - –Custom based on 28 user-specific occupancy types (e.g., single family homes, industrial buildings, etc.)
- **Distribution of decontamination technologies**
  - –Washing
  - –Abrasive removal
  - –Strippable coatings
  - –2 user-defined decontamination technologies
  - –"No decontamination" option

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Example Results

	Zone 1		Zone 2		Zone 3		Total	
	Mass	Volume	Mass	Volume	Mass	Volume	Mass	Volume
Media	MT	m^3	MT	m^3	MT	m^3	MT	m^3
Ground Materials and Trees	21,000	9,700	226,000	107,000	543,000	267,000	790,000	383,000
Building Demolition	67,000	28,000	83,000	34,000	142,000	59,000	292,000	121,000
Building Decontamination	900	300	85,000	37,000	72,000	33,000	159,000	71,000
Wastewater (L)		5.3E+07		1.5E+10		2.8E+10		4.2E+10

Results from Liberty RadEx National Level Exercise Scenario

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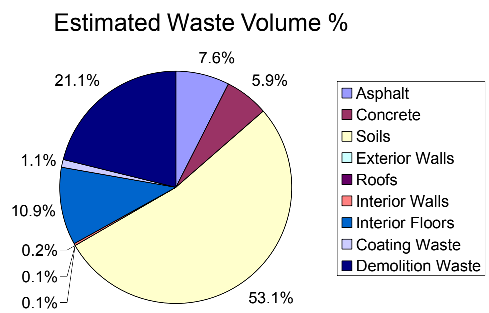
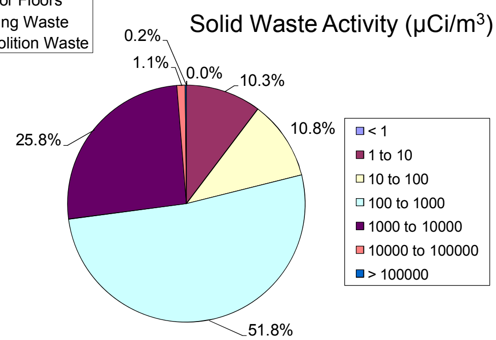
Example Results





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Implications Identified by the Tool

- **Highlights benefit of considering waste when selecting decontamination options**
- **Identify resource constraints (e.g., wash water)**
- **Help refine decontamination strategy based on infrastructure, time, & radionuclide activity**
- **Advantages of on-site treatment to reduce waste**
  - Soil is prime candidate for on-site treatment and waste minimization activities
- **Identifies starting point for policy discussions**
  - Use of conventional or hazardous waste landfills for minimally-contaminated materials
  - Use of low-level radioactive waste disposal capacity for materials contaminated at higher levels

Updates

- Version 2.0 (Oct. 2013)
  - ArcGIS 10.x support
  - Significant automation of data processing steps
  - Building occupancy-specific decontamination/demolition
  - Support for multi-state scenarios
- Version 2.1 (Feb. 2014)
  - Generate reports
  - Detailed user guide

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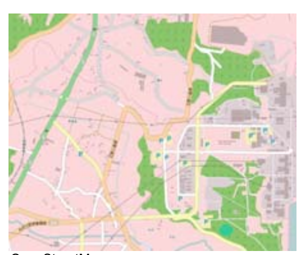
The Future?

- Import building stock (Shapefile or OpenStreetMap)
- Support for OCONUS
- Essential facilities (IC)
- Building contents (I-WASTE)
- Estimate biomass/vehicles (USDA)
- Cost & logistical support
- Plot results in GIS
- All-hazard support (chem/bio)
- EPA GeoPlatform support


Shapefile


OpenStreetMap

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Thank You

- **Contact Info:**

Tim Boe
boe.timothy@epa.gov
919-541-2482

Paul Lemieux
lemieux.paul@epa.gov
919-541-0962

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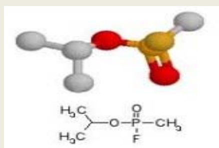
Waste Management Planning Application

OFFICE OF RESOURCE CONSERVATION AND RECOVERY (ORCR)

HOMELAND SECURITY PROGRAM

NOV. 5, 2013



Molecular Structure of Sarin

BACKGROUND

1

Based on experience from meetings, conferences, exercises and actual incidents, the following became clear:

- Waste management (WM) issues have a major impact during a homeland security (HS) incident response
- Visibility of WM issues during a HS incident is increasing
- Pre–Incident WM Planning can significantly ease decision making during response
- WM Planning often overlooked
  - Lack of resources (staff, funding, time)
  - Lack of guidance
  - Lack of awareness of impacts
  - Perception of low urgency

Requests for assistance to aid plan development from state and local officials

Goal:

2

To encourage state and local emergency planners to develop pre-incident plans to address waste management during large scale HS incidents.

In order to achieve this goal, ORCR, with input from other EPA Offices and Regions, has initiated the development of an online application (intended to be similar to "turbotax"), to assist them in developing these plans.

This application would integrate materials which are being developed as part of an overall "toolbox", along with self-contained information (CD, possible Smartphone/tablet app) usable on site/during incident.

Development Status

3

To date, the EPA has:

- Identified the recommended contents for a typical pre-incident waste management plan for HS incidents, and developed suggestions, considerations, and resources that would form the basis of the future application
- Hosted two focus group meetings to present the application concept and solicit input from state planners in R3 & R5
  - Feedback from participants used to revise the ORCR guidance, and refine application concept
- Begun identifying information technology (IT) requirements for the application, and is currently discussing funding options. *

Focus Group Meetings Summary

4

- Participants supportive of application concept
- Recommended an “All Hazards” approach
- Provided examples of plans for similar, past incidents
- Provided suggestions for additional resources for various parts of the tool
- Requested the application provide additional guidance/information on certain issues, such as carcass disposal.
- Noted significant differences between level of experience and degree of planning of participating States. Recommended flexibility to accommodate differences
- Stressed importance of integration with other related tools (such as IWASTE) and adherence to existing EPA data standards
- Mentioned importance of coordination with Federal Emergency Management Agency (FEMA) (and with U.S. Army Corps of Engineers (COE) and US Coast Guard (USCG) to lesser extent)
- Emphasized value of users’ ability to share information with each other

Summary of Primary IT Requirements for Application

5

Must Have:

- User web accessibility
- Commonly and commercially available format
- Scalability—add new fields , new relationship and new data user can access (i.e. ,“guidance” or “considerations)”
- Security: password protected
- Ability for user to:
- - save data on server or offline, for use in more than one login session
- - move sequentially from field to field
- - enter information either into text box AND/OR drop down menu(s) – combinable
- Ability to create “wizards” to aid user in entering data
- Allowance for importation of data from other databases (such as IWASTE) into one or more fields
- Ability to move through fields sequentially or dynamically
- Allowance for external links

Ideally Have:

- Ability to:
- - create and work with mobile apps
- - choose to share final product with other users
- - have multiple simultaneous users
- Capability to store large quantity of data

Nice Extras:

- Ability to incorporate video into wizards (or other information provided to user)

Contact Information

6

For additional information, please contact:

Anna Tschursin
e-mail: tschursin.anna@epa.gov
Telephone: 703-308-8805

Waste Characterization Branch
Materials Recovery and Waste Management Division (MC-5304P)
Office of Resource Conservation and Recovery, USEPA
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

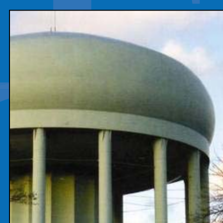
Wednesday, November 6, 2013

General Session 3

Risk Communication and Systems Approach

Anticipating the Public's Questions during a Water Emergency

Cynthia Yund, PhD
Scott Minamyer



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Decontamination Conference
November 6, 2013

Acknowledgements

- City of Chicago Department of Water Management
- City of San Diego Public Utilities Department
- Charlotte-Mecklenburg Utilities
- Massachusetts Water Resources Authority
- Public Participants
- Association of Metropolitan Water Agencies/WaterISAC
- Oak Ridge Institute for Science and Education (ORISE)
  - Dick Tardif
  - Kelli Martin
  - Mark Herring (Mark Herring Associates)

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Risk Communication

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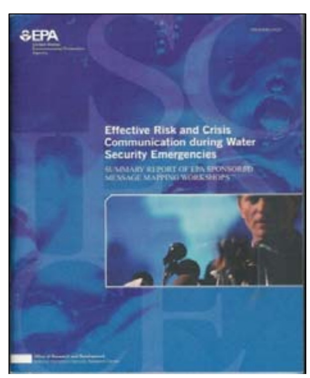
Objectives

- Critical information needs of public during water emergency
- Differences in perceptions



- Support crisis communication planning

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Research Methods

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Professional Sessions

- Contamination scenario
  - –Unfit for use/cause unknown
    Intentional act/terrorist attack
- Questions the public would want answered

"If you can keep the…public informed…

you can help the public manage the situation."

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Public Sessions

“

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Professional and Public Differences

- Professional
  - –Medical care
  - –Fire protection
  - –Business uses

- Public
  - –Time
  - –Personal safety
  - –Obtaining “safe” water

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Reactions

- “Attack” and “terrorism” negative connotations
- Supply protection

“anger…panic…will there be others?”

“You didn’t figure this out until enough people got sick?”

Beliefs

- Point of attack source water (e.g., reservoir, river)
- Contamination will spread throughout the system

Distribution Systems

- Complexity
- Isolate portions of the system
- Alternative sources of water
- Limitations

Professional: “The public takes most of this for granted.”

Public: “I don’t know if I believe it could be that isolated.”

Biological vs. Chemical

- Bacterium are alive
- Remediation more difficult
- Pesticides less alarming
  - Ingested
  - Used in homes

"Big difference…we eat pesticides."

"A biological agent will grow rather than be diluted."

"[Biological agent] automatic…sick, gut-wrenching feeling"

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"Safe" Water

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Conclusions

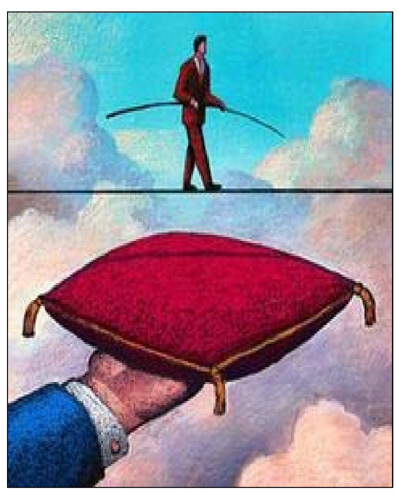
- Construct
- Capacity
- Collaborate
- Communicate

Professional: "The health information must come from health officials."

Public: "I'd have to have someone come out, open the faucet, and drink it."

Draft Messages

- Preference for
  - –Directives
  - –Short concise sentences
  - –Protective actions
  - –Results rather than process
  - –Sense of time/predictability



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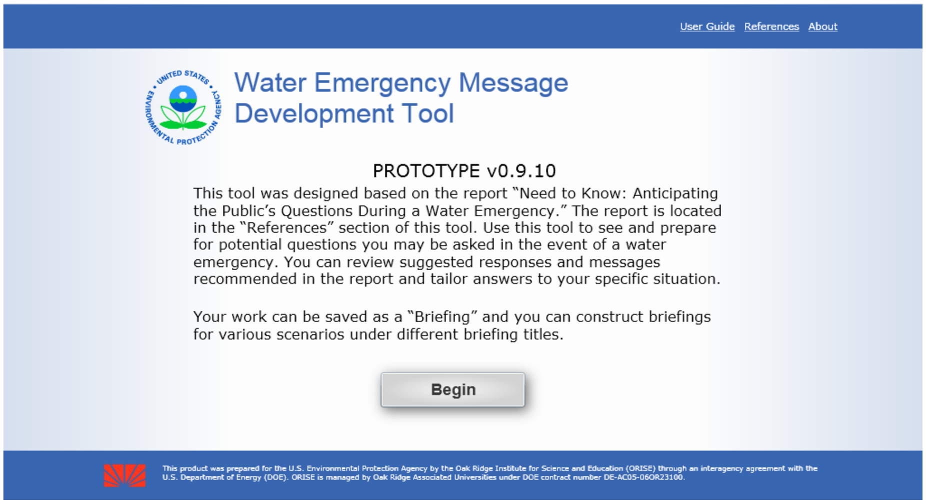
Message Development Tool



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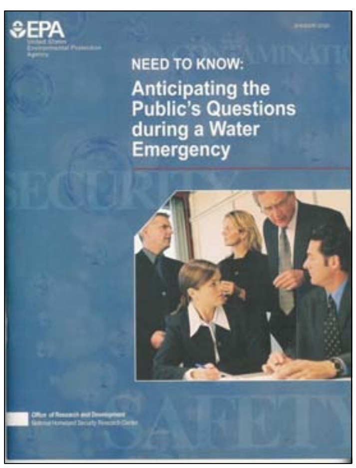
Report Availability



- Website
  - www.epa.gov/nhsrc
- For more information, contact
  - Scott Minamyer
    WIPD
    minamyer.scott@epa.gov
  - Cynthia Yund, PhD
    TCAD
    yund.cynthia@epa.gov

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2013 EPA Decon Conference
Risk Communication and Systems Approach Session

Perceptions of Risk Communication Messages During a Long-Term Biological Remediation

Charlena Bowling[1], David Malet[2], Mark Korbitz[3], Jody Carrillo[4], Elizabeth Penrod[4], Cynthia Yund[1]

[1]US Environmental Protection Agency, 26 W. Martin Luther King Dr., MS NG16, Cincinnati OH 45268; [2]University of Melbourne, Grattan St., Parkville VIC 3010, Australia; [3]Otero Junior College, 1802 Colorado Ave., La Junta CO 81050; [4]Pueblo County/City Health Department, 101 W. 9th St., Pueblo CO 81003

Introduction

- Effective communication strategies ensure trust
- Strategies must be diverse
- Involvement between public and risk communicators
- During long term events, public may be less attentive

Background

- Grant funded 3-year study conducted by Pueblo City/County Health Department of Colorado and EPA-NHSRC
- Focused on the research need for risk communication practices during remediation phase of biological event
- Study and participants based in Pueblo due to diverse demographics of local population

Objective

- Determine which message content and delivery methods are more likely to foster understanding and trust from target audiences during the remediation phase of a biological event

Outcome

- Enhanced knowledge of specific community information/communication needs during a long term event

Project Overview

Phase 1
- Emergency responders, government, public officials
- Messages via email
- In-person feedback session
- Telephone interviews
- Completed

Phase 2
- Public volunteers
- Scenario messages via Facebook
- In-person feedback session
- Ongoing

Phase 3
- Data analysis using ATLAS.ti software
- Compilation of results for public safety agencies
- Ongoing

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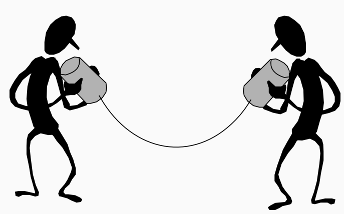
Phase 1 Methods

- 17 messages describing remediation efforts following a bioterrorist attack
- Distributed via email
- Directed to reply with how they would act if events were real and to focus feedback on risk perception
- Face-to-face feedback session
- Telephone interviews



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Scenario:

Bacillus anthracis

Colorado State Parks
Lake Pueblo State Park

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Scenario:

Foot & Mouth Disease

Colorado State Fair

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Scenario Messages

- Messages modeled after mass media reports
- Initial messages describe illnesses, presence of anthrax, and later FMD
- Mid-event focus on public pressure, demands, concerns
- Focus turns to recovery and publicity campaigns

Participant Responses

- Confusion over email messages and instructions for response
- Feedback session used to clarify participant responses and views
- Follow-up telephone interviews assessed value of exercise

Feedback Session

- Participants assigned to tables of 6-8 individuals
- Recorders and digital tape recorders collected responses
- Determine most effective messages for communicating decontamination data to the lay public

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Findings Discussion

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1. Expectation of cleanup to "zero" residual risk

"My response would be to support the decision to treat the water…"

"'Remain calm and the public is not at risk'…yeah right!"

"…I do not want to be the one who gets anthrax from the 0.1% that was not killed in the water."

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2. Local agencies assume high level agencies will take control

"…I don't know how much we would be involved in this. I really don't because I think the CDC would come down and really…it's been their pattern to kind of come down and just say we're taking over."

"The CDC would take over and say 'you're gone'."

"I don't think it would be local anymore… is that something our community would accept? I think they would because they'd be so afraid, but…"

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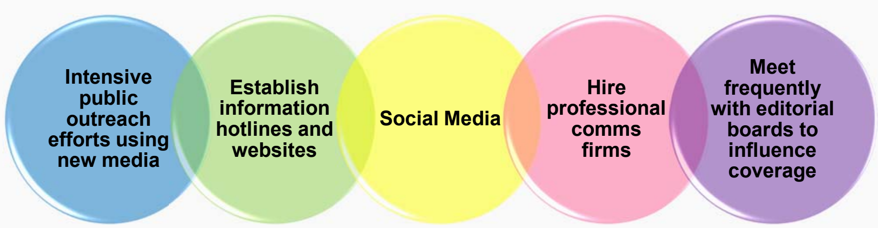
3. Positive emotions increased with the progression of messages

"best message to date"

"happy"

"messages read very well"

4. Participants suggested communications strategies even though many were not currently using them



5. Communicating risk is a challenge in simplification

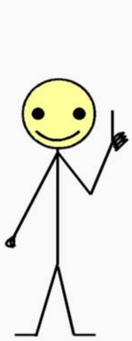
"...how do you make people aware, but not panicked."

"I remember feeling like I did not have the technical expertise to respond to this."

"Communicating uncertainty is always difficult..."

"…it is a struggle to convey scientific information in a way that the general audience can understand."

Conclusions



- ✓ Emergency management personnel may not be uniformly prepared to respond with full effectiveness
- ✓ State and local response personnel must work together
- ✓ Social media's potential may not be fully utilized even though its influence is apparent
- ✓ Long term events have unique communication demands
- ✓ Involvement with community is key

Next Steps

- Phase 2
  - Messaging portion completed
  - Data gathering and analysis ongoing
- Phase 3 in process
  - Content analysis

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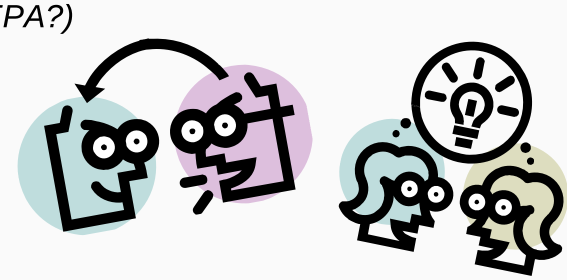
Looking Ahead

Local and state responders rely on Federal resources and information – so what else do our partners and stakeholders need (i.e. what other research is needed from EPA?)



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Thank You! Questions?

Charlena Bowling
bowling.charlena@epa.gov
513-569-7648
www.epa.gov/nhsrc

A Systems Approach to Characterizing the Social Environment for Decontamination and Resilience

Dr. Keely Maxwell, AAAS Fellow, EPA National Homeland Security Research Center

U.S. EPA International Decontamination Research & Development Conference

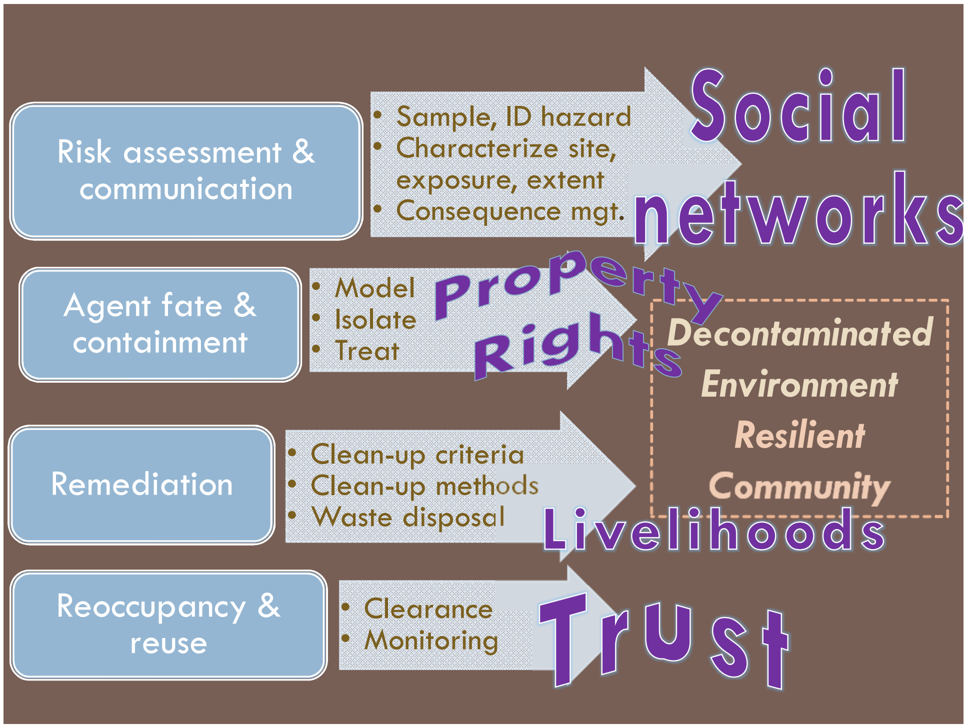
November 6, 2013

Talk outline

1. The social environment of decontamination
2. Systems approach to characterizing the social environment

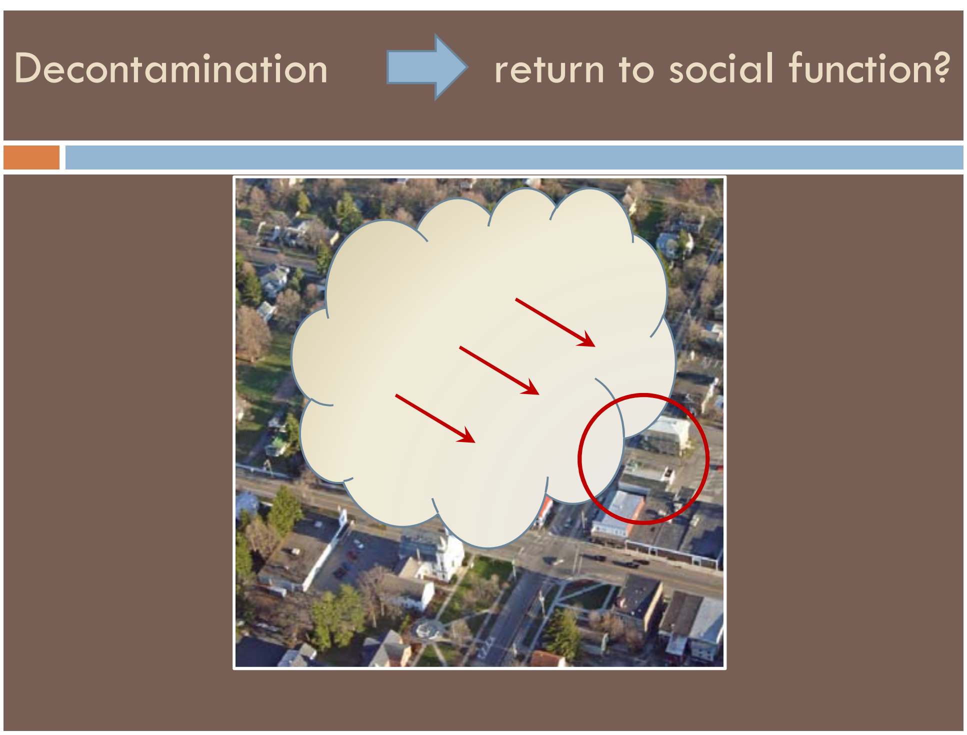
Decontaminated Environment

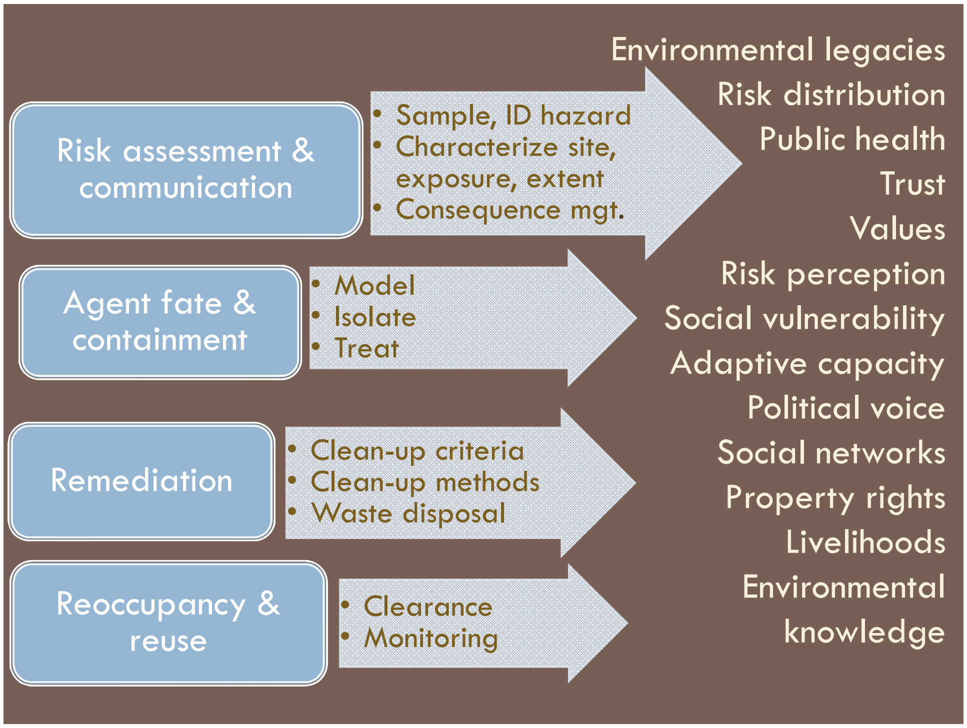
Resilient Community


Risk assessment & communication
Sample, ID hazard
Characterize site, exposure, extent
Consequence mgt.
Social networks
Agent fate & containment
Model
Isolate
Treat
Property Rights
Decontaminated
Environment
Resilient
Community
Remediation
Clean-up criteria
Clean-up methods
Waste disposal
Livelihoods
Reoccupancy & reuse
Clearance
Monitoring
Trust


The social environment of decontamination
Risk
Values
rights


Social environment
capacity for individual & collective action
Social networks
Social vulnerability


Decontamination
return to social function?



Indicator Category	Coupled Human-Natural System Resilience Indicators		
	Pre-disaster		Post-disaster
	Vulnerability	Capacity	Recovery Outcomes
Demographic	Vulnerable populations Uneven risk distribution	Educational attainment Religious adherents /capita Owner: renter	Population growth rate USPS vacancy rates Domestic violence rates
Governance & Planning	No disaster planning Political fragmentation Risk (mis)perception	Scenario exercises Risk communication Hazard mitigation planning	Adaptive capacity Compliance rates Organizational learning
Economic	Income & wealth inequality Household access to cash, vehicles, phones, insurance	Human development index Livelihood diversity Females in labor force	Housing affordability Unemployment rates & wages Business disruption
Infrastructure	Vulnerable housing stock Low arterial miles/ area Bottlenecks	Critical infrastructure and lifeline redundancy Structural protection	Property damage Time until return to function Degrades gracefully
Public Health	Unhealthy population & behavior patterns Crime rates	Access to doctor, hospital, insurance, pharmacy Health literacy	Disaster related morbidity Disease incidence Perception of well-being
Social networks & collective action	Limited sense of place Lack of trust Community values not ID'd	Civic organizations Voter registration rates Volunteering rates	Access to public spaces Memorialization undertaken Political voice in recovery
Environment	Environmental legacies Environmental injustice Soil erosion	Environmental knowledge Biodiversity Land use planning	Contaminant levels Waste management Resource property rights

Indicator Category	Coupled Human-Natural System Resilience Indicators		
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Social networks & collective action	Limited Lack o Comm		blic spaces tion undertaken e in recovery
Environment	Enviror Enviror Soil er		levels agement perty rights

Metric	US Census Data
Multiple generation households	Households w members <18 and 65+, as % total households
Single parent households	F or M householder, no spouse present, w/own children <18, as % total households w/own children <18

Indicator Category	Coupled Human-Natural System Resilience Indicators		
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Metric	Data
???	??
??	??

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Risk assessment & communication

- Characterize *social* environment
- **2-way risk communication**

Agent fate & containment

- **Incorporate local environmental knowledge**

Remediation

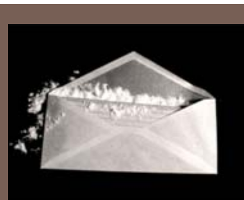
- Clean-up values
- Return to social function

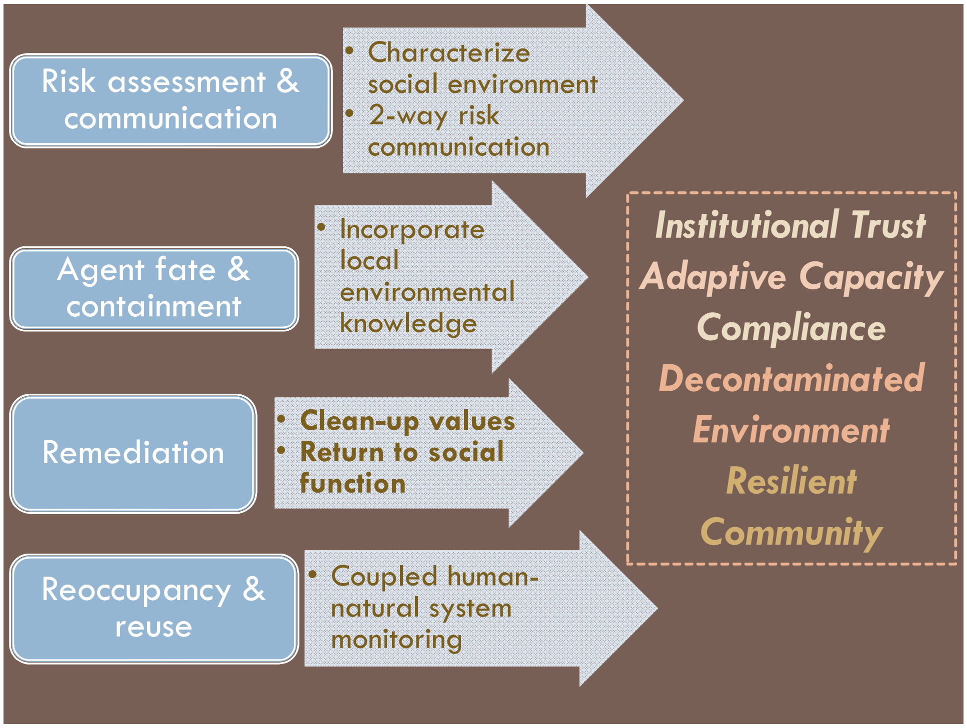
Reoccupancy & reuse

- Coupled human-natural system monitoring

Institutional Trust
Adaptive Capacity
Compliance
Decontaminated Environment
Resilient Community

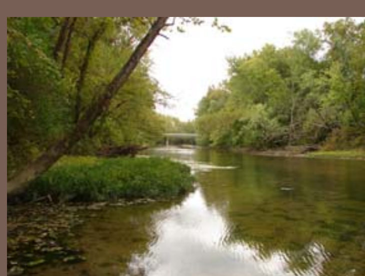
Moving forward: local environmental knowledge & risk communication





Moving forward: public values & remediation criteria

Sugar Creek, OH: polluted watershed. Locally controlled water quality testing. Used pollution levels & **social significance** to prioritize clean-up hotspots.



Rocky Flats, CO: Superfund site. Community Radionuclide Soil Action Level Oversight Panel held monthly public meetings. Methodology & report on soil action levels.

Risk assessment & communication

- Characterize social environment
- 2-way risk communication

Agent fate & containment

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Reoccupancy & reuse

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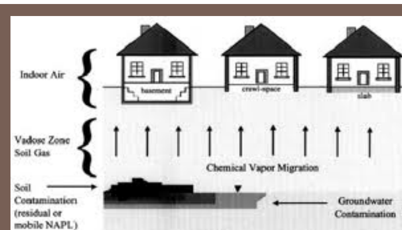
Moving forward: coupled human-natural system monitoring



Endicott, NY. 1979: TCE spills into groundwater.
Remediation: house ventilation limits vapor intrusion
Monitoring: # houses with ventilation, public health

System monitoring: trust in institutions, property values, attachment to place

Photo: P. Little

Thank you! Please provide information & ideas to:

Dr. Keely Maxwell, AAAS Fellow, EPA NHSRC
Maxwell.Keely@epa.gov
(202) 564-3193

Disclaimer

The views expressed in this presentation are those of the author and do not necessarily reflect the views or policies of the United States Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Wednesday, November 6, 2013

General Session 3

Food Safety-Decontamination and Disposal Issues

USDA United States Department of Agriculture

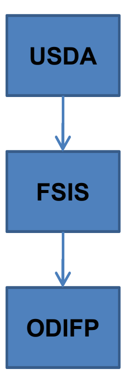
U.S. EPA Decontamination
Conference

Intentional Contamination of Food

Nicholas B. Bauer
USDA
Food Safety and Inspection Service
November 6, 2013

USDA United States Department of Agriculture

Who We Are and Our Mission



- Food Safety and Inspection Service (FSIS)
  - Public health agency in U.S. Department of Agriculture (USDA)
  - Mission: ensure that U.S. supply of **meat, poultry, and processed egg products** is safe, wholesome, and correctly labeled and packaged
- FSIS Office of Data Integration and Food Protection (ODIFP)
  - Mission: prevent, prepare for, and coordinate a response to intentional and unintentional contamination, significant food emergencies, and natural disasters

USDA United States Department of Agriculture

U.S. Agriculture

- $1 trillion in food business
  - $141 billion agriculture exports (2012)
  - $103 billion agriculture imports (2012)
  - ~10 – 15% total U.S. economic activity
  - ~18% of total U.S. jobs

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USDA United States Department of Agriculture

Food Defense

Food Safety – the efforts to prevent accidental (unintentional) contamination of food products by agents reasonably likely to occur in the food supply

- **Natural / environmental source of contamination**

Food Defense – the efforts to prevent intentional contamination of food products by biological, chemical, physical, or radiological agents

- **Human intervention as the source of contamination**

Food Defense is Voluntary!

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USDA United States Department of Agriculture

Potential Targets: From Farm to Fork

- Crops
- Livestock
- Employees
- Import Facilities
- Food and agriculture transportation systems
- Food processing facilities
- Food storage/ distribution facilities
- Restaurants, grocery stores, markets

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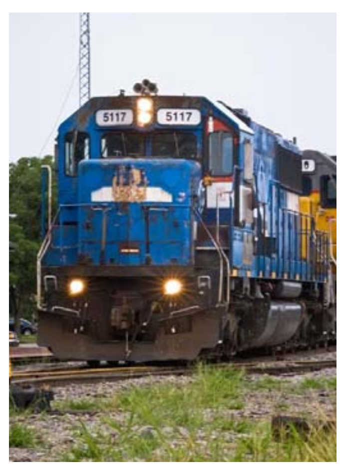
Why Attack Food?

- Food is often prepared or held in large batches (many servings)
- Extremely rapid, widespread distribution with just-in-time deliveries
- Industry consolidation of food processing facilities



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Food as a Weapon

- The food and agriculture sector could be used as a vehicle to disseminate threat agents, with potentially catastrophic impacts:
  - Public Health
  - Economic and trade
  - Psychological
  - Loss of public confidence
- Even the threat of intentional contamination could pose serious problems for public health and the international economy
- Intelligence indicates terrorists have discussed attacking components of the food sector

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USDA United States Department of Agriculture

Intentional Contamination of Food

- Latest Terror Threat in US Aimed to Poison Food (December 2010)
- Afghan cops: Food poisoning at border post (February 2012)

The Telegraph

- Milk alert as poison terrorist strikes (December 2003)

THE INDEPENDENT

- 'Al-Qa'ida' attempt to poison Rome's water supply foiled (February 2002)

JOURNAL OF FORENSIC SCIENCES

- Arsenic Poisoning Caused by Intentional Contamination of Coffee at a Church Gathering—An Epidemiological Approach to a Forensic Investigation (April 2010)

CRIENGLISH.COM

- The food poisoning of 203 hospital patients in northeast China was a criminal act involving the intentional use of dangerous substances, the police said… (April 2007)

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Potential Impact of Intentional Contamination

- Scenario: Ground Beef

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Threat Agents

Left: Illegally imported pesticide containing brodifacoum.

Right, from top to bottom: Botulism slurry, Castor beans, Ricin mash, Cyanide Salt, Crude Hydrogen Cyanide

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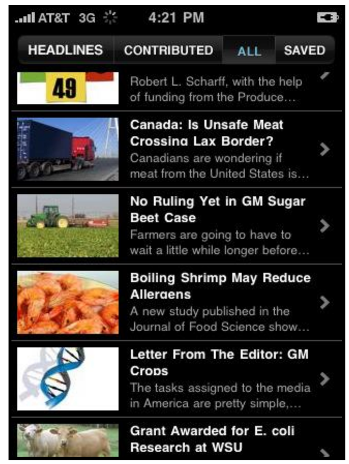
United States Department of Agriculture

Where to Find Information



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United States Department of Agriculture

Identifying and Assessing the Threat

- Analytical methods
  - Food matrices are varied and complex
  - Food-specific extraction and analysis methods must be developed and validated
- Ingestion toxicity
  - USG funding often focuses on inhalation and dermal exposure—not ingestion and food

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USDA United States Department of Agriculture

Response and Recovery: Decontamination and Disposal

- Methods for decontamination of food facilities
  - Equipment
  - Buildings
  - How clean is clean?
- Methods for treatment and disposal of contaminated food
  - Treatment
  - Testing
  - Permitting

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Decontamination and Disposal Challenges

- Large volumes—even a moderate-sized establishment can produce 1 million pounds/week
- Geographically dispersed production, distribution, and retail facilities
- Consumer homes and facilities
- Complex matrices

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United States Department of Agriculture

Food Safety Modernization Act

- FSMA §208 identifies EPA as lead agency to assist state, local, and tribal governments in preparing for, assessing, decontaminating, and recovering from an agricultural or food emergency.
  - Development of standards
  - Development of model plans
  - Exercises
- Resilience is key

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United States Department of Agriculture

Ensuring Response Capabilities

- USG roles and responsibilities in response to an attack on food or agriculture need to be well defined and tested
  - NSTC Chemical Defense R&D Subcommittee:
    - Coordinates technical aspects
    - FSIS, DHS, EPA, FDA, DoD, HHS
  - NSS Chemical Preparedness Sub-Interagency Policy Committee (Sub-IPC)

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Contact Information

Nick Bauer
202-690-6372
Nick.Bauer@usda.fsis.gov

Wednesday, November 6, 2013

Concurrent Sessions 1

Biological Agent Decontamination

DE LA RECHERCHE À L'INDUSTRIE

GELS AND FOAMS FOR CBRN DECONTAMINATION OF FACILITIES

S. Faure[1], V. Tanchou[2], F. Goettmann[1], C. Bossuet[3]

1 -CEA, Nuclear Energy Division/Center of Marcoule DTCD/SPDE/LCFI,
30 207 Bagnols/Cèze, France
2 -CEA, Life Science Division/Center of Marcoule DSV/SBTN/LDCAE,
30 207 Bagnols/Cèze, France
3-CEA, Military applications Division/Center of Marcoule DAM/DSNP/NRBCE
30 207 Bagnols/Cèze, France

CEA : French Atomic Energy and Alternatives Energies Commission

Laboratory of Complex Fluids and Irradiation

2013, November 6th, EPA International Decon Conference,
Research Triangle Park, NC

Summary : studies at CEA

- **R Decontamination studies at CEA**
  - **ASPIGELS: self drying and cracking gels for 2D surface decontamination**
  - **GELIFOAM: viscosified or gelified foams for 3D decontamination (high volume and complex shapes)**
- **B Decontamination GELIBIO**
- **C Decontamination (FOAM for TICs: OP, pesticides, ammonia, chlorine…)**
- **Conclusion: Gels and foams are promising technologies for CBRN decon**

NR Decontamination studies at CEA

➢**Motivations**

❖Increasing of **maintenance or cleaning** facilities and **dismantling projects** all other the world: fission products tanks, hot cells, gloves boxes, concrete of buildings, PWR steam generator maintenance, pools cleaning…

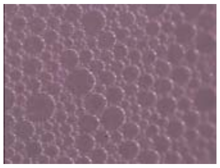
❖**Accident case** (Fukushima)

❖**CBRN terrorism**

Which R decon process?

Need of novel, safe, reliable, "teleoperable" or easily deployable **decontamination processes for solids limiting waste volume and easing the final waste treatment and conditioning**

AQUEOUS GELS AND AQUEOUS FOAMS

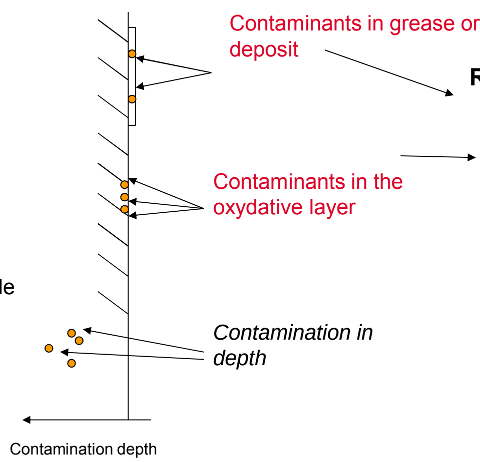



di/triphasic fluids to avoid usual liquid decon/rinsing

Different kinds of Fixed Radioactive Contamination

Solid: metal, concrete, plastic

● = Radionuclide



R DECONTAMINATION
=
Specific process to transfer the contamination from the surface to a liquid or solid phase easier to treat:

↓

Simple physical transfer by sorption on particles or « smart transfer » assisted by chemistry (dissolution, comlexation)

SMART NR GELS AND FOAMS

-Formulation of **«smart» complex fluids** (gels or foams) that do not damage the surface of the materials (soft homogeneous corrosion) and transfer rapidly the radiocontaminants onto the colloids (sorption)

-To **obtain less generated secondary liquid effluent (emulsions and foams) or avoid liquid effluent (self drying gels)**

-To **enhance the efficiency** of the classical decontamination technique using acidics or alkalin media

Surfactants and/or colloidal particles

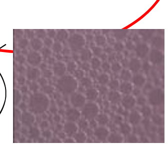
I

Gel phase: to formulate Self-Drying and Cracking gels and to «catch » the radiocontaminants

II

Foam for filling or spraying

Solids radioactive wastes



Summary

- **R Decontamination studies at CEA**
  - **ASPIGELS: self drying and cracking gels for 2D surface decontamination**
  - **GELIFOAM: viscosified or gelified foams for 3D decontamination (high volume and complex shapes)**
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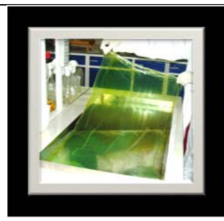
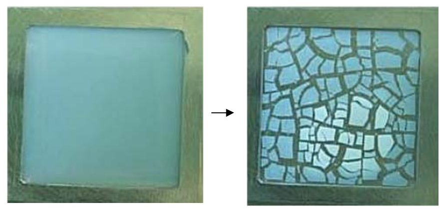
Some decon gels in the world…

	
Alara 1146 cavity Decon Stripcoat TLC Strippable Decon gel (USA)	Kaminski Supergel (ANL USA)



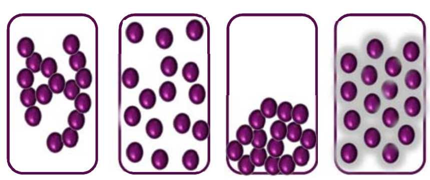
Transfer with Strippable organic gel = no chemistry



CEA mineral drying and cracking gel : ASPIGEL

I- NR Gels: ASPIGELS®

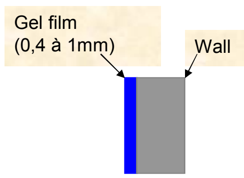
- ASPIGEL can be considered as a **concentrated colloidal suspension** of silica or alumina in water containing suitable chemical reagent for decontamination.

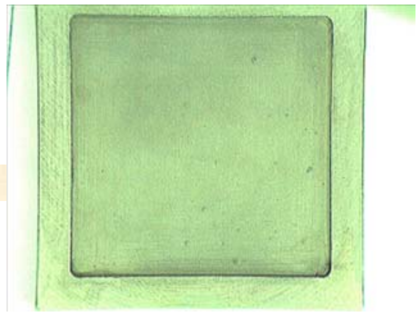


Stable particulate gel with repulsion between particles

- These gels are **easily prepared** by mixing silica or alumina with chemical reagents in water.

Radioactive decontamination using drying/cracking gels





- Rheology (spraying, adhesion)
- Corrosion (0 to 2 µm)
- Drying (3 to 24 hours)
- Cracking formation
- Pellets Adhesion

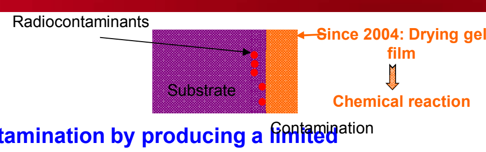
3 Ph D students 2004, 2007, 2013

Advantages

- No liquid effluent
- Fixed contamination
- Reduction of secondary wastes volume

CEA NR Gel story of these last 20 years

- ***PRINCIPLE***



- ***AIM***

To remove contamination by producing a limited quantity of solid wastes easily conditionnable

Various nature of materials to be treated

Metals (stainless steel, aluminium, steal, iron)

Cement matrix (concrete, mortar)

- ☞ 1991 : First patent on gels (gels which have to be rinsed)
- ☞ 2004 : Patent on **"self drying and cracking gels" (SDC Gels or ASPIGELS)**
- ☞ 2007: Patent on SDC gels **containing surfactants (improved formulations)**

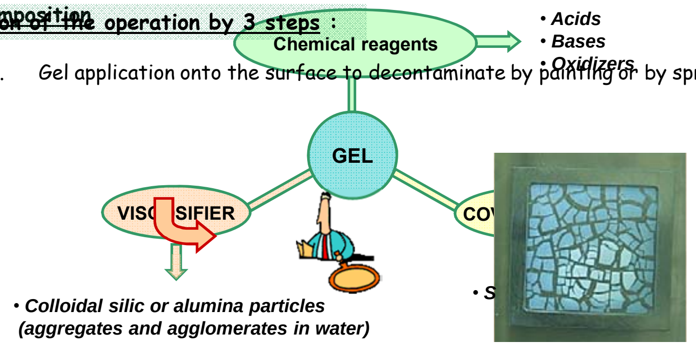
Formulations – CEA Patents 2004 and 2005

«SDC ASPIGELS » : gels that can dry and crack in a few hours at room temperature and lead to solid tiles/flakes easy to remove from the surface by brushing or vacuum cleaning **CEA/AREVA S. Faure et al, Patents n° WO03008529 and WO2007039598**

Gels composition

Evolution of the operation by 3 steps :

1. Gel application onto the surface to decontaminate by painting or by spraying



2. Drying (chemical attack, cracking, pellets formation)

3. Brushing and/or vaccum to recover dry pellets including contamination

.

Metal and concrete decontamination

Commercial SDC gels : ASPIGELS®

ASPIGEL 100	☞	Stainless Steel
ASPIGE 100 E	☞	**Stainless Steel 2011 in Hanford USA**
ASPIGEL 200	☞	Steel
ASPIGEL 300	☞	Lead
ASPIGEL 400	☞	Aluminium
ASPIGEL 500	☞	**Concrete, mortar**
ASPIGEL 50	☞	Degreasing gel

Synthesis and selling license : FEVDI (Corbas-France)

Real decontamination of ISAI cells in CEA Marcoule using ASPIGEL 100

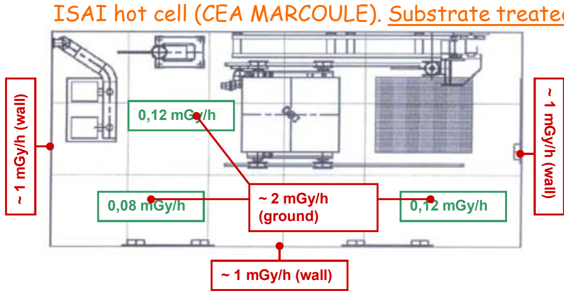
Pulverization of a ASPIGEL 100 thin film (500 µm) :

Silica colloidal particles AEROSIL and/or TIXOSIL

Recovering of the dried pellets by brushing or vacuum cleaning

Experience feedback about decontamination operations using drying gels

First implementation of the drying gel process during the decontamination of ISAI hot cell (CEA MARCOULE). Substrate treated : stainless steel



- Dose rate before treatment
- Dose rate after treatment

- *80 Kg of sprayed gel*
- *Treated surface: 130 m²*
  Gel quantity : 600 g/m²
- *Drying time = 48 hours*
  (Temperature = 25°C, Humidity = 55 %, Ventilation = 200 m³/h)
- *20 Kg of dry pellets producted*

16,5 < DF < 25

DF : Decontamination factor calculated with regard to the dose rate

Experience feedback about decontamination operations using drying gels

2007 : ☞ Decontamination of GUYENNE hot cell (CEA Fontenay aux Roses)

GUYENNE hot cell

- Substrate : stainless steel
- Nature of the contamination α : ^{241}Am, ^{244}Cm, ^{238}Pu
- Nature of the contamination β : ^{137}Cs, ^{241}Pu, ^{90}Sr, ^{90}Y

Gel during its applying by painting

☞ Application of 2,650 Kg of gel by painting because of the small area treated (4 m²)

☞ Drying time = 48 hours

☞ < 1 Kg of dry pellets produced

Dry pellets during brushing and vacuum cleaning

Experience feedback about decontamination operations using drying gels

☞ Results of the process efficiency obtained on CYRANO

> ☞ DF ~ 10
>
> ☞ After gel decontamination, all radiological requirements fixed at initial time were reached

☞ The contamination retired from the stainless steel is trapped in the solid tiles removed by vaccum succion

Solid residu (pellets) after drying

	Activity of solid tiles (Bq.kg^{-1})
^{241}Am	$2{,}0.10^{6}$
^{137}Cs	$1{,}3.10^{7}$
^{154}Eu	$3{,}5.10^{5}$

Spectrometry analysis of solid waste

What to do with the particulate pellets?

Immobilization of the pellets in mortar for final storage
in ANDRA facilities

Marcoule ⇨ Conditionning as an heterogeneous waste

Pellets in the
vacuum bag

118 l cask
to compact

Compaction of 2
to 6 casks

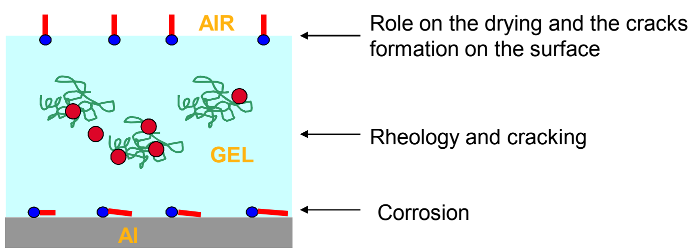
Mortar for
immobilization

Role of the silica particles and surfactants

•To perform the spraying of the gel like a paint (rheology)

• **To control the drying and cracking and to obtain millimetric solid pellets** **(no volatil dust)**

•**To «catch» the radiocontaminant**



Summary

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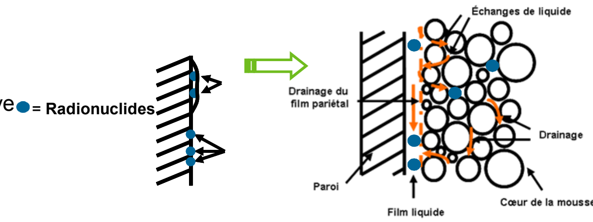
Radioactive decontamination stable foams: GELIFOAM (patent)

Static (high volume, complex shapes) GELIFOAM

Radioactive decontamination foams

- acidic ou alkaline, and:or oxydative
- **liquid fraction from 3 to 10%**



Circulation

Static (high volume, complex shapes) GELIFOAM

Spraying

Conditionning: dilution for liquid treatment station or vitrification

DECONTAMINATION with aqueous FOAMS

Liquid convection: Decontamination and Destabilization

Decontamination efficiency ⇨ Depends on foam lifetime

Foam destabilization mechanisms

- ✓ **gravitational drainage**
- ✓ **pressure-driven drainage**
- ✓ **bubbles coalescence**

Formulation = Equilibrium → **Stability**; **Reaction kinetics**

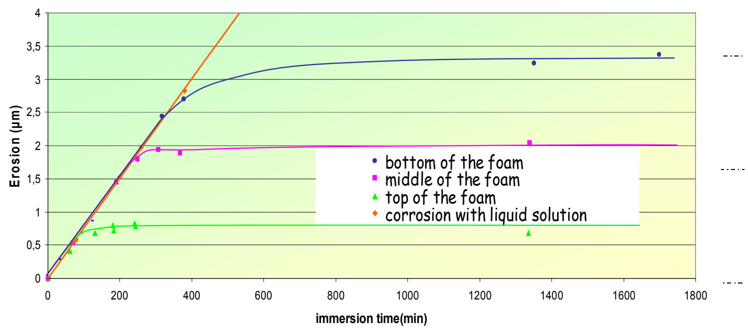
Viscosified foam video film

Foam flow rate =85 m^3/h , ΔP = 250 mbar

Viscosified foam video film

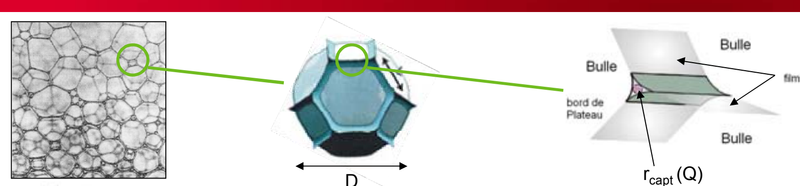
Foams as much efficient as liquids

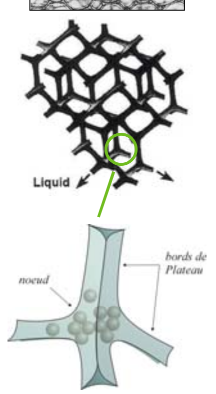
Metal corrosion obtained with acidic foams[1]



- Foam is active on every point of the solid/foam interface
- The corrosion depends on the contact time of the foam with the metal surface
- **The foam efficiency is similar to the liquid**
- **Evidence of weeting liquid film between the foam and the surface**

Foam stabilization with particles into channels





Which size for the pore ?

For a dry foam (ε ~ qq%) :

Radius for capture $r_{capt} \propto D\varepsilon^{1/2}/6$

D ~ 200 µm et ε ~ 0.02 → r_{Capt} ~ 5 µm

r_{capt} ~ qq µm to qq 10 µm

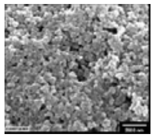
Which colloids?

S. Guignot, S. Faure, M. Vignes-Adler, O. Pitois "Liquid and particle in foamed suspensions" Chemical Engineering Science, Volume 65, Issue 8, 15 April 2010, Pages 2579-2585

New foaming particles at the interfaces

Grafting of fluorinated short chains

Alumina CERALOX APA 0,5
$\varnothing_m$ = **400** nm
S ≈ 8.5 m^2.g^{-1}



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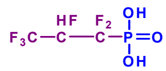
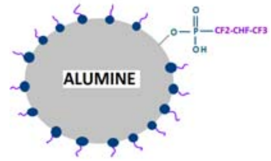
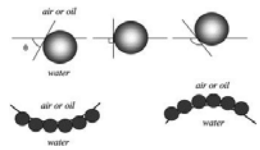


Grafting reaction



Alumina particles | *Particles partially grafted* | *Particles highly grafted*



Decreasing hydrophily: particles attached to the interface

= foaming particles

. **Faure, S. et al "Synthesis of new fluorinated foaming particles",** ***Colloids and Surfaces A: Physicochemical and Engineering Aspects*****, *Volume 382, Issues 1–3, 5 June 2011, Pages 139-144***

Summary

- **R Decontamination studies at CEA**
  - **ASPIGELS: self drying and cracking gels for 2D surface decontamination**
  - **GELIFOAM: viscosified or gelified foams for 3D decontamination (high volume and complex shapes)**
- **B Decontamination GELIBIO**
- **C Decontamination (FOAM for TICs: OP, pesticides, ammonia, chlorine…)**
- **Conclusion: Gels and foams are promising technologies for CBRN decon**

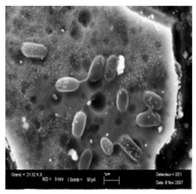
GELIBIO ASPIGEL for B decontamination

Bt spores on different metallic surfaces

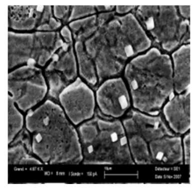
or concrete or ceramics surfaces

Sprayed GEL FILM < 1 mm

After drying only 100g of residue vacuum cleaned /m²



Bt Spores on metallic surface



After decon

*GELIBIO 1: in 2010 more dedicated for concrete surface using sodium hydroxyde and alumina, soft chemistry without peroxydes, Efficiency > 4 log

*GELIBIO 2, more aggressive (bleach), Efficiency > 7 log, CEA contracted the license with NBC-Sys French Company

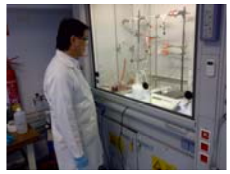
(GELIFOAM using viscosified foams for B is now under process…)

**CEA Patent 2010 and 2013*

Summary

- R Decontamination studies at CEA
  - ASPIGELS: self drying and cracking gels for 2D surface decontamination
  - GELIFOAM: viscosified or gelified foams for 3D decontamination (high volume and complex shapes)
- B Decontamination GELIBIO
- C Decontamination (FOAM for TICs: OP, pesticides, ammonia, chlorine…)
- Conclusion: Gels and foams are emerging technologies for CBRN decon

Foams for TICs



•First encouraging results to neutralize gases or organophosphates (pesticides)..

•Under process…

CONCLUSION

2 kinds of <u>promising</u> complex fluids for CBRN decontamination limiting the volume of generated wastes:

- **Surface decontamination**: **self-drying and cracking gels** (SDC Gels) for metal et concrete decontamination **by simple spraying**, flakes vacuum cleaned after drying

-ASPIGEL® (NR)
-GELIBIO (B) → **Solid wastes**

- **Volume decontamination** : Use of **stable gelified foams** for huge surfaces and complex shapes by **filling or spraying**

-GELIFOAM (NR) → **Cementation or vitification of the reduced liquid waste**

-GELIFOAM (B) and FOAMSTIC (for TICs C decon) → **Easy Liquid treatment**

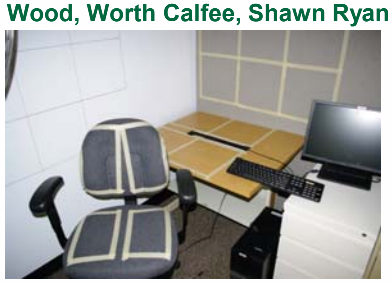
Future : to go on the optimizing of the chemical decontaminations formulations (gels and foams) in order to increase efficiency and reduce even more the quantity of secondary wastes

Multipurpose formulations, promising technologies…

Evaluating *Bacillus* Spore Inactivation in an Office Environment Using Low Levels of Chlorine Dioxide

Matt Clayton, Abderrahmane Touati, Nicole Griffin-Gatchalian, Stella McDonald, Rob Delafield, Tim McArthur (ARCADIS)

Joseph Wood, Worth Calfee, Shawn Ryan (EPA)



Presented at US EPA Decontamination Research Conference, Research Triangle Park, NC, November 5-7, 2013

Acknowledgements

- Other participants:
  - Shannon Serre, Kim Egler, Joshua Nardin, Neal McSweeney, and Christina Slone

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Disclaimer

- Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government, and shall not be used for advertising or product endorsement purposes.

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Outline

- Background
- Methods
- Preliminary results
- Summary, lessons learned

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Background

- In a wide area release of anthrax spores, many decontamination tools will be needed
- ClO_2 fumigation has been demonstrated at high concentrations, but few companies have technology to generate high levels
- Purpose is to find conditions and materials in which low levels of ClO_2 are effective, thus allowing more companies to assist in remediation efforts (in the event of a wide area release)
  - –Using a realistic, full scale test bed

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Background (continued)

- Proof of concept small scale glove box tests with coupons showed that > 6 LR achievable at 100 ppm ClO_2, 8 hours on wood, carpet, drywall, galvanized metal, concrete
  - –Would these results transfer to full-scale scenario?
- Added benefit with using low levels ClO_2: would have less impact on materials
  - –In some fumigation tests, computers were included in office and were minimally impacted based on software analyses of computer systems

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Methods

- COnsequence ManageMent ANd Decontamination Evaluation Room (COMMANDER) test chamber and mock office
- ClO_2 generation and measurement
- Test variables and matrix
- General approach for each test
- Microbiological sampling and analysis

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COMMANDER Test Chamber

- State of the art decontamination chamber
- Measure and/or control temperature, relative humidity, ClO_2 concentration, air flows, pressure

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Mock Office Set up

- Office finished with carpeting, painted drywall, ceiling tile
- Equipped with desk, chairs, filing cabinet, pin cushion screen, computer/keyboard, catalogues/books, electrical socket

ClO_2 generation and measurement

- ClorDiSys GMP
- ClO_2 measurement
  - EMS
  - titration
- T, RH

Test variables/matrix

- ClO_2 levels ranged from 100 – 3000 ppm
- Contact time ranged from 4 - 24 hours
- Nearly all tests conducted at 75% RH, 25 ° C.

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General Approach for each test

- Collect negative samples in office
- Place coupons, BIs, RMCs
- Disseminate spores, let settle
- Collect positive control samples
- Fumigate, then aerate
- Collect test samples
- Reset office/chamber with VHP

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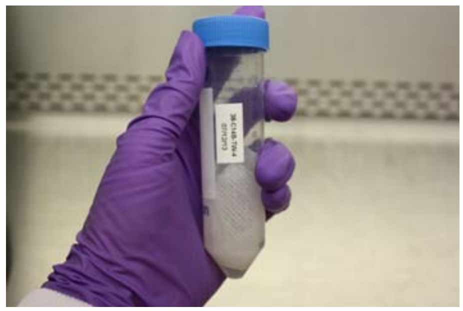
Microbiological sampling and analysis

- Approx. 3.5 x 10^{10} colony forming units (CFU) of *Bacillus atrophaeus* disseminated via dry fluidized bed
- Sampling, extraction, dilution and filter plating
- Detection limit



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Microbiological Sample Summary

- Pre-dissemination samples:10 surfaces + 2 blanks
- Characterize and post decon samples:
  - 25 surface samples
    - HEPA vacuum and wipes
  - 6 Reference Measurement Coupons (1 for post decon)
  - 3 swab samples
  - 1 air sample (Viacell®)
  - biological indicators

–TOTAL= 81 samples per test

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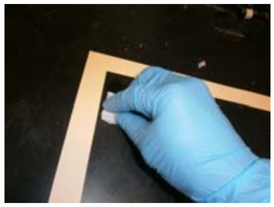
Microbiological sampling and analysis



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Preliminary Results – Pre Decontamination

- Average surface levels ranged from 4.9 – 7.2 log CFU/sq ft.
  - Overall average of 6.4 log CFU/sq ft.
- RMC results correlated well with office surface loadings
  - Correlation coefficient of 0.9
- Spore loadings on horizontal surfaces ~ 0.5 log CFU > vertical surfaces
  - Vertical surfaces ~ 0.5 log CFU > ceiling tile
- Spore levels in air ranged from 0.24 – 20 CFU/liter

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Preliminary Results – Post Decon Example data – 200 ppm, 4 hours

	n	Average Pre-decon	Average Post-decon
		CFU/ft²	
catalogue	1	6.18E+04	ND
keyboard	1	2.66E+06	ND
chair back	2	3.55E+05	1.55E+00
chair seat	2	1.73E+06	ND
pin cushion screen	3	9.00E+04	ND
ceiling tile	3	9.46E+04	ND
carpet	5	2.54E+05	ND
Desk top	3	1.05E+06	ND
drywall	5	7.60E+04	ND
filing cabinet	3	1.97E+04	ND
geometric mean		**2.26E+05**	
log of geo mean		**5.35**	**0.19**
electrical socket swab	1	G	NG
keyboard swab	1		NG
computer swab	1		NG
Viacell® air sample (CFU/liter)	1	2.43E-01	2.17E-02

	Average Pre-decon	Average Post-decon
RMCs	**CFU/ft²**	
wall	8.35E+03	
inside computer	2.88E+03	
corner of floor	1.44E+03	
center of chair	4.32E+03	
keyboard	1.15E+03	
filing cabinet	1.22E+07	
inside computer post-test		ND
Average RMC	**2.04E+06**	
log of geo mean RMC	**4.05**	

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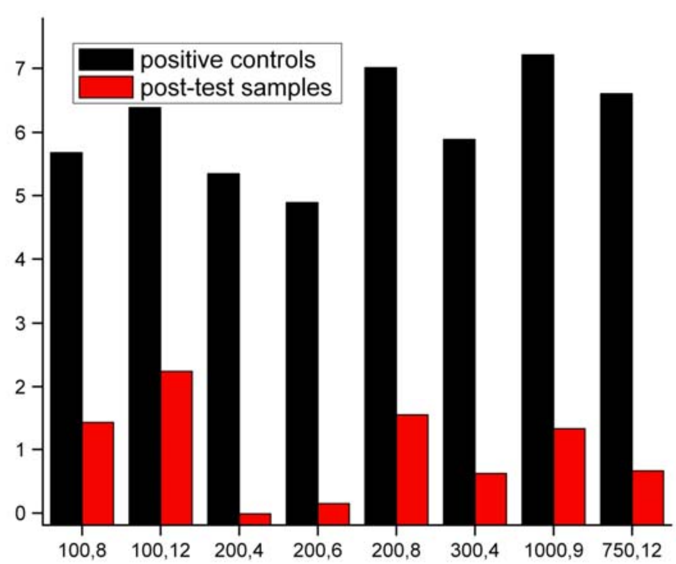
Preliminary Results for Surface Samples



Number over red bar indicates how many post decon surfaces samples (out of 25) that came back negative

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Preliminary Results – Post Decontamination

- Post decon surface spore loading correlations:
  - –0.90 correlation with post-decon spore levels in air
  - –0.61 correlation with pre decon spore surface levels
  - –0.50 correlation with fumigation contact time
  - –0.34 correlation with ClO_2 concentration (ppm) x time (hours)
  - –0.29 correlation with ppm level

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Summary, Lessons Learned

- First comprehensive parametric near full-scale study on ClO_2 fumigation
  - –Mock office allows for realistic sampling, but loss of experimental control on surface loading, fume conditions, etc
  - –Focus on low level ClO_2
  - –Numerous and diverse set of samples each test
- Low detection limits achieved via filter plating
  - –LR for many tests/samples > 6 (considered effective), yet many samples came back positive
- 200 ppm @ 4 and 6 hours had least number of positives, but also lowest surface loadings
- Bench scale test chamber results may not always transfer to full-scale results

Summary, Lessons Learned

- Effective low levels would allow more contractors to participate in remediation efforts after a wide area event
- Tests are ongoing, still analyzing data, drawing conclusions
- Further research needed to find conditions (eg contact time) where low levels of ClO_2 will be effective on higher spore loadings (> 6 log CFU/sq. ft)
- Current results show low ClO_2 levels effective at spore loadings < 5 log CFU/sq. ft

Methyl Iodide Fumigation of Bacillus Anthracis Spores

U.S. EPA Decon Conference
November 2013

Mark Sutton, PhD

Lawrence Livermore National Laboratory

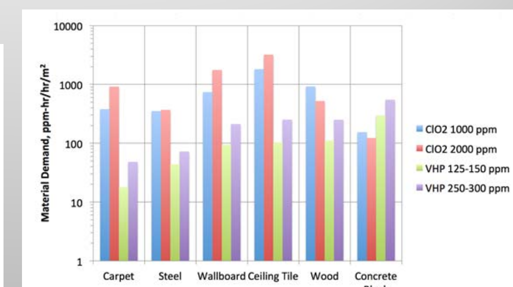
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore Nat onal Laboratory under Contract DE AC52 07NA27344. Lawrence L vermore Na ona Secur y LLC

LLNL PRES 644838

Traditional Fumigation Techniques

- Chlorine dioxide and vaporous hydrogen peroxide are often incompatible with materials found in a variety of buildings causing damage, reaction or high material demand (absorption).
- This results in damage to sensitive or valuable items and infrastructure, reduced efficacy per kg of fumigant and increased waste volume.

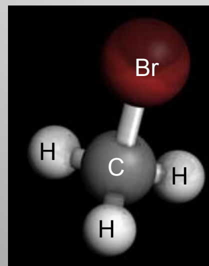
Material Demand Studies: Interaction of Chlorine Dioxide Gas With Building Materials, EPA/600/R-08/091 (Sept 2008)



Recreated from: Interaction of Chlorine Dioxide Gas With Building Materials, EPA/600/R-08/091 (Sept 2008) and Materials Sorption of Vaporized Hydrogen Peroxide, EPA/600/R-10/002 (May 2010)

Methyl Bromide Fumigation

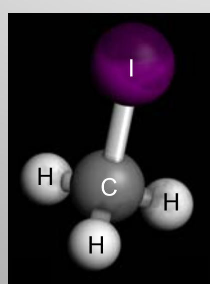
- Methyl bromide has been shown to be an effective fumigant for *B. anthracis* and was widely used in the agricultural and import community.
- Methyl bromide general use has been phased out as part of the Montreal Protocol, an international agreement to reduce ozone-depleting gases.
- Prof. Rudolf Scheffrahn at U. Florida has been researching MeBr fumigation of *B. anthracis.*



http://news.ifas.ufl.edu/2003/06/uf-research-on-anthrax-decontamination-confirmed-by-illinois-tests/

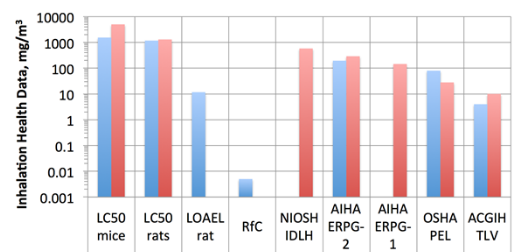
Methyl Iodide Fumigation

- Methyl iodide has similar methylation properties and was used as a replacement for methyl bromide in fumigating strawberries.
- Methyl bromide is not subject to the Montreal Agreement, making justification for use in fumigation easier, although a FIFRA crisis exemption would still be required for use in fumigating *B. anthracis*.



MeI vs. MeBr Health Effects

- LC50, AIHA ERPG-2 and ACGIH guidance suggests MeI health effects are slightly less than those of MeBr.
- OSHA guidance suggests MeI effects are slightly worse than MeBr.



	LC50 mice	LC50 rats	LOAEL rat	RfC	NIOSH IDLH	AIHA ERPG-2	AIHA ERPG-1	OSHA PEL	ACGIH TLV
MeBr	1540	1173	11.7	0.005		195		80	4
MeI	5000	1300			580	290	145	28	10

References available on request

Methyl Iodide Fumigation Studies (1)

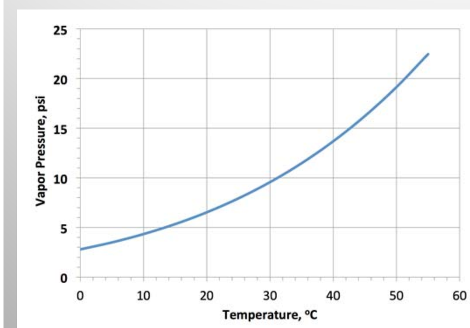
- In 2012 and 2013, LLNL scientists performed two different studies:
  - ✓ Evaluation of MeI efficacy of MeI in fumigating B. anthracis (DTRA);
  - ✓ Evaluation of the effects of MeI on delicate/irreplaceable materials (DHS).

Methyl Iodide Fumigation Studies (2)

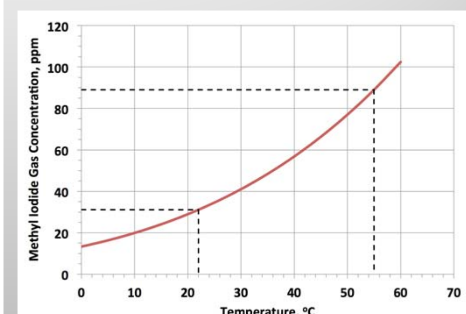
- MeI is a liquid at room temperature (bpt: 42.4°C, 108°F)
- Vapor pressure even at room temperature provides MeI gas-phase exposure to samples suspended above liquid.
- Since vessels were sealed, complete evaporation is not physically possible.

Methyl Iodide Fumigation Studies (3)

- Heating liquid in a sealed vessel increases gas-phase concentration



Relationship between vapor pressure and temperature for methyl iodide and water vapor (data recreated from Lorenz et al, 1976 and CRC Handbook of Chemistry and Physics, 2011)



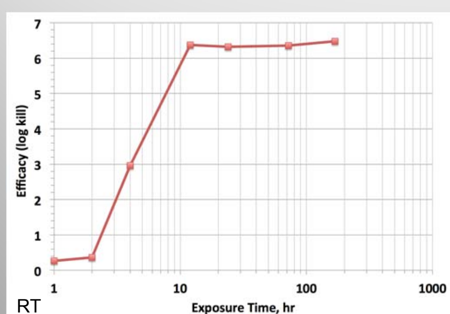
Theoretical concentration of methyl iodide in the gas phase in 90 ml pressure tubes containing 20 ml methyl iodide solution at temperatures from 0 to 55ºC

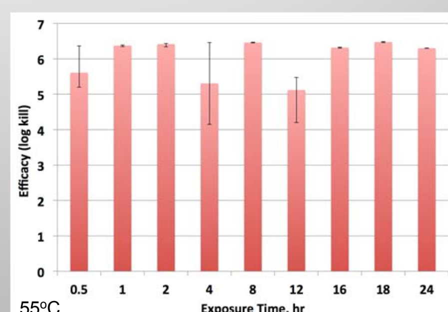
Methyl Iodide Fumigation Efficacy (1)

- *B. anthracis* Sterne spores (3 x 10^6) were applied to stainless steel coupons placed inside sealed glass pressure tubes containing methyl iodide liquid.
- Subjected to methyl iodide fumigation at room temperature and at 55°C.
- Efficacy was measured on a log-scale with a 6-log reduction in colony forming units being considered successful.
- Additionally, spore fumigation on concrete was performed at 55°C.

Methyl Iodide Fumigation Efficacy (2)

- 3 x 10^6 *B. anthracis* Sterne spores on stainless steel
- Efficacies greater than a 6-log reduction in CFUs were obtained after 12 hours at room temperature and just 1 hour at 55°C





Methyl Iodide Fumigation Efficacy (3)

- Lower efficacy on concrete
  - At 55^{o}C, efficacies of 2.6 and 5.1 log kill were measured after 2 and 4 hours respectively.
  - Not known whether this was due to difficulty removing and collecting spores from porous/reactive surface or greater material demand for MeI compared to stainless steel.
  - Extraction method produced fine particles in solution that had sloughed off the sample and spores adhered to the particles rather than being in solution prior to analysis.

Methyl Iodide Material Compatibility (1)

- Previous studies showed that ClO_2 and VHP were detrimental to some delicate/historic items.
- If MeI can be shown to not damage such items, could provide useful for decontamination of *B. anthracis* contaminated items. Coupons included:
  - — 3 B&W and sepia photographs from the 19th and early 20th century;
  - — 2 types of hand-written note-paper from collections dated a collection dated 1909 to 1957 and 1860 to 1890;
  - — 3 pages from printed books dated 1884, 1893 and 1904;
  - — 2 monochromatic oil painting surrogates representative of palette and techniques used in historical paintings;
  - — 1 historical light/cool color palette oil painting from 1885.

Methyl Iodide Material Compatibility (2)

- Objective of this study was to evaluate material effects, not efficacy, so no spores were added to the surface of the coupons
- Coupons were exposed to gas-phase MeI at room temperature (24 hrs) or 55°C (1 hr).
- Coupons allowed to degas at room temperature for 48 hrs.
- Temperature and RH was monitored before, during and after fumigation.

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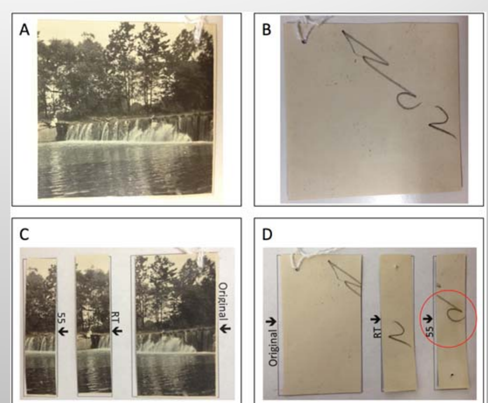
Methyl Iodide Material Compatibility (3)

- Painting coupons showed no qualitative visible degradation after fumigation with MeI at room temperature or elevated temperature
- One of the three historical photographs suffered discoloration consistent with methyl iodide absorption followed by photodegradation or reaction with the photographic paper at 55°C



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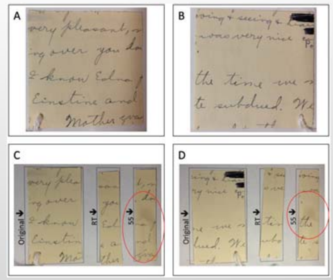
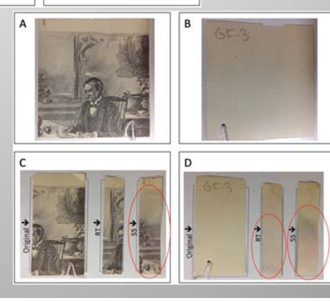
Methyl Iodide Material Compatibility (4)

- 1 of 2 historical pages with hand-written notes suffered discoloration after exposure at 55ºC
- 1 of the 3 historical books exposed to methyl iodide at both room temperature and 55ºC showed discoloration consistent with absorption of methyl iodide after degasing and exposure to light





Methyl Iodide Material Compatibility (5)

- Prior results from a recent EPA study showed that methyl bromide fumigation resulted in no degradation of the samples tested (a portion of the same samples were tested in this methyl iodide study).
- Since MeI is photosensitive, absorbed reagent remaining after degassing will lead to discoloration of the material.
- Given the observed discoloration on photograph, book and note-paper samples exposed to methyl iodide in the LLNL study, methyl bromide should be favored over methyl iodide in the fumigation of historic, irreplaceable artifacts, particularly in those cases where the fumigant can be absorbed into the surface of the material.

Summary

- > 6 log reduction observed for B. anthracis Sterne on stainless steel.
- Lower efficacy observed for B. anthracis Sterne on concrete coupon (either due to material demand or difficulty in recovery).
- Material compatibility testing of delicate/historic artifacts showed MeI absorption in some cases leading to discoloration.
- Results suggest MeI fumigation may be more appropriate for non-porous surfaces.

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Acknowledgements

- Funding: DTRA and DHS
- Laboratory efficacy studies: Stacy Kane and Jessica Wollard (LLNL)
- Material compatibility coupons: Shannon Serre (EPA)

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Wednesday, November 6, 2013

Concurrent Sessions 1

Chemical Agent Sampling and Detection

Decontamination and Verification Techniques Used At U.S. Army Chemical Agent Disposal Facilities and Applications for Clearing Contaminated Areas

Theodore E. Ruff, PE
Environmental Engineer
Joseph Padayhag, CSP, CIH
Chemical Engineer

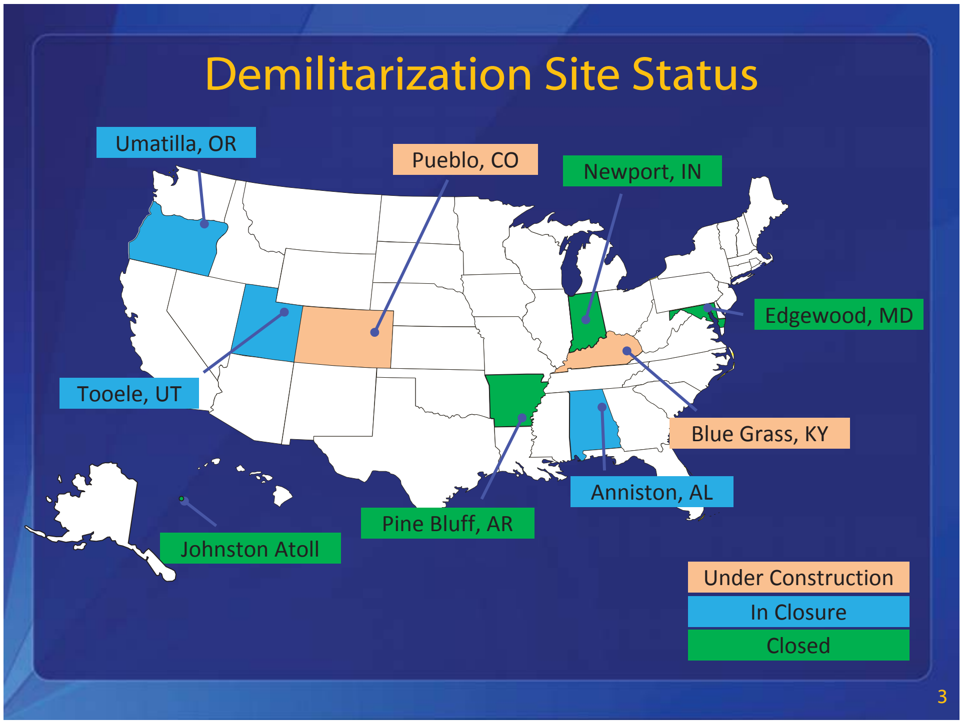
2013 EPA International Decontamination Research and Development Conference
5-7 November 2013

National Center for Environmental Health
Division of Emergency and Environmental Health Services

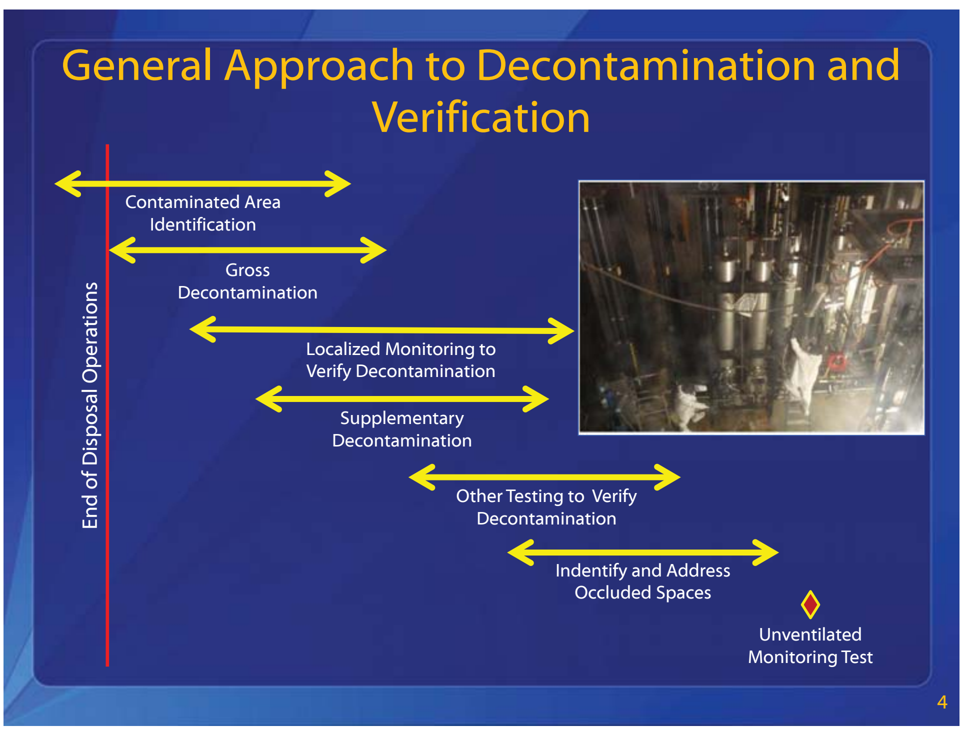
Centers for Disease Control/ Environmental Public Health Readiness Branch Oversight

- Title 50 of the U.S. Code, Section 1512 requires CDC to review particulars associated with disposal and transportation of chemical warfare agents and recommend precautionary measures to protect public health and safety, if necessary.
- U.S. stockpile and non-stockpile items.
- Continues through closure of facilities until agent hazard is eliminated.

2



Demilitarization Site Status
Umatilla, OR
Pueblo, CO
Newport, IN
Edgewood, MD
Tooele, UT
Blue Grass, KY
Anniston, AL
Pine Bluff, AR
Johnston Atoll
Under Construction
In Closure
Closed
3



General Approach to Decontamination and Verification
End of Disposal Operations
Contaminated Area Identification
Gross Decontamination
Localized Monitoring to Verify Decontamination
Supplementary Decontamination
Other Testing to Verify Decontamination
Indentify and Address Occluded Spaces
Unventilated Monitoring Test
4

Waste Shipment

- Chemical Materials Agency (CMA)* *Bounding Transportation Risk Assessment* (Bounding TRA) for >1 Vapor Screening Level Waste was proposed to
  - Develop bounding conditions for shipment of chemical warfare agent-contaminated secondary waste.
  - Identify and assesses potential release and exposure risks associated with an accident during ground transportation to a treatment, storage, and disposal facility.
- CDC recommended establishing a maximum concentration for the interior headspace of each drum to be no higher than ½ the Immediately Dangerous to Life or Health (IDLH) value to give personnel opportunity to safely exit the area in the event of an accident.

* CMA is now Joint Program Manager – Elimination (JPM-E)

5

Waste Shipment Con't

The Bounding TRA specifies limits on the level of agent contamination in the waste and the total number of shipments that can be completed.

- The limits on agent contamination are provided to limit downwind hazard in the event of an accident to a level that would result in little or no health impact.
- The limits on total number of shipments are provided to limit the probability of an accident during the shipment operation.

6

Waste Shipment Con't

The Bounding TRA is just one of many safeguards to ensure protection of the public, workers, and the environment during shipment operations. Other items include:

- Monitoring and characterization of the waste.
- Packaging and segregation of the waste.
- Loading and unloading operations.
- Transportation planning and procedures.
- Emergency response planning and procedures.

7

Decontamination

- Flushing.
- Removal of contaminated equipment.
- Pressure washing.
- Detergent, bleach, peroxide.
- Hot air.
- Steam.

8

Occluded Space Survey

9

Monitoring Requirements

- Monitoring conducted within closed volumes at temperatures >70°F.
- NRT and/or sorbent tube monitoring was used to detect residual agent.
- Monitoring to < 1 VSL*.

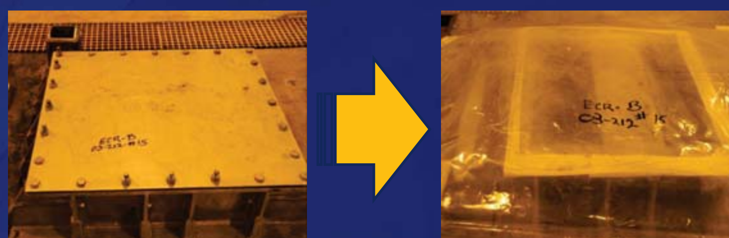
* VSL is equal to the concentration associated with the Short Term Exposure Limit:

HD = 0.003 mg/m^3
GB = 0.0001 mg/m^3
VX = 0.00001 mg/m^3

10

Localized Monitoring Tests

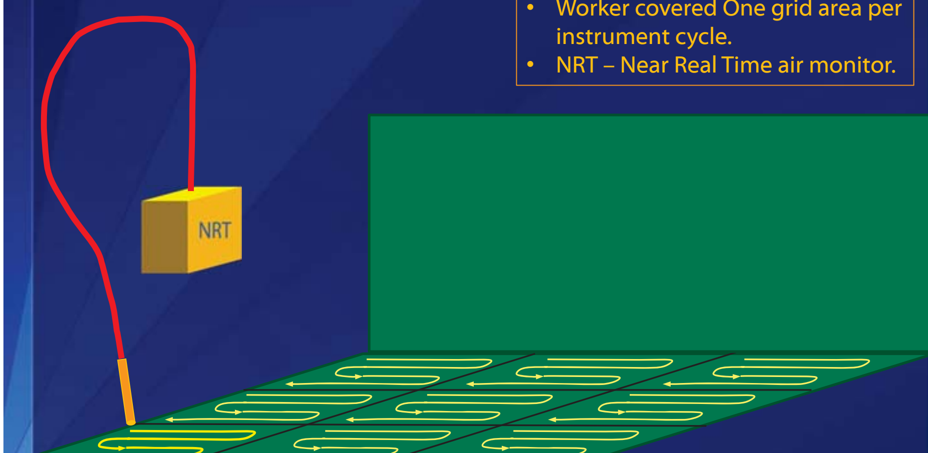
- HVAC ductwork and plenums.
- Tanks.
- Tents.
- Room monitoring.



11

Point Source Monitoring

- Grid floors (and other surfaces) to control area of sample.
- Worker covered One grid area per instrument cycle.
- NRT – Near Real Time air monitor.



12

Other Verification Methods

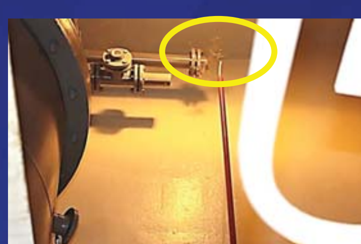
- Rinsate sampling.
- Concrete sampling.
  - Judgmental where history indicated past potential for contamination.
  - Random where history indicated no contamination.

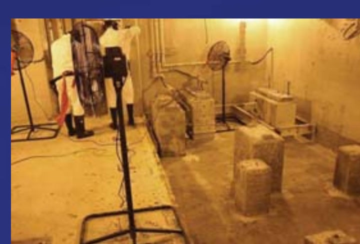
13

Unventilated Monitoring Test Preparation


Sealing opening for unventilated room monitoring.


Smoke testing around sealed wall opening.


Smoke testing flanged pipe.

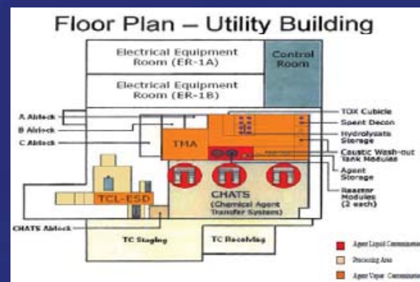

Fan placement for air mixing.

14

Final Unventilated Monitoring Test

Required successful completion of

- Decontamination.
- Occluded space survey and decontamination.
- Localized monitoring tests (tenting, tanks, etc.).
- Isolation of areas from ventilation.
- Concrete Sampling (where required).



Conduct of test included

- Use of Near Real Time and sorbent tubes for sampling.
- Multiple monitoring locations.
- Pre and post testing of sample line transmission.

15

Significant Considerations

- Established methodology for waste shipment.
- Decontamination planning based on contamination history.
- Thorough and documented decontamination.
- Preliminary, targeted verification.
- Occluded space survey.
- Use of other verification methods (concrete sampling).
- Structured review process to verify required activities were completed.
- Unventilated Monitoring Test (UMT).
  - Verify isolation from facility ventilation.
  - Temperature.
  - QA/QC requirements.
  - Air mixing.
  - Generally, the goal was to be below the programmatic level of quantitation.
  - Some sites set lower monitoring levels as the goal.

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Summary

- Appropriate decontamination methods and identification of occluded space essential to successful clearance.
- Air monitoring to verify decontamination proved effective.
- Other verification methods still important – rinsate, solids, wipe samples.
- Selection of appropriate acceptance criteria and agreement by stakeholders key consideration.

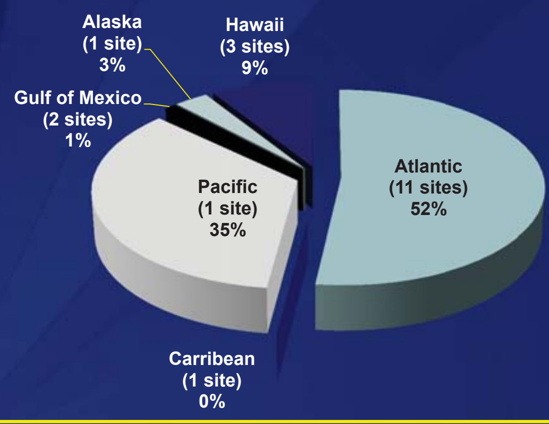
17

Retrieval of Chemical Munition by Fishing Vessel

18

Where Did DoD Conduct CWM Disposal Operations in US Coastal Waters?

Percentage based on Agent Weight



Approximately 27,000 metric tons (30,000 tons) of chemical agent was disposed in US waters

Data published in Defense Environmental Programs FY08 Annual Report to Congress (ARC), Appendix Q

19

ESS Pursuit Incident

- June 6th ESS Pursuit recovers WWI era munitions.
  - One munition falls of sorting table and breaks open.
  - While tossing munition overboard 2 crew members are exposed.
- June 7th ESS Pursuit off loads catch at Seawatch processing plant.
  - Exposed fisherman is transported to St. Luke's Hospital with blisters.
  - Transportation type unknown.

20

ESS Pursuit Incident

- Approximately 6:00 am on June 7, Nurse at St. Luke's Hospital identified fisherman's blisters as a sulfur mustard exposure.
- Sequence of events from identification to notification of emergency response personnel unclear.
- By mid-day June 7th Incident Command System had been established.

21

ESS Pursuit Incident

Incident Command System included:

- New Bedford (MA) Fire Department.
- New Bedford (MA) HAZMAT.
- MA National Guard – Civil Support Team.
- U.S. Coast Guard.
- U.S. EPA.
- MA Department of Emergency Preparedness.
- MA Department of Public Health.
- MA Division of Marine Fisheries.

22

ESS Pursuit Incident

MA National Guard Civil Support Team decontaminated the vessel

- ATSDR (Part of CDC/NCEH) Region 1 was contacted to determine the level to clear the vessel.
- ATSDR reached back to NCEH/EPHRB Chemical Weapons Program for advice.
- NCEH/EPRHB provided ATSDR with the Airborne Exposure Levels and sampling techniques the U.S. Army uses at chemical weapons demilitarization site.

23

ESS Pursuit Incident

Clearance Sampling

- EPA clearance strategies uses wipe samples.
- NCEH/ATSDR clearance strategies uses air samples.
- The two separate philosophies created delays and confusion.
- Ultimately both clearance methods were employed.

24

Lessons Learned

Potential for reoccurrence:

MA Department of Health Representative related that during conversations with Captain and crew the following statements had been made:

- They recover munitions during every fishing trip
- Approximately 50 % of the munitions smell of garlic (a indication of a ruptured munition).
- The fisherman have painted rocks and tossed them overboard with other refuse and have then retrieved the same rock on sub-sequent fishing trips in the same area.

25

Lessons Learned

Worked Well

- CDC/Division of Laboratory Science intra-laboratory bio-monitoring with state of MA.
- Health care provider training conducted by the MA Department of Public Health.
- Sulfur Mustard exposure identification visual aid provided by the MA Department of Public Health.

Areas for Improvement

- Emergency responders notification network.
- ICS and UCS were not effective:
  - Confusion about who had authority and jurisdiction.
  - Confusion about authority over a private vessel.
- Clearance Sampling: Difference in philosophies between agencies.

26

Future Applications

- CDC/EPHRB working with EPA to draft clearance process guidance
  - Building and facilities
  - First draft provides general considerations and principles
  - Currently under internal review & comment

Future Applications – Considerations

- Extrapolate from Army's experience

  Decontamination.
  Intermediate verification.
  Documentation.
  Verification.

- Extrapolation of CDC Airborne Exposure Levels (AELs)

  Army currently uses GPL as basis to clear for unrestricted use.
  Army used WPL as goal at some sites.

CDC Recommended AELs

Exposure Limit	HD (mg/m^3)	GB, GA (mg/m^3)	VX (mg/m^3)
Short Term Exposure Limit (STEL)	0.003 (15-min)	1×10^{-4} (15-min)	1×10^{-5} (15-min)
Worker Population Limit (WPL)	0.0004 (8-hour)	3×10^{-5} (8-hour)	1×10^{-6} (8-hour)
General Population Limit (GPL)	0.00002 (12-hour)	1×10^{-6} (24-hours)	1×10^{-7} (24-hours)

Multi-Laboratory Study of Analytical Protocols for Chemical Warfare Agents in Environmental Matrices

Romy Campisano

Office of Research and Development
Nat onal Home and Secur ty Research Center, Threat and Consequence Assessment D vision

November 6, 2013

Partners and collaborators

- Terry Smith: EPA Office of Emergency Management
- Carolyn Koester: Lawrence Livermore National Lab
- Joan Cuddeback, Eric Boring: CSC (contractor)

- Participating Labs
  - –EPA Regions 1, 3, 6, 9, and 10
  - –State Labs of Virginia and Florida
  - –EPA PHILIS (mobile lab)

1

EPA United States Environmental Protection Agency

Selected Analytical Methods for Environmental Remediation and Recovery (SAM) 2012

- Section include Chemicals, Radiochemicals, Pathogens and Biotoxins

Chemicals	141 analytes	5 matrices
Pathogens	31 analytes	4 matrices
Radiochemicals	25 analytes	6 matrices
Biotoxins	18 analytes	4 matrices

- www.epa.gov/sam

2

EPA United States Environmental Protection Agency

Chemical Applicability Tiers

- Indicate the extent of data available to support each method for analyte/sample type pair.
- The fitness of a method for an intended use is related to site-specific data quality objectives for a particular environmental remediation activity.

3

Chemical Warfare Agent (CWA) Analysis

- Analytes
  - –Sarin (GB), soman (GD), cyclosarin (GF), sulfur mustard (HD), and VX
- Sample Types
  - –Soil
  - –Water
  - –Wipes
- Analytical Technique
  - –Gas Chromatography/Mass Spectrometry (GC/MS)
  - –Gas Chromatography/Time-of-Flight Mass Spectrometry (GC/TOF-MS)

4

Ultra-dilute CWAs Used for EPA Research

EPA has worked with the US Army and US Department of Energy to obtain ultra-dilute CWA quantities for research purposes and develop standards for EPA's Environmental Response Laboratory Network (ERLN).

- Ultra-dilute* chemical warfare agents are limited to a concentration of 10 parts per million (ppm).
  - o Ultra-dilute standards are used by 8 ERLN labs.
- US Army defines dilute thresholds of 1000 ppm (V-agents), 2000 ppm (G-agents), and 10,000 ppm (H-agents).#

* Ultra-dilute is new term established for quantities under EPA-DOE Interagency Agreement
# United States (2008). Chemical Surety, Army regulation 50-6, Washington, DC: Headquarters, Dept. of the Army

5

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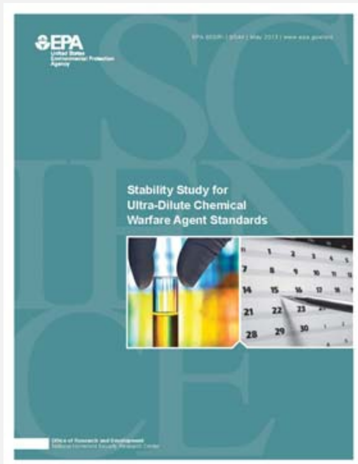
Shelf Lives for CWAs Single-Component Solutions



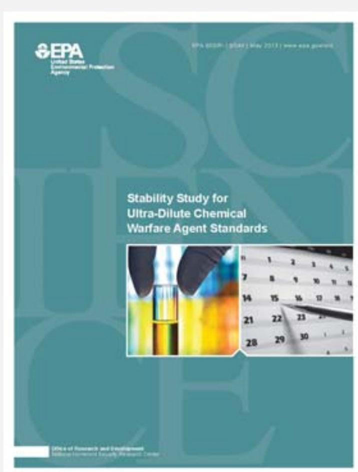
Estimated Shelf Lives for CWAs in Single-Component Solutions (months)				
	Dichloromethane		Hexane	
	Screw-cap Vial	Sealed Ampoule	Screw-cap Vial	Sealed Ampoule
GB	5	12	4	2
GD	12	12	12	12
GF	12	12	12	12
HD	6	12	4	6
VX	2*	12	5	3

* Large variabilities between replicate analyses were noted (relative standard deviation >50%). A subsequent VX preservation study is ongoing.

6

EPA United States Environmental Protection Agency

Shelf Lives for CWAs Multiple-Component Solutions



Estimated Shelf Lives for CWAs in Multiple-Component Solutions (months)				
	Dichloromethane		Hexane	
	Screw-cap Vial	Sealed Ampoule	Screw-cap Vial	Sealed Ampoule
GB	9	12	0.3	9
GD	12	6	0.7	9
GF	12	12	12	12
HD	6	6	3	6
VX	0.2	≤ 1*	12	≤ 1*

* Large variabilities between replicate analyses were noted (relative standard deviation >50%). A subsequent VX preservation study is ongoing.

7

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Sample Preparation - Water

- Microscale extraction technique using methylene chloride
  - 35 ml water sample
  - Sodium chloride is added
  - 2 mL of methylene chloride is added
  - Sample allowed to settle or is centrifuged
  - ~1 mL of the methylene chloride is pipetted for analysis

8

EPA United States Environmental Protection Agency

Sample Preparation - Soils

- Microscale extraction technique using methylene chloride
  - 10 g sample
  - Anhydrous sodium sulfate and glass beads added
  - 25 mL of methylene chloride is added
  - Use shaker table or sonicator for 15 min
  - Sample allowed to settle or is centrifuged
  - Decant or pipet solvent
  - Concentrate sample with nitrogen evaporation

9

EPA United States Environmental Protection Agency

Sample Preparation - Wipes

- Microscale extraction technique using methylene chloride
  - 1 wipe sample
  - 15 mL of methylene chloride is added
  - Use shaker table or sonicator for 15 min
  - Decant or pipet solvent
  - Concentrate sample with nitrogen evaporation

10

EPA United States Environmental Protection Agency

Analysis by GC/MS

- Study was conducted using standard quadrupole gas chromatography/mass spectrometry (GC/MS) and gas chromatography/time-of-flight mass spectrometry.
- Preliminary results indicate method detection limits of approximately 1 µg/L for water, 2 µg/kg for soil, and 0.04 µg/wipe for surface wipe matrices using quadrupole mass spectrometry
- Approximately one order of magnitude lower was achieved using TOF.

11

Additional CWA research

- Single-laboratory study for analysis of GA, HN-1, HN-3 and R-VX in soil, wipes and water
- Report for Lewisite analysis by LC/MS/MS
- Report for the surface analysis of organophosphorus degradates by LC/MS/MS
- VX preservation study report
- CWA wipe sampling efficiencies on porous, permeable or uneven surfaces

12

Conclusions

- Ultra-dilute standards
  - –Allow EPA to handle chemical warfare agents
  - –Holding time and stability studies
- Analytical protocols for environmental matrices for remediation and recovery
- Collaboration

For more information: http://www.epa.gov/nhsrc

Romy Campisano
campisano.romy@epa.gov

DISCLAIMER
The views expressed in this presentation are those of the author and do not necessarily reflect the views and policies of the U.S. Environmental Protection Agency.

13

Accelerated Remediation at a Region 1 Residential Clean-up Site Using PHILIS On-site Analytical Laboratories

U.S. Environmental Protection Agency
Lawrence Kaelin OEM/CBRN-CMAT,
Michael Nalipinski, Region 1 OSC,

NHSRC Decon Workshop, 2013

Site History

The property was near the former St. Albans Gas & Light Company, where 4,000 tons of PAH-contaminated soils were excavated and disposed of off-site in 2005.

St. Albans Site History

Spring 2011, heavy rains flooded Stevens Brook

- Residents in nearby apartments noticed odors and coal tar wastes in basement sumps
- Workers found coal tar wastes in area manholes
- VT DEC temporarily stabilized the situation by pumping out basements and ventilating buildings

3

Site Conditions

- After Hurricane Irene in the Fall of 2011, additional complaints of tar and oil like odors came from the apartment residents
- Contamination was suspected in soil, sump water, and brook sediment
- VT DEC requested assistance from Region 1 EPA to determine whether coal tar waste contamination exists on residential properties abutting Stevens Brook

Region 1 Response

- Region 1 provided support to the VT DEC, responding as a Time Critical Removal under CERCLA authority
- Mike Nalipinski was assigned OSC for the St. Albans Gas & Light Site
- An Accelerated Remediation Clean-up Concept was proposed to minimize community impact
- Region 1 requested the use of OEM/CMAT's PHILIS mobile labs to provide on-site analysis of soil, water, soil gas and air samples

Accelerated Remediation Concept

- On-site sampling and analysis activities maximize the utilization of EPA response assets to reduce time and costs for effective site assessment and clean-up actions
- Rapid on-site laboratory results that meet all 2009 TNI (NELAP) requirements for accredited parameters from the PHILIS mobile labs will achieve accelerated clean-up objectives

Accelerated Remediation Goals

- Maximize site resources to reduce time to remediation
- Direct on-going soil coring activities using rapid analytical results to maximize usage of contractor and on-site assets
- Capture the boundaries of the vertical and horizontal extent of soil contamination in a single mobilization
- Determine the source and extent of the in-door air contamination in the apartment complex
- Provide rapid, on-site NELAP accredited, confirmatory data for daily decisions, briefings to local authorities (VT DEC)
- Reduce number and longevity of site visits normally required to support a Time Critical RAM
- Direct excavation activities based on data from a single site mobilization – “one and done” concept

PHILIS Mobilization and Site Work

- On May 7th, 2012 Region 1 START contractors and PHILIS mobile labs were deployed to conduct sampling and analysis to determine the extent of coal tar waste contamination
- Contaminants of concern included benzene, naphthalene and SVOCs, particularly PAHs and benzo(a)pyrene
- In the course of 4 days, over 250 samples were collected and analyzed on-site for PAH, benzene or naphthalene contamination

PHILIS Mobile Laboratory Assets – Dual Use

- PHILIS units are the EPA's mobile laboratory assets under the Environmental Response Laboratory Network (ERLN)
- Mission Chemical Warfare Agents (CWA) and Toxic Industrial Chemicals (TIC) in environmental samples
- They are stationed in Edison, NJ and Castle Rock, CO and can be deployed within 24 to 48 hours to support emergency response and clean-up actions



PHILIS Capabilities

- Deployable within 6 hours of notification/operational within 6 hours of being on-site
- Operate via internal generators/supplies for 4 days before restocking/refueling required
- TNI accredited for VOCs, SVOCs and PCBs in water and soil using EPA Methods 8260c/8270d/8082a. Mobile lab confirmatory analysis meets 2009 TNI requirements
- Pursuing accreditation for TO air methods and LC/MS/MS methodology for carbamates and pharmaceutical compounds
- Estimate 100-200 samples/day for CWAs and TICs (24hr operations) for all matrices
- Analysis of environmental samples for CWAs via ERLN's Ultra-dilute agent (UDA) program. Detection limits to health-based clearance via EPA's SAM methods

PHILIS Labs at St. Albans Site

APL01 – Volatiles Mobile Lab for EPA method 8260 for soil, sediment and water samples via purge & trap.

Modified TO method for benzene and naphthalene in air and soil gas via automated thermal desorption unit

Purge & Trap for soils & waters

Tedlar bag analysis soil gas

Tenax tube analysis air

PHILIS Labs at St. Albans Site

APL02 – semi-volatiles lab, & sample prep trailer, set up for EPA prep methods 3535A and 3545A

APL02 with GC/MS instruments set up for method 8270D.

SPA01 Trailer w/automated PSE & SPE Apparatus.

Region 1 START Sampling Effort

Sampling water from sump and ambient air in basements

Soil cores at surface and at depth via Geoprobe

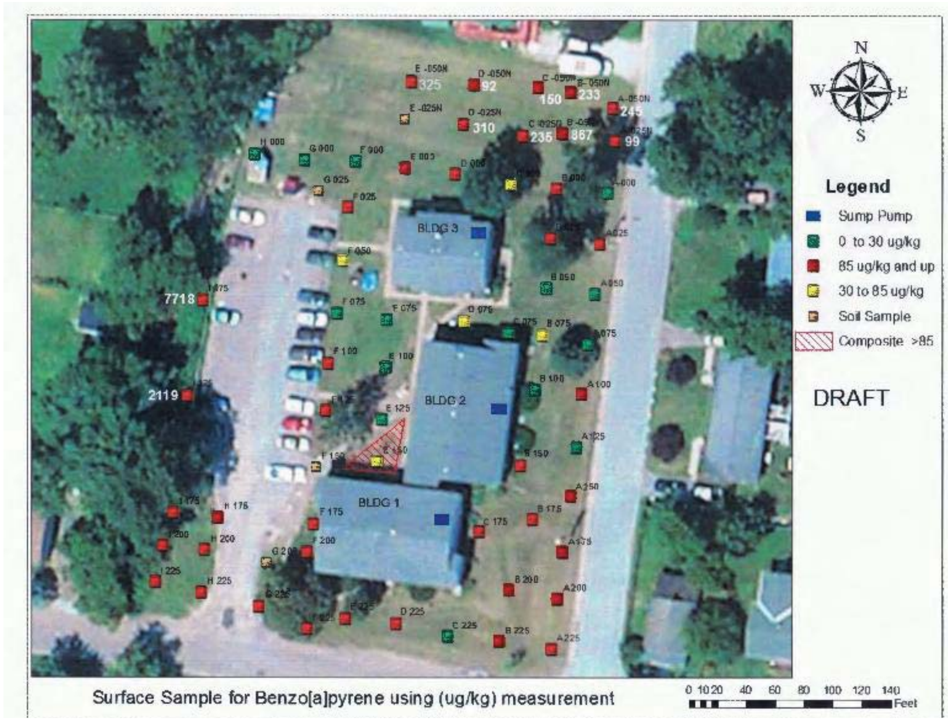
Soil-gas samples in Tedlar bags via Geoprobe

Daily Briefing and Data Depiction

- Region 1 OSC Mike Nalipinski conferred with the VT DEC representatives on a daily basis using analytical data presented in GIS site maps
- OSC used on-site data to direct daily site work

Daily briefing with VT DEC.

Daily posting of soil data on GIS site map



Region 1 Removal/Mitigation Actions

- Using the rapid site sampling and analysis capability brought to bear at the St. Albans Gas & Light Site, the OSC was able to prepare a Time Critical Removal Action Memo (RAM) recommending soil excavation at the Colony Apartments and the installation of a system to mitigate in-door air contamination posed by the coal tar wastes

In door air basement mitigation system

Excavations Begins

- On-site sampling and analysis defined the spatial and subsurface extent of contamination

Excavation starts at the Colony Square Apts

Common borrow Place at corner of Maple & Lasalle

Soil cores are "logged", screened and Sampled at discrete depths

Goals of Accelerated Remediation Concept were Meet

- In the course of approximately 4 days, over 250 samples were collected and analyzed on-site for PAHs, benzene or naphthalene contamination in air, soil and water matrices
- Expedited RAM was issued was issued
- Accelerated remediation completed using initial data set – no new samples required, "1 & done"
- The on-site abilities provided by PHILIS allowed the OSC to complete all the site soil assessments, excavation, removal and site restoration activities within 90 days of the initial site visit

Colony Apts Remediated

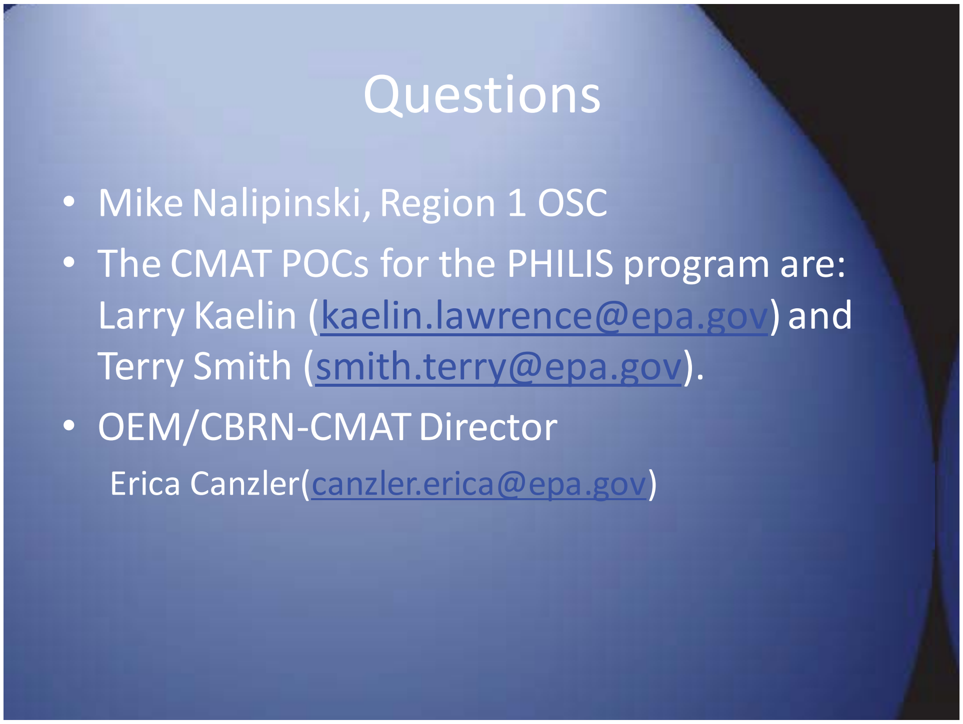
- The accelerated remediation plan for the Colony Apts accomplished on site sampling and analysis data from a single site visit
- Top 2 feet of soil removed from specific zones identified by PHILIS on site analysis and sent for disposal. Backfill with clean top soil
- The possibly of runoff to Steven Brooks was reduced by the rip rap and other soil retention measures
- Official demobilization on October 2012


Colony Square Apts, September 2012 after backfill and hydro seeding


Stevens Brook runoff and soil retention measures, rip rap, & geo-fabric

Costs/Benefits

- Estimations of actual PHILIS analytical cost/sample from the St. Albans site effort were determined to be below most commercial lab costs, ranging from $250-325/sample which included fuel, mob/demob costs, travel, pre diem, sample analysis, QA review and report writing
- Man-hours for St Albans site were covered under the PHILIS contract. Future mobilizations may not
- Cost sharing options can be explored for future sites.
- PHILIS costs should drop ~ $50-100/sample based on “lessons learned” and optimization of assets
- The greater time and cost savings were realized for the OSC by having the most effective use of their site assets in an accelerated time frame


Questions
• Mike Nalipinski, Region 1 OSC
• The CMAT POCs for the PHILIS program are: Larry Kaelin (kaelin.lawrence@epa.gov) and Terry Smith (smith.terry@epa.gov).
• OEM/CBRN-CMAT Director
Erica Canzler(canzler.erica@epa.gov)

2013 US EPA International Decontamination Research and Development Conference
Research Triangle Park, NC

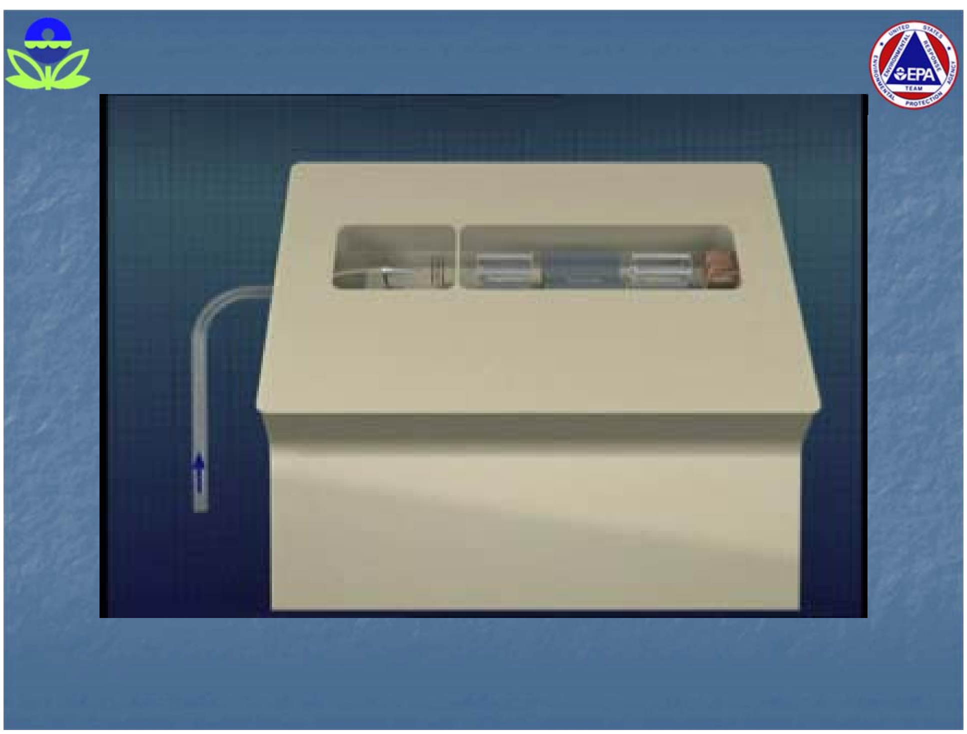
Chemical Warfare Agent Analysis Using The Trace Atmospheric Gas Analyzer (TAGA)

November 2013

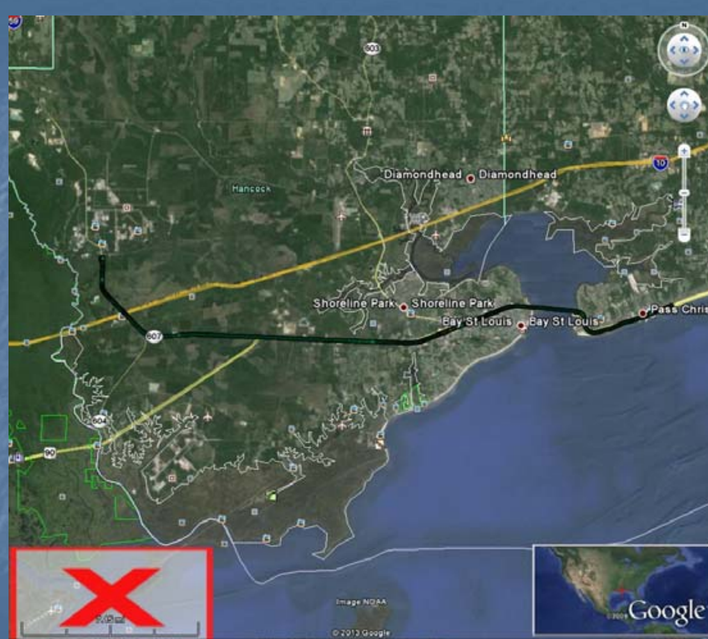
David B. Mickunas
US EPA/ERT

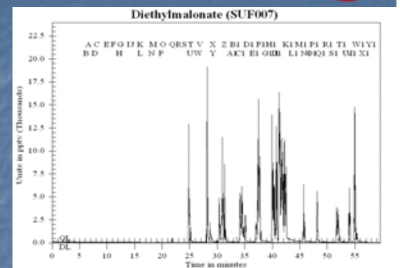
TAGA Mobile Laboratories

TAGA Instrumentation

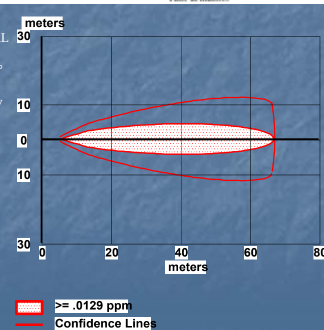


Mobile Monitoring



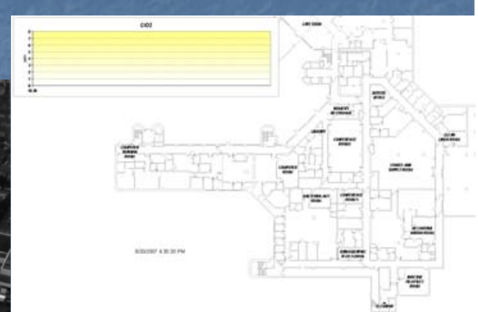


ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 4 meters/second from 315° true at 3 meters
Ground Roughness: open country
Cloud Cover: 0 tenths
Air Temperature: 18.1° C
Stability Class: D
No Inversion Height
Relative Humidity: 25%

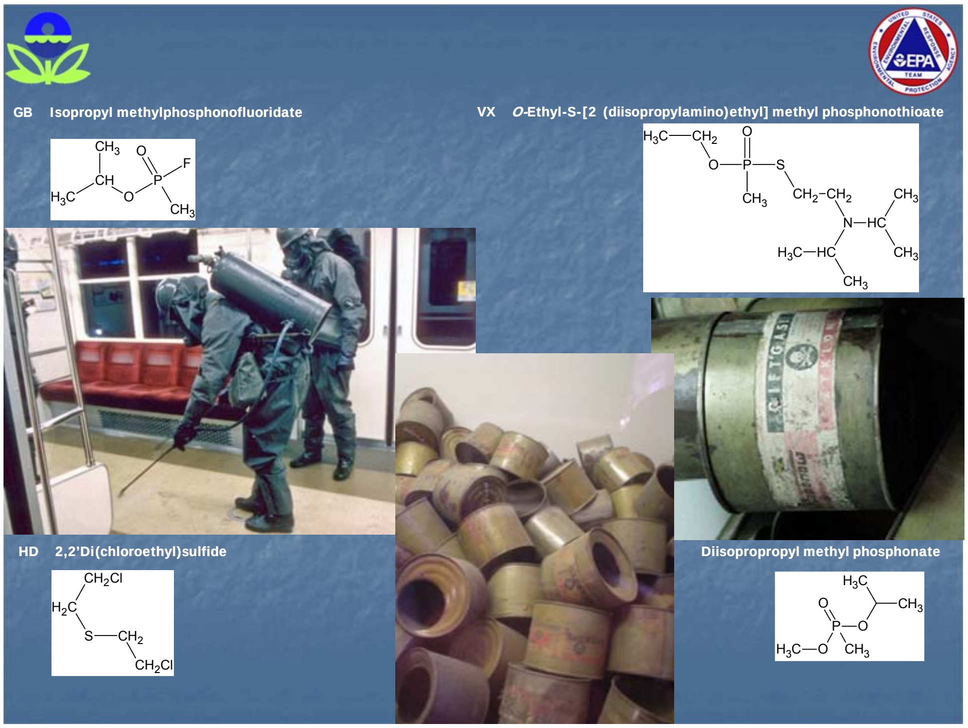


Indoor Monitoring

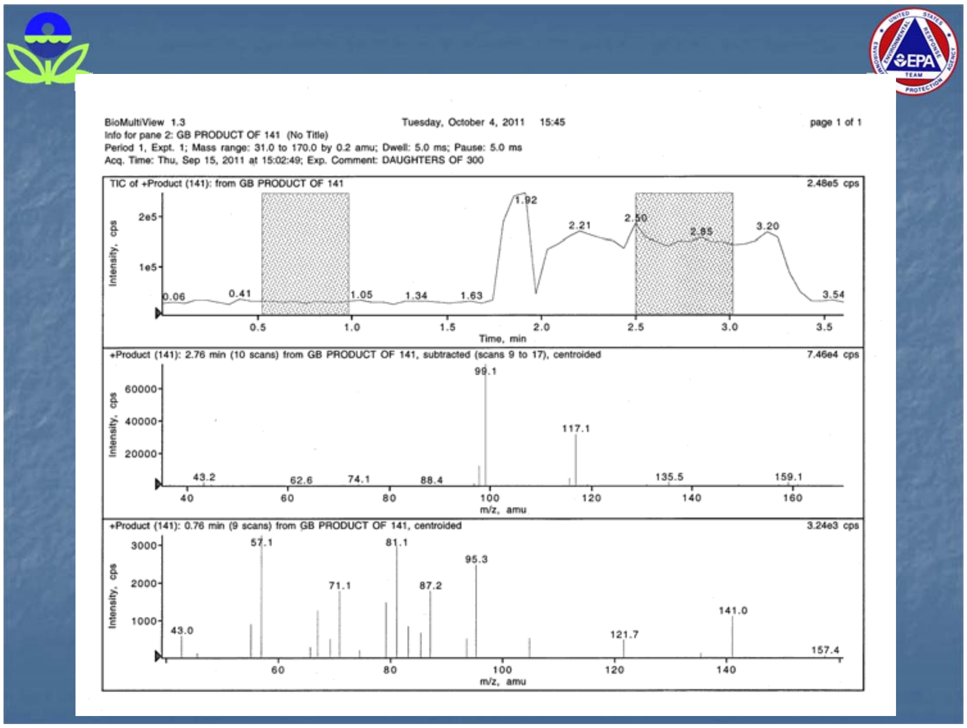

NO SMOKING



CWA Monitoring


GB Isopropyl methylphosphonofluoridate
VX O-Ethyl-S-[2 (diisopropylamino)ethyl] methyl phosphonothioate
HD 2,2'Di(chloroethyl)sulfide
Diisopropropyl methyl phosphonate

SARIN


BioMultiView 1.3
Tuesday, October 4, 2011 15:45
page 1 of 1
Info for pane 2: GB PRODUCT OF 141 (No Title)
Period 1, Expt. 1; Mass range: 31.0 to 170.0 by 0.2 amu; Dwell: 5.0 ms; Pause: 5.0 ms
Acq. Time: Thu, Sep 15, 2011 at 15:02:49; Exp. Comment: DAUGHTERS OF 300
TIC of +Product (141): from GB PRODUCT OF 141
2.48e5 cps
Intensity, cps
Time, min
+Product (141): 2.76 min (10 scans) from GB PRODUCT OF 141, subtracted (scans 9 to 17), centroided
7.46e4 cps
m/z, amu
+Product (141): 0.76 min (9 scans) from GB PRODUCT OF 141, centroided
3.24e3 cps
m/z, amu

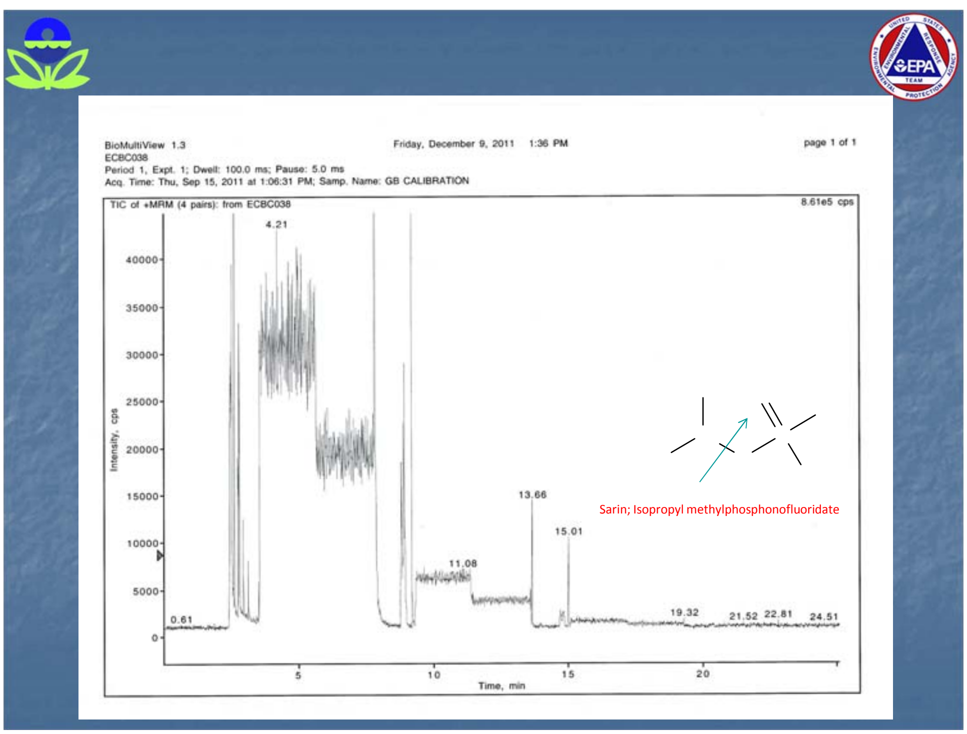
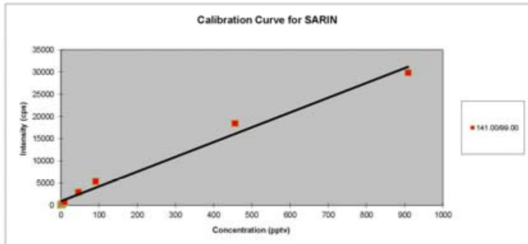

BioMultiView 1.3
Friday, December 9, 2011 1:36 PM
page 1 of 1
ECBC038
Period 1, Expt. 1; Dwell: 100.0 ms; Pause: 5.0 ms
Acq. Time: Thu, Sep 15, 2011 at 1:06:31 PM; Samp. Name: GB CALIBRATION
TIC of +MRM (4 pairs): from ECBC038
8.61e5 cps
Intensity, cps
Time, min
Sarin; Isopropyl methylphosphonofluoridate

FIGURE 2B Calibration Curve for Sarin (GB)

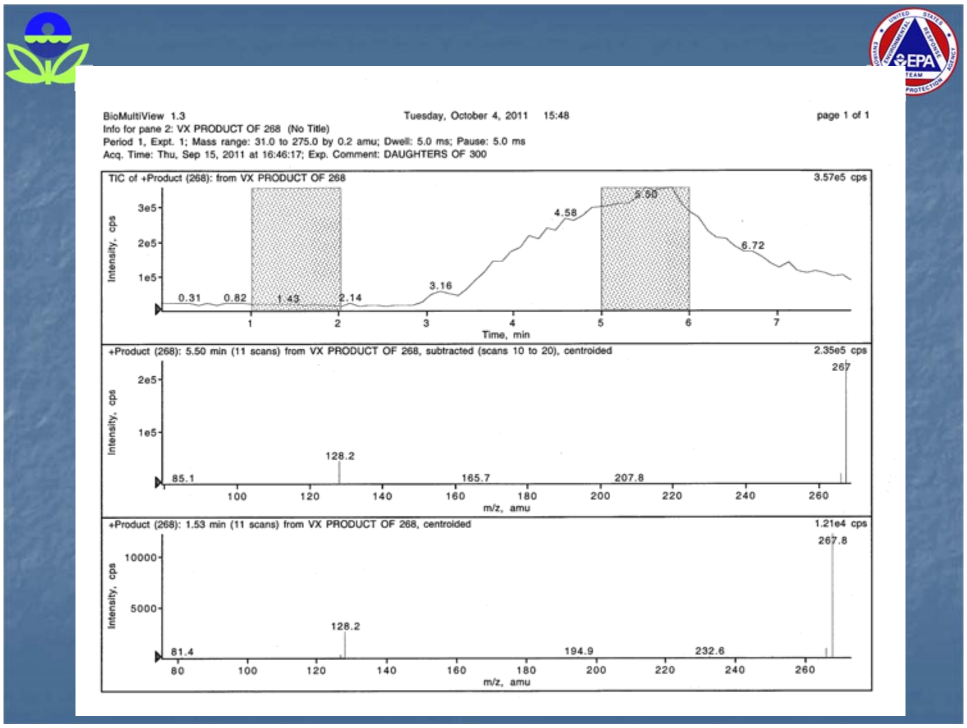


Filename:	ECBC038 et al.							
Compound name:	SARIN							
Conc. units:	pptv							
Width (min):	0.5							
User name:	DLM							
Comment:								
Date:	Thursday, September 15, 2011 13:34:46							
Num. ions:	1							
Num. concs.	8							
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Ctr Pt.(min):	24.2	21.45	18.29	16.37	12.72	10.59	6.69	4.61

	Ion 1
Q1 Mass:	141
Q3 Mass:	99
Slope:	33.2515811
Intercept:	943.771119
Correlation:	0.99308588

Concentrations	141.00/99.00
0	97.8472222
0.909	155.555556
4.56	392.430556
9.09	705.763889
45.6	2931.38889
90.9	5389.65278
456	1.85E+04
909	2.98E+04

VX


BioMultiView 1.3
Tuesday, October 4, 2011 15:48
page 1 of 1
Info for pane 2: VX PRODUCT OF 268 (No Title)
Period 1, Expt. 1; Mass range: 31.0 to 275.0 by 0.2 amu; Dwell: 5.0 ms; Pause: 5.0 ms
Acq. Time: Thu, Sep 15, 2011 at 16:46:17; Exp. Comment: DAUGHTERS OF 300
TIC of +Product (268): from VX PRODUCT OF 268
3.57e5 cps
Intensity, cps
Time, min
+Product (268): 5.50 min (11 scans) from VX PRODUCT OF 268, subtracted (scans 10 to 20), centroided
2.35e5 cps
m/z, amu
+Product (268): 1.53 min (11 scans) from VX PRODUCT OF 268, centroided
1.21e4 cps
m/z, amu

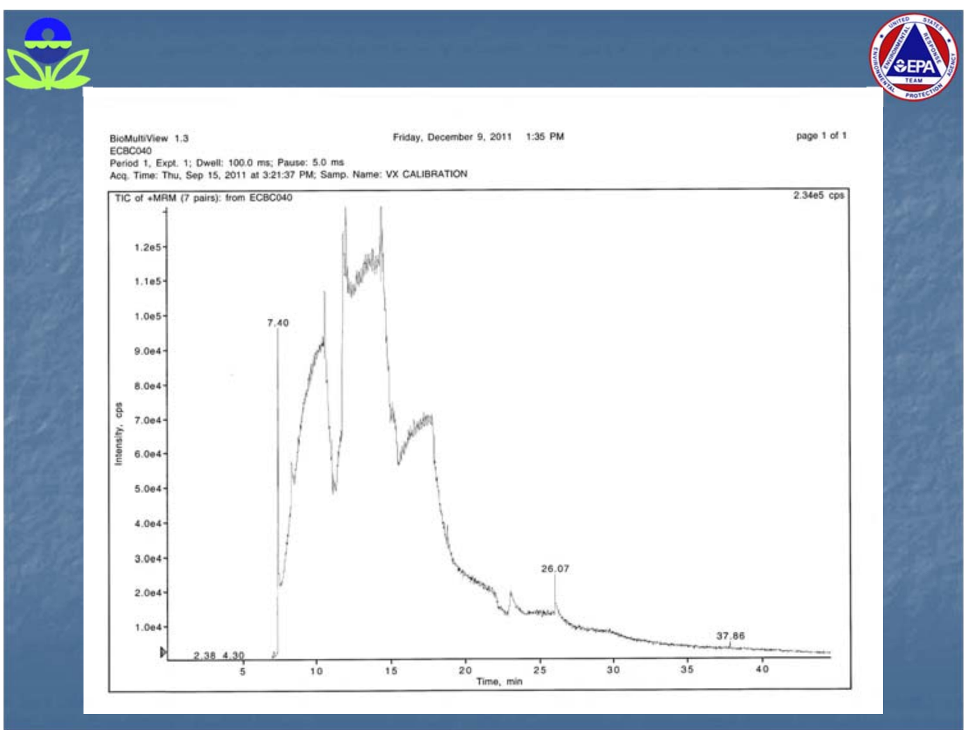
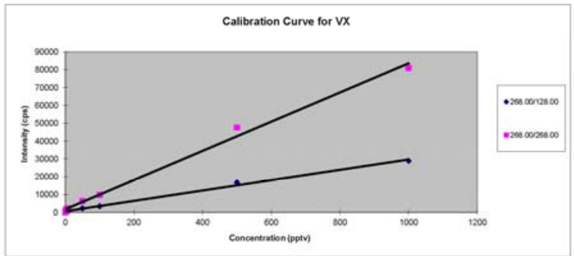

BioMultiView 1.3
Friday, December 9, 2011 1:35 PM
page 1 of 1
ECBC040
Period 1, Expt. 1; Dwell: 100.0 ms; Pause: 5.0 ms
Acq. Time: Thu, Sep 15, 2011 at 3:21:37 PM; Samp. Name: VX CALIBRATION
TIC of +MRM (7 pairs): from ECBC040
2.34e5 cps
Intensity, cps
Time, min

FIGURE 2D Calibration Curve for O-Ethyl-S-(2-Diisopropylaminoethyl) Methyl Phosphonothiolate (VX)

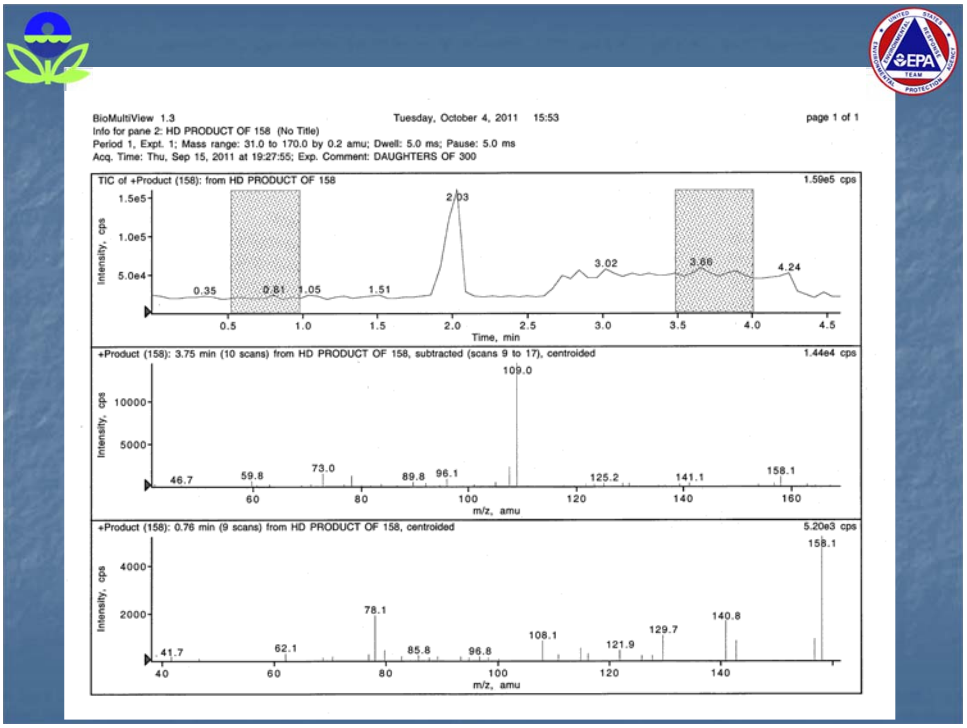


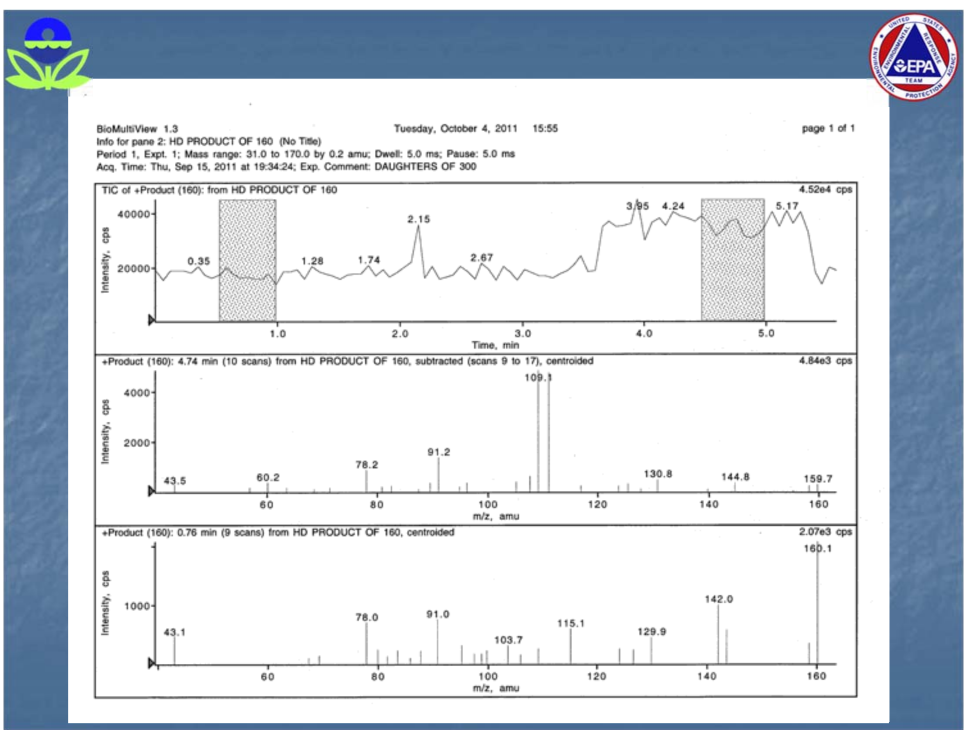
Filename:	ECBC040 et al.							
Compound name:	VX							
Conc. units:	pptv							
Width (min):	0.5							
User name:	DLM							
Comment:								
Date:	Thursday, September 15, 2011 16:16:15							
Num. ions:	2							
Num. concs.	8							
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Ctr Pt.(min):	1.3	43.2	40	36.65	28.27	24.86	16.59	13.24

	Ion 1	Ion 2
Q1 Mass:	268	268
Q3 Mass:	128	268
Slope:	29.0669978	81.8612826
Intercept:	591.395118	1746.83985
Correlation:	0.99768944	0.99721774

Concentrations		
	268.00/128.0(	268.00/268.00
0	2.65060241	22.1686747
1	458.915663	1334.93976
5	659.268293	1808.04878
10	798.313253	2342.6506
50	2238.41463	6288.65854
100	3421.95122	9802.31707
500	1.67E+04	4.76E+04
1000	2.89E+04	8.11E+04

HD


BioMultiView 1.3
Tuesday, October 4, 2011 15:53
page 1 of 1
Info for pane 2: HD PRODUCT OF 158 (No Title)
Period 1, Expt. 1; Mass range: 31.0 to 170.0 by 0.2 amu; Dwell: 5.0 ms; Pause: 5.0 ms
Acq. Time: Thu, Sep 15, 2011 at 19:27:55; Exp. Comment: DAUGHTERS OF 300
TIC of +Product (158): from HD PRODUCT OF 158
1.59e5 cps
Intensity, cps
Time, min
+Product (158): 3.75 min (10 scans) from HD PRODUCT OF 158, subtracted (scans 9 to 17), centroided
1.44e4 cps
m/z, amu
+Product (158): 0.76 min (9 scans) from HD PRODUCT OF 158, centroided
5.20e3 cps


BioMultiView 1.3
Tuesday, October 4, 2011 15:55
page 1 of 1
Info for pane 2: HD PRODUCT OF 160 (No Title)
Period 1, Expt. 1; Mass range: 31.0 to 170.0 by 0.2 amu; Dwell: 5.0 ms; Pause: 5.0 ms
Acq. Time: Thu, Sep 15, 2011 at 19:34:24; Exp. Comment: DAUGHTERS OF 300
TIC of +Product (160): from HD PRODUCT OF 160
4.52e4 cps
Intensity, cps
Time, min
+Product (160): 4.74 min (10 scans) from HD PRODUCT OF 160, subtracted (scans 9 to 17), centroided
4.84e3 cps
m/z, amu
+Product (160): 0.76 min (9 scans) from HD PRODUCT OF 160, centroided
2.07e3 cps

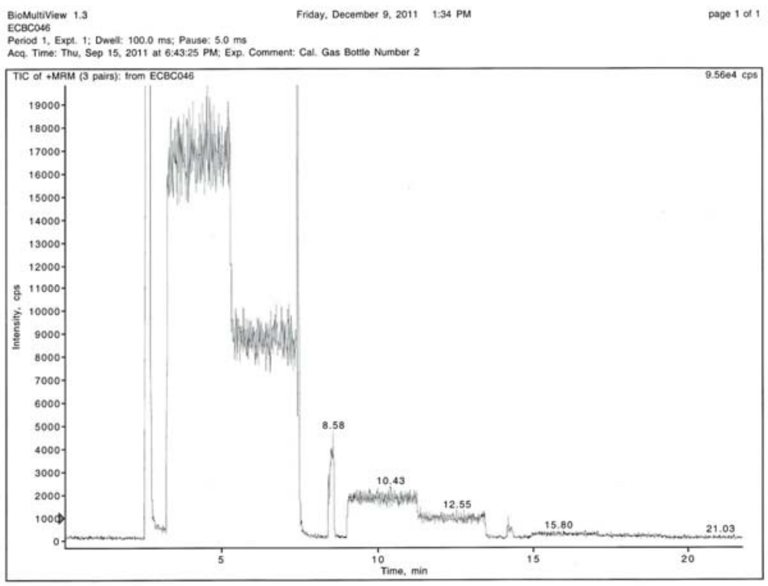
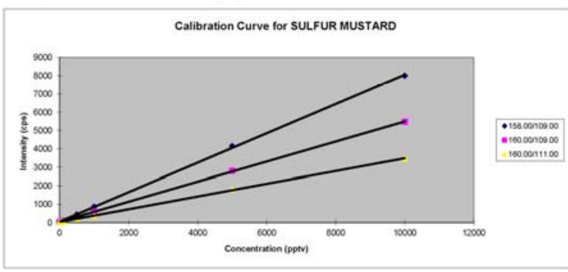


FIGURE 2F Calibration Curve for Sulfur Mustard (HD)



Filename:	ECBC046 et al.						
Compound name:	SULFUR MUSTARD						
Conc. units:	pptv						
Width (min):	0.5						
User name:	DLM						
Comment:							
Date:	Thursday, September 15, 2011 19:14:22						
Num. ions:	3						
Num. concs.	7						
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Ctr Pt.(min):	21	18.12	16.3	12.55	10.22	6.47	4.41

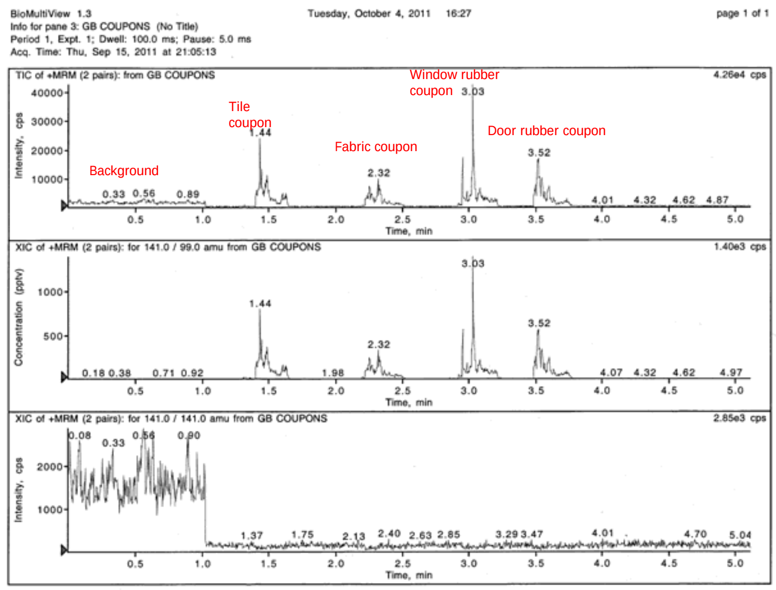
	Ion 1	Ion 2	Ion 3
Q1 Mass:	158	160	160
Q3 Mass:	109	109	111
Slope:	0.800049979	0.544446488	0.345191957
Intercept:	48.18991337	44.49666657	38.04384575
Correlation:	0.999871662	0.999954264	0.999895522

Concentrations	158.00/109.00	160.00/109.00	160.00/111.00
0	30.94240838	34.08376963	30.31413613
50	65.39267016	61.09947644	47.95811518
100	108.8020833	90.41666667	63.54166667
500	442.34375	316.0416667	209.6354167
1000	864.2408377	600.8376963	389.2146597
5000	4149.057592	2805.445026	1803.089005
1.00E+04	7997.382199	5468.586387	3470

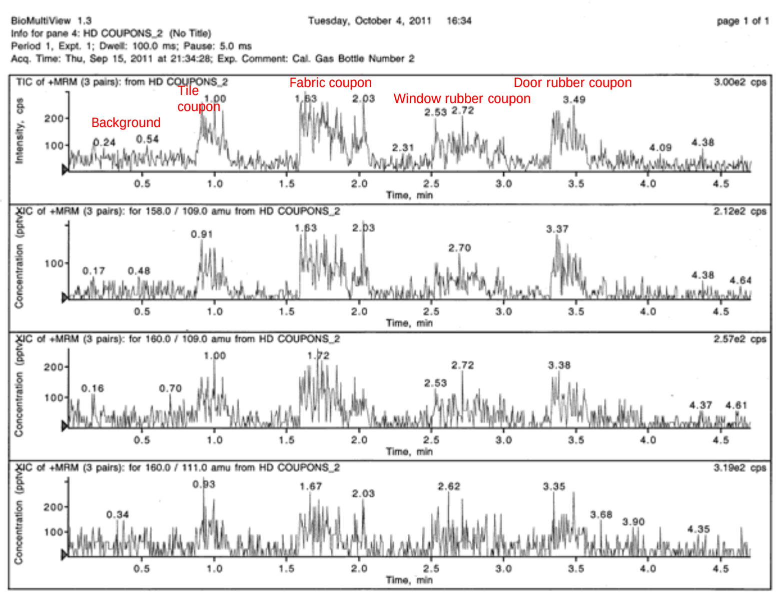
Acronym	Chemical Name	CAS Number	Detection Limit (pptv)	Detection Limit (mg/m3)	Quantitation Limit (pptv)	Quantitation Limit (mg/m3)
GB	Sarin; Isopropyl methylphosphonofluoridate	107 44 8	3.2	1.8*10 5	11	6.3*10 5
VX	O ethyl S (2 diisopropylaminoethyl)methyl phosphonothiolate	50782 69 9	0.58	6.3*10 6	1.9	2.1*10 5
HD	Sulfur Mustard; Bis(2 chloroethyl)sulfide	505 60 2	119	7.8*10 4	398	2.6*10 3
L	Lewisite; 2 Chloroethenylarsonous dichloride	541 25 3	NA	NA	NA	NA
DMMP	Dimethyl methylphosphonate	756 79 6	6.8	3.4*10 5	23	1.2*10 4

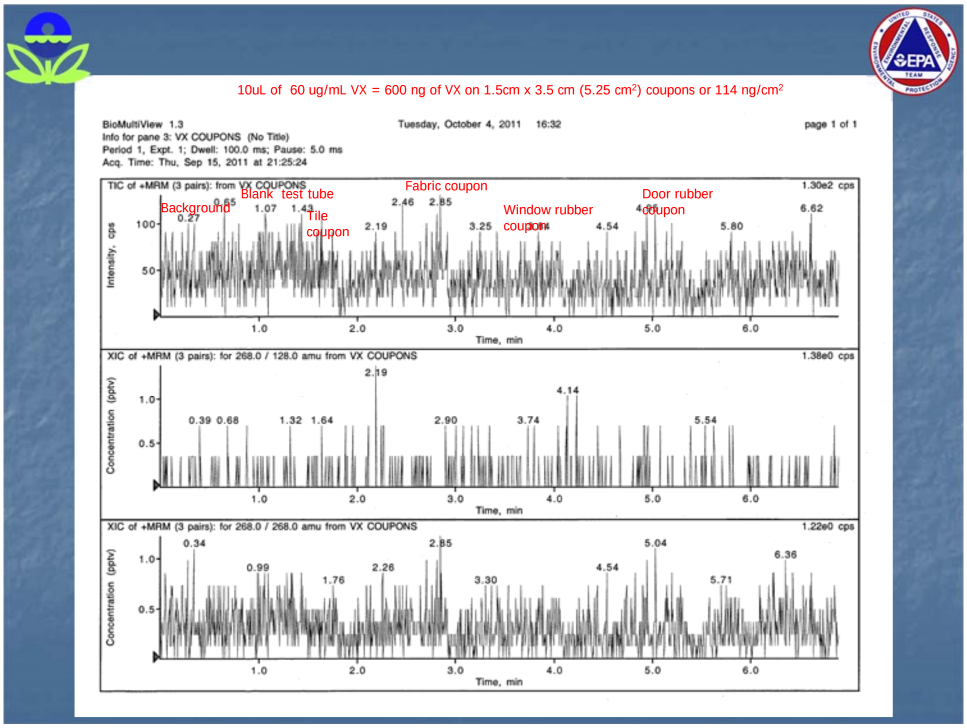
Material Coupons in Culture Tubes

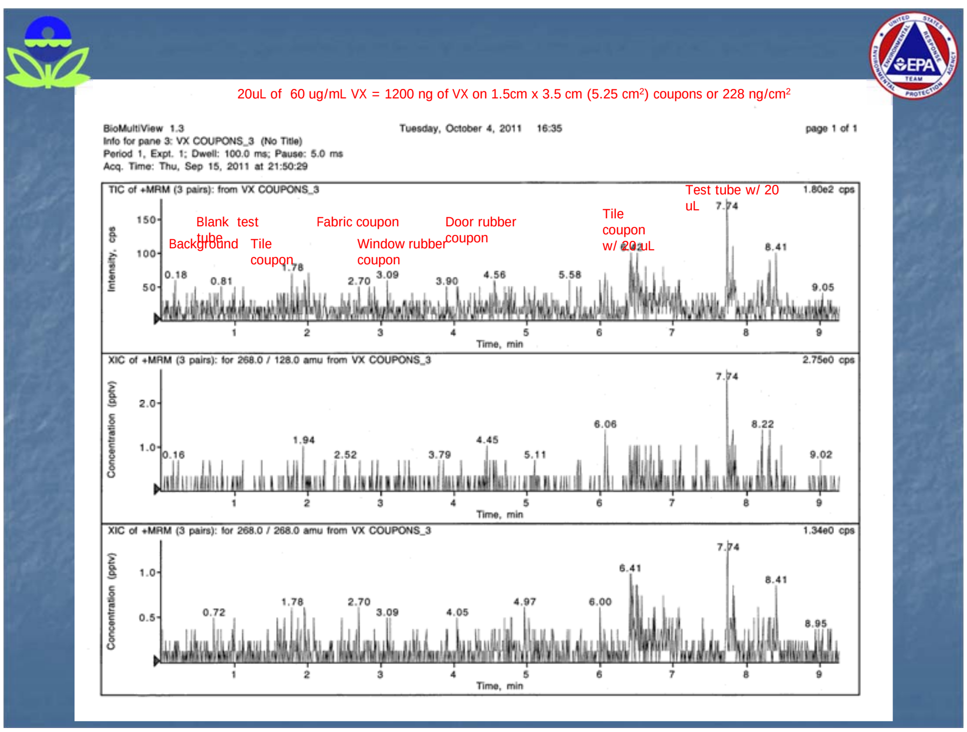
2uL of 100 ug/mL GB = 200 ng of GB on 1.5cm x 3.5 cm (5.25 cm^2) coupons or 38ng/cm^2



10uL of 1000 ug/mL HD = 10 ug of HD on 1.5cm x 3.5 cm (5.25 cm^2) coupons or 1.9ug/cm^2




10uL of 60 ug/mL VX = 600 ng of VX on 1.5cm x 3.5 cm (5.25 cm²) coupons or 114 ng/cm²
BioMultiView 1.3
Info for pane 3: VX COUPONS (No Title)
Period 1, Expt. 1; Dwell: 100.0 ms; Pause: 5.0 ms
Acq. Time: Thu, Sep 15, 2011 at 21:25:24
Tuesday, October 4, 2011 16:32
page 1 of 1
TIC of +MRM (3 pairs): from VX COUPONS
1.30e2 cps
Background
Blank test tube
Tile coupon
Fabric coupon
Window rubber coupon
Door rubber coupon
Intensity, cps
Time, min
XIC of +MRM (3 pairs): for 268.0 / 128.0 amu from VX COUPONS
1.38e0 cps
Concentration (pptv)
Time, min
XIC of +MRM (3 pairs): for 268.0 / 268.0 amu from VX COUPONS
1.22e0 cps
Concentration (pptv)
Time, min


20uL of 60 ug/mL VX = 1200 ng of VX on 1.5cm x 3.5 cm (5.25 cm²) coupons or 228 ng/cm²
BioMultiView 1.3
Info for pane 3: VX COUPONS_3 (No Title)
Period 1, Expt. 1; Dwell: 100.0 ms; Pause: 5.0 ms
Acq. Time: Thu, Sep 15, 2011 at 21:50:29
Tuesday, October 4, 2011 16:35
page 1 of 1
TIC of +MRM (3 pairs): from VX COUPONS_3
1.80e2 cps
Background
Blank test tube
Tile coupon
Fabric coupon
Window rubber coupon
Door rubber coupon
Tile coupon w/ 20 uL
Test tube w/ 20 uL
Intensity, cps
Time, min
XIC of +MRM (3 pairs): for 268.0 / 128.0 amu from VX COUPONS_3
2.75e0 cps
Concentration (pptv)
Time, min
XIC of +MRM (3 pairs): for 268.0 / 268.0 amu from VX COUPONS_3
1.34e0 cps
Concentration (pptv)
Time, min

Media: AIR	Standard Name	Population	Exposure Scenario	H/HD/HT	GB (Sarin)	VX
TAGA Detection Limits mg/m3				**0.00078** [7.8xE-4]	**0.000018** [1.8E-5]	**0.0000064** [6.4E-6]
Airborne Exposure Limits mg/m3	**IDLH** *Immediately Dangerous to Life and Health*	DoD Workers (civilian)	Acute 30 minute exposure	**0.7**	**0.1**	**0.003**
	STEL *Short Term Exposure Limit*	DoD Workers (civilian)	Occasional (4x day) 15 minute exposure	**0.003** [3x10E-3]	**0.0001** [1x10E 4]	**0.00001** [1x10E 5]
	WPL *Worker Population Limit*	DoD Workers (civilian)	8 hr daily/ multi yr time weighted average (TWA)	**0.0004** [4x10E-4]	**0.00003** [3x10E 5]	**0.000001** [1x10E-6]
	GPL *General Population Limit*	Civilian General Population	24 hr/daily lifetime time weighted average (TWA)	**0.00002** [2x10E 5]	**0.000001** [1x10E 6]	**0.0000006** [6x10E 7]

Acute Exposure Guideline Levels (AEGLs) mg/m3	Acute Exposure Guideline Levels	Emergency/ Accident Scenario	1 time exposure	H/HD/HT	GB (Sarin)	VX
	AEGL Level 1 Above this potential for some minor discomfort or noticeable but reversible effects	Civilian General Population	10 min 30 min 1 hr 4 hr 8 hr	**0.40** **0.13** **0.067** **0.017** **0.008**	**0.0069** **0.0040** **0.0028** **0.0014** **0.0010**	**0.00057** **0.00033** **0.00017** **0.00010** **0.000071**
	AEGL Level 2 Above this more obvious effects begin; potentially impacting functional abilities or ability to escape; potential delayed recovery	Civilian General Population	10 min 30 min 1 hr 4 hr 8 hr	**0.60** **0.20** **0.10** **0.025** **0.013**	**0.087** **0.050** **0.035** **0.017** **0.013**	**0.0072** **0.0042** **0.0029** **0.0015** **0.0010**
	AEGL Level 3 Above this level potential for serious effects potential life threatening	Civilian General Population	10 min 30 min 1 hr 4 hr 8 hr	**3.9** **2.7** **2.1** **0.53** **0.27**	**0.38** **0.19** **0.13** **0.070** **0.051**	**0.029** **0.015** **0.010** **0.0052** **0.0038**
TAGA Detection Limits mg/m3				**0.00078** [7.8xE-4]	**0.000018** [1.8E-5]	**0.0000064** [6.4E-6]

USA PHC* Chemical Agent Health-Based Standards and Guidelines Summary Table 1: Criteria for AIRBORNE Exposures as of July 2011**

Media: AIR	Standard Name	Population	Exposure Scenario	H/HD/HT	GA (Tabun)	GB (Sarin)	GD/GF	VX	Lewisite	Notes/Status
Airborne Exposure Limits (AELs) mg/m^3 see references and Notes	**IDLH** *Immediately Dangerous to Life and Health*	DoD Workers (civilian)	Acute 30 minute exposure	0.7	0.1	0.1	0.05	0.003	(**)	This Table supersedes previous versions and represents the most current information known to PHC at time noted. *GD/GF values were developed by Army/USACHPPM based on the relative potency to the CDC value of GB *(ref a3)* **Since not significant in US Stockpile, Lewisite criteria had not been reevaluated since 1988 - so the value 0.003 mg/m^3 - a detection value- was used as a safe level for all exposures including long term. Though cited in DA Pam 385-61 as 'surrogate' Lewisite IDLH – was non health based/not a true IDLH – Army OTSG prepared a new IDLH equivalent of 0.36 mg/m^3 in Aug 2009 (see note next page)
	STEL *Short Term Exposure Limit*	DoD Workers (civilian)	Occasional(4x day) 15 minute exposure	0.003 [3x10E-3]	0.0001 [1x10E-4]	0.0001 [1x10E-4]	0.00005 [5x10E-5]	0.00001 [1x10E-5]	NA	
	WPL *Worker Population Limit*	DoD Workers (civilian)	8 hr daily/ multi yr time weighted average (TWA)	0.0004 [4x10E-4]	0.00003 [3x10E-5]	0.00003 [3x10E-5]	0.00003 [3x10E-5]	0.000001 [1x10E-6]	0.003**	
	GPL *General Population Limit*	Civilian General Population	24 hr/daily lifetime time weighted average (TWA)	0.00002 [2x10E-5]	0.000001 [1x10E-6]	0.000001 [1x10E-6]	0.000001 [1x10E-6]	0.0000006 [6x10E-7]	0.003**	
Acute Exposure Guideline Levels (AEGLs) mg/m^3 see references, b and c for derivation, refs a and d for application	**Acute Exposure Guideline Levels**	Emergency/ Accident Scenario	1 time exposure	**HD**	**GA**	**GB**	**GD/GF**	**VX**	**Lewisite**	Final AEGL values (for HD, VX, G Agents) were published in May 2003 by National Research Council (NRC) Committee on Toxicology (COT) (available at www.nap.edu) *ref b* Lewisite AEGLs are based on interim report dated July 2007: "Acute Exposure Guideline Levels (AEGLs) for: Lewisite Compounds" *ref c* These are guidelines, not regulatory standards. However, there is an Army-FEMA policy letter requiring use of these AEGLs for the Chemical Stockpile Emergency Planning Program (CSEPP) *ref d*; associated CSEPP guidance provide suggested use (such as AEGL 2 as action level for shelter in place/ evacuation); but policy includes allowance for site specific (state, local) decision making) See refs e & f for AEGL applications
	AEGL – Level 1 Above this potential for some minor discomfort or noticeable but reversible effects	Civilian General Population	10 min 30 min 1 hr 4 hr 8 hr	0.40 0.13 0.067 0.017 0.008	0.0069 0.0040 0.0028 0.0014 0.0010	0.0069 0.0040 0.0028 0.0014 0.0010	0.0035 0.0020 0.0014 0.00070 0.00050	0.00057 0.00033 0.00017 0.00010 0.000071	NR NR NR NR NR	
	AEGL – Level 2 Above this more obvious effects begin; potentially impacting functional abilities or ability to escape; potential delayed recovery	Civilian General Population	10 min 30 min 1 hr 4 hr 8 hr	0.60 0.20 0.10 0.025 0.013	0.087 0.050 0.035 0.017 0.013	0.087 0.050 0.035 0.017 0.013	0.044 0.025 0.018 0.0085 0.0065	0.0072 0.0042 0.0029 0.0015 0.0010	0.65 0.23 0.12 0.035 0.018	
	AEGL – Level 3 Above this level potential for serious effects potential life threatening	Civilian General Population	10 min 30 min 1 hr 4 hr 8 hr	3.9 2.7 2.1 0.53 0.27	0.76 0.38 0.26 0.14 0.10	0.38 0.19 0.13 0.070 0.051	0.38 0.19 0.13 0.070 0.051	0.029 0.015 0.010 0.0052 0.0038	3.9 1.4 0.74 0.21 0.11	
Military Exposure Guideline (MEG) mg/m^3	**MEGs** *multiple severity levels and acute exposure durations -*	The chemical agent values for military deployment health and safety decision making include Negligible, Marginal, Critical and Catastrophic MEGs for 10 minute to eight hour timeframes. They are cited USACHPPM Technical Report (TR) 64-FF-07Z2-07, July 2008 (**ref g**) and new (2010) version of USAPHC Technical Guide (TG) 230 (**ref h**). NOTE: MEGs are primarily based on hierarchy selection of published CIVILIAN criteria; for short term air MEGs the first choice in hierarchy are the AEGL values, but for HD and Nerve Agents only AEGL 1 criteria are used as MEGs (e.g. as for Negligible MEGs). Marginal, Critical and Catastrophic are based on military toxicity values (though Marginal and Critical MEGs are generally comparable with the AEGL 2 and 3 estimates (see ref e)).								

Future Work

Repeat Spectra and Calibration Curves
Optimize Charge Transfer Agent Concentration
Address Coupon Spiking Techniques
Determine Minimum Detectable Levels on Coupons
Employ Surrogate During Calibrations and Monitoring
Examine Potential Interferences
Analyze Additional Agents

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Danielle McCall, Lockheed Martin/SERAS
William Weeks, Lockheed Martin/SERAS
Richard Magan, Lockheed Martin/SERAS

For additional information concerning the scheduling, capabilities, and applications of the TAGA mobile laboratories, contact:

David Mickunas
US EPA/ERT-Research Triangle Park, NC
Telephone - (919) 541 4191
E-mail - Mickunas.Dave@epa.gov

Wednesday, November 6, 2013

Concurrent Sessions 2

Biological Agent Sampling and Detection

Vacuum Sampling
Spores from Porous Surfaces

M. Worth Calfee and Laura J. Rose

National Center for Emerging and Zoonotic Infectious Diseases
DHQP/CEMB/TEAM

Why?

- **Previously developed sampling methods limited to non-porous surfaces & small surface area**
  - Swab – 2″ x 2″
  - Wipe – 10″ x 10″
- **Responders need more tools for indoor and outdoor surfaces:**
  - Carpet
  - Upholstery
  - Concrete
  - HVAC filters

What ?

- Vacuum Sock
  - X-Cell- 100, Midwest Filtration Co.

- 37mm cassettes (SKC, Inc)
  - MCE 0.8μm & 0.45 μm pore
  - PTFE 0.3 μm pore

- Forensic Vacuum Filter (3M FF-1)

- HVAC filters
  - Electrostatic: Purafilter
  - Mechanical: Natural Aire

How?

- CDC/DHQP (FY 2011 - 2013):
  - Develop lab processing/extraction protocols for each device
  - Develop sampling protocols for each device
- EPA NHSRC - Research Triangle Park (FY 2012 -2013):
  - Deposit *B. atrophaeus* (BG) spores on 4 materials as aerosol using patented method
  - Use vacuum devices to sample spores
  - Process/extract spores with CDC - developed protocols
  - Determine two best devices to validate (planned for FY 2013)

PROCESSING/EXTRACTION PROTOCOL DEVELOPMENT

Midwest Filtration Vacuum Sock

- **Protocol developed in 2002**
    - Posted to LRN as "interim"
  - Hold sock over cup of 50 ml PBST
  - Dip to moisten while cutting
  - Sections fall into PBST
  - Shake 30 min @ 300 rpm
  - Centrifuge eluent, decant
  - Dilute remaining 5 ml in series and plate

37 mm Filter Cassettes

37 mm Filter Cassette

- **Inoculation :**
  - 10^4 spores onto membrane
  - Dried 3 hrs
  - Added buffer
  - Processed
  - Diluted and plated
- **Evaluated:**
  - 4 filter types
  - 3 elution buffers
  - 3 elution methods

37 mm Filter Cassette

- **Optimum recovery:**
  - 2 oz. polypropylene jar
  - Sonicate 3 min in 5 ml PBST
  - dilute and plate
    - Filter 1 ml - low level detection

Liquid Inoculum:
Mean % R =95.8 (sd 18.6)
PTFE 1.0 µm pore size

Vacuum Pumps Evaluated For Use with 37mm Cassettes

Airlite	Vac-U-Go	Quick Take 30
- Personal sampler - Compensating Battery operated - 3 LPM	- Non-compensating - Keeps running as filter loads - Plug-in - Up to 30 LPM	- Compensatingpump - Works harder as filter loads - Battery operated -10- 30 LPM
Too weak to pick up dust	**Chosen for study**	Turns itself off when filter is loaded

3M Forensic Filter (Trace Evidence Filters)

- **Inoculation:**
  - 10^5 spores/filter
  - Resealed the housing
  - Applied vacuum for 30 seconds
- **Evaluated**
  - Two elution buffers,
  - Two elution volumes
  - Four elution methods

3M Forensic Filters

FINAL PROCESSING PROTOCOL

- Inside moistened before opening
- Filter removed and placed into stomacher bag
- Case is rinsed, rinsate transferred into stomacher bag with 90 mls of PBST .
- Stomacher run 1 min @ 260 rpm
- Eluent centrifuged to pellet
- All but 3 ml decanted
- Diluted, plated, incubated

Mean %R = 66.9 (sd 25.8)
(Liquid inoculum)

3M Forensic Filters: Filter Collapse and Sample Loss

Omega-Vac: Need to Reduce Power to 790 LPM

HVAC Filters

- **Two filter types***
  - Electrostatic Merv 8 filter – Purafilter 2000 (Kimberly Clark Filtration)
  - Mechanical Merv 8 filter – Natural Aire FPR 4 (Flanders Corp.)
- **Inoculated, allowed to dry overnight**
- **Evaluated liquid processing**
  - Three buffers, several volumes
  - Four processing methods

* Commonly used for homes, industrial bldgs. and subway cars

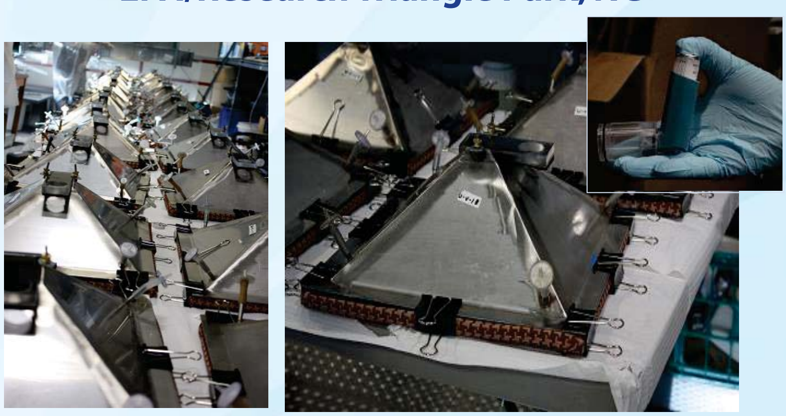
HVAC Filters

- **Optimum HVAC liquid extraction:**
  - 2″ x 4″
    - In specimen cup w/50 ml PBST
    - Sonicate 3 min
  - 6″ x 6″
    - In 1 L Nalgene® bottle w/500 ml PBST
    - Add Shake 30 min @200 rpm
  - Centrifuge eluent to pellet
  - Decant all but 5 ml, re-suspend
  - Plate, incubate

Mean % Recovery	
-Electrostatic filters	69.4 % (sd 20.2)
-Mechanical filters	87.1 % (sd 14.3)

AEROSOL SPORE APPLICATION AND SAMPLING

Aerosol Application of Spores
EPA/Research Triangle Park, NC



Metered Dose Inhalers: 50 µL doses, ~ 10^8 spores/dose
Initially prepared by U.S. Army Edgewood Chemical Biological Center
Currently prepared by Cirrus Pharmaceuticals

Calfee MW, Lee SD, Ryan SP. 2013. J. Microbiol. Meth. 92: 375-380.

Vacuum Sampling Upholstery Using Vacuum Sock

Experimental design

Inoculum ~1 x 10^5 CFU cm-2

Trial	Sampling Method	Sample Area (cm^2)	Surface Material	Replicates (n)
1	Vacuum Sock (fast)	2787	Carpet	10
			Concrete	10
			Upholstery	10
	Gauze Wipe[1]	929	Stainless Steel	5
2	Vacuum Sock (slow)	2787	Carpet	10
			Concrete	10
			Upholstery	10
	Gauze Wipe[1]	929	Stainless Steel	5
3	37 mm MCE	929	Carpet	10
			Concrete	10
			Upholstery	10
	Gauze Wipe	929	Stainless Steel	5
4	37 mm PTFE	929	Carpet	10
			Concrete	10
			Upholstery	10
	Gauze Wipe	929	Stainless Steel	5
5	Forensics Filter	2787	Carpet	10
			Concrete	10
			Upholstery	10
	Gauze Wipe[1]	929	Stainless Steel	5

[1]Three test days (one for each material type) were required for those devices (vacuum sock and forensics filter) where 3 coupons per sample were sampled. Accordingly, a unique set of gauze wipe samples were collected on each test day.

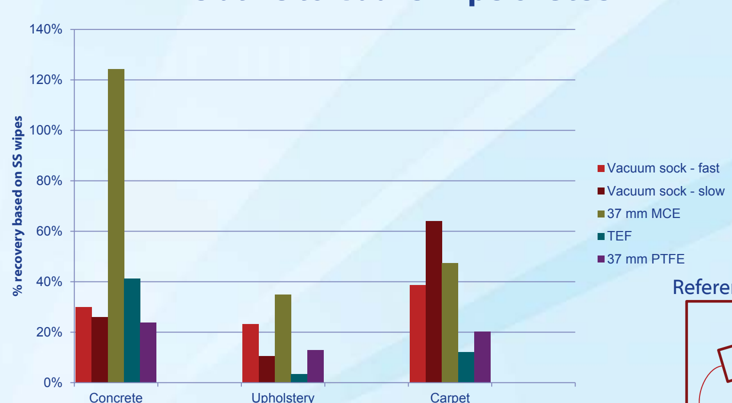
Calfee, MW et al., J. Microbiol. Methods. *In Press.*

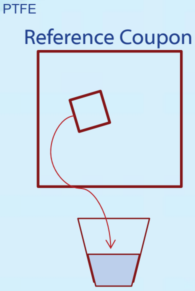
Consistency of spore deposition and wipe sampling: stainless steel reference coupons

Test run n = 3 each	CFU/ft^2	CV
A	1.34×10^7	0.27
B	2.02×10^7	0.24
C	2.87×10^7	0.20
D	1.64×10^7	0.18
E	1.79×10^7	0.03
Mean	1.93×10^7	0.19

From: U.S. EPA. Effectiveness of Physical and Chemical Cleaning and Disinfection Methods for Removing, Reducing or Inactivating Agricultural Biological Threat Agents . U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-11/092, 2011

Percent Recovery from 3 Surfaces Relative to Gauze Wipe of Steel





1. 37 mm cassettes better than socks or TEF

   *120% means 1.2 times more efficient than gauze wipes on steel-

2. Speed of sock sampling doesn't improve collection

Analysis Time and Observations

Vacuum Socks

- 90 min/12 sock batch or 7.5 min/sample* to process
- Custom made racks needed for shaking cups
- Gaps/holes in sock occasionally found

37mm Cassettes

- 120 min per 12 filter batch or 10 min/sample to process
- Rinsing cassette and transferring can be difficult, if debris present
- Nozzle processed separately – sometimes contained debris/fibers

3M Forensic Filter

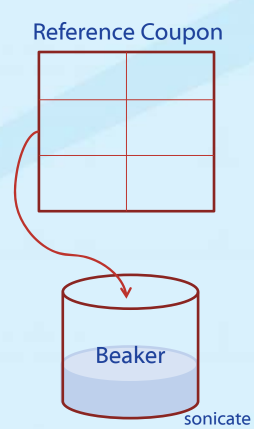
- 180 min per 10 filter batch or 18 min per sample to process
- Omitted from further evaluation – breakthrough issues and cost

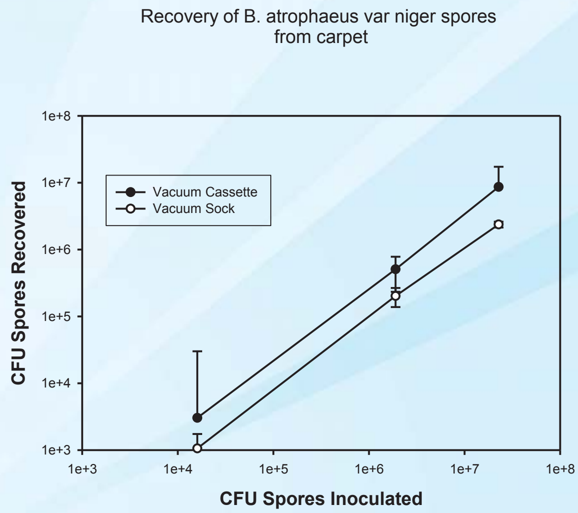
* Unpackaging and processing to liquid – does not include serial dilutions, plating or analysis

Percent Recovery from Carpet

Relative to Liquid Extraction of Reference Coupon

Log_{10} Inoculum	Vacuum Sock	MCE Filter Cassette
4.2	7 %	15%
6.3	10 %	26 %
7.4	11 %	38.%
Overall	9.3 %	26.3%





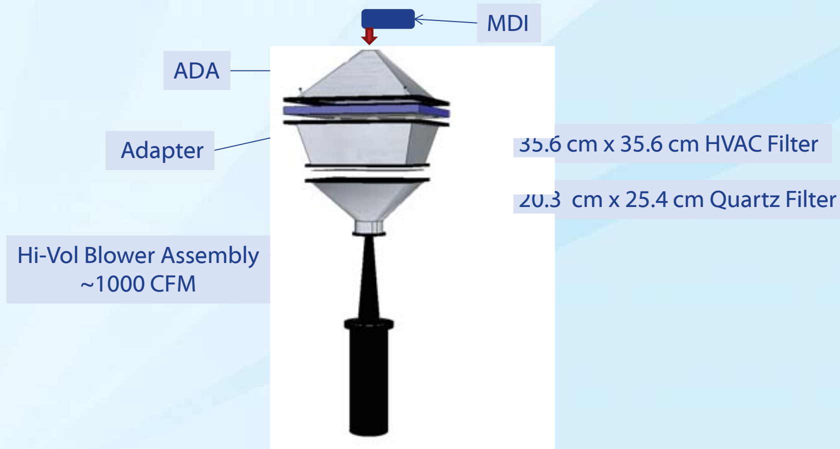
Reproducibility Between Analysts

% Recovery (n=10)			
	Lab 1	Lab2	p
37mm MCE	12.4% (4.6)	13.7% (4.6)	0.52
Vacuum Sock	6.8% (3.7)	8.4% (1.7)	0.23

- No significant difference between recoveries of two laboratories
- When data pooled, significant difference between two vacuum devices ($p<0.001$)

HVAC Filter Inoculation

Simulated HVAC air flow during inoculation



HVAC Filter Inoculation

Simulated HVAC air flow during inoculation

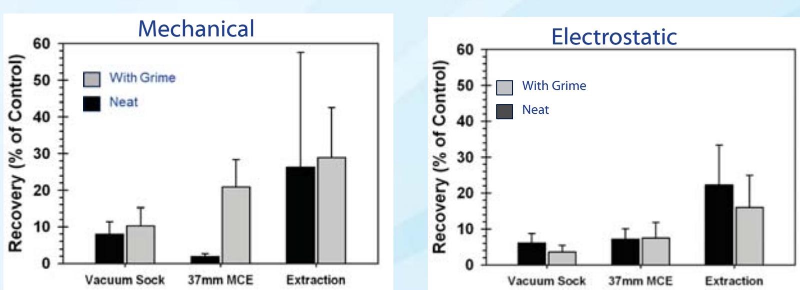
HVAC Filters

Neat

With Grime

Grime:
Carbon black , ISO fine dust, Cotton Linters
Loaded to 50% of holding capacity

Relative* Spore Recoveries from HVAC Filters: Vacuum-based Sampling vs. Extraction



*Relative to liquid extraction of stainless steel reference coupon

Calfee MW et al. J. Microbiol. Methods. In Press.

Liquid Extraction of HVAC Filter

- **Pros:**
  - greater spore recovery
- **Cons:**
  - Sectioning field and in lab problematic
    - Industrial filters might contain wire backing
    - Requires sterile wire cutters
    - Dispersion of spores during cutting
  - Liquid extraction requires 10 x more liquid
  - Processing longer (30 min shaking) – reducing throughput.
  - Limited to 6" x 6" section per sample

Summary

- **Processing protocols optimized**
- **Vacuum pumps evaluated for each sampling device**
- **4 materials inoculated with aerosolized spores**
- **Sampling conducted with each vacuum device**
  - % Recovery
    - Relative to recovery by gauze wipe of inoculated steel
    - Relative to recovery by submersion and sonication of inoculated steel
  - Linearity
  - Reproducibility
- **Two best devices chosen for continued evaluation**

Concerns and Limitations

- **Vacuum Sock**
  - Quality control – frequent reports of gaps/holes in socks
  - Potential loss of sample
  - Potential to contaminate other samples, BSC, Lab
- **37mm Cassette**
  - Limited sample area due to small nozzle
  - Slow to collect sample – 5 min per ft^2

FY 2014: Enhance Field Use 37mm Cassette

- **Improve 37mm Cassette method**
  - Develop a wider nozzle for faster sampling
- **Evaluate variables:**
  - Use of personal air sample pump (3 LPM)
  - Collection speed
  - Larger Sampling area
  - Increased humidity: 90%RH
  - Presence of dust/grime
  - Other surfaces: tile, laminate

Prototype nozzle

Future Work Needed

- **Compare efficiency:** *B. anthracis* **vs.** *B. atrophaeus (BG)*
  - EPA to conduct bridge study with aerosolized spores
- **LOD and False negative rate evaluations**
  - Very low inoculum levels
- **"Validate" vacuum devices – determine variability**
  - Multiple surfaces: Carpet, Concrete, Upholstery, HVAC filter
  - Multiple Lab participants

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- **Jenia Tufts**
- **Sangdon Lee**
- **Sarah Taft**

CDC

- **Stephen Morse**
- **Angela Weber**
- **Mustafa Mazher**
- **Jordan Zambrana**

Report: www.epa.gov/ord
EPA 600/R-13/137

EPA United States Environmental Protection Agency

Evaluation of Surface Sampling for *Bacillus* Spores Using Commercially-available Cleaning Robots

Leroy Mickelsen, Sang Don Lee, Worth Calfee

Office of Research and Development
National Homeland Security Research Center

Date

Background

Following the 2001 *Bacillus anthracis* letter attacks, sampling methods such as:

- –wetted gauze wipe,
- –vacuum sock,
- –swab, and
- –air filtration samples

were used to determine the presence, magnitude, and spatial extent of contamination.

11/20/2013 U.S. Environmental Protection Agency 1

Capacity Problem

There were some sample related issues:

- Sampling and analysis has been a bottle neck,
  - Validation of those sampling methods has progressed, &
  - Laboratory capacity has been expanded

However,

- Wide-area release scenarios continue to show sampling and analysis as critical bottle necks, &
- Wipe, sponge stick, and vacuum-based sample collection procedures are labor intensive and would generate a large number of samples during a wide-area response

Robot Cleaners as a Potential Capacity Solution

- Off the shelf
- Multiple makers and models to select from
- Operate with little set up and oversight
- Cover a large area with one sample
- Applicable to horizontal surfaces which have the highest contamination probability

Test Approach

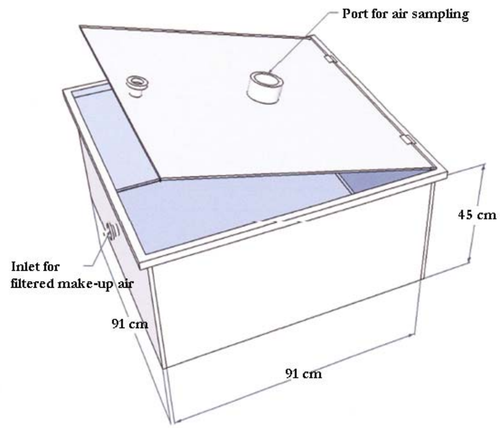
- Cleaning robot selection: commercially available off the shelf robots
- Test Surface Types: carpet, laminate, and tile
- Surface Contamination: aerosol deposited *B. atrophaeus* spores
- Target Contamination Level: 10^2, 10^4, and 10^6 colony forming units (CFUs) per ft^2
- Comparative Rato (CR): robot sampling results are compared to the vacuum sock or sponge wipe results

$$CR\ (\%) = \frac{average\ recovery from\ robot\ (CFUs)}{average\ recovery\ from\ comparative\ surface\ sampling\ method\ (CFUs)} \times 100$$

Robotic Cleaners

Robot	Model	Picture	Cleaning type	Applicable Surfaces
R1	Roomba 760® iRobot®		Vacuum with HEPA filter and rotating bristle brush	All surfaces
R2	XV-11 Neato robotics®		Vacuum with air filter and rotating silicone flat beater	All surfaces
R3	P3 P4920 P3 International		Vacuum with air filter (no surface agitation tool)	All surfaces
R4	Mint 4200 Evolution Robotics, Inc.		Sweep and mop	Hard floors
R5	Scooba 380® iRobot®		Wet vacuum	Hard floors

Test Chamber



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Sampling Media Extraction Efficiency

Robot's spore collection media were extracted and analyzed quantitatively for viable spores.

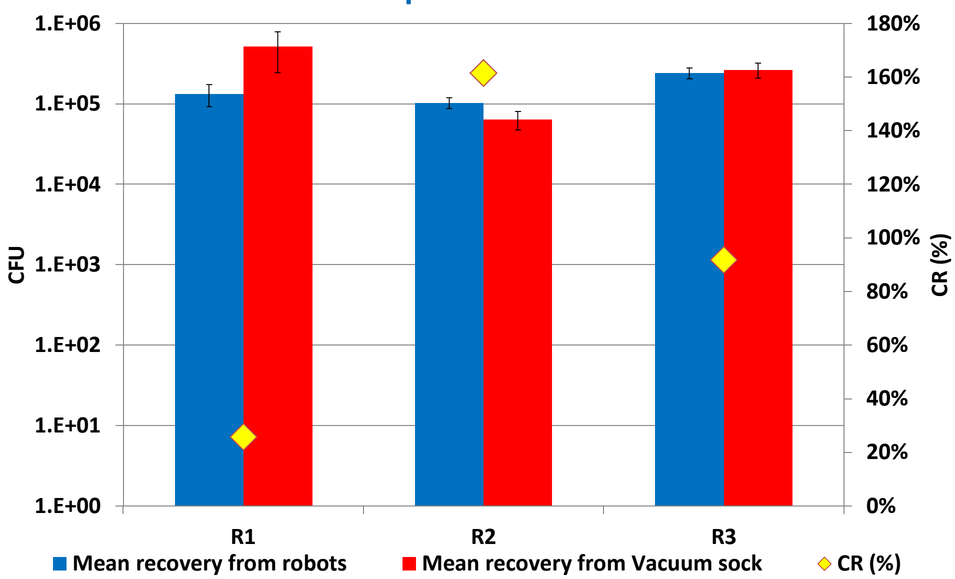
Robots	Extracted Parts	Extraction Method	Average Extraction Efficiency (%)
R1	Filter, dust bin	Orbital shaking	64.9 $\pm$ 14.1
R2	Filter, dust bin	Orbital shaking	56.7 $\pm$ 7.6
R3	Filter, dust bin	Orbital shaking	67.2 $\pm$ 4.1
R4	Wipe cloth	Stomaching	49.1 $\pm$ 7.1
R5	Tank	Rinsing	89.6 $\pm$ 6.9

7

Sampling Efficiency Results from Cleaning Robots

8

Carpet Floor



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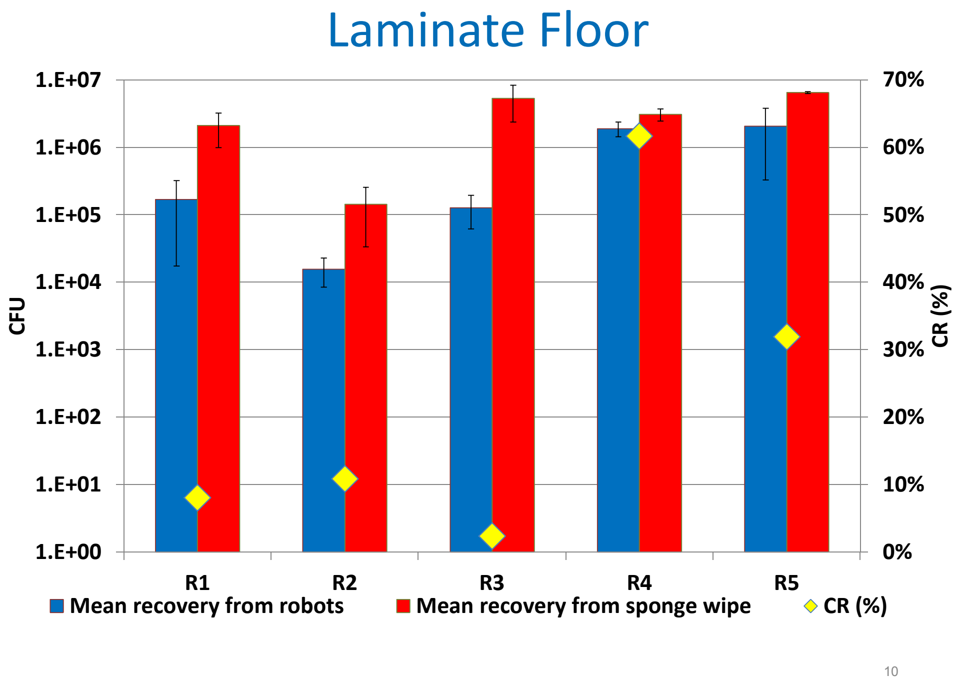
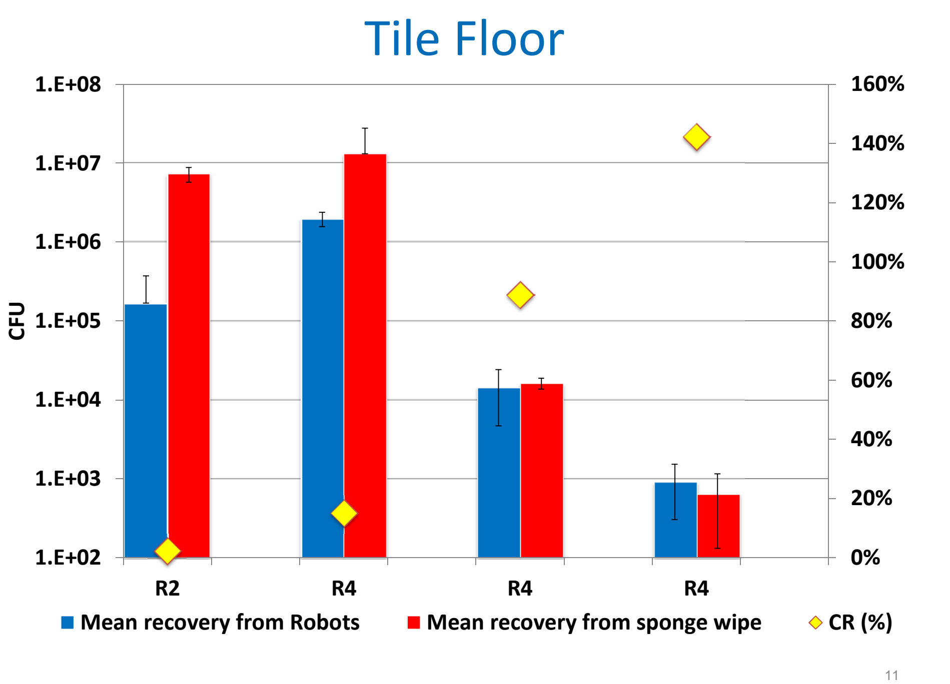

Laminate Floor
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
CFU
70%
60%
50%
40%
30%
20%
10%
0%
CR (%)
R1
R2
R3
R4
R5
Mean recovery from robots
Mean recovery from sponge wipe
CR (%)
10


Tile Floor
1.E+08
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
CFU
160%
140%
120%
100%
80%
60%
40%
20%
0%
R2
R4
R4
R4
Mean recovery from Robots
Mean recovery from sponge wipe
CR (%)
11

Scenario-based Tests

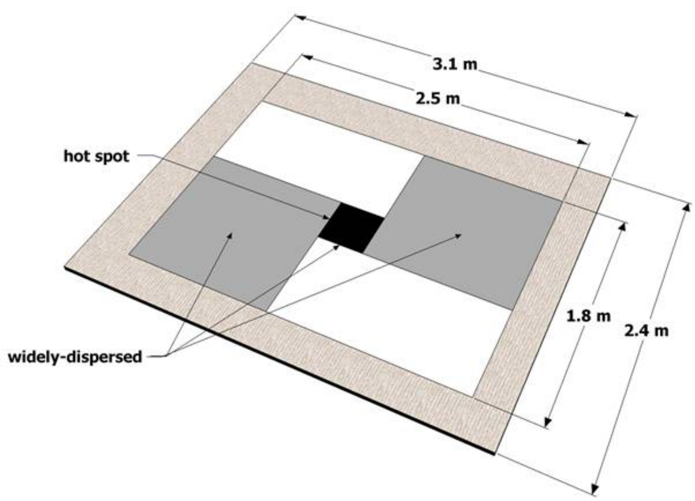
1. Hotspot test

2. Low level wide dispersed test

Scenario Type	Surface	Robot	Target Spore loading (CFUs/cm^2)
Hot Spot	Carpet	R2	10^4
Hot Spot			10^4
Widely-dispersed Contamination			10^1
Widely-dispersed Contamination			10^1
Hot Spot	Laminate	R4	10^4
Hot Spot			10^4
Widely-dispersed Contamination			10^{-1}
Widely-dispersed Contamination			10^{-1}

12

Test Setup



13

Scenario-based Test Results

14

Hotspot Test Results

Surface type	robot	Average Currently-Used Surface Sampling Recovery (CFUs/929 cm^2), n=3	Robot Sampling Recovery (CFUs)
Carpet	R2	$1.6 \times 10^6 \pm 6.1 \times 10^5$	1.4×10^5
Carpet	R2	$1.9 \times 10^6 \pm 1.7 \times 10^6$	5.8×10^5
laminate	R4	$1.6 \times 10^7 \pm 3.9 \times 10^6$	1.2×10^7
laminate	R4	$1.7 \times 10^6 \pm 1.4 \times 10^6$	2.1×10^6

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Widely-Dispersed Test Results

Surface type	robot	Average Currently-Used Surface Sampling Recovery (CFUs/929 cm^2), n=3	Robot Sampling Recovery (CFUs)
Carpet	R2	$9.6 \times 10^2 \pm 5.2 \times 10^2$	5.0×10^3
Carpet	R2	$2.3 \times 10^2 \pm 4.2 \times 10^1$	3.2×10^2
laminate	R4	$4.5 \times 10^2 \pm 4.5 \times 10^2$	2.8×10^3
laminate	R4	$6.6 \times 10^1 \pm 3.8 \times 10^1$	4.9×10^2

Conclusions

- Robotic samplers demonstrated recoveries similar to conventional methods (head to head comparison)
- Robots sample large surface areas
- Increase probability of hot-spot detection
- Increase detection of low level contamination

Potential Benefits of Augmenting Sampling Efforts with Cleaning Robots

- Reduced number of sampling personnel required
  - reduce cost
  - reduce risk
- Increase spatial coverage and representativeness of samples
- Reduce number of samples collected
  - reduce burden to processing labs
  - reduce cost

Future Directions

- Evaluate Robots in difficult to sample environments (HVAC, outdoors, subway, etc)
- Improve Robots to increase collection efficiency or improve field-ability

Further Reading

- Evaluation of Surface Sampling for *Bacillus* Spores Using Commercially-available Cleaning Robots, U.S. Environmental Protection Agency, Office of Research and Development, National Homeland Security Research Center, Washington, DC, 600/R/13/100. 2013

- Sang Don Lee, M. Worth Calfee, Leroy Mickelsen, Stephen Wolfe, Jayson Griffin, Matt Clayton, Nicole Griffin-Gatchalian and Abderrahmane Touati. Evaluation of Commercially-available Cleaning Robots for *Bacillus* Spore Surface Sampling. Environmental Science and Technology, 2013, 47: 2595-2601

- Sang Don Lee, M. Worth Calfee, Leroy Mickelsen, Matt Clayton and Abderrahmance Touati. Scenario-based Evaluation of Commercially-available Cleaning Robots for Collection of *Bacillus* Spores from Environmental Surfaces. In submission, Journal of Microbiological Methods

Disclaimer: This presentation has been peer and administratively reviewed and has been approved for publication. It does not represent EPA Policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use of a specific product.

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Independent Testing of Hand Portable Biodetection Equipment

RACHEL BARTHOLOMEW, PH.D.
Pacific Northwest National Laboratory
Richland, WA

Presentation at:
EPA International Decontamination Research and Development Conference
November 5-7, 2013
Research Triangle Park, NC

The Suspicious "White" Powder Challenge

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- Thousands of suspicious powder events have been reported since 9-11
  - Events are costly: from local to state and federal level
    - Total estimated yearly cost for suspicious powder events: >$19M
    - Does not include impacts due to diverting resources from other needs to bio response
  - Can lead to illness and loss of life

- What instrument(s) can be used to rapidly determine if a powder/unknown sample contains a biological threat?
  - Cost for instrument and analyses?
  - Ease of use and time to result?
  - Confidence of the information/data?

2

Ground-Up Approach: Biodetection Technology ID, Assessment and Transition

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- ***Define*** performance requirements with stakeholder and end user input
  - ***Conduct*** interviews with end users
  - ***Bring together*** end users and key agency reps PH/LRN, CST, DHS, etc.) in workshops to fully understand and define key needs and gaps

- ***Perform*** technology foraging (collect, compile info)
- ***Establish*** technology test plans
- ***Conduct*** 3rd party independent testing and evaluation; support and facilitate end-usertesting

- ***Publish*** and disseminate instrument and assay testing results and summaries for instrument use, limitations, cost/benefit
- ***Facilitate*** adoption of approved equipment lists

3

Technology Foraging

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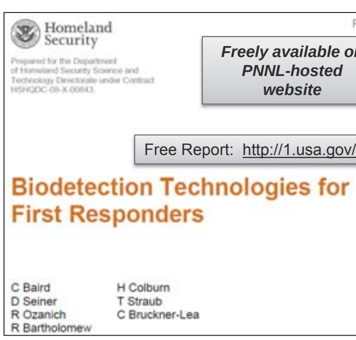
Homeland Security

Prepared for the Department of Homeland Security Science and Technology Directorate under Contract HSHQDC-08-X-00843

Biodetection Technologies for First Responders

C Baird
D Seiner
R Ozanich
R Bartholomew

H Colburn
T Straub
C Bruckner-Lea

Freely available on PNNL-hosted website

Free Report: http://1.usa.gov/17RHdt8

- Technologies identified included:
  - Non-specific:
    - Protein, adenosine tri-phosphate (ATP), and total DNA tests
    - Fourier transform infrared spectroscopy (FTIR)
  - Specific:
    - Protein-based: immunoassays
    - DNA-based: Polymerase chain reaction (PCR)

Initial Evaluation of Hand Portable PCR Instruments Using *Bacillus* DNA

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- Goal: assess initial PCR instrument performance with purified samples
- 5 PCR-based biodetection platforms:
  - FilmArray (BioFire Diagnostics) +17 biothreat panel (pX01, pX02, and chrom tests)
  - RAZOR (BioFire Diagnostics) +10 threat pouch (pX02 test)
  - BioSeeq PLUS (Smiths Detection) +pX02 test
  - T-COR4 (Tetracore) +pX02 test
  - POCKIT (Gene Reach USA) +pX02 test
- Test samples: purified genomic *Bacillus anthracis* and near neighbor DNA using PNNL-developed test plan
  - Inclusivity panel DNAs (n=13)
    - Starting test concentration: 2,000 copies/mL; exception BioSeeq PLUS: 20,000 copies/mL
    - Each strain analyzed in triplicate
  - Exclusivity panel DNAs (n=18)
    - Starting test concentration: 20,000 copies/mL; exception BioSeeq PLUS: 200,000 copies/mL
    - Each strain analyzed in duplicate
- Follow on publication of results pending

Criteria for Successful Testing

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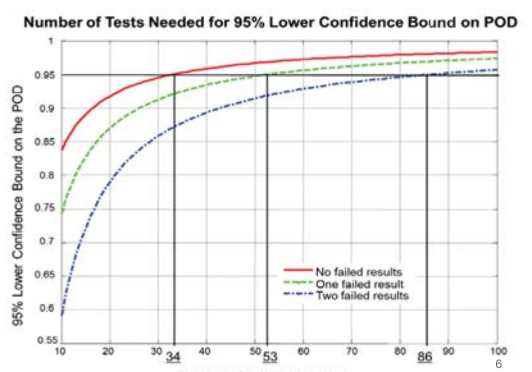
- Testing following existing AOAC test guidance* can be extremely burdensome
- Because biodetection technology and assays are rapidly evolving, with new versions appearing almost annually, a more efficient, but still statistically based testing approach is needed
- PNNL Approach: The following number of samples with 0-2 failed results (shown by the different curves) need to be run in order to achieve the minimum Probability of Detection (0.95) with the desired confidence (95%).

• 34 samples must be tested without a single failed result,
• 53 samples must be tested with no more than a single failed result, or
• 86 samples must be tested with no more than two failed results.

(assumes all inclusivity strains and all exclusivity strains provide equivalent information)

*AOAC guidelines: "Standard method performance requirements for PCR methods for detection of Bac*illus anthracis* in Aerosol collection filters and/or liquids", SPMR: Journal of AOAC International, 95(4), 2011, 1347-1351



(calculated using a one sided confidence interval and the normal approximation to the binomial distribution)

Hand Portable Biodetection Testing: Instrument Pass/Fail Metrics

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- Inclusivity Testing (n = 13)
  - Test 3 replicates X 13 strains (39 tests total). If no failures, instrument passes.
  - If one failure, test additional replicates to reach 53 total tests. If no additional failures, instrument passes.
  - If two failures, test additional replicates to reach 86 total tests. If no additional failures, instrument passes.
  - If three or more failures, instrument does not meet POD and testing is halted.
- Exclusivity Testing (n = 18)
  - Test 2 replicates X 18 strains (total of 36 tests). If no failures, instrument passes.
  - If one failure, test additional replicates to reach 53 total tests. If no additional failures, instrument passes.
  - If two failures, test additional replicates to reach 86 total tests. If no additional failures, instrument passes.
  - If three or more failures, instrument does not meet POD and testing is halted.

This test plan follows AOAC inclusivity, exclusivity and 95% confidence for 0.95 POD guidelines, and requires only 75 to 172 tests per instrument

Totals do not include blank or positive controls

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Hand Portable PCR Platform Test Results

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Instrument	Type of test	# Analyses	Positive	Negative	Overall # of Failed Tests	
FilmArray	Inclusivity	39	39	0	0	Pass
	Exclusivity	36	0	36	0	
	Blank	18	0	18	0	
RAZOR	Inclusivity	39	39	0	0	Pass
	Exclusivity	54	1	53	1	
	Blank	24	0	24	0	
T-COR 4	Inclusivity	39	39	0	0	Pass
	Exclusivity	36	0	36	0	
	Blank	17	0	17	0	
	Positive Controls	6	6	0	0	
BioSeeq Plus	I					Fail 3 false negative inclusivity samples
	Exclusivity	36	0	36	0	
	Blank	16	0	15	1	
POCKIT	Inclusivity	39	39	0	0	Fail 3 false positive exclusivity samples
	Blank	22	0	22	0	
	Positive Controls	12	12	0	0	

8

Screening of Environmental Powders for Possible Interference with Biodetection Technologies

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- Goal: understand instrument performance, limitations, and cost/benefit of assays/biodetection platforms
- Test samples:
  - Environmental material and potentially interfering common powders (10 mg/test)
- Screening Assays:
  - General Protein: 20/20 Bioresponse (BioCheck) and Indipro strips (Macherey-Nagel)
  - Biochemical/ATP: Clean-Trace tests (3M), Profile 1 (New Horizons Diagnostics)
  - General DNA: Prime Alert (GenPrime)
  - Pending:
    - *Protein: BioScreener (Field Forensics)*
    - *Chemical/Spectroscopic: HazMat ID 360 (Smiths Detection)*
    - *Immunoassays: RAID 8 (Alexeter) and Pro Strips (Advnt)*
    - *PCR Assays: Razor, FilmArray, T-COR4, POCKIT, and BioSeeq PLUS*
- Outcome of these tests will help to formulate additional testing, including studies with white powder + *Ba* and ricin mixtures using PNNL developed test plan

Environmental Test Materials	
Bt powder (Dipel)	Cornstarch
Powdered milk	Baking powder
Powdered infant formula	Kaolin
Powdered coffee creamer	Borax
Powdered sugar	Brewer's yeast
Talcum powder	$MgSO_4$ (Epsom salt)
White flour	Powdered toothpaste
Baking soda	Popcorn salt
Chalk dust ($CaCO_3$)	Acetaminophen
Chalk dust ($MgCO_3$)	Instant pectin
Road dust	Miralax

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Environmental Powder Screening: Protein Tests

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Class of Powder	Powder Type	Indipro Protein Test	20/20 Protein Test	20/20 Acid-Base Result
Organic, Biological	Brewers Yeast Powder	Positive (3)	Positive (3)	Neutral (3)
	Dipel dust	Negative (3)	Negative (3)	Neutral (3)
Organic, Protein-Containing	Milk Powder	Positive (3)	Positive (3)	Slightly Acidic (3)
	Infant Formula	Positive (3)	Positive (3)	Slightly Acidic (3)
	White flour	Positive (3)	Positive (3)	Neutral (3)
Organic, No Protein	Coffee creamer (non-dairy)	Positive (3)	Negative (3)	Neutral (3)
	Instant pectin	Positive (2/3)	Negative (3)	Neutral (3)
	acetaminophen	Negative (3)	Positive (3)	Neutral (3)
	Powdered Sugar	Negative (3)	Negative (3)	Neutral (3)
	Corn starch	Negative (3)	Negative (3)	Neutral (3)
	Polyethylene glycol 3300	Negative (3)	Negative (3)	Neutral (3)
Inorganic	Toothpaste powder with fluoride	Positive (3)	Negative (3)	Basic (2), Slightly Basic (1)
	Baking powder (aluminum free)	Positive (3)	Negative (3)	Slightly Basic (3)
	antacid (calcium carbonate)	Positive(3)	Negative (3)	Neutral (1), Slightly Basic (2)
	Baking soda	Positive (3)	Negative (3)	Basic (3)
	Epsom salt	Negative (3)	Positive (2), Negative (1)	Slightly Acidic (2), Neutral (1)
	gym chalk (magnesium carbonate)	Positive(3)	Positive (1), Negative (2)	Basic (3)
	Borax	Negative (3)	Negative (3)	Basic (3)
	Talc	Negative (3)	Negative (3)	Neutral (3)
	Road Dust	Negative (3)	Negative (3)	Neutral (3)
	Kaolin	Negative (3)	Negative (3)	Neutral (3)
	Salt	Negative (3)	Negative (3)	Neutral (3)

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Environmental Powder Screening: ATP and DNA Tests

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Class of Powder	Powder Type	Clean Trace ATP (>300 is positive)	Profile 1 ATP (>10000 is positive)	Prime Alert DNA (>1500 is positive)
Organic, Biological	Brewers Yeast Powder	231508, 368570, 365886	108628, clogged	13374, 13903, 9715
	Dipel dust	87, 123, 110	305817, 296151, 420386	257, 213, 183
Organic, Protein-Containing	Milk Powder	2930, 2435, 3009	clogged	1007, 1109, 929
	Infant Formula	125, 120, 105	clogged	305, 370, 287
	White flour	1720, 1853, 1615	clogged	336, 351, 657
Organic, No Protein	Coffee creamer (non-dairy)	78, 92, 70	clogged	261, 693, 948
	Instant pectin	6, 7, 8	7713, 8488, 605	59, 61, 38
	acetaminophen	9, 8, 9	35, 526, 134	92, 72, 57
	Powdered Sugar	14, 11, 14	1284, 33, 18	38, 67, 31
	Corn starch	35, 42, 36	762, 136, 53	215, 118, 142
	Polyethylene glycol 3300	7, 6, 6	58, 62, 131	47, 29, 5
Inorganic	Toothpaste powder with fluoride	6, 8, 8	84, 138, 651	138, 175, 128
	Baking powder (aluminum free)	275, 208, 338	776, 696, 678	111, 115, 41
	antacid (calcium carbonate)	16, 19, 16	clogged	436, 745, 234
	Baking soda	4, 5, 8	467, 597, 5976	49, 24, 21
	Epsom salt	7, 5, 6	163, 148, 167	52, 50, 55
	gym chalk (magnesium carbonate)	11, 11, 10	277, 450, 540	327, 271, 76
	Borax	5, 6, 5	265, 867, 497	19, 52, 33
	Talc	15, 13, 15	218, 180, 14	146, 164, 235
	Road Dust	140, 150, 132	687, 371, 887	211, 228, 262
	Kaolin	7, 7, 7	300, 352, 497	420, 700, 790
	Salt	6, 3, 3	170, 85, 61	71, 59, 30

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Environmental Powder Screening: Summary To Date

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- Protein tests result in positives from many environmental powders:
  - Protein test positives:
    - Indipro: Brewer's yeast, milk powder, infant formula, white flour, gym chalk, coffee creamer, instant pectin, toothpaste powder, baking powder, antacid, and baking soda
    - 20/20: Brewer's yeast, milk powder, infant formula, white flour, gym chalk, acetaminophen, and Epsom salt
- ATP and DNA tests result in only a few positives from environmental powders; Dipel dust not positive in some cases (but expect positive)
  - ATP test positives:
    - Clean Trace: Brewer's yeast, milk powder, and white flour (note: Dipel not +)
    - Profile 1: Brewer's yeast, Dipel dust;clogging problems with 5 powders
  - Prime Alert DNA test positives:Br ewer's yeast (note: Dipel not +)
- Next steps: Perform additional testing to understand test limitations and value of the tests for sample screening and triage.

Testresults w ill provide key information for first responders regarding the limitations of screening tests and effect of powders on test outcome

2

Future Testing: *Bacillus anthracis* Spores and Ricin

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- Goal: understand instrument performance, limitations, and cost/benefit of assays/biodetection platforms
- Test samples:
  - *Bacillus anthracis* spores
    - BSL-2 and BSL-3
    - 0.1 – 10 mg/test
  - Ricin toxin
    - 4 preparations of varying purity: crude prep to pure toxin
    - 0.1 – 10 mg/test
- Screening Assays:
  - General Protein: 20/20 kits, Indipro strips, and BioScreener
  - Biochemical: ATP/luminometer test: Clean Trace and Profile 1 tests
  - General DNA: Prime Alert
  - Chemical/Spectroscopic: HazMat ID 360 FTIR
  - Immunoassays: RAID 8 and Pro Strips
  - PCR Assays: RAZOR, FilmArray, T-COR4, POCKIT, and BioSeeq PLUS
- Outcome of these tests will help to formulate additional testing, including LOD studies with powder + *Ba* and ricin mixtures

Testing Outcomes and Info Dissemination

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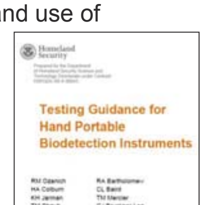
- PNNL laboratory testing
  - Establish LOD, dynamic range, potential for false positive/negative results, and impact of other substances such as common hoax powders
  - Identify technology deficiencies/limitations prior to high cost/effort field testing
  - Evaluate strategies for instrument use
  - Develop objective information and guidance for selection and use of biodetection technology
- Publish and disseminate information
  - COTS biodetection instrument summary reports
  - Peer-reviewed publications of COTS instrument testing
  - Dissemination of PNNL Test Plan for future instrument testing and transition

Evaluation of the FilmArray® system for detection of *Bacillus anthracis, Francisella tularensis* and *Yersinia pestis*

Volume **114**, Issue 4, pages 992–1000, April 2013



Evaluate Strategies for Instrument Use

- Assess limitations, ability to achieve probability of detection goal, cost/benefit
  - A few example strategies are listed below

Biodetection Strategy #1

Protein Test → PCR

Biodetection Strategy #2

FTIR → Protein Test → Immunoassay

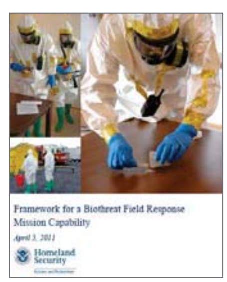
Biodetection Strategy #3

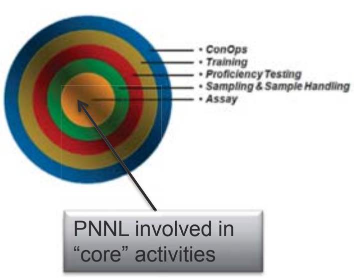
Protein Test → Immunoassay → PCR

Each Strategy = different probability of agent detection along with specific costs and limitations for a given test

Summary of Path Forward

- Continue technology foraging and instrument testing
- Conduct additional Working Meeting with first responders in 2014 to report testing results, present instrument use/guidelines and solicit stakeholder feedback
- Provide information to end-users to assist in making more informed decisions on equipment selection, improving training and better understanding of equipment use and limitations





- In partnership with Public Health and other Agencies (APHL, LRN, CST, FBI, NIST, Others), support field biodetection exercises
- Support DHS and other agencies in the implementation of key elements of the Biothreat Field Response Mission Capability

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It Takes A Village

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- ***Principle Investigator:*** Cindy Bruckner-Lea
- ***Project Manager:*** Rachel Bartholomew
  - rachel.bartholomew@pnnl.gov; 509-371-6906
- ***Project Team:***
  - Cheryl Baird
  - Heather Colburn
  - Janine Hutchison
  - Kris Jarman
  - Ann Lesperance
  - Terre Mercier
  - Richard Ozanich
  - Jessica Sandusky
  - Timothy Straub
  - Kristin Victry
  - Pamela Kinsey

- ***DHS Program Manager:*** Anne Hultgren
- This effort is funded by the Department of Homeland Security Science and Technology Directorate under Contract HSHQDC-08-X-00843.

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Wednesday, November 6, 2013

Concurrent Sessions 2

Radiological Agent Fate, Transport, and Decontamination

Migration of Radiocesium, Radiostrontium and Radiocobalt in Urban Building Materials and their Wash-off by Rainwater

MASLOVA K.[1], GUSAROV A.[1], KONOPLEV A.[1], LEE S.D.[2], POPOV V.[1], STEPINA I.[1]

[1] *RPA "Typhoon", Obninsk, Russia*
[2] *National Homeland Security Research Center, US EPA, USA*

Introduction (1)

- The previous experience from radiological accidents, such as Chernobyl (1986) and Fukushima (2011) shows that there can be a hazard from contamination of the urban environment by long-lived radionuclides such as radiocesium, radiostrontium and radiocobalt.
- These radionuclides are also believed to be potential agents that may be used in radiological dispersal devices in acts of terrorism.

Introduction (2)

- Basically there are two main ways of decreasing the contamination: natural attenuation and artificial decontamination;
- The natural attenuation processes on urban materials include radioactive decay, run-off, short-term and long-term weathering;
- These weathering processes greatly depend on the meteorological conditions. A better understanding of the interactions of radionuclides with building materials under varied atmospheric conditions will help increase the effectiveness of artificial decontamination methods.

US EPA-ISTC Partner Project #4007 «Fate and transport of radiocesium, radiostrontium and radiocobalt on urban building materials»

Objective:

To investigate and characterize the fate and transport of water soluble radiocesium, radiostrontium and radiocobalt particles deposited on common urban building materials, especially concrete, brick, asphalt, limestone, granite and components of drinking water distribution systems (iron, copper and plastic pipes), under various environmental conditions.

Tasks of the Project

1. Determination of the radioactive material migration profile through urban building materials at various times and relative humidities. Wash-off of radionuclides by rain from contaminated surfaces(this presentation);
2. Determination of sorption and desorption coefficients and distribution coefficients of radionuclides in water-powdered building material system (presentation of K. Maslova);
3. Identification of interaction mechanisms between target compounds and urban materials and characterization of their interactions as a function of time (presentation of K. Maslova);
4. Laboratory study of radiocesium, radiostrontium and radiocobalt sorption/desorption on components of drinking water distribution systems iron, plastic, copper and concrete pipes (presentation of I. Stepina).

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Radionuclides under study: ^{137}Cs, ^{60}Co, ^{85}Sr (as analog ^{90}Sr)

Building materials under study (provided by US EPA):


Asphalt


Limestone


Concrete


Brick


Granite

Material	Bulk Density, g/cm³	Porosity, %	CEC, meq/kg	C_{org},%	pH	
					H_2O	KCl
Asphalt	2.34±0.08	2.2±1.0	88±4	2.9±0.3	9.6	9.5
Limestone	2.1±0.1	15.3±2.4	33±4	0.10±0.01	9.5	9.6
Concrete	1.68±0.06	20.3±0.9	64±5	0.36±0.03	12.3	12.5
Brick	2.0±0.1	20.3±0.3	69±1	0.30±0.08	10.7	10.5
Granite	2.41±0.14	1.5±0.5	59±6	0.10±0.01	10.0	9.7

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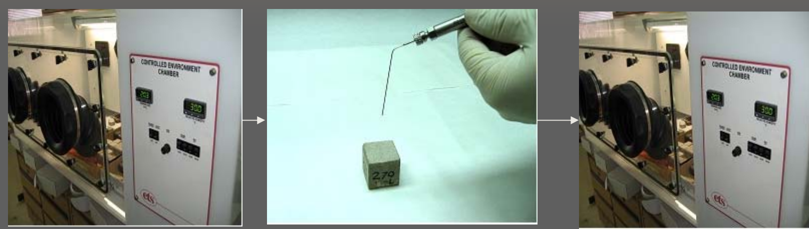
Radionuclide migration through building materials. Method



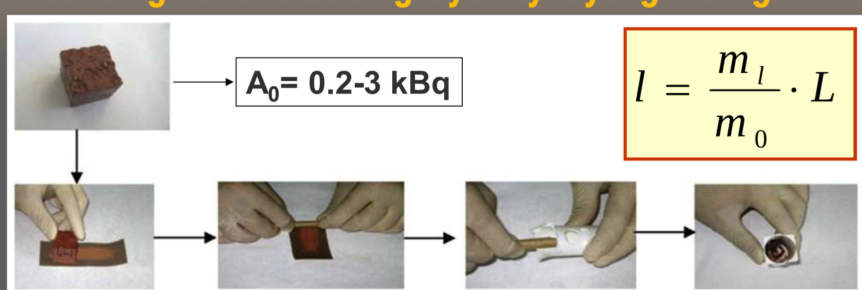
Equilibration

Radionuclide injection

Incubation

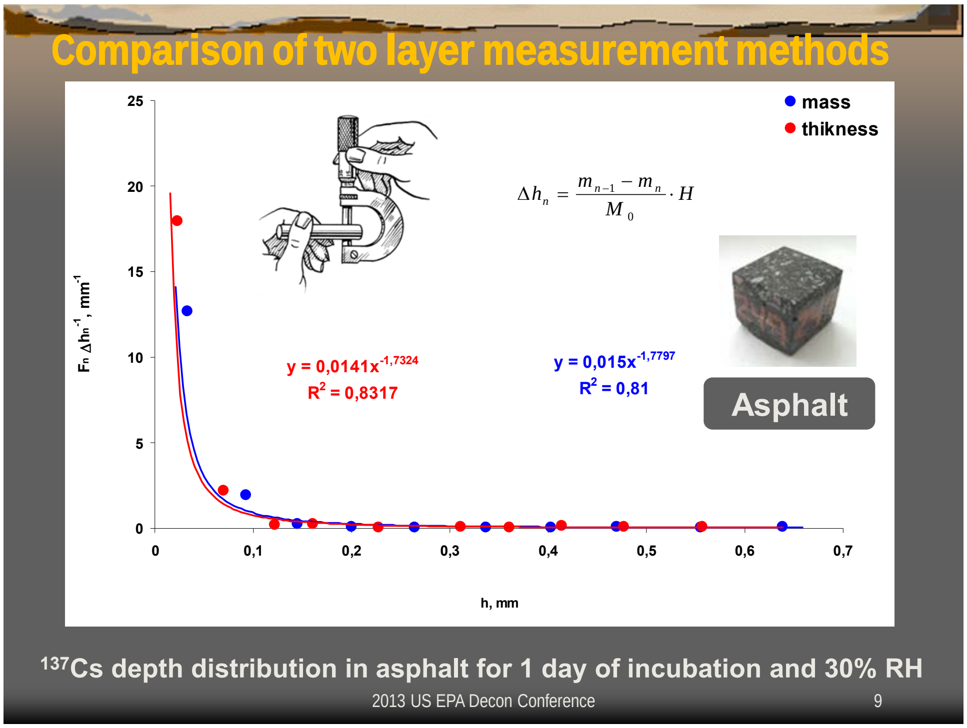
Temperatures: 5^{o}C; 20^{o}C, 35^{o}C; Relative Humidities: 30% and 87%
Time of incubation: 1, 7, 14 and 28 days

Methodology for determining radionuclides depth profile in building materials using layer-by-layer grinding



$$l = \frac{m_l}{m_0} \cdot L$$

- To determine RN depth distribution in the layer less than 0,1 mm the sample was sanded;
- The layer thickness (l, mm) was calculated from the sample weight before and after sanding;
- The activity of each layer was determined directly in the sandpaper rolled up and placed into the holder for measurements using gamma-counter.


Comparison of two layer measurement methods
mass
thikness
$\Delta h_n = \frac{m_{n-1} - m_n}{M_0} \cdot H$
y = 0,0141x^-1,7324
R^2 = 0,8317
y = 0,015x^-1,7797
R^2 = 0,81
Asphalt
Fn Δhn^-1, mm^-1
h, mm
0 5 10 15 20 25
0 0,1 0,2 0,3 0,4 0,5 0,6 0,7
137Cs depth distribution in asphalt for 1 day of incubation and 30% RH
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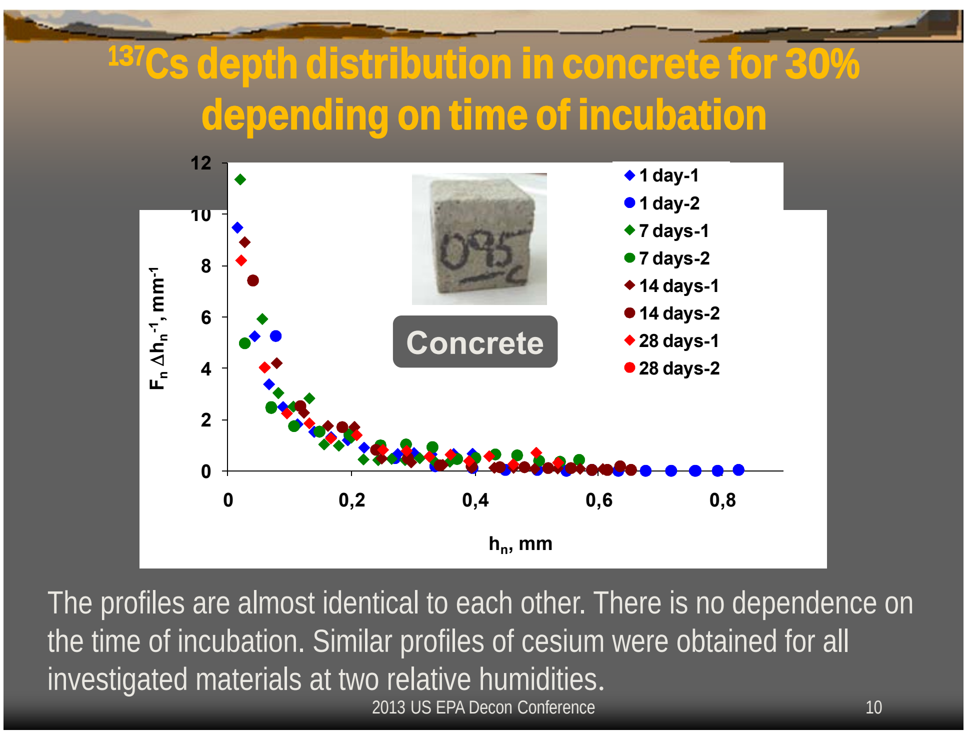
137Cs depth distribution in concrete for 30% depending on time of incubation
1 day-1
1 day-2
7 days-1
7 days-2
14 days-1
14 days-2
28 days-1
28 days-2
Concrete
Fn Δhn^-1, mm^-1
hn, mm
0 2 4 6 8 10 12
0 0,2 0,4 0,6 0,8
The profiles are almost identical to each other. There is no dependence on the time of incubation. Similar profiles of cesium were obtained for all investigated materials at two relative humidities.
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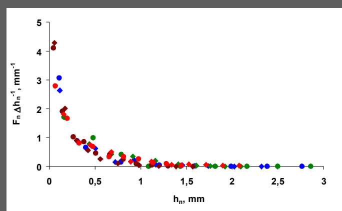
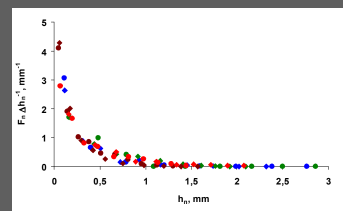
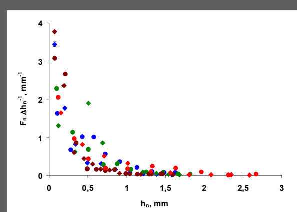
^{60}Co depth distribution in limestone and brick for different time of incubation and RH – no dependence.

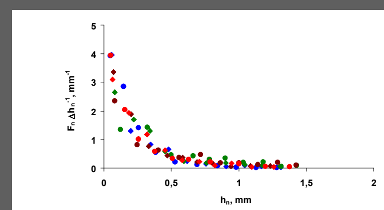


Limestone

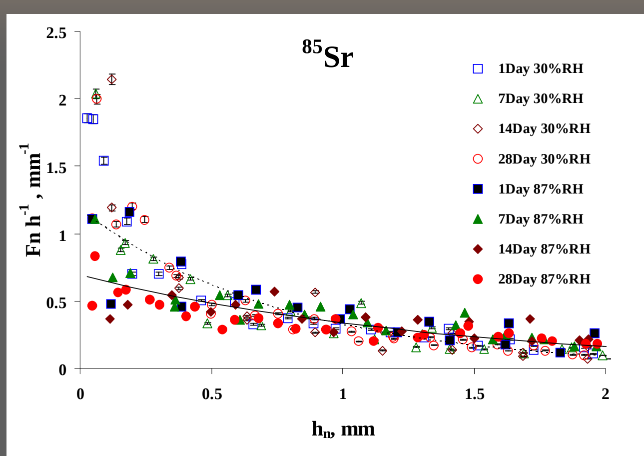




Brick



^{90}Sr migration profile in brick at various incubation times and relative humidities



Brick

Brick: Penetration is essentially higher for ^{85}Sr than for ^{137}Cs and ^{60}Co

Radionuclide penetration into building materials was characterized in terms of $h_{90\%}$ - depth where 90% of RN occurs.

- For *asphalt, limestone and concrete* penetration depth does not depend on a specific radionuclide, relative humidity and time of contact of the radionuclide with building material.
- A significant dependence of the penetration depth for different radionuclides is seen for *brick*. While the median value $h_{90\%}$ for ^{85}Sr changes from 2.1 to 3.6, for ^{137}Cs and ^{60}Co this value changes from 0.7 to 0.9 mm.
- The most pronounced differences in the penetration depths of radionuclides are seen for *granite*. While for ^{85}Sr the median values $h_{90\%}$ are about 6.0-6.5 mm, for ^{137}Cs and ^{60}Co this value is practically 5 times lower and equals about 0.3-1.7 mm.

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Artificial raining of building materials. Method.

Incubation of building materials at 30 or 87% RH for 1 or 28 days at 5, 20, or 35 °C

Raining water composition

Ion	Concentration, mg/l
Cl	0.53
NO_3	0.32
HCO_3	1.06
SO_4^{2-}	3.0
Na^+	0.4
K^+	0.2
Mg^{2+}	0.68
NH_4^+	0.05
Ca^{2+}	0.3

Raining:
Intensity - 20 mm/h
Duration - 30 min.

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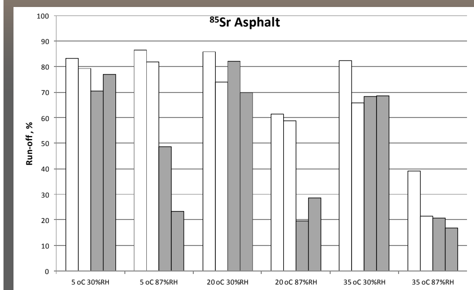
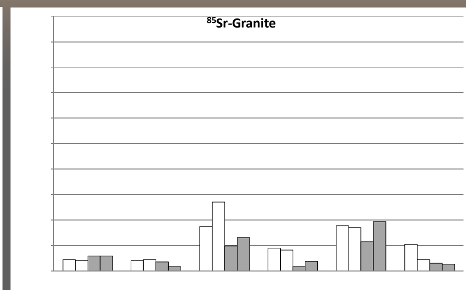
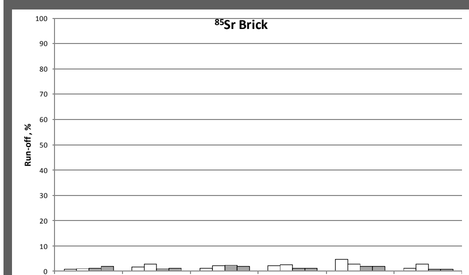
Wash-off of radionuclides from building materials

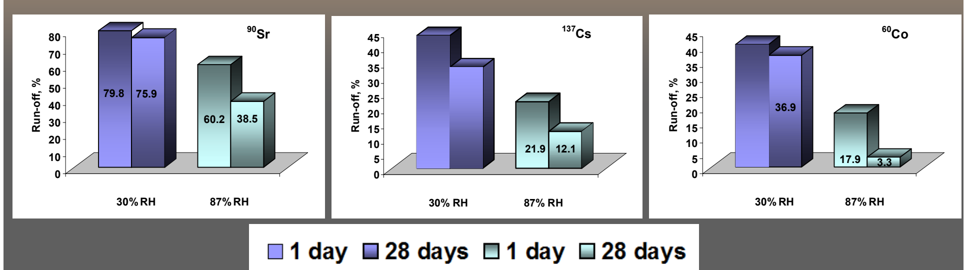






- Highest wash-off is characteristic for asphalt, then goes granite;
- Wash-off from porous materials (brick, limestone and concrete) is low.

Radionuclide wash-off from asphalt depending on RH and time of interaction



Radionuclide wash-off from asphalt surface is significantly dependent on relative humidity of the air:

- At RH 30% the radionuclide wash-off is weakly dependent on interaction time;
- At RH 87% the wash-off decreased by a factor of 1.5 for ^{85}Sr and ^{137}Cs and as much as by a factor of 5 for ^{60}Co, with the interaction time increasing from 1 to 28 days.

Radionuclide wash-off: general conclusions

- At 20 ^{o}C and 30% RH the ^{137}Cs and ^{60}Co wash-off for asphalt ranged from 32 to 44% and for granite from 13 to 27 %. The ^{85}Sr wash-off for asphalt was 76-80% and for granite 11-22%.
- For other materials the radionuclide wash-off was typically 2-6%.
- Increasing the RH from 30 to 87 % affected wash-off of all radionuclides for granite and asphalt and ^{137}Cs for concrete and brick.
- The most pronounced RH effect was observed for ^{60}Co behavior in asphalt (^{60}Co wash-off decreased from 29-45% to 2-5% when RH increased from 30 to 87% for 28 days of incubation).
- Temperature of incubation (5, 20 or 35 ^{o}C) did not affect significantly the wash-off of radionuclides from the building materials.

Thank you very much for your attention!

Questions?

Evaluation of Scalability Challenges for Radiological Decontamination Technologies in the Urban Environment

John Drake

National Homeland Security Research Center
Decontamination and Consequence Management
Research Triangle Park, NC

If an RDD were to occur today, what technologies could EPA use for recovery?

- What technologies are available now and how well do they work?
- What constitutes a "wide-area applicable" decon technology?
- Are there technologies ready for wide-area deployment?
- What would it take to adapt or "scale-up" other existing technologies for the wide area?

What technologies are available and how well do they work?

- 2006: Decon Technology Survey
- 2007: Developed decon efficacy testing methodology*
- 2008-present: Efficacy testing of commercially available technologies**
  - Coatings/gels (5 products)
  - Liquids/foams (10 products)
  - Mechanical methods (7 products)

* Based on Radionuclide Detection and Decontamination Program, Broad Agency Announcement 03-013, U.S. Department of Defense, Defense Advanced Research Projects Agency (DARPA) , 2003
** Reports available at http://www.epa.gov/nhsrc/pubs.html

What constitutes a "wide-area applicable" decon technology?

- Affected Area: greater than 100 m^2
- Speed: greater than 5 m^2/hour
- Availability: sufficient quantity, deliverable
- Cost: affordable in needed quantities
- Operational Feasibility: transport, utilities required, skill level
- Desired End State: minimally destructive, secondary waste

Are there technologies ready for wide-area deployment?

What would it take to adapt or "scale-up" other existing technologies for the wide area?

- Identify all existing technologies, down-select those with potential for wide-area deployment
- Evaluate feasibility and technical challenges to adapt or "scale-up" these technologies for the wide area
- Utilize expertise from EPA operational community, R&D, DOE

Identify universe of decon technologies potentially applicable to the wide area

Identify Available Rad Decon Technologies → **EPA Review Team** (Subject Matter Experts) → **Compendium of Potential Technologies for Wide Area**

Technology Reference Guides
EPA Technology Eval Reports
Databases: DTIC
Science Direct
Compendex
Knovel
IEEE Explorer
SMEs: EPA, DOE, industry
Literature/Internet search

OEM/CMAT
EPA OSCs Regions 4 & 5
NHSRC
DOE/INL
Battelle

Physical Removal (17)
Strippable Coatings, Gels (20)
Chemical Foams/Liquids (11)

Final "Short List" of potential technologies/challenges

Category	Some Examples	Challenges/Limitations
Strippable Coatings and Gels (7 products)	Argonne SuperGel ALARA 1146 DeconGel	Removal may be difficult Wide-area spray not thoroughly tested No efficacy data for some technologies
Liquids Foams (4 products)	Canadian UDF EAI Rad-Release TechXtract	Secondary waste collection/disposition (media) Some technologies are labor intensive No efficacy data for some technologies
Physical Removal (10 products)	Abrasive blasting surface grinding vacuum pressure washing	Secondary waste collection/disposition (blast media, removed surface material) Some technologies have low decon rate Some technologies are labor intensive Some technologies not tested against rad Destructive to surface Vacuum only effective for loose contamination

Potential R&D to address technical challenges

Challenges/Limitations	Potential R&D or solution
Coating removal may be difficult Wide-area spray not thoroughly tested	Demonstrate on large scale (non-radiological)
Secondary waste collection/disposition	Investigate effluent capture mechanisms; demonstrate retrofits; collaborate with vendors
Some technologies are labor intensive Some technologies have low decon rate	Investigate potential design mods; collaborate with vendors
No efficacy data for some coatings/gels/liquids/foams Some physical removal technologies not tested against rad	Perform efficacy evaluation (radiological testing)

Conclusions:

- No surface cleaning technology is ready for wide area deployment, but some are close
- Large scale demonstration could provide valuable assurance for wide-area deployment (strippable coatings, foams)
- Effluent capture remains a primary limitation (water/media blast, abrasive surface removal)
- Some potentially viable products still need efficacy testing

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For additional information go to:
http://www.epa.gov/nhsrc/pubs.html

or contact

John Drake
drake.john@epa.gov, (513)235-4273

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Sorption and Speciation of ^{137}Cs, ^{60}Co and ^{85}Sr in Building Materials

ISTC Project No. 4007
"Fate and Transport of Cesium, Strontium and Cobalt Particles on Urban Surfaces"

Katerina Maslova[1], Stepina I.[1], Popov V.[1], Konoplev A.[1], Lee S.D.[2], Gusarov A[1].

[1]RPA "Typhoon", Russia
[2] US EPA, NC USA

U.S. EPA International Decontamination Research and Development Conference

5 – 7 November 2013
Durham, NC USA

OUTLINE

Part 1

- ✓ Building materials properties
- ✓ Kinetics of ^{60}Co, ^{85}Sr and ^{137}Cs sorption in building materials by the batch method
- ✓ Prediction of K_d ^{137}Cs of building materials using experimental values of Radiocesium Interception Potentials(RIP) and K^+ concentrations

Part 2

- ✓ Sequential extraction methods and Ammonium extractions
- ✓ ^{137}Cs, ^{60}Co, ^{85}Sr speciation as a function of time

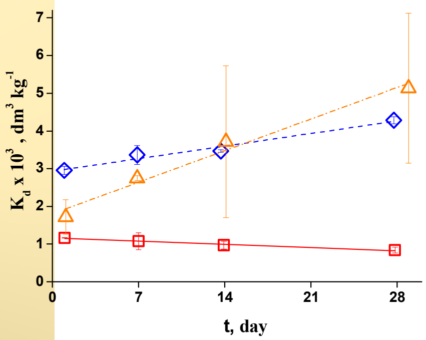
Building Materials

Crushing ⟹ Grinding ⟹ Sieving ⟹ Fraction <0.125 mm (Fine fraction)

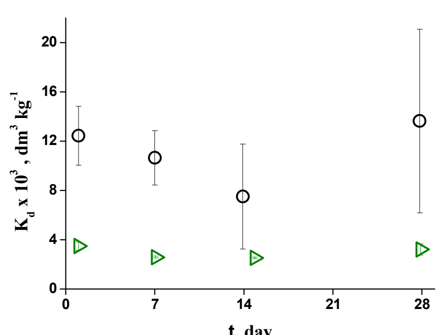
Building material	Porosity, %	Particle density, g/cm^3	CEC, cmol(+) /kg	pH_{KCl}	Organic C, %
Concrete	20.3±0.9	2.10±0.11	6.4±0.5	12.5	0.36±0.03
Granite	1.5±0.5	2.44±0.13	5.9±0.6	9.7	0.092±0.004
Limestone	15.3±2.4	2.52±0.06	3.3±0.4	9.6	0.092±0.004
Asphalt	2.2±1.0	2.39±0.06	8.8±0.4	9.5	2.9±0.3
Brick	20.28±0.25	2.53±0.01	6.9±0.1	10.5	0.30±0.08

Kinetics of ^{60}Co sorption by building materials* using the batch method

△ - granite; ◇ - concrete; □ - brick;



▷- asphalt; O - limestone;



*Maslova et al.
Journal of Environmental Radioactivity 125 (2013) 74 – 80.

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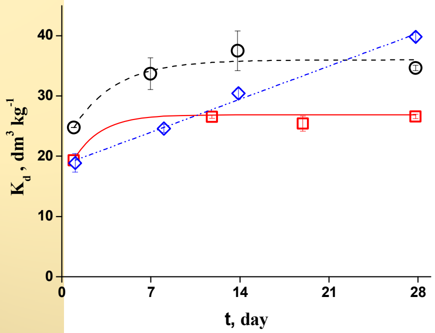
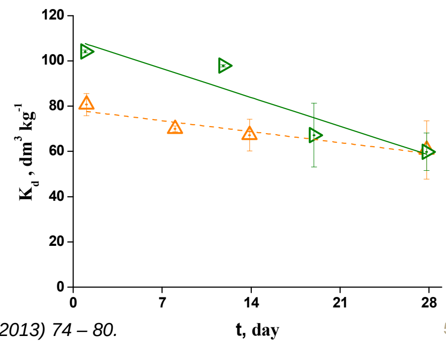
Kinetics of ^{85}Sr sorption by building materials using the batch method*



O - *limestone;* ◇ - *concrete;* □ - *brick;*

▷- *asphalt;* △ - *granite;*



**Maslova et al.*
Journal of Environmental Radioactivity 125 (2013) 74 – 80.

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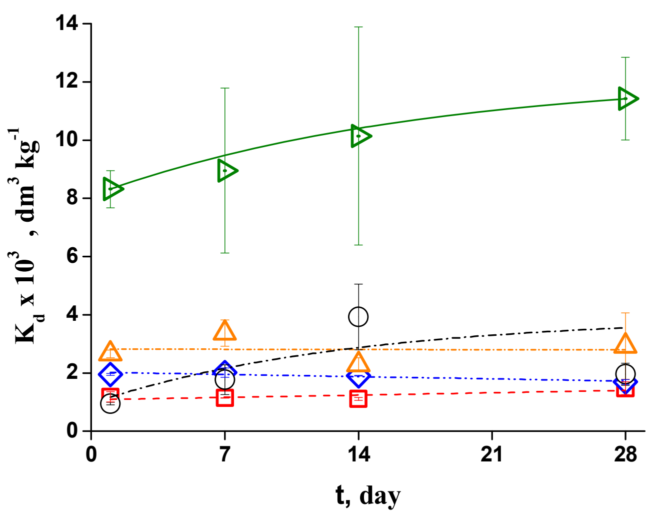
Kinetics of ^{137}Cs sorption in building materials using the batch method*

▷ - *asphalt;* △ - *granite;* ◇ - *concrete;* O - *limestone;* □ - *brick;*



**Maslova et al. Journal of Environmental Radioactivity 125 (2013) 74 – 80.*

Radiocesium Interception Potentials can be used to predict K_d ^{137}Cs

(1)

$$K_d = \frac{RIP(M)}{C_M}$$

Where M is K^+ or NH_4^+

C_M is the concentration of a competing cation M

Trace Selectivity coefficient of NH_4^+ to K^+ exchange on FES $K_c(K/N)$ is a parameter indicating leading mechanism of Cs sorption

(2)

$$K_c(K/N) = \frac{K_c^{FES}(Cs/K)}{K_c^{FES}(Cs/N)} = \frac{K_d^{Cs} \cdot C_K}{K_d^{Cs} \cdot C_N} = \frac{RIP(K)}{RIP(N)}$$

For illite $K_c(K/N) = 5$

RIP(K) and RIP(N) ^{137}Cs of building materials

Building material	RIP(K) suspension, mM/kg <0.125	K_c(K/N) <0.125	RIP(N) suspension, mM/kg <0.125
Asphalt	**280.5 ± 16.3**	**9.5**	**29.5 ± 0.6**
Limestone	**12.5 ± 0.4**	**6.6**	**1.9 ± 0.3**
Granite	**204.3 ± 21.0**	**17.7**	**11.5 ± 0.9**
Concrete	**185.4 ± 5.0**	**1.0**	**195.4 ± 1.5**
Brick	**14.9 ± 3.0**	**2.8**	**5.4 ± 0.6**

De Preter (1990)

New brick: ***RIP(K)=31-61*** *mM/kg*

RIP(N)=18-37 *mM/kg*

Old brick: ***RIP(K)=380*** *mM/kg*

RIP(N)=120 *mM/kg*

K_d ^{137}Cs for intact building materials predicted using experimental values of RIP(K) and C_K *

$$K_d = \frac{RIP(K)}{C_K} \quad (1)$$

C_K as function of $(m_L : m_S)$ (2)

$$m_L \div m_S = \frac{Porosity \cdot \rho_{water}}{(1 - Porosity) \cdot \rho_{particle}} \quad (3)$$

Building material	m_L: m_S dm^3 /kg for intact samples	Predicted C_K, mM/dm^3 for intact samples	Predicted K_d (^{137}Cs), dm^3/kg for intact samples	Suspension 1:50 K_d (^{137}Cs), dm^3/kg for 1 day
Concrete	0.172	0.11 ± 0.04	1700 ± 600	1950 ± 27
Granite	0.020	7.8 ± 1.6	26 ± 5	2654 ± 131
Limestone	0.077	0.83 ± 0.20	15 ± 4	950 ± 44
Asphalt	0.089	0.71 ± 0.13	390 ± 70	8316 ± 644
Brick	0.163	0.61 ± 0.06	25 ± 6	1180 ± 176

*Stepina et al. Radiochemistry, 2013. Vol. 55, No. 3, pp. 305-309.

Results summary

1. ***^{60}Co sorption by granite and concrete increases with time during 28 days. For brick the ^{60}Co K_d slowly decreases with time. There is no time dependence of the ^{60}Co K_d for asphalt and limestone.***

2. ***^{85}Sr sorption by asphalt and granite is decreasing of with time. ^{85}Sr sorption by brick, limestone and concrete increases approximately 1.5-2 times.***

3. ***The K_d value of ^{137}Cs increases with time. For asphalt and limestone K_d ^{137}Cs increases approximately 2 times during 28 days of interaction. There is no time dependence of the ^{137}Cs K_d for other materials.***

4. ***Selective sorption of ^{137}Cs ranges from 20 to 300 mM/kg in the order:***

   Brick > Granite > Asphalt > Limestone > Concrete.

5. ***Predicted K_d of ^{137}Cs for intact samples is significantly lower than experimental K_d values for suspension. This results could be applicable in radionuclide transport models.***

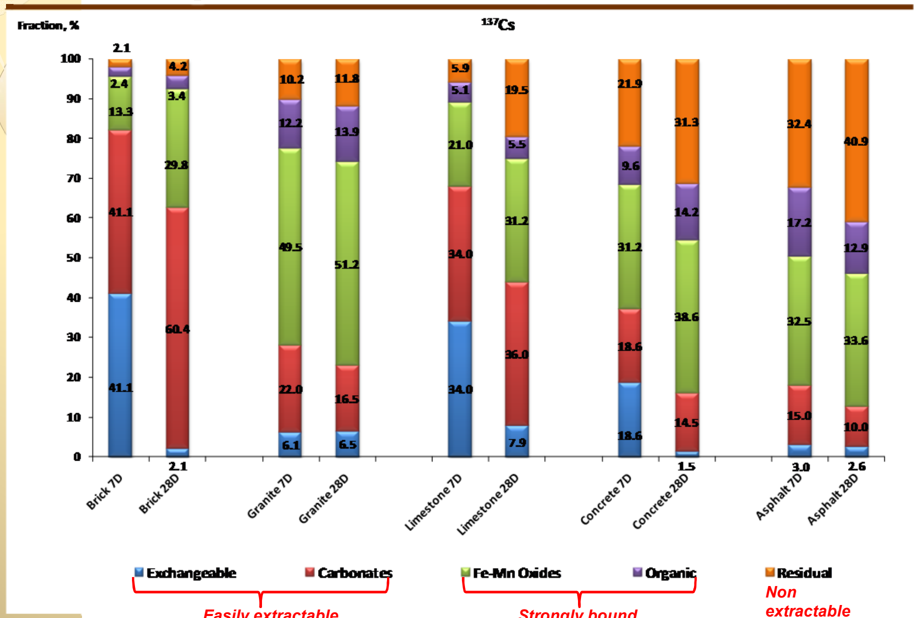
Sequential extractions methods

Easily extractable: Ion-exchange fraction; Fraction bound to carbonates
Strongly bound: Fraction bound to oxides of Fe-Mn; Fraction bound to the organic matter
Non extractable: Residual fraction

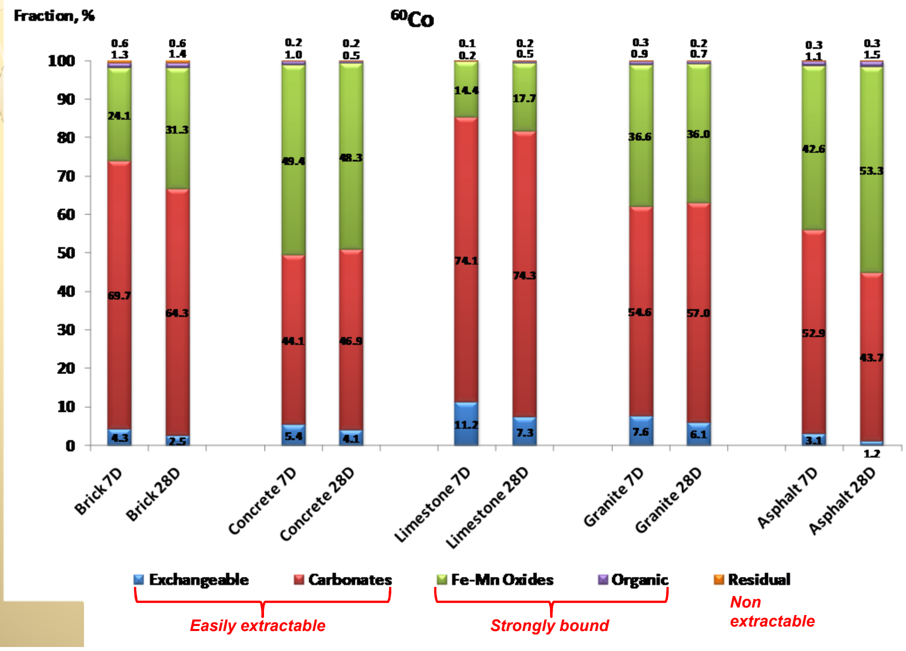
Title	Tessier (1979)	Riise(1990)	Bunzl (1997)	Niesiobedzka (2000)	Knox (2001)
Ion-exchange fraction	1M $MgCl_2$	1M CH_3COONH_4	1M CH_3COONH_4	1M CH_3COONH_4	1M CH_3COONa
Fraction bound to carbonates	1M CH_3COONa	0.04M NH_2OH*HCl-25% CH_3COOH	0.04M NH_2OH.HCl-25% CH_3COOH	0.04M NH_2OH*HCl-25% CH_3COOH	0.25M NH_2OH*HCl-0.25M HCl
Fraction bound to oxides of Fe-Mn	0.04M NH_2OH*HCl-25% CH_3COOH	30% H_2O_2 + 3,2 M CH_3COONH_4	30% H_2O_2 + 3,2 M CH_3COONH_4	30% H_2O_2 + 3,2 M CH_3COONH_4	1M NH_2OH*HCl-25% CH_3COOH
Fraction bound to the organic matter	0.02M HNO_3 + 30% H_2O_2 + 3,2 M CH_3COONH_4	7 M HNO3	7 M HNO_3	HNO_3	0.02M HNO_3 + 30% H_2O_2
Residual fraction	measured RN on solid phase	Total activity - (F1+F2+F3+F4)	measured RN on solid phase	measured RN on solid phase	measured RN on solid phase

Ammonium extraction was performed using 50 mL of 1 M CH_3COONH_4 solution (pH=7), the suspension was shaken on a to-and-fro shaker at 20 °C. The extraction time was 1 hour and 24 hours.

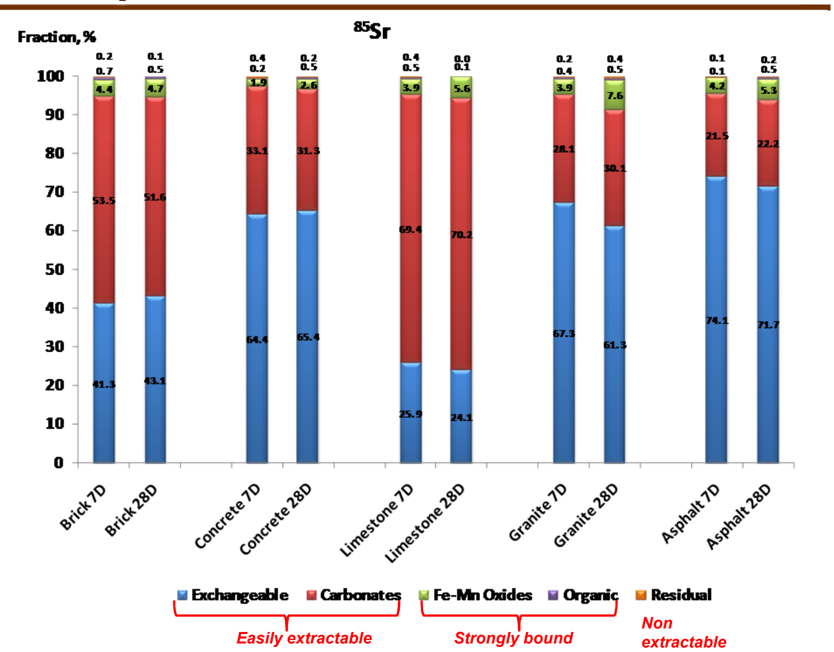
^{137}Cs speciation as a function of time



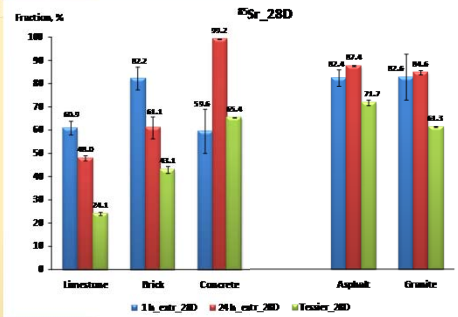
^{60}Co speciation as a function of time

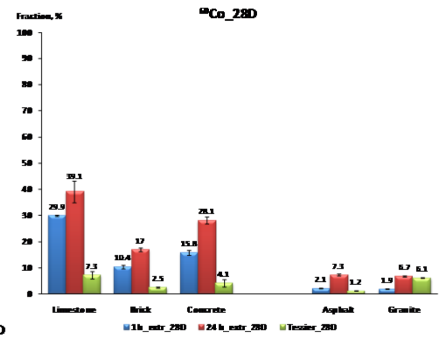


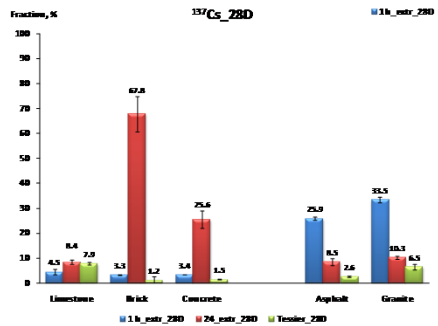
^{85}Sr speciation as a function of time



Ammonium extractions







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Results summary

1. *By ^{137}Cs concentration in Strongly bound & non extractable fraction, the materials form the following sequence: asphalt > concrete > granite > limestone > brick.*

2. *^{85}Sr sorption by all materials is a practically completely reversible. The concentration of ^{60}Co in the residual fraction, like for ^{85}Sr , also did not exceed 1%.*

3. *For all radionuclides under study the CH_3COONH_4 solution is the most effective agent for extracting the exchangeable fraction from all building materials. The optimum extraction time for ^{137}Cs is 24 hours, for ^{60}Co – 24 hours and ^{85}Sr – 1 hour.*

4. *With time the exchangeable fraction of radionuclides is decreasing in all materials, the maximum fixation is seen for ^{37}Cs. For ^{60}Co and ^{85}Sr, the changes in its exchangeable fraction were insignificant. However, ^{60}Co with time converted into strongly bound fraction. >*

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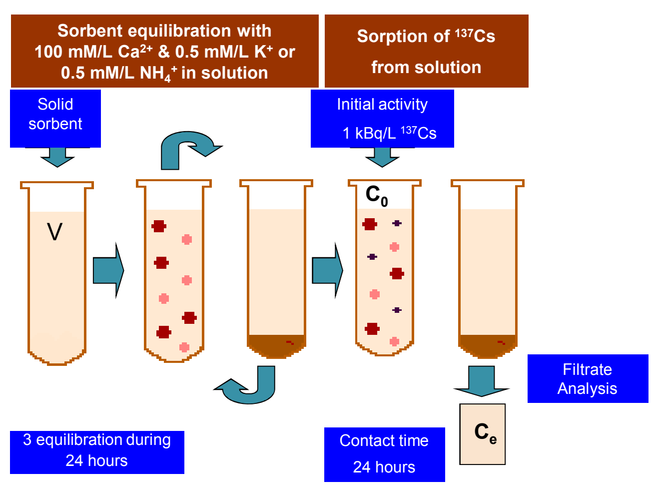
THANK YOU FOR YOUR ATTENTION!

Method of RIP determination *(Wauters et al. 1996)*



Sorbed ^{137}Cs

$$A_S = V \cdot (C_0 - C_e)$$

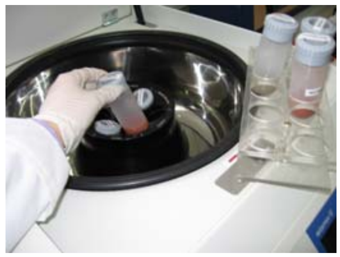
RIP ^{137}Cs

$$RIP\ (C_M) = \frac{A_S \cdot C_M}{m_s \cdot C_e}$$

Experimental Method

1. Powdered materials were put into centrifuges tubes

2. After the sorption period (7 or 28 days) it was washed by deionized water and centrifuged.



3. The extractions were performed according to Tessier procedure. After each step the samples were washed with deionized water and centrifuged.

4. The amount of extracted radionuclide in the supernatant liquid was determined with automated gamma-counter Wizard 1480.

Tessier scheme

***(1) Ion-exchange fraction:** 16 mL of 1 M solution of $MgCl_2$, the suspension shaken on a to-and-fro shaker at 20 °C during 1 hour.*

***(2) Fraction bound to carbonates:** 16 mL of 1 M solution of CH_3COONa was added, brought to pH = 5 with acetic acid (CH_3COOH). The vials were shaken at 20 °C during 5 hours.*

***(3) Fraction bound to oxides of Fe-Mn:** 40 ml of 0.04 M solution of NH_2OH*HCl in 25% acetic acid (CH_3COOH). The tubes were kept during 6 hours in drier at temperature 96±3 ^{0}C, the samples were shaken occasionally (during 20 minutes every 2 hours).*

***(4) Fraction bound to the organic matter:** 6 ml of 0.02 M solution of HNO_3 and 10 mL of 27% solution of H_2O_2 (pH=2), kept at temperature 85±2 ^{0}C during 2 hours shaking the samples occasionally. After that the tubes were added again with 6 ml of 27% solution of H_2O_2 (pH=2) and kept for three hours at temperature 85±2 ^{0}C, shaking the samples occasionally. After cooling, the solution was added with 10 ml of 3,2 M solution of CH_3COONH_4 diluted with 20% solution of nitric acid (HNO_3) and shaken during 30 minutes.*

***(5) Residual fraction:** For determining the residual activity in the solid phase of the materials the remaining samples were put in the vials (20 mL) and radionuclide activity was measured in the solid phase.*

Humic Acid-Based Sorbents for Area Decontamination

A.V. Sosnov[1], S.V. Sadovnikov[1], Y. G. Putsykin[2], A.A. Shapovalov[2], K. Volchek[3], W. Kuang[3], P. Azmi[3], and C.E. Brown[3]

[1]NPP OrCheMed, Russian Academy of Sciences, Moscow, Russia
[2]Agrosyntez LLC, Moscow, Russia
[3]Environment Canada, Ottawa, Ontario, Canada

2013 EPA International Decontamination Research and Development Conference
Research Triangle Park, NC, US
November 5-7, 2013

S&T Bases for Use Humic acids (HA) in Decontamination Technics

1) Humic acids (HA) are main organic component of soil, lignate (brown coal), leonardite, and peat

- brown coal is main raw material for preparation of low cost and cross functional sorbents

2) Formulations of activated humic acids (AHA) can be used as effective adsorbents for toxic chemical substances, such as:

- cations of heavy metals
- cations of radionuclides
- hydrophobic and hydrophilic organic contaminants like CW, dioxins and pesticides

3) Humic acids is natural matrix for accumulation and living of soil microorganisms for biological degradation of organic contaminants

- increasing HA concentration in soil leads to increased concentration and activity of natural soil microorganisms to promote biodegradation
- there are formulations – stable concentrates of various microorganisms – promoters of biodegradation based on HA matrix

Origin and Structure of Humic Acids

- **Soil Organic Matter**
  - **Fulvic acids** — Water soluble
  - **Humic substances** — Soluble in base
    - **LMW organic compounds**
    - **Humic acids** — Resistant to soil microorganisms
  - **Humin** — Organic soluble
  - **Fresh organic residue**

Two theories of humic materials formation:

- **Degradation pathway:**
- Plant material → Humin → Humic Acid → Fulvic Acid → Small molecule
- **Synthetic pathway:**
- Plant material → Small molecule → Fulvic Acid → Humic Acid → Humin

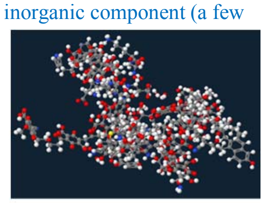
Main natural sources of the HA:

- Leonardite - 50% - 70%, Brown coal - 30% - 50%
- Peat - 15% - 25%
- Sapropel - 15% - 25%
- Soil - 0.5% - 10%

Useful Properties of Humic and Fulvic Acids

Humic acids:

- pH-dependent natural organic polymer compounds with essential inorganic component (a few percent of inorganic minerals, e.g. Montmorillonite)
- CAS#1415-93-6, exact chemical structure is unknown
- regulation of soil properties:
  - to improve thermal conditions and soil or substrate structure
  - to enhance the ion - exchange capacity
  - to stimulate living of microorganisms
- resistant to soil microorganisms up to pH < 10
- form insoluble salts with cations of heavy metals and radionuclides
- **use for decontamination:** irreversibly bind cations of heavy metals and radionuclides in soil, greatly reduce their mobility in the environment, protect living water and living organisms from contamination



H.-R. Schulten and M. Schnitzer. 1997. *Soil Sci* 162:115-130
http://virtual-museum.soils.wisc.edu/som/index.html

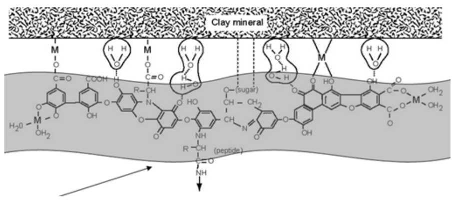
Fulvic acids:

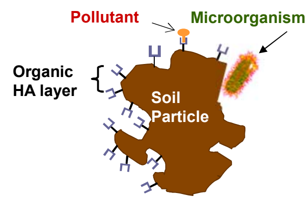
- natural organic polymer compounds
- soluble in acid and base
- **use for soil decontamination**: turns salts of heavy metals and radionuclides into soluble forms that are absorbed by plants and no longer present in soil

Unique Features of HA

Ability to form biocompatible nano-films on inorganic surfaces

- natural starting mechanism of soil formation from inorganic ground
- mechanism of soil fertilization use industrial HA products





Biocompatible nanofilm on inorganic surfaces

Ability to form soil particles as a living environment for useful microorganisms

Ability to adsorb inorganic cations, hydrophobic and hydrophilic organic compound including contaminants

Hypothesis: HA are key organic component of soil to making vital functions of microorganisms and plants

Our Approach for Commercial Purification and Activation of HA

Stage 1. General approach. Preparation of HA formulations for soil fertilization and remediation. Low cost and non-toxic materials.

- HA extraction from raw materials
- HA hydration

Stage 2. **General approach + know-how.** Preparation of sorbents for heavy metals, radionuclides, and cleaning products for wide industrial application incl. **decontamination.** Low cost, non-toxic and easy-to-use natural sorbents.

- HA purification (general approach) and activation (partial know-how) remove of inorganic micro particles and most of adsorbed inorganic compounds/cations)

Stage 3. **Know-how.** Preparation of high-purified HA sorbents for veterinary and medical use, materials for chemical industry.

- HA purification against natural LMW organic compounds use microorganisms – decomposers
- Purified HA resistant to soil microorganisms under normal conditions

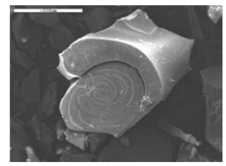
Stage 4. **General approach + know-how.** Preparation of sorbents with soil microorganisms on HA matrix to enhance biodegradation of organic pollutants. This is approach for R&D new stabilized formulations of microbiological preparations for various applications.

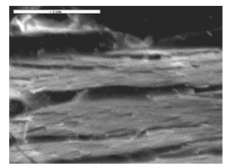
Unique Features of Purified HA Sorbents

Unique feature of highly purified HA sorbents is their self-structuring. Depend of their origin HA form the original particles look like crystals or filaments.

Microstructures of highly purified HA illustrate their self-structuring and ability to make nano-films on inorganic surfaces, for example:

- roll of potassium humate
- 45-70 nm HA nanofilm on inorganic surface





Investigation of microstructures of highly purified HA in water solutions is important for understanding of building mechanism of soils, natural sorbents and creation of new sorbents and biocompatible materials:

- our results demonstrate polydispersed particles of HA in water solution with size 50-150 nm
- some publications demonstrate changes in forms and size particles of HA in water solution depends on HA concentration, pH and ionic force of the solution

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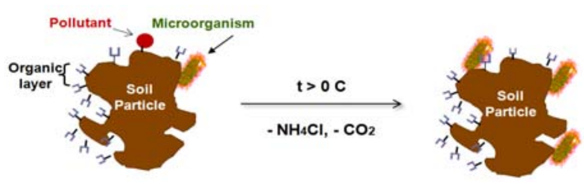
Suitability of HA-based Sorbents

Application of various HA formulations (results of our field tests see on site http://agrosintez.ru/):

- detoxification of soil contaminated with polychlorinated biphenyls, benzopyrenes, dioxins, pesticides etc., in concentrations up to 2-4% by weight of soil
- detoxification of land contaminated with fuels, oil and gas condensate at pollution level up to 5% by weight of soil



HA formulations enhance biodegradation of organic pollutants

- rehabilitation of land-locked water reservoirs and waste waters contaminated with heavy metals and radionuclides (precipitation of insoluble forms)
- remediation of water contaminated with crude oil and its products
- acceleration of waste in sewage processing plants

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HA-based Sorbents for Heavy Metals

HA retention of heavy metal (HM) cations is a function of the initial metal concentration and pH

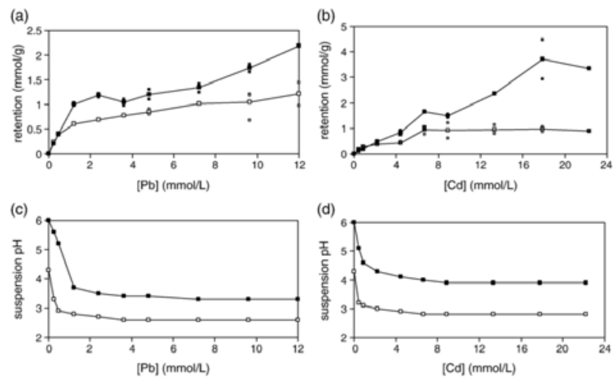


Fig. 2. a) Pb retention by HA at pH 4 (□) and pH 6 (■), b) Cd retention by HA at pH 4 (□) and pH 6 (■), c) final pHs of suspensions with Pb and HA, and d) final pHs of suspensions with Cd and HA, with all values as a function of the initial metal concentration.
C.A. Coles, R.N. Yong. Engineering Geology 85 (2006) 26–32

Formulations to be Used in the Study

Several different types of adsorbents based on activated HA for soil remediation were developed in this study:

- Powder formulation (45% of extractable HA): base composition for soil humification and binding of toxic cations, special modification for bioremediation
- pH-neutral aqueous gel (10% of HA as emulsion), special modification contains useful soil microorganisms (don't lose their activity up to one year)
- Aqueous solution (10% of HA as potassium salts)
- Concentrate of soil microorganisms on HA matrix (10^{11} cells/mL, pH 7.0)

The adsorption capacity heavy metal cations and radionuclides can be as high at ~10% (w/w)

Main features:

- Non-toxic to humans and the environment
- Low cost
- Easy-to-use
- Broad range of modifications
- Potential for dual applications (e.g., agricultural use and response to CBRN emergencies).

HA-based Sorbents for Heavy Metals in Greenhouse Tests

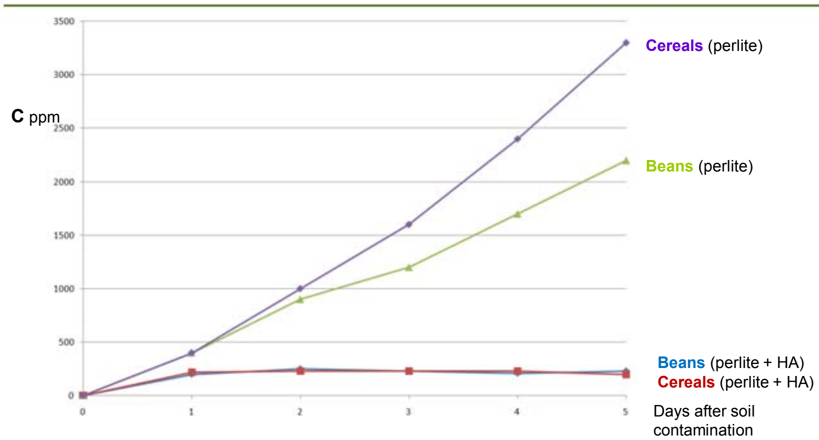
Phytotron (artificial light/climate room) conditions of the experiment:

- Light intensity - 8000 Lux/8 hours/day
- Temperature - 25-28^{O}C
- Relative humidity - 40-50%
- Soil simulant - granulated perlite (doesn't absorb HM cations)
- Duration of the experiment period - 21 days
- Addition of HA formulations – 1.5% w/w perlite

Estimated parameters and examples of experiment:

- Dry weight of top of a plant (grains and beans) in control experiment and in experiment with HA formulation;
- Metal concentration (ICP-MS) in dry mass of the plant in control experiment and in experiment with HA formulation;
- Example (on the photo): effect of water soluble HA liquid formulations on beans growth in the presence of chromium, lead and mercury (50 and 150 mg/kg perlite)
- Adsorption efficiency decreases in the row: Hg^{2+}> Cd^{2+}> Pb^{2+} > Cr^{3+} and Ni^{2+} > Zn^{2+} > Cu^{2+} > Fe^{3+}

HA Prevents Adsorption of Heavy Metals by Plants



Cadmium concentration (ppm) in top part of plants (beans and cereals) as a function of exposure time, in the absence (upper curves) and presence (lower curves) of HA. Cd^{2+} in the soil: 50 mg/kg. Comparative experiment by adding of water-soluble HA formulation in amounts of 1.5% by weight of perlite.

HA-based Sorbents for Radionuclides

There is deficit of detailed and reliable information in the field of HA application for sorption of radionuclides cations. The reasons for this are:

- absence of purified Standard Samples of HA (activated) adsorbents for testing and evaluation
- depends HA degree of purification, pH and technique on sorption capacity
- absence of validated methods
- high cost of the research

But:

- there is prototype technology - two-stage process for selective removal of lanthanides: (1st) sorption of lanthanide cations on HA, (2nd) incineration of the spent adsorbent and preparation of concentrated sample
- our experiments (ICP-MS) demonstrated adsorption > 10% (w/w) La^{3+} ion on sample of activated HA

Application of HA-based Adsorbents in Area Mitigation and Decontamination

Mitigation and decontamination of terrain, highways, urban infrastructure, buildings, equipment, and even humans and animals

Decontamination of proving grounds, construction and demolition waste, landfills, etc.

Opportunity for the use of various conventional equipment:

- Fire trucks, street sweepers, etc.



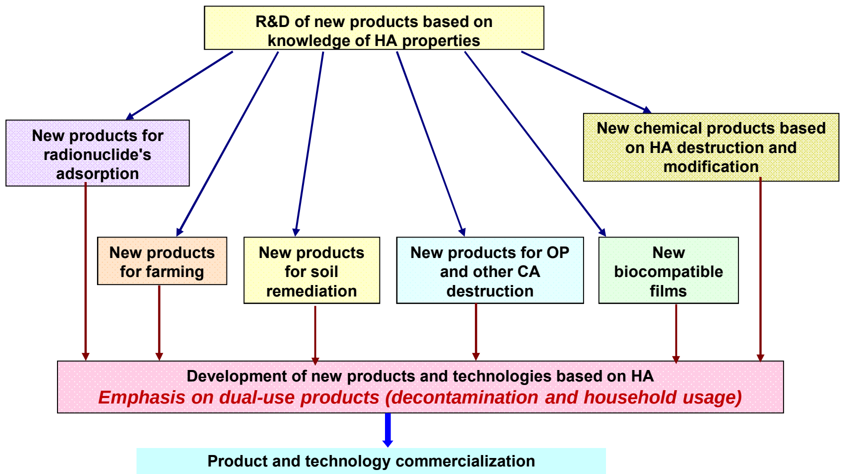


- Agricultural machinery, etc.





HA Product Development Strategy



Scope of Current Research

Task I	• Selection of candidate adsorbents and their targeted modification • Bench-scale evaluation of their performance.
Task II	• Development of standard samples of HA adsorbents for testing and evaluation
Task III	• Application of adsorbents for area mitigation after radiological incidents
Task IV	• Development of methods for environmental remediation of contaminated sites.

Project Partners

Canada	• Environment Canada • Atomic Energy Canada Ltd. • Royal Military College of Canada • Allen Vanguard • Ottawa Fire Services
United States	• US EPA, National Homeland Security Research Center
Russian Federation	• NPP "OrCheMed" Russian Academy of Sciences

Environment Canada Environnement Canada 17 Canada

Acknowledgement

- The research is funded in part by the Canadian Safety and Security Program, Project CSSP-2013-CP-1029

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Wednesday, November 6, 2013

Concurrent Sessions 3

Biological Agent Fate and Transport

Public Health England

Re-Aerosolisation of Bacterial Spores from Indoor Surfaces

Allan Bennett and Susan Macken Public Health England, Porton Down

Public Health England

Introduction

- Study background
- Methodology
- Results
- Risk assessment
- Conclusions

Public Health England

Anthrax Investigations

- Unknown level of contamination on flooring
- Unknown potential for re-aerosolisation from potentially contaminated surfaces
- High level respiratory protection recommended on precautionary principle
- Made responses and remediation more challenging and of longer duration

3 Re-aerosolisation from Flooring US EPA Conference 2013

Public Health England

Other applications

- **Hospital and healthcare environments**
  - Noroviruses, *Clostridium difficile*
  - Dried human bodily fluids on flooring
- **Responses to laboratory accidents**
  - Dropped flasks
- **What are the risks?**

4 Re-aerosolisation from Flooring US EPA Conference 2013

Public Health England

Study rationale

- To quantify re-aerosolisation from two flooring materials, carpet and vinyl
- To develop methods that could be used in further re-aerosolisation studies
- To use information gained to allow risk assessments to be performed

Public Health England

Aerosol Deposition

- *B. atrophaeus* used
- Several contaminating systems were assessed
- An artists airbrush was chosen to contaminate surfaces
- Fine dispersed contamination
- Allowed a high level of contamination to be achieved

Public Health England

Samplers Used

- Sartorius MD8 used to measure total aerosols at 0m and 1m
- Andersen Samplers used to measure particles size distribution at 0m and 1m
- Surface samples taken after each experiment
- Slit sampler used at 1.5m

7 Re-aerosolisation from Flooring US EPA Conference 2013

Public Health England

Study Methodology

- Study carried on a strip of flooring in a clean room
- Walking defined as light, medium or heavy
- Ten replicates carried out at each condition
- Surface samples taken
- Air vented between each run

8 Re-aerosolisation from Flooring US EPA Conference 2013

Public Health England

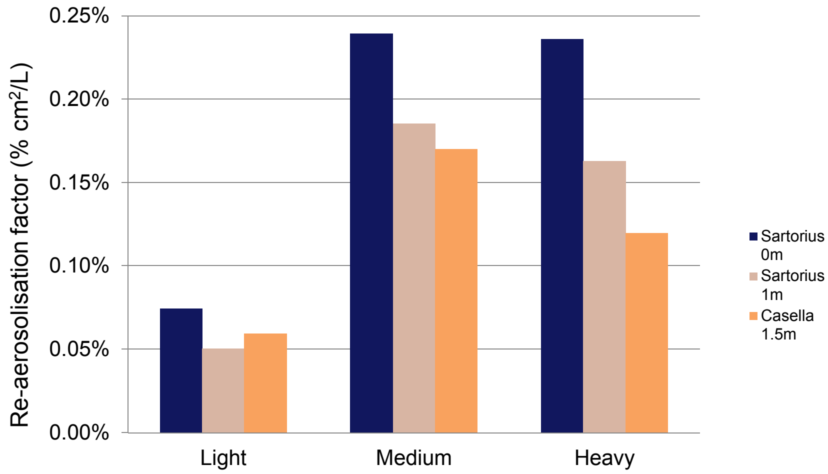
Definition of Results

- Since this is an artificial system an attempt has been made to define the results in terms of a ratio of aerosol to surface contamination
- This is defined as cfu.L^{-1}/cfu.cm^2
- It is defined as our re-aerosolisation ratio %cm^2/L
- This represents the percentage of the material in one square centimetre that ends up in a litre of air

Public Health England

Carpet Results

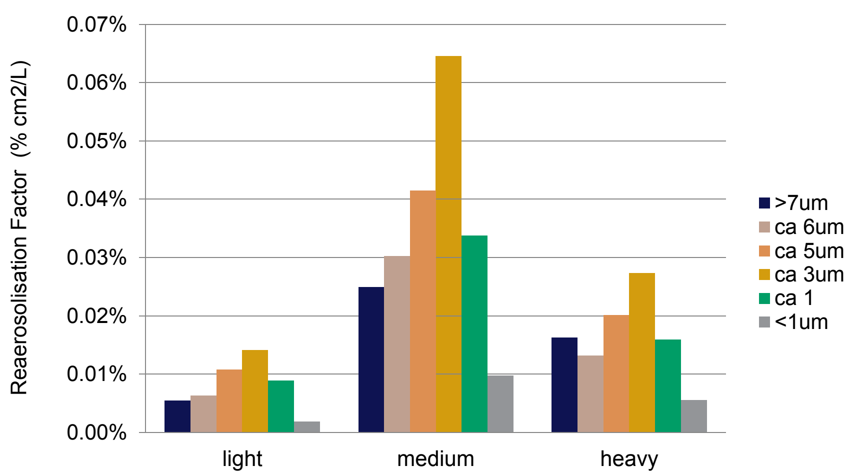
Re-aerosolisation from carpet at different heights



Activity type. Light n=8, Medium n=10, Heavy n=10

Public Health England

Particle size distribution from carpet



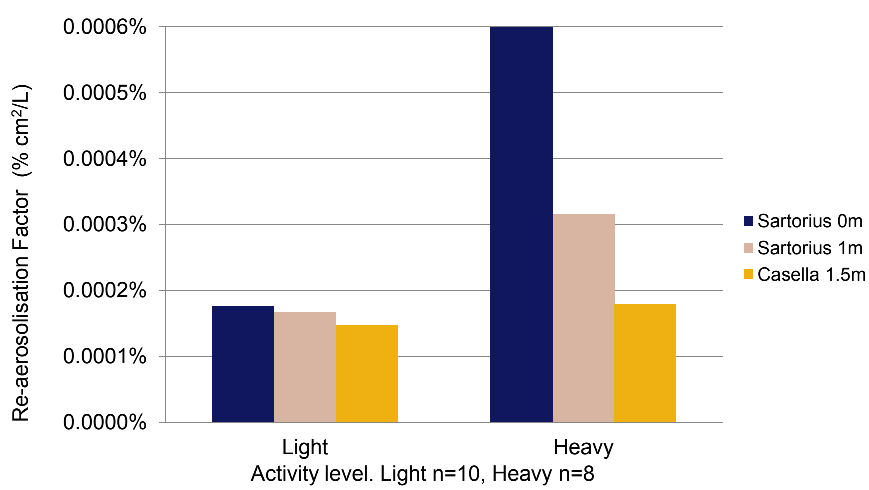
Activity type. Light n=8, Medium n=10, Heavy n=10

Public Health England

PVC Flooring Results

Public Health England

Reaerosolisation from PVC at different heights



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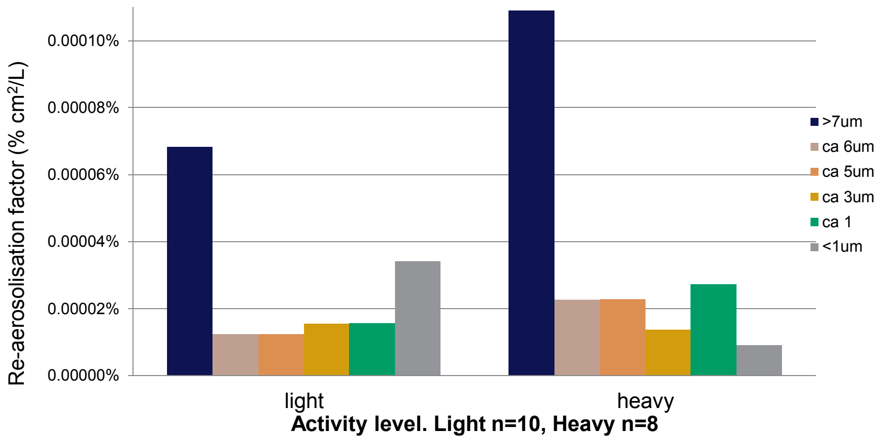
Particle Size Distribution from PVC



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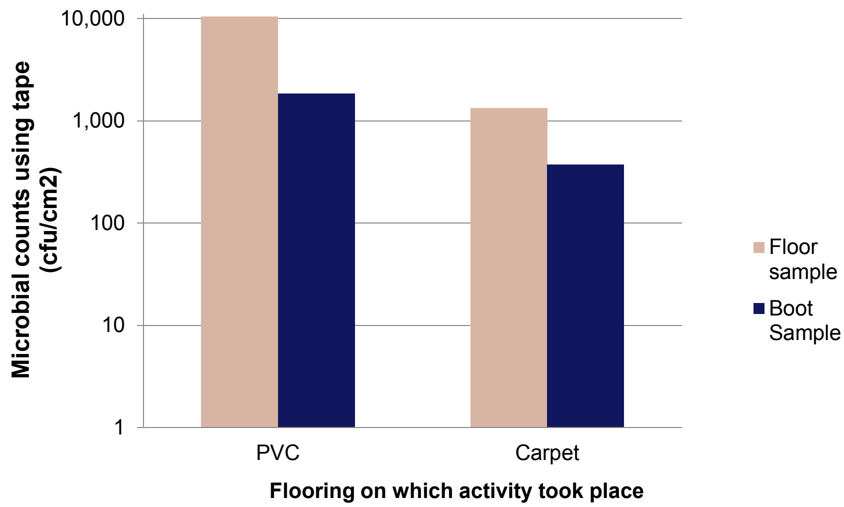
Conclusions of Re-aerosolisation Studies

- Much lower re-aerosolisation factor found from PVC than Carpet.
- Maximum re-aerosolisation factor at 1.5m, Carpet: 0.1%, PVC: 0.0002%
- Particles generated were within respirable range.
- Average particle size for carpet was 2.2μm for PVC it was 4.8μm both at 1m.

Public Health England

Surface Results



17 Re-aerosolisation from Flooring US EPA Conference 2013

Public Health England

Risk Assessment Analysis

Surface Contamination (cfu/cm²)	Maximum Aerosol Exposure on Carpet (cfu/l)	Maximum Aerosol Exposure on PVC (cfu/l)
10^2	0.1	0.0002
10^3	1	0.002
10^4	10	0.02
10^5	100	0.2
10^6	1000	2

18 Re-aerosolisation from Flooring US EPA Conference 2013

Public Health England

Conclusions

- A model system for the measurement of re-aerosolisation has been developed
- An indication of the potential aerosolisation from two floorings has been obtained
- Many variables still need to be investigated
- PVC flooring causes far less re-aerosolisation than carpets

Public Health England

Future Work

- Impact of variables on aerosolisation process:
  - Operator: interpersonal differences, shoe type
  - Contamination level
  - Organism
  - Flooring type
  - Humidity/Temperature/Air flows
  - Modelling

Public Health England

Questions

Informing Response and Recovery Decisions: The Scientific Program on Reaerosolization and Exposure (SPORE), Program Overview

CAPT Marshall S. Gray, Jr, CIH
EPA ORD NHSRC

6 November 2013

Homeland Security

SPORE Summary

Purpose: ***Understand reaerosolization of Bacillus anthracis to inform decisions that reduce risk to the public.***

Interagency Collaborative:

- DHS S&T - Donald Bansleben, PhD; Matthew Moe
- HHS ASPR – John Koerner, CIH
- HHS CDC - Angela Weber
- DoD DTRA – Sari Paikoff, PhD
- EPA ORD NHSRC – CAPT Marshall Gray, CIH (Interagency Lead)

2

Federal Subject Matter Expert Review, December 2012

- 32 subject matter experts (SME) from partner agencies
- Challenged to identify top gap in four focus areas:
  1. Reaerosolization
  2. Detection, Sampling, Analysis
  3. Fate and Transport
  4. Health Endpoints
- Assigned to focus area based on expertise

3

Gap Prioritization

Focal Area	Gap ID	Brief Description of Gap*	Grp 1	Grp 2	Grp 3	Grp 4	Total
Reaerosolization	R1	Sensitivity analysis					0
	R2	Impact of parameters		1	1	1	3
	R3	Model validation	1				1
	R4	Determining suitable surrogates	1		1		2
Detection, Sampling, and Analysis	D1	Data communications					0
	D2	Air sampling collection methods	1	1	1	1	4
	D3	Standardized vacuum sampling procedures					0
	D4	Trained responders					0
	D5	Large-area sampling devices					0
	D6	Rapid viability assays					0
	D7	Sampling processing methods	1				1
Fate & Transport	F1	Ba spore characteristics					0
	F2	Characterize similar size non-biological particles					0
	F3	Verify tracer gases/particulate studies					0
	F4	Confirm atmospheric models		1			1
	F5	Identifying surrogates					0
Health Endpoints – Exposure Assessment (*Likelihood of Exposure*)	H1	Identifying sampling and analytical methods, and strategies		1		1	2
	H2	Considerations for exposure duration/frequency					0
	H3	Outdoor activities that increase exposure					0
Health Endpoints – Endpoint Assessment (*Likelihood of Disease*)	H4	Quantifiable dose for various durations				1	1
	H5	Human deposition doses for different spore characteristics					0
	H6	Susceptible subpopulations					0
	H7	Extrapolating animal dose-response data					0
Health Endpoints – Risk Characterization	H8	Best methodology for characterizing human-health risk			1		1

- Top gaps were identified for each focus area
- All gaps were consolidated
- Groups of SMEs were mixed, separated, and requested to independently vote for the "top four" gaps

NOTE: Many attendees believed that the Fate and Transport and Health Endpoints focal areas were important, however, the research necessary in these areas is highly dependent upon research results from the Detection, Sampling, and Analysis and/or Reaerosolization focal areas

4

Final Identification of Gaps

The group as a whole identified four priority gaps overall:

1. **Development of appropriate and validated air sample collection methods for reaerosolized viable and inhalable spores.** Standardization of air sampling methods, including collection procedures, and validation of analytical methods that would improve reliability and interpretability of potential airborne exposure data.
2. **Determination of reaerosolization through controlled, experimental data generation, assessing the impact of various parameters (e.g., particle size, surface properties, charge, dissemination method, forces [i.e., environmental, anthropogenic]).**
3. **Determination of suitable surrogates or simulants (e.g., non-pathogenic spores, inert particles) for *Ba* spores**, for use in lab and field studies based on empirical reaerosolization data.
4. **Determination of sampling and analytical methods, as well as sampling strategies that would provide data with the most utility for an exposure assessment.**

5

Identified Potential Projects/Studies

SMEs were challenged to determine how to address the gaps, including time and funding.

Examples of potential studies identified:

1. Determine the predictability of reaerosolization to inform decisions to mitigate hazard/risk.
2. Conduct a requirements study focused on the development of an adequate air sampler.

NOTE: The group emphasized that it is **critical to first understand parameters influencing reaerosolization** to establish data quality objectives.

Current SPORE Research is addressing :

- Identification of non-pathogenic simulants for *Bacillus anthracis (Ba)*
- Identification of outdoor urban surface types from which *Ba* may be prone to reaerosolization
- Identify factors influencing reaerosolization (force, spore preparation, surface properties)
- NOTE: Other interagency projects (CDC, DTRA) may assist in informing gaps.

6

SPORE Recommended Projects

GAP	Potential Project(s)	Duration	Status
Identify forces to initiate reaerosolization from urban surfaces, identify surrogates for *Ba*	Existing reaerosolization wind tunnel (RWT) projects between EPA/DHS/DPG	Through mid FY-14	Funded through FY-14
Surface treatment methods to mitigate reaerosolization	Modification of RWT projects to introduce surface Treatment	FY 14 - 15	Unfunded – dependent upon success of initial test to ID surrogates
"Translation Guide" of forces causing reaerosolization	Evaluate forces caused by human activity as compared to RWT	FY 14	Unfunded
Temporal decay – how long will reaerosolization occur	Scale up from RWT	FY 15 - 17	Unfunded – dependent upon success of surrogates – top priority
Washdown transport and subsequent pooling / "hot spot" identification	TBD	FY 14 - 15	Unfunded – dependent upon success of surrogates
Fomite transport (how spores transport on dirt / debris)	Modification of RWT projects and scale up	FY 15 - 16	Unfunded – dependent upon success of surrogates
Outdoor Test and Evaluation	TBD (Limited by detection sensitivity for reaerosolization outdoors)	FY 16 - 18	Unfunded – dependent upon success of surrogates

Disclaimer

Quantitative Analysis of Reaerosolization

Task 1 – SPORE

Russell W. Wiener, Ph.D.
EPA ORD NHSRC

6 November 2013

Disclaimer

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2

SPORE Summary

Purpose:

Provide a quantitative assessment of the energy required to reaerosolize *Bacillus anthracis* (*Ba*) and surrogate materials

Collaborators:

- EPA ORD NHSRC – Russell Wiener (lead), Marshall Gray, Worth Calfee, Sang Don Lee
- DOD DPG – Jeffery Hogan, Kar Tsang
- DHS S&T – Donald Bansleben, Matthew Moe
- Alion Science and Technology – Laurie Brixey, Alfred Eisner
- Arcadis – Dahman Touati, Nicole Griffin

3

Identified Programmatic Gaps

Gap	Potential Projects	Duration	Status
Identification of (1) forces to initiate reaerosolization from urban surfaces (2) surrogates for *Ba*	Existing EPA/DHS/DPG reaerosolization wind tunnel (RWT) projects	Through mid FY-14	Funded through FY-14

4

Key Questions for Better Understanding Reaerosolization

- What are appropriate simulants for *Ba*?
- What level of force is required to reaerosolize spores?
- Do bioagent preparations and release mechanisms impact reaerosolization?
- What is necessary to quantify reaerosolization?

5

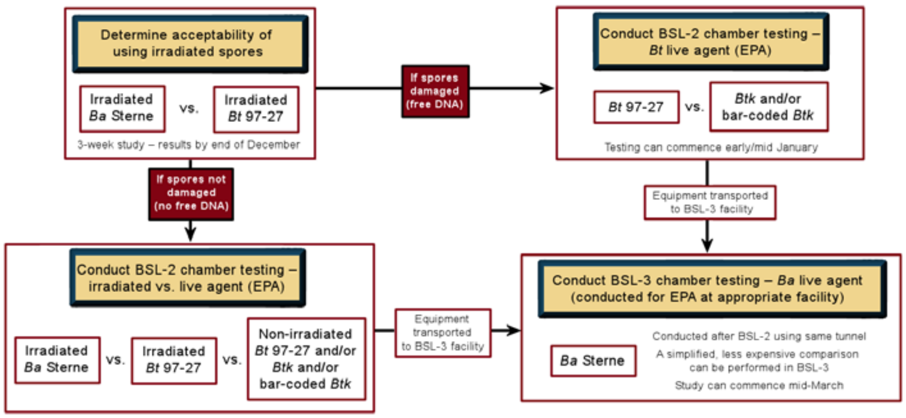
Experimental Focus

- Determine if *Ba* reaerosolizes
- Identify non-pathogenic simulants for *Ba*-Ames
- Identify the most important test surface characteristics that affect *Ba* reaerosolization
- Identify the most important factors, such as spore type, preparation, and method of deposition, that affect *Ba* reaerosolization

6

Initial Approach

Simulant for *Ba* reaerosolization in a wide-area urban release



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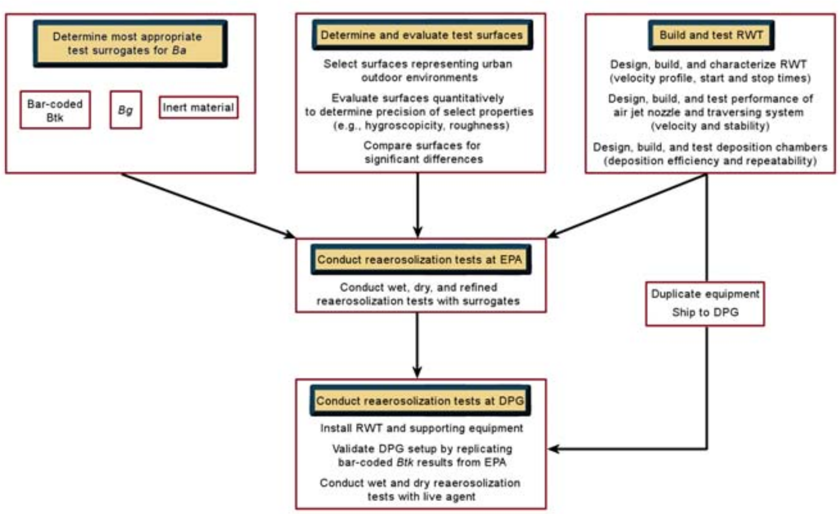
Current Approach



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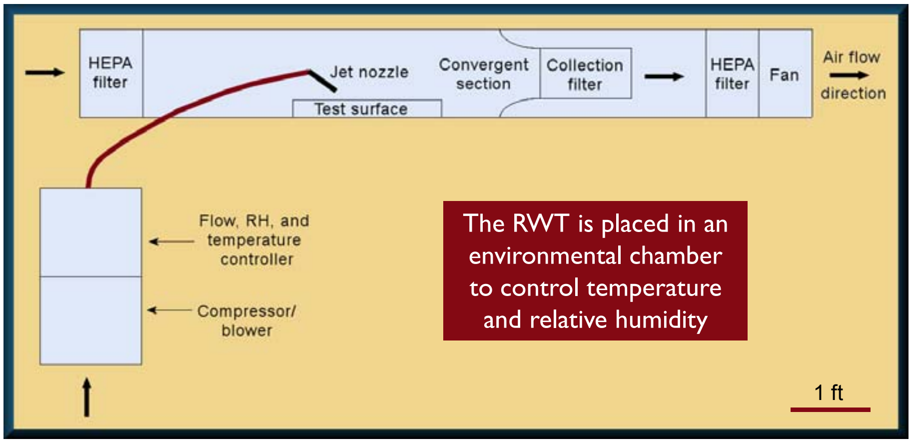
RWT Concept Drawing



9

Potential Experimental Variable Features for a Spore Reaerosolization Study

Particle Properties	
Feature	**Potential Experimental Variables**
Spore type	*B. anthracis* Ames, *B. thuringiensis* var *kurstaki* (bar coded), *B. atrophaeus* subspecies *globigii*
Prep	Wet powder, powder (milled paste), refined powder
Agglomeration	Singles versus agglomerate, packing/surface density
Surface Structure	Chemistry, geometry, electrostatic properties, hydrophilic/ hydrophobic, coating, roughness
Concentration	Colony-forming unit per unit mass or volume, viable fraction
Additives	Mixers, buffers, reagents

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Potential Experimental Variable Features for a Spore Reaerosolization Study

Test Surface Properties	
Feature	**Potential Experimental Variables**
Material	Glass, concrete/cement, asphalt shingles
Intrinsic physical chemistry	Chemical reactivity, hygroscopicity, wettability, electrostatic properties, moisture content
Surface roughness	Porosity, asperity height
Jet velocity	Speed magnitude and direction, speed variability, turbulence
Atmospheric conditions	Temperature, relative humidity
Time	Length of time since spore deposited on surface and time for jet to remove particle

11

Experimental Objectives

- Maximize number of data points collected by using a small wind tunnel
- Minimize common errors in reaerosolization experiments by measuring and controlling variables
- Collect total reaerosolized matter to avoid sampling errors
- Use an air jet to provide a wide range of energies (detachment forces) under controlled and repeatable conditions
- Test a variety of controlled surfaces similar to those found in the outdoor urban environment
- Conduct highly controlled and reproducible experiments from which data can be used for future non-dimensional analysis

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Wednesday, November 6, 2013

Concurrent Sessions 3

Chemical Agent Fate, Persistence, and Transport

Predictive modeling of transport processes at environmental interfaces following chemical contamination

James R. Hunt, Beaufort, NC
(formerly UC Berkeley)

Adam H. Love, Roux Associates, Inc., San Francisco
(formerly Johnson Wright Inc.)

US EPA Decontamination Conference, Nov. 2013

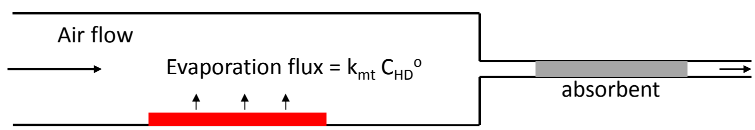
Goal:
- Utilize experimental data to develop predictive models
- Calibrate and then predict under different conditions

Approach:
- Data determine modeling complexity

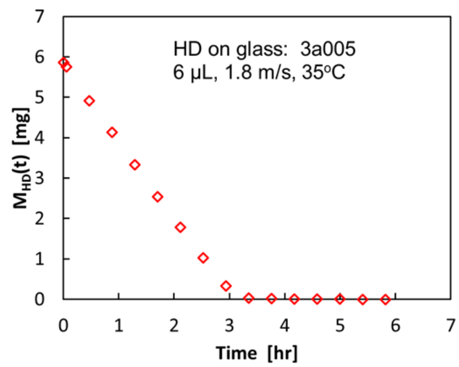
Illustrative examples:
- Wind tunnel evaporation data for HD
- Coupon evaporation data for HD, GB, and VX

Observation:
- Need better integration of modeling and experimentation

1. Edgewood 5 cm wind tunnel evaporation of HD



$$M_{HD}(t) = M_{HD}(t{=}0) - \int_0^t Q\,C_{HD}(t')\,dt'$$

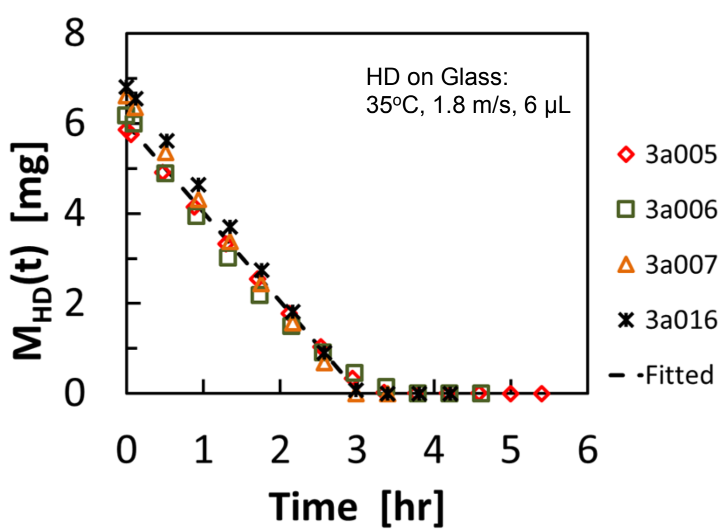


Mass transfer model

$$M_{HD}(t) = M_{HD}(t=0) - (k_{mt}A)C_{HD}^{o}t$$

Data from Brevett et al. (2008, ECBC)

Model Calibration of Lumped Parameter (k_o A_o)



Data from Brevett et al. (2008, ECBC)

Scaling for Different Temperature (15, 35, 50°C), Wind (0.22, 1.8, 3.6 m/s) and Agent Volume (1, 6, 9 µL)

- Temperature only controls vapor pressure

$$C^{o}_{HD}(T_k) = \frac{P^{o}_{HD}(T_k) MW_{HD}}{R\ T_k}$$

- Velocity sets shear velocity, u^*, and $k_{mt} \sim u^*$

$$k_j = k_o \frac{u^*(U_j)}{u^*_o}$$

- Initial drop volume, V, determines surface area

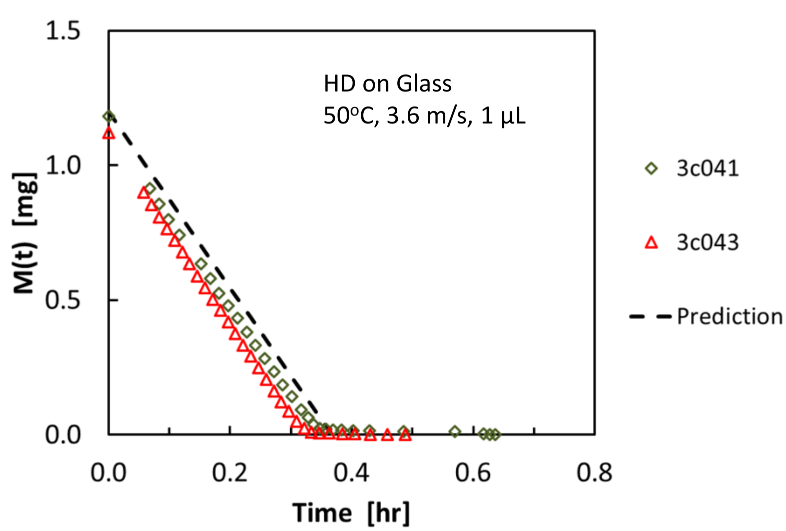
$$A_i = A_o \left(\frac{V_i}{V_o}\right)^{\frac{2}{3}}$$

Predictions using lumped parameter $k_o A_o$ and scaling relationships:

$$M_{HD}(t) = M_{HD}(0) - k_o A_o \left[\frac{u^*(U_j)}{u^*_o}\right] \left(\frac{V_i}{V_o}\right)^{\frac{2}{3}} C^{o}_{HD}(T_k)\, t$$

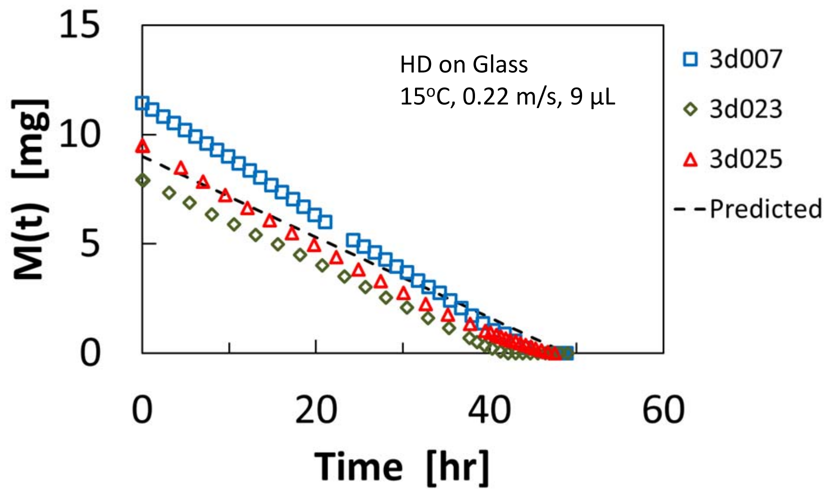
$$\mathbf{M_{HD}(t) = M_{HD}(t{=}0)\ [\ 1 - t/t_{life}\ ]}$$

Model Testing at the Extremes



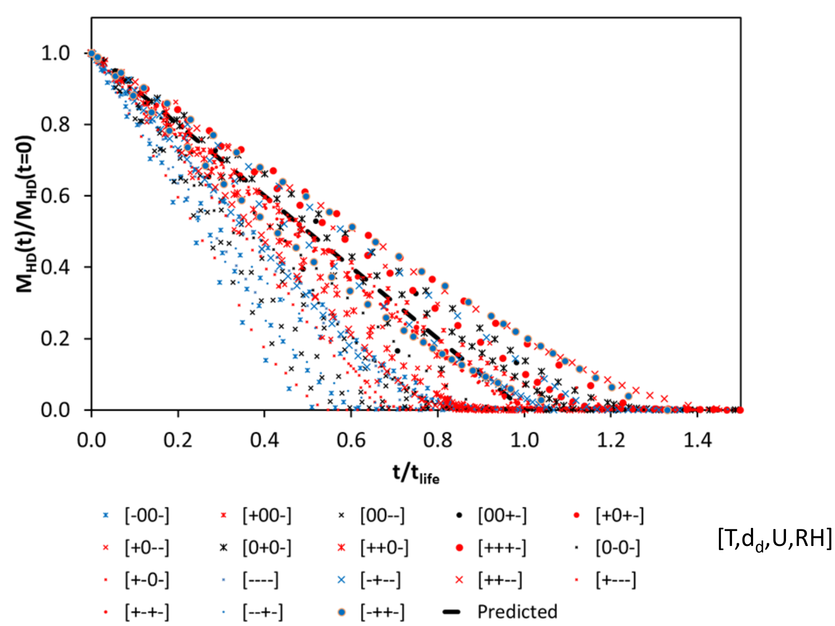
Data from Brevett et al. (2008, ECBC)

Model Testing at the Extremes

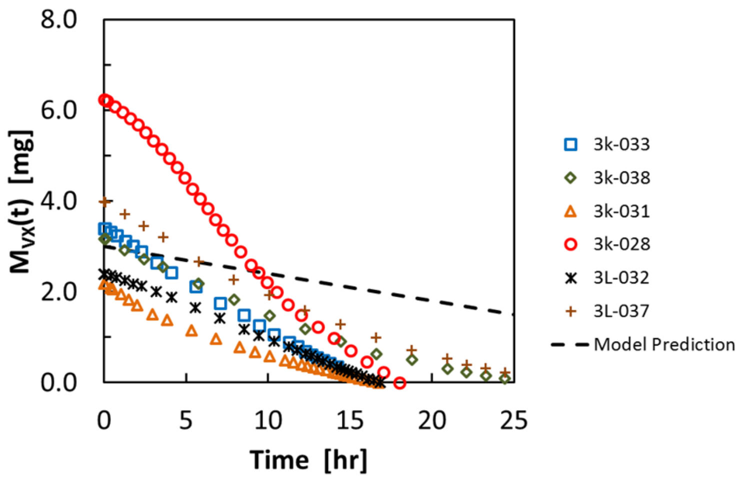


Data from Brevett et al. (2008, ECBC)

Model Generalization of 54 Experimental Runs of HD on Glass

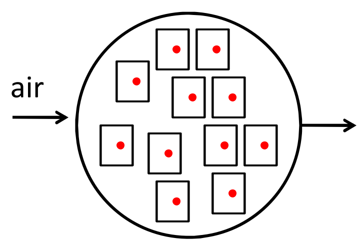


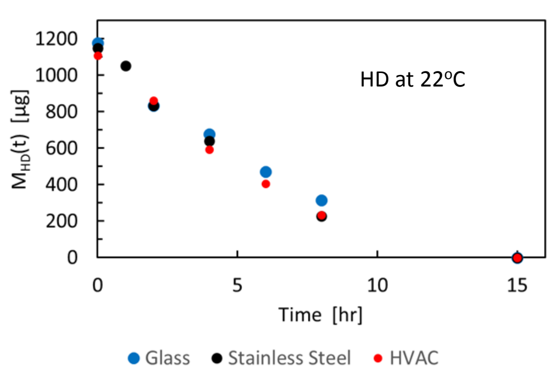
VX on Glass: 6 μL, 1.8 m/s, 42°C
There are problems with experimental methods



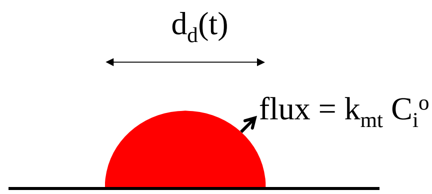
Data from Brevett et al. (2010, ECBC)

2. Agent Evaporation from Surfaces at LLNL
    - Impermeable Surfaces:
      Glass
      Silanized Glass
      Stainless Steel
      Flexible HVAC metal duct
    - Measured mass remaining on coupons over time, $M_i(t)$.





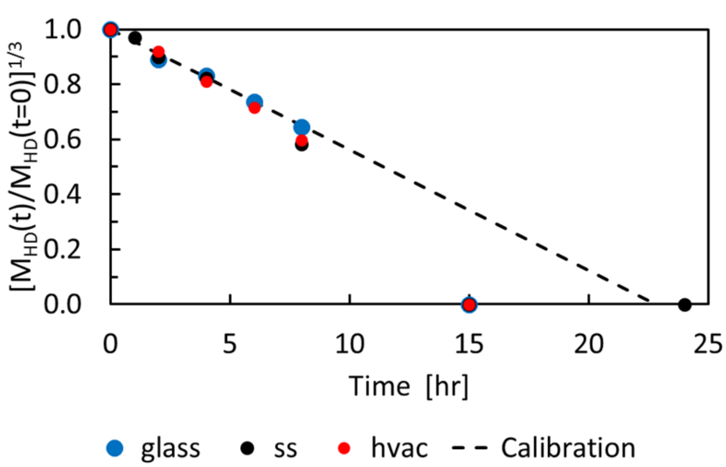
Model for agent evaporation from a shrinking hemi-sphere



$$M_i(t) = M_i(t=0)\left(1 - \frac{2\,k_{mt}C_i^o}{\rho_L\ d_d(t=0)}\ t\right)^3$$

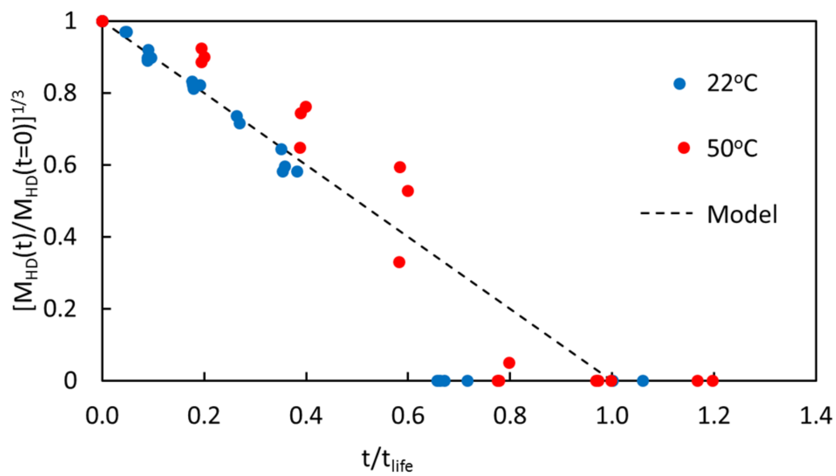
$$\left[\frac{M_i(t)}{M_i(t=0)}\right]^{\frac{1}{3}} = 1 - \frac{t}{t_{life}}$$

Calibration of mass transfer model for HD at 22^{o}C

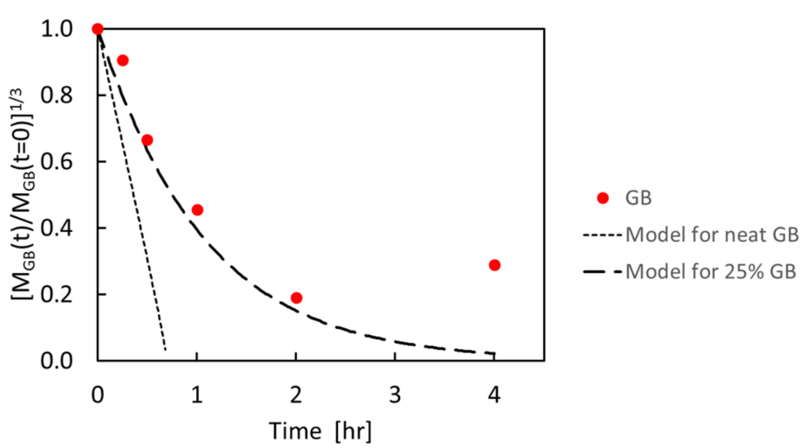


LLNL HD Results:

Calibration on 22°C Data and Prediction at 50°C



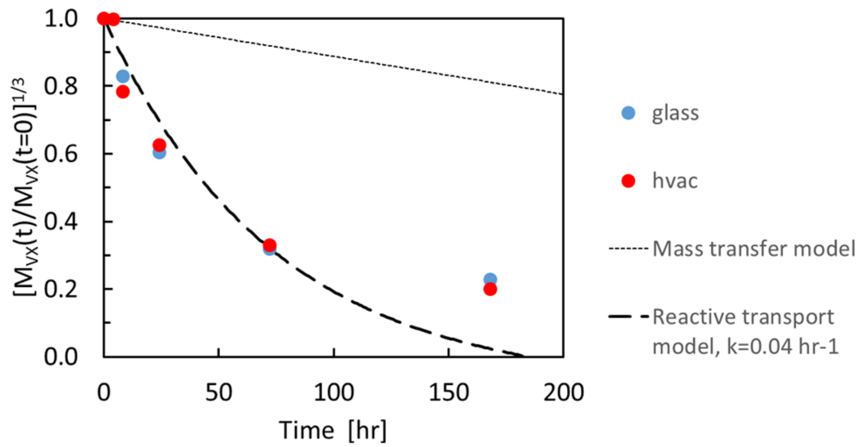
GB evaporation at 22°C



The longer term GB persistence might be from either

- Inert, nonvolatile material, or
- Diffusion limitations within residual liquid

VX Evaporation at 22°C
Data suggests VX removal by reaction



Summary:

- Liquid agent evaporation did not depend upon impermeable surface type (glass, metal)
- Predictive models under laboratory conditions are good to ±50% for HD
- Data for other agents suggest
  Presence of other chemicals
  Transport limitations within residual drops
  Reactivity
- Modeling and experimentation must be coupled
- Issues that were not addressed
  - Liquid water
  - Permeable, porous, polymeric surfaces

Contact information:

James R. Hunt
121 Carrot Island Lane
Beaufort, NC 28516
hunt@ce.Berkeley.edu
phone: 925 451 2761

Adam H. Love
Roux Associates, Inc.
221 Main Street, Suite 1590
San Francisco, CA 94105
alove@rouxinc.com
phone: (415) 967-6023

Adsorption and Desorption of Chemical Warfare Agents on Activated Carbons:

Impact of Temperature and Relative Humidity

Lukas Oudejans, Ph.D.
US Environmental Protection Agency
National Homeland Security Research Center
Decontamination and Consequence Management Division

Kent Hofacre, John Shaw, Anbo Wang
Battelle
West Jefferson, OH

2013 U.S. Environmental Protection Agency (EPA)
International Decontamination Research and Development Conference
November 5-7, 2013

- Work conducted under EPA Contract EP-C-10-001 with Battelle.

- Battelle is a contractor to U.S. EPA and provided technical support for the work described.

- Project management
  - EPA: Lukas Oudejans
  - Battelle: Kent Hofacre, John Shaw

- DISCLAIMER:

The United States Environmental Protection Agency through its Office of Research and Development funded and managed the research described here. It has been subjected to Agency's administrative review and approved for publication.

The views expressed in this presentation are those of the authors and do not necessarily reflect the views or policies of the Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Background

- Hot air decontamination has been proposed as a low cost approach to remove chemical agent ("decontaminate") from a facility through increased volatilization of the chemical agent with temperature

25 °C	Vapor pressure (mm Hg)
GB	2.9
GD	0.4
HD	0.08
VX	0.0007

- Considered a valid option for more volatile chemical warfare agents (CWAs)
  - GB, HD;
  - Not likely effective for VX (within 24 hr)

- A maximum temperature for hot air decontamination has been recommended of 55 °C (131 °F) based on incompatibility with e.g. electrical wiring in facility at higher temperatures

Background

- Effluent air of hot air decon technologies must flow through media like (metal impregnated) activated carbon beds that can sorb CWA vapors

- Absorption characteristics of CWAs on various carbons is reasonably well established (e.g. filter cartridges on personal protection equipment)
  - Most data are either limited to room temperature or associated with surrogate testing
  - Evidence in literature that "obvious" surrogates do not behave like their CWA counterpart
  - Need also to consider impact of RH as water vapor could be a competing vapor that affects the ability to absorb CWAs

Impact / Objectives

Questions to ask when implementing hot air decontamination:

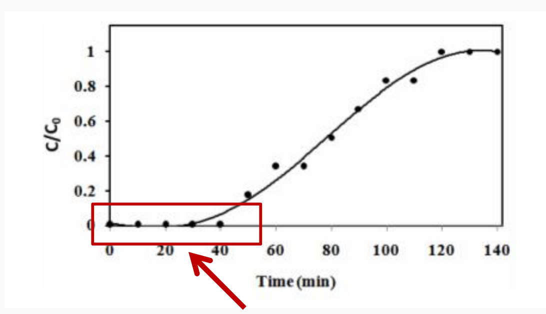
- ❖ If carbon filters are present (e.g., in HVAC system), can they be used safely (at higher T,RH) to capture CWAs?
- ❖ If no carbon is present in HVAC system or carbon needs to be selected in e.g. negative air machines, what carbons are suitable?

Objectives:

1. Determine the impact of temperature and relative humidity (RH) on the ability of a carbon bed to absorb chemical agent (absorption phase)
2. Determine if off gassing from carbon beds occurs once absorption process ends (desorption phase) as when carbon filters are being removed from service

Experimental Approach

Measurement of vapor **breakthrough curves** under various environmental conditions:



time period of interest

Experimental Constrains when working with CWAs

- Duration of test
  - Need to conduct experiments on relative short timescale (<1 day)
    - ➢ Cannot use low CWA concentrations during absorbing phase

- Need to limit amount of CWA being used
  1. Carbon bed size
     - ➢ As small in diameter as possible to reduce amount of carbon
       - ❑ ASTM Standard Guide for Gas-Phase Adsorption Testing of Activated Carbon, D5160-95 (Reapproved 2008):
         - ▪ Bed diameter at least 12x the largest carbon particle diameter
         - ▪ A 4 cm bed diameter used
           - ✓ Meets criteria for carbons with mesh number ≥6
  2. Carbon bed depth
     - ➢ Representative of typical HVAC filter thickness: 2.5 cm [at onset of exp.]
     - ➢ Amount of carbon to create 2.5 cm bed is 14-20 g, depending on carbon

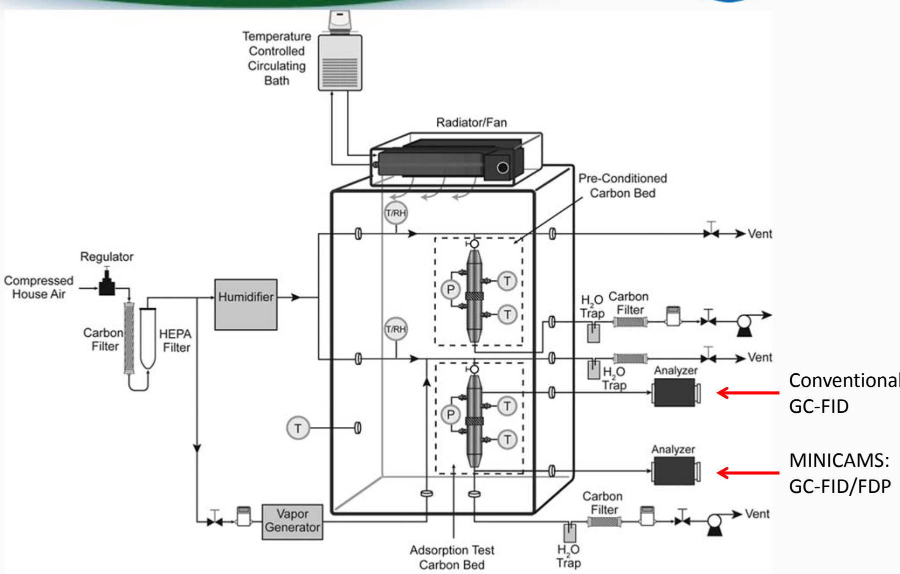
Scenario:

- Release of 1 L of GB (or HD) in office (2700 sq feet, 250 m^2) or (normal T,P); HVAC was shutdown shortly after release so liquid still present in area

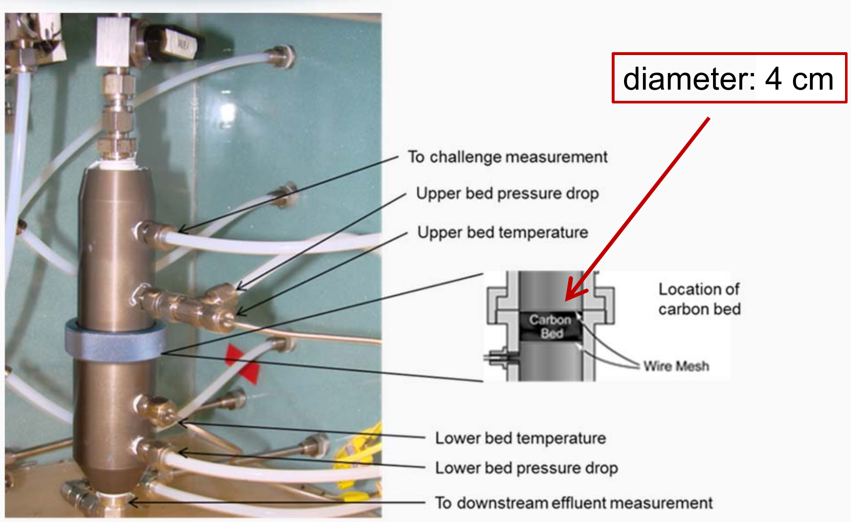
- For GB: all liquid can evaporate; concentration (excluding absorption or adsorption) may reach 1500 mg/m^3
  (IDLH is 0.1 mg/m^3)

- For HD: gaseous concentration reaches point where saturation may occur: 500 mg/m^3 concentration
  (IDLH is 0.7 mg/m^3)

Experimental Setup - Diagram

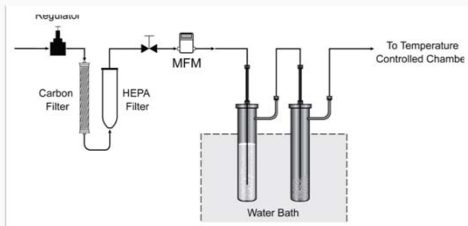


Experimental Setup

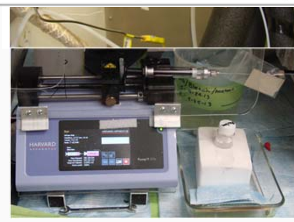


Experimental Setup

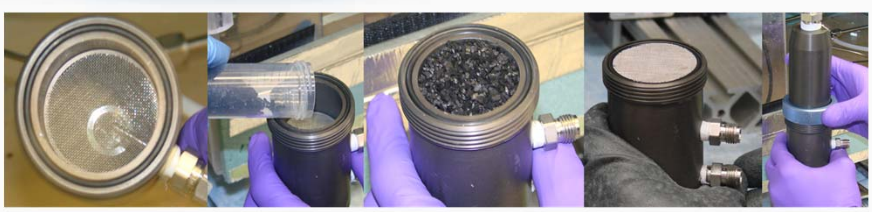
- CWA challenge vapor generation:
  - Bubbler



  - Syringe pump



Experimental Procedure



A B C D E

Loading the carbon test cell with Ionex™ 03-001 carbon (8 x 16 mesh) :
(A) mesh screen in bottom cell piece and O-ring in the well at the top of the cell
(B) pre-weighed carbon loaded into bottom cell piece
(C) cell bottom with level and packed loaded carbon
(D) mesh screen on top of carbon bed
(E) top cell piece screwed on using locking ring

Test Variables

- Carbon types / sizes
- GB, HD agent
- Environmental conditions (T and RH)

Fixed conditions:

- Nominal challenge concentrations GB: 1,500 mg/m^3; HD: 500 mg/m^3
- Nominal gas flow rate: 9.0 ± 0.2 LPM
  - Face velocity: 12 cm/s (residence time of ~0.28 sec in 2.5 cm bed)
- Preconditioning of carbon bed prior to absorption test under same T/RH conditions as actual test
  - Equilibrium times determined prior to tests by measurement of carbon weight gain with time

Test Matrix

Carbon Type	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
ASZM-TEDA™	6x16	**GB**	X			2.5 -- 3.5	Bubbler
IONEX™ 03-001	8x16	**GB**	X	X		3.5	Bubbler
ASZM-TEDA™	12x30	**GB**	X	X	X [50% RH]	2.5	Syringe
Vapure™ 612	6x12	**GB**	X	X		3.5	Bubbler
ASZM-TEDA™	6x16	**HD**	X			2.5	Syringe
IONEX™ 03-001	8x16	**HD**	X	X	X [50% RH]	2.5	Syringe
ASZM-TEDA™	12x30	**HD**	X	X	X [20% RH]	2.5	Syringe

Carbon characteristics:

ASZM-TEDA™ carbon, Calgon Carbon Corporation (Pittsburgh, PA). Coal based activated carbon impregnated with chemical compounds containing copper, silver, zinc, molybdenum and triethylene diamine (TEDA)

Ionex™ carbon, IONEX Research Corporation (LaFayette, CO), Cocoanut shell based activated carbon; not impregnated

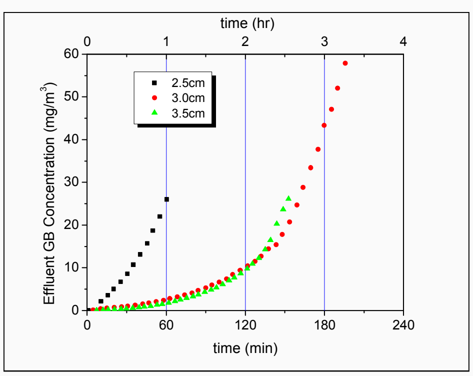
Vapure™ 612 carbon, Norit (Marshall, TX). Coal based carbon; not impregnated

Sarin (GB) results:

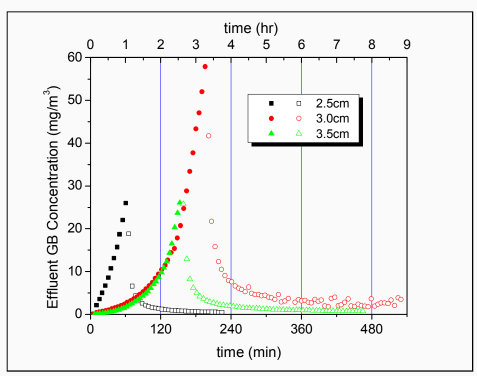
Results Sarin (GB)
Bed depth dependence

Carbon Type / mass	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
ASZM-TEDA™ 20.7-29.0 g	6x16	GB	X			2.5 -- 3.5	Bubbler

GB challenge concentration: 1500mg/m^3



Absorption phase

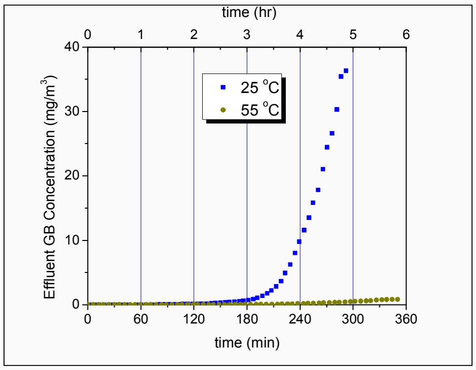


Absorption + Desorption phase

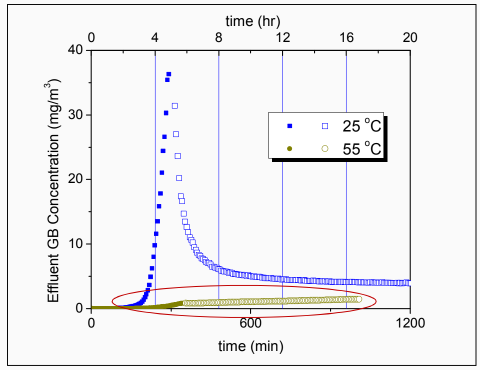
Results Sarin (GB)

Carbon Type / mass	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
IONEX™ 03-001 18.8 g	8x16	GB	X	X		3.5	Bubbler

GB challenge concentration: 1500mg/m³



Absorption phase

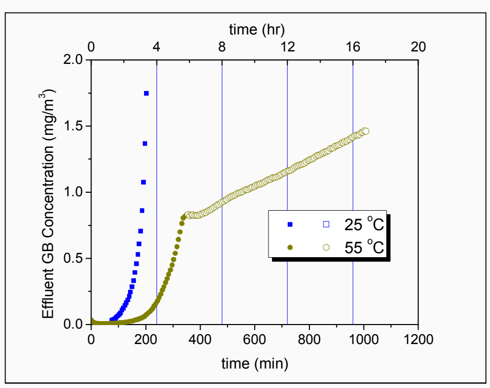


Absorption + Desorption phase

Results Sarin (GB)

Carbon Type / mass	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
IONEX™ 03-001 18.8 g	8x16	GB	X	X		3.5	Bubbler

GB challenge concentration: 1500mg/m³

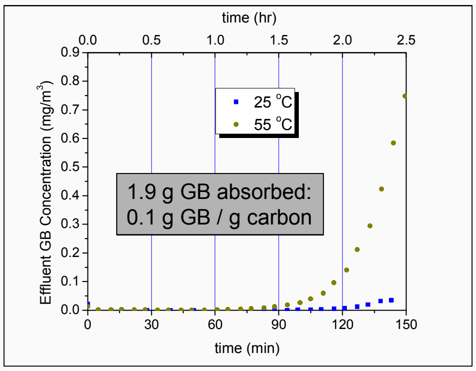


Desorption phase / 55 °C enlarged

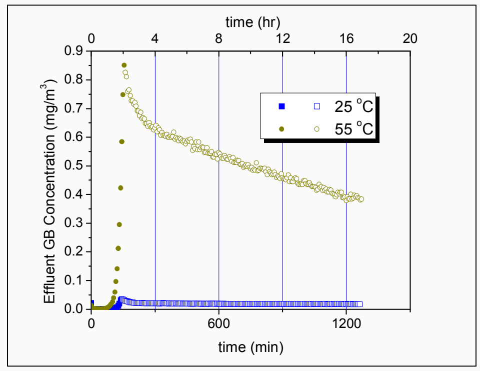
Results Sarin (GB)

Carbon Type / mass	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
ASZM-TEDA™ 17.3 g	12x30	GB	X	X	X [50%]	2.5	Syringe

GB challenge concentration: 1500mg/m³



Absorption phase

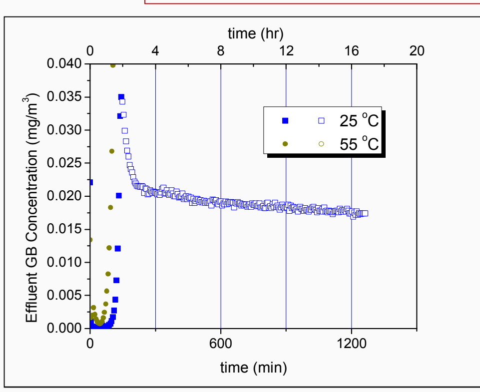


Absorption + Desorption phase

Results Sarin (GB)

Carbon Type / mass	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
ASZM-TEDA™ 17.3 g	12x30	GB	X	X	X [50%]	2.5	Syringe

GB challenge concentration: 1500mg/m³



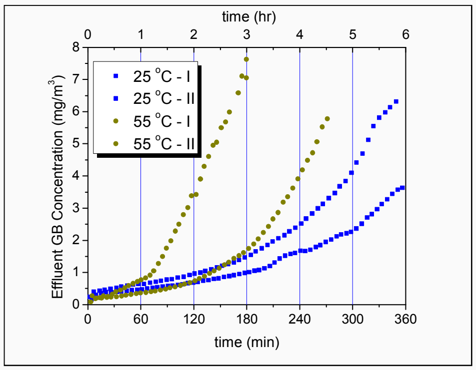
Desorption phase / 55 °C enlarged

High Humidity result:
HF formation at 55 °C / 50% RH.
No breakthrough curve measured

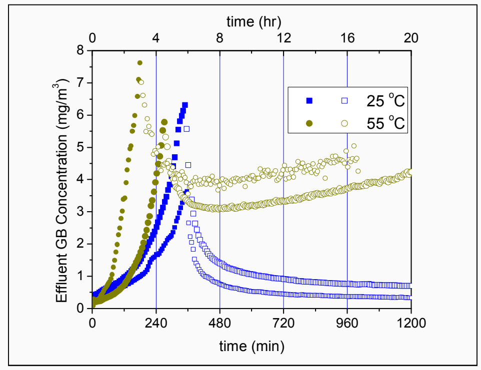
Results Sarin (GB)

Carbon type	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
Vapure™ 612	6x12	GB	X	X		3.5	Bubbler

GB challenge concentration: 1500mg/m³



Absorption phase



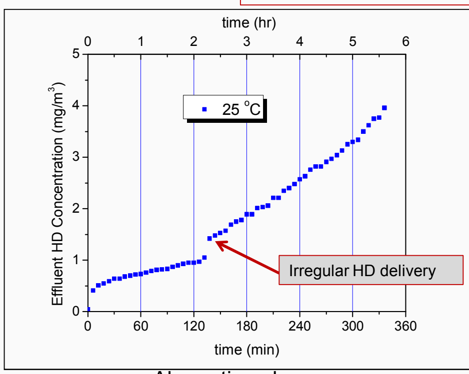
Absorption + Desorption phase

Sulfur mustard (HD) results:

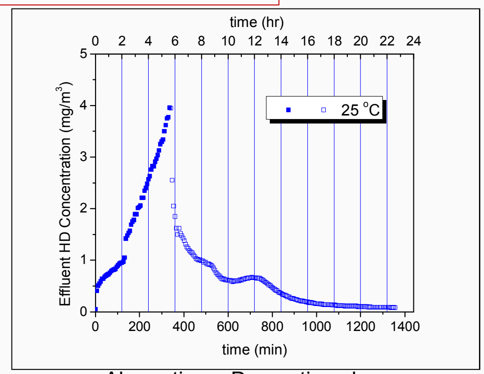
RESULTS (HD)

Carbon Type / mass	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
ASZM-TEDA™ 20.7 g	6x16	HD	X			2.5	Syringe

HD challenge concentration: 500mg/m³



Absorption phase

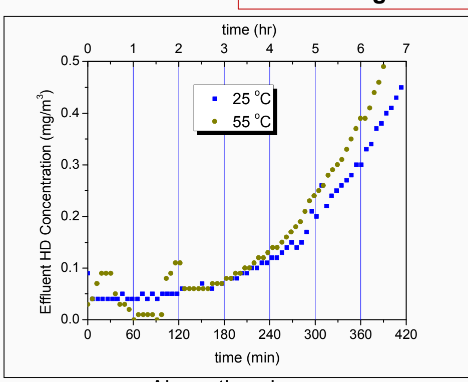


Absorption + Desorption phase

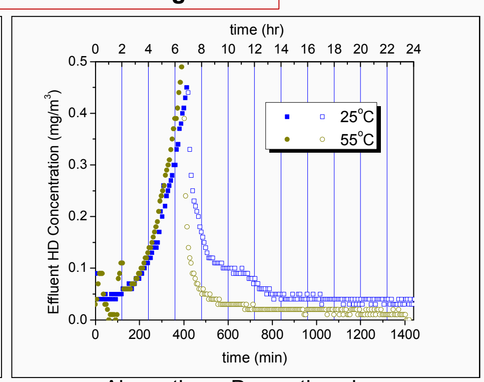
RESULTS (HD)

Carbon Type / mass	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
IONEX™ 03-001 13.7 g	8x16	HD	X	X	X [50% RH]	2.5	Syringe

HD challenge concentration: 500mg/m³



Absorption phase



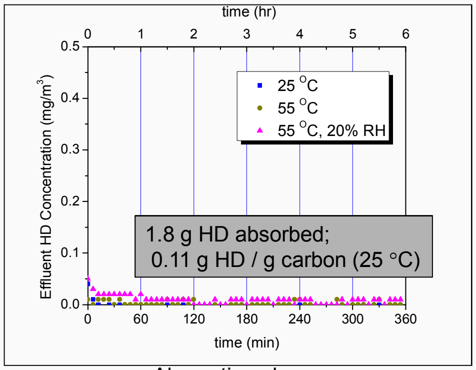
Absorption + Desorption phase

55 C / 50% RH test was not completed due to excessive (water vapor) condensation in flow controllers after 260 min (effluent < 0.025 mg/m3) ⇔ no breakthrough

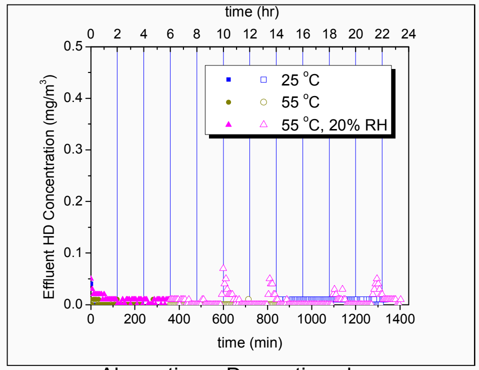
RESULTS (HD)

Carbon Type / mass	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
ASZM-TEDA™ 17.3 g	12x30	HD	X	X	X [20% RH]	2.5	Syringe

HD challenge concentration: 500mg/m³



Absorption phase



Absorption + Desorption phase

Results (HD)

Carbon Type / mass	Mesh	Agent	T / RH 25 / dry	T / RH 55 / dry	T / RH 55/ Humid	Bed depth (cm)	Agent Delivery
ASZM-TEDA™ 17.3 g	12x30	HD	X	X	X [20% RH]	2.5	Syringe

HD challenge concentration: 500mg/m³

Before

After

- Discoloration only observed for HD; picture following 25 °C / dry test.
- Thiodiglycol byproduct observed, indicative of HD hydrolysis

Summary of absorption characteristics

- As expected, absorptive capacity increases with carbon depth /amount (GB)
- Mesh size (diameter carbon particle) impacts breakthrough times (GB, ASZM TEDA)
- The absorbing characteristics for sarin, GB:
  DO NOT deteriorate with increase in temperature for IONEX™ 03-001
  DO deteriorate with increase in temperature for ASZM-TEDA™ 12x30
  DO deteriorate with increase in temperature for Vapure™ 612
- Absorbing characteristics sulfur mustard, HD
  DO deteriorate marginally with temperature for IONEX™ 03-001
  DO NOT change with temperature for ASZM-TEDA™ 12x30
  on timescale measured (no breakthrough observed)
- Higher humidity (GB) results in HF formation; not further investigated

Summary of desorption characteristics

GB:

- Desorption (under same conditions as absorption without agent) at higher temperature leads to an increased release of absorbed GB on IONEX™ 8x16 carbon and Vapure™ 612
- This GB release / offgassing appears less for ASZM-TEDA™ 12x30 carbon, however, the peak concentration was lower compared to other carbon tested (at the high temperature)
- High humidity results in hydrogen fluoride (HF) formation that needs to be addressed

HD:

- Desorption characteristics of HD do not change with temperature on Ionex™ 03-001
- No HD desorption observed for ASZM-TEDA™ 12x30 on timescale studied

Thursday, November 7, 2013

Concurrent Sessions 4

Biological Agent Persistence

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EPA
United States
Environmental Protection
Agency

PERSISTENCE OF VEGETATIVE *BACILLUS ANTHRACIS* (AMES)

Thomas Kelly, Andrew Lastivka, and Morgan Wendling, Battelle

Joseph Wood, U.S. EPA National Homeland Security Research Center

EPA International Decontamination Research and Development Conference
Research Triangle Park, NC November 5-7, 2013

Acknowledgements and Disclaimer

- ✓ Work conducted under EPA Contract EP-C-10-001 with Battelle.
  - ➢ Battelle is a contractor to U.S. EPA and provided technical support for the work described.
- ✓ For intellectual input to project direction
  - ➢ EPA: Worth Calfee, Shawn Ryan, Leroy Mickelsen
  - ➢ Battelle: Young W. Choi

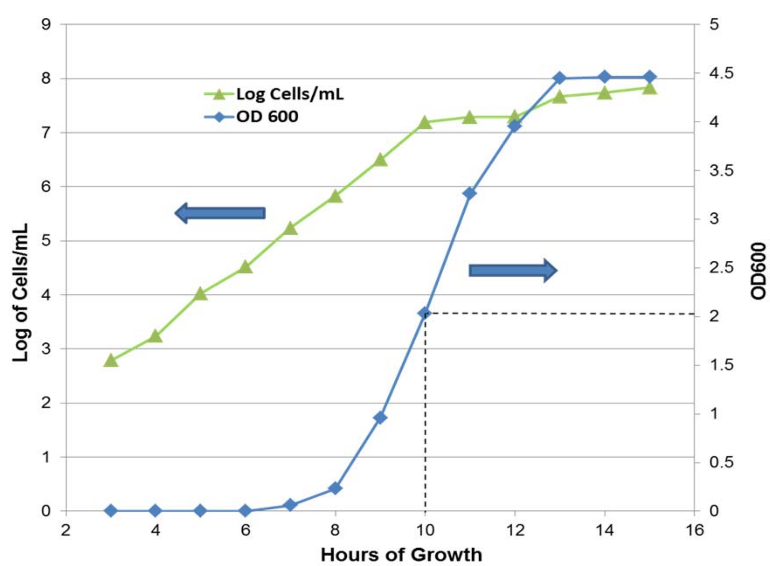
- ✓ Disclaimer
  - ➢ Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government, and shall not be used for advertising or product endorsement purposes.

Why Should We Care about Vegetative *B. anthracis*?

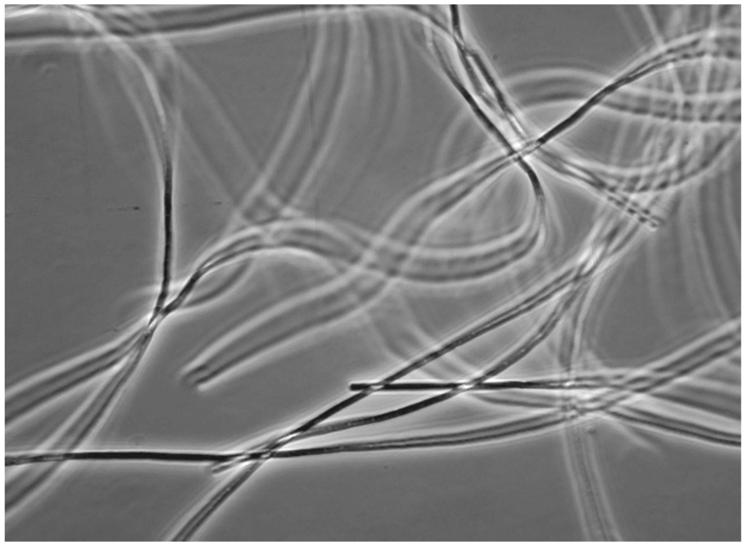
- ✓ Germinants may be used to convert *B. anthracis* spores to vegetative cells, facilitating possible decontamination with the use of non-sporicidal techniques

- ✓ Vegetative *B. anthracis* may die off on its own without the use of decontaminants
  - ➢ What environmental conditions and materials contribute to its persistence or lack thereof?

Production of Vegetative *B. anthracis* (Ames)



Highly Pure Vegetative *B. anthracis* (Ames) at 10-Hour End Point

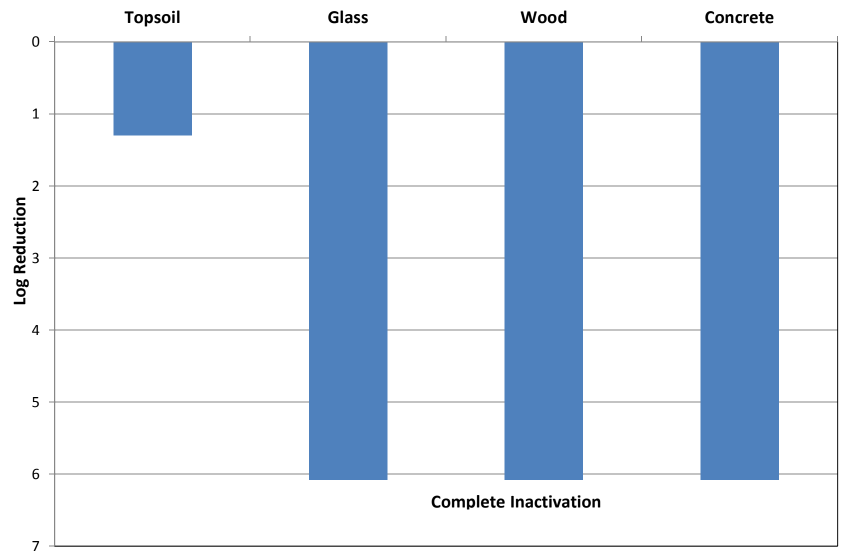


Non-UV Persistence Testing

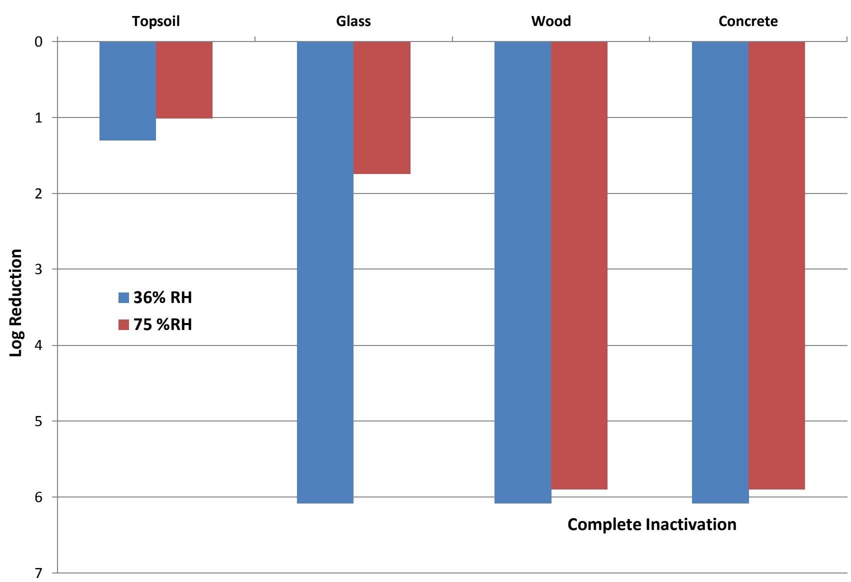
- ✓ Four coupon materials
  - ➢ Topsoil, glass, bare pine wood, concrete
- ✓ Tests to Date
  - ➢ 1 to 120 hours duration
  - ➢ 36% to 75% RH
  - ➢ 1 to 4 materials at a time
  - ➢ Ambient lab temperature

- ✓ Persistence determined by extracting, plating, and enumerating *B. anthracis* (Ames) from test coupons
  - ➢ Comparison to cell inoculation onto coupons
  - ➢ Heat shocked every sample to confirm presence of only cells and no spores

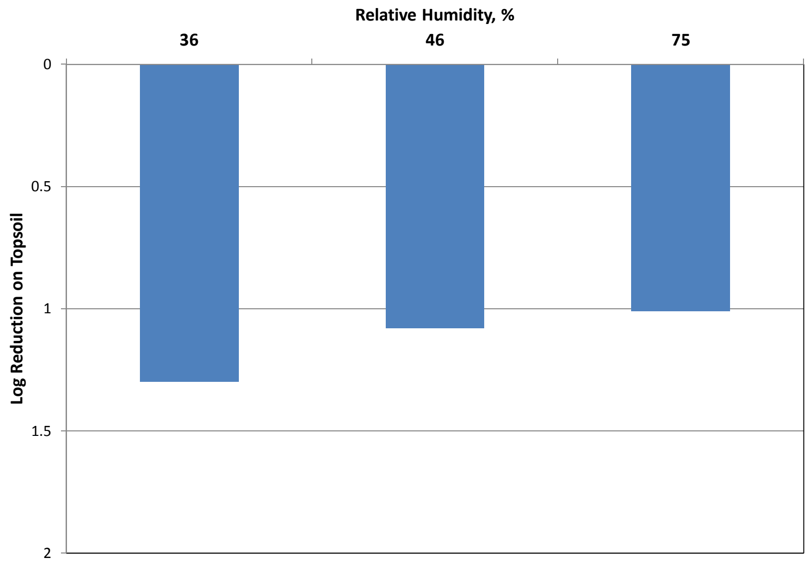
Persistence on topsoil over 1 hour at 36% RH, ambient temperature



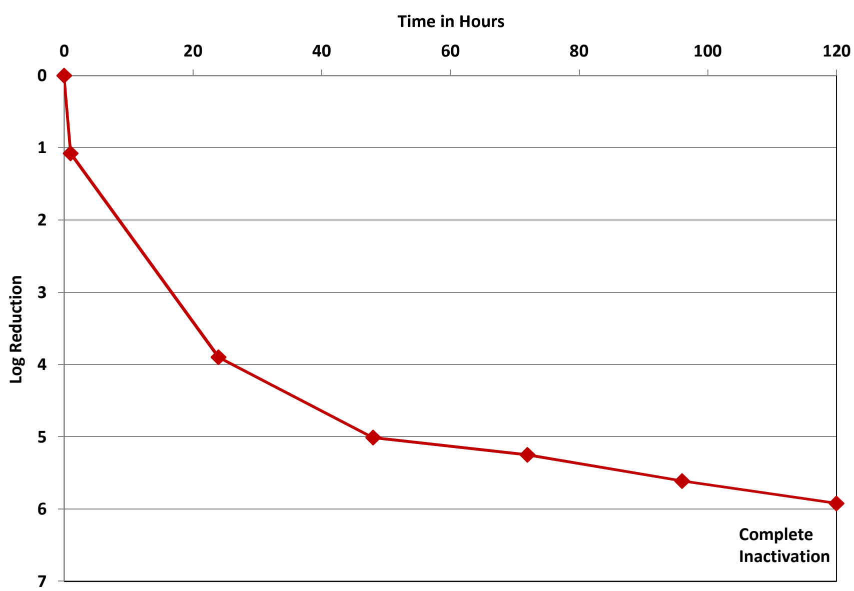
Persistence on glass increases with higher humidity (1 hour at 36% and 75% RH)



Persistence on topsoil over 1 hour increases slightly with higher humidity



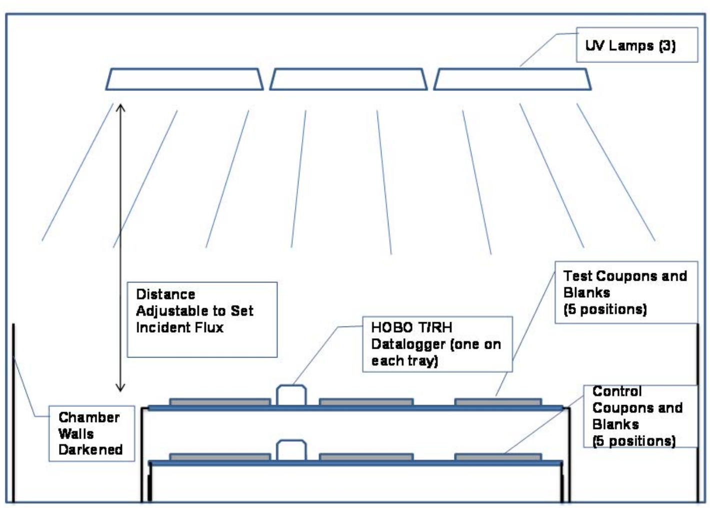
Persistence on topsoil coupons over 120 hours



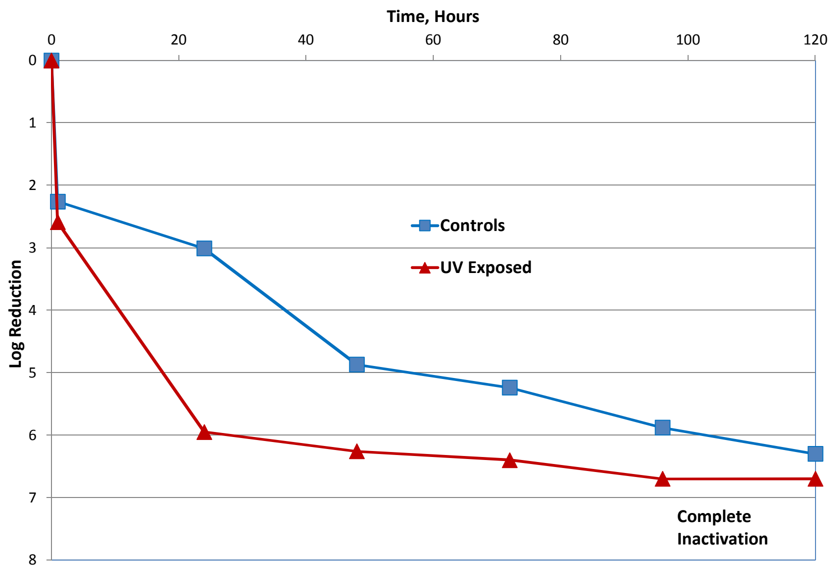
UV Exposure (simulated sunlight) Testing

- ✓ Persistence of vegetative *B. anthracis* under UV exposure on topsoil at ≈ 60 %RH
  - ➢ 120 hours with Low UV-A/UV-B ratio
  - ➢ 120 hours with High UV-A/UV-B ratio
- ✓ Low UV Ratio:
  - ➢ 100 μW/cm^2 UV-A (320 – 400 nm)
  - ➢ 44 μW/cm^2 UV-B (290 – 320 nm)
- ✓ High UV Ratio
  - ➢ 1,785 μW/cm^2 UV-A
  - ➢ 44 μW/cm^2 UV-B

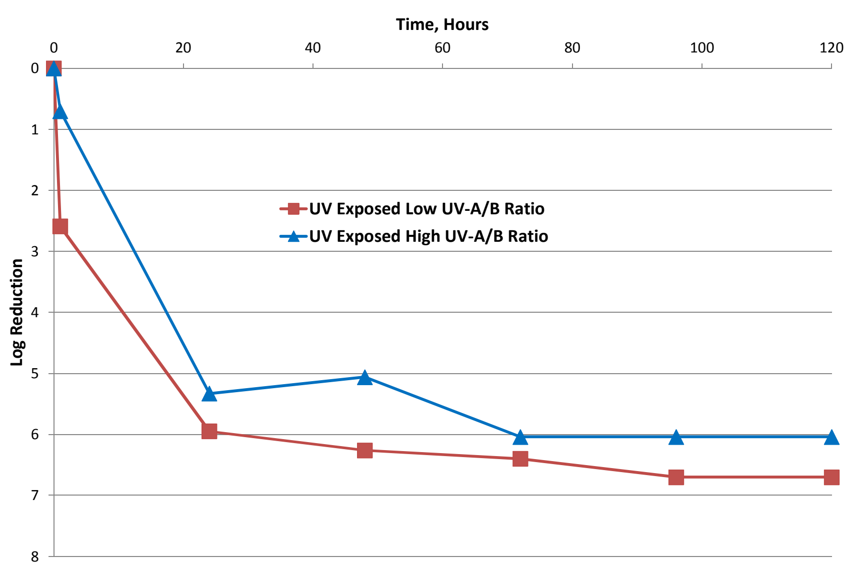
UV Exposure Test Procedures



Low UV-A/B Exposure Impact on Persistence on Topsoil



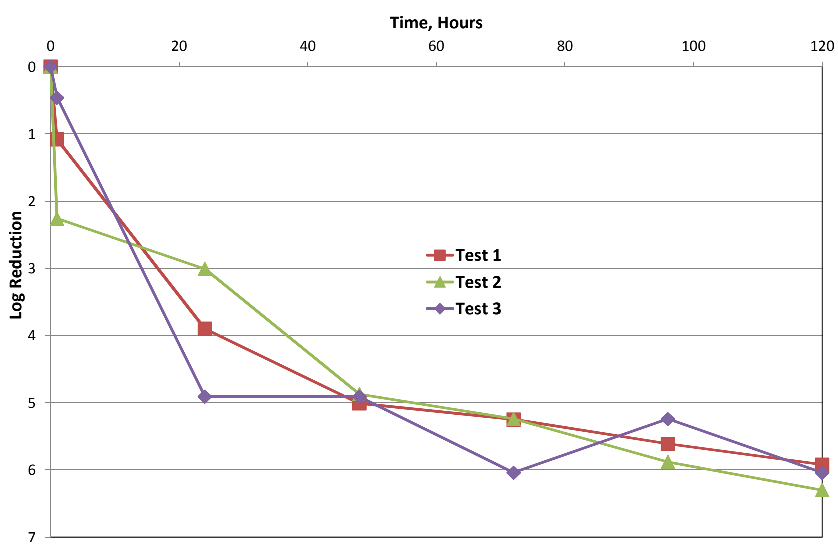
High UV-A/B ratio does not enhance *B. anthracis* (Ames) inactivation on topsoil



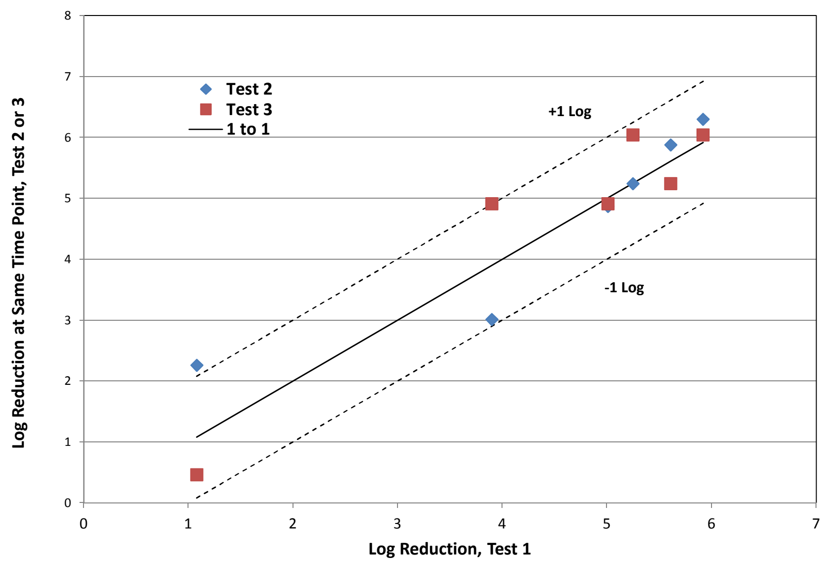
How reproducible are persistence results for vegetative *B. anthracis* (Ames) in topsoil?

- ✓ Compare log reduction over time in three tests:
  - ➢ Test 1: Test coupons in 120 hr topsoil persistence test (No UV)
  - ➢ Test 2: Control (non-exposed) coupons in 120 hr topsoil test with Low UV-A/B
  - ➢ Test 3: Control (non-exposed) coupons in 120 hr topsoil test with High UV-A/B

Persistence on topsoil in three comparable tests



Persistence in replicate runs is reproducible within about 1 Log



Preliminary Conclusions

- ✓ Vegetative *B. anthracis* (Ames):
  - ➢ Persistence the greatest on topsoil, for up to 120 hours, at ambient lab temperature and RH
  - ➢ Persists < 1 hr wood, concrete; < 8 hrs on glass
- ✓ Exposure to simulated sunlight (UV-A/B) reduces persistence on topsoil only slightly
  - ➢ May not be significant
- ✓ Higher RH enhances persistence
- ✓ Heat shocking of all samples showed that vegetative *B. anthracis* (Ames) either die off or persist, but do not sporulate

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United States Environmental Protection Agency

Thursday, November 7, 2013

Concurrent Sessions 4

Water and Waste Water Management

UK capability to manage contaminated water

Dr Carmel Ramwell, Dr Paul Robb, Dr Nigel Cook (Fera)

Dr Hasmitta Stewart, Dr Tony Arkell (GDS)

2013 EPA International Decontamination Research and Development Conference

Why contaminated water?

- Part of a suite of investigative work

Contaminated water

Contaminated water treatment

- Chemical & biological agents
- Decontaminants
- To what extent can different processes treat these challenges
- What processes exist & where – STW and WTW
- Theory vs Practice

Water companies & sewerage undertakers

© Water UK

Water Treatment Works - Processes

	Chlorination	Coagulants	Filtration	Ion exchange	Lime sorbing	Ozone	Reverse-osmosis	Sorbents (incl. GAC & PAC)	UV
Sarin (GB)							Y	Y	
Sulphur Mustard (HD)	Y								
VX							Y	Y	
Arsenic		Y	Y		Y				
Cadmium		Y	Y	Y	Y		Y		
Mercury		Y	Y		Y			Y	
Chlorinated solvent mixtures		Y	Y					Y	
Chlordane								Y	
PCBs			Y		Y			Y	
Aldicarb	Y					Y		Y	Y
Carbofuran						Y	Y	Y	Y
Phorate		Y				Y			Y
Biologicals	Y								

Source: WCIT

- WCIT – invaluable!
- Disinfection byproducts.

What WTW processes are where?

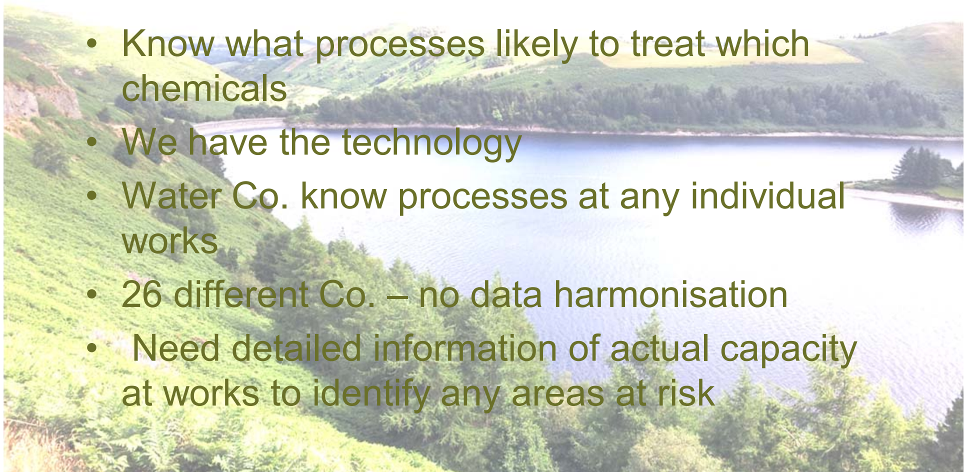
- Treatment processes tailored to catchment
  - Land Use
  - Degree of urbanisation
  - Industrial activities
  - Existing water protection zones
  - Inventory of point discharges
  - Sewage outfalls
  - Industrial Discharges
  - Aquifer characteristics
  - Recharge area, flow rate, flow direction, response to surface activities

- Water Safety Plan

Groundwater

- Groundwater relatively clean
- Lower standard of treatment processes
- WTW less likely to be able to treat contaminated water
- Impact likely to be delayed, so time to implement mitigation
- Technology exists for treating contaminated groundwater
  - Legacy of contaminated land from industries

Summary – WTW



Sewage Treatment Works

- Activated sludge
- Few data on the fate of agents in activated sludge
    - EMPA < 30% degraded
    - *Bacillus* spp. exists in sewage
    - Unlikely to be an effect of sludge on Biological agents
- Extrapolate from other chem/bio ‘classes’

Chemical dissipation in STW

		Removal %
PAHs	Benzene	83 - 99
	Napthalene	85 - 95
	Anthracene	32 - 80
	Fluoranthene	66 - 97
Pesticides	Lindane	45 - 80
	Isoproturon	< 10
	Diuron	< 10
	Alachlor	< 10
	Simazine	< 40
	Atrazine	< 40
	Chlorpyrifos	0
	Chlorfenvinphos	0% (30 mg/L) to 83% (3.4 μg/L)

Source: Seriki et al (2008)

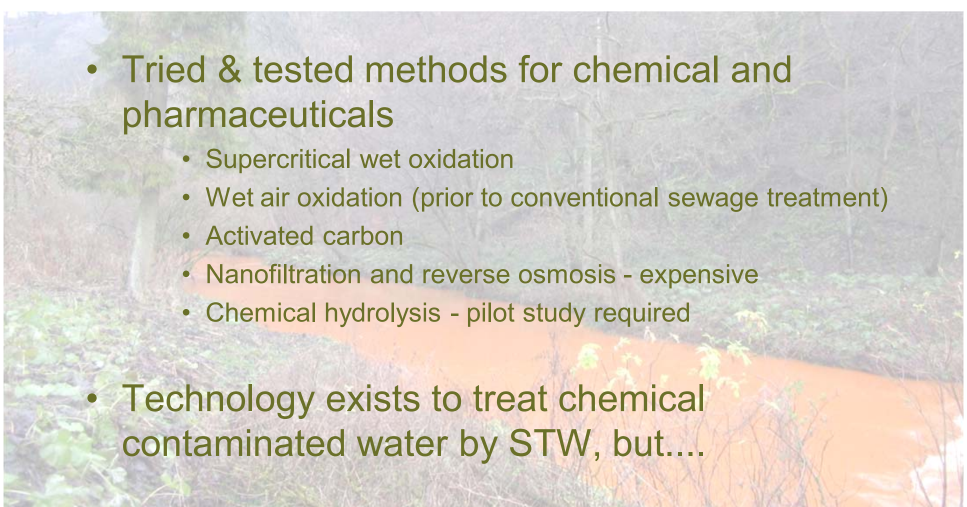
Volatilisation

Sorption

Biodegradation

Water soluble
Low sorption potential
Volatile

Industrial Wastewater Treatment Works



- Tried & tested methods for chemical and pharmaceuticals
  - Supercritical wet oxidation
  - Wet air oxidation (prior to conventional sewage treatment)
  - Activated carbon
  - Nanofiltration and reverse osmosis - expensive
  - Chemical hydrolysis - pilot study required
- Technology exists to treat chemical contaminated water by STW, but....

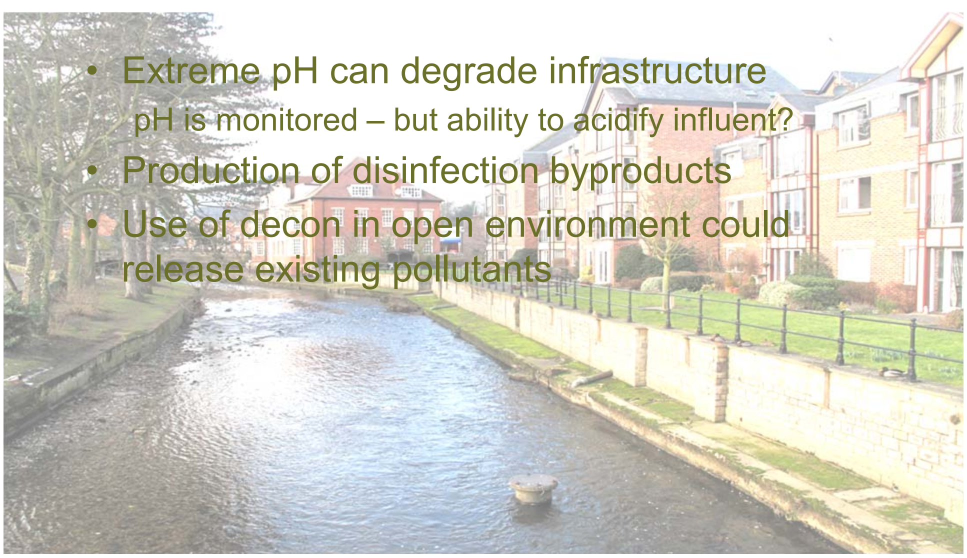
Do decontaminants have an impact?

- On microflora in sludge

	Dose with low impact	Comment
Hypochlorite	< 6 kg Cl_2 / 10^3 kg sludge / day	Already used to maintain the efficacy of activated sludge.
Chlorine dioxide	<10 mg ClO_2/g dry sludge < 2.5 mg ClO_2/g TSS	Research
Hydrogen peroxide	?	
Ozone	< 20 mg O_3/g TSS	Research
Peracetic acid	< 80 g PAA/kg dissolved solids	Research
Sodium hydroxide	?	Already used to control pH of influent

- Conditions not tested at full scale!

Impact of decontaminants



- Extreme pH can degrade infrastructure
  - pH is monitored – but ability to acidify influent?
- Production of disinfection byproducts
- Use of decon in open environment could release existing pollutants

Potential Issues

- How much chlorine/chlorite can be:
  - Stored on site
  - Administered
- Alkaline decon can reduce the efficacy of Cl
  - On-site monitoring could correct Cl levels
- Alkalinity can increase the production of THMs.

Data gaps

- The dose is key!
  - Contaminant & decon
- Volume of decon/firewater used
- Is decon neutralised in-pipe?
- Magnitude of biologicals for establishment
- Impact on other treatment processes
- Impact on population dynamics

Any questions?

EPA Water Security Division (WSD): Update on Water Decontamination Activities

2013 EPA International Decontamination Research and Development Conference

11/7/2013

Marissa Lynch

Outline

- EPA Homeland Security Roles
- Decontamination Website
- Available Products
- On-going Projects
- Upcoming Projects
- Supporting Research by EPA's Homeland Security Research Program

EPA Homeland Security Roles

- Protecting drinking water and wastewater **infrastructure**
- Indoor and outdoor clean-up following an attack, natural disaster, industrial accident, etc.
  - can use **millions of gallons of water**
  - can **result in even more contaminated wastewater**
- Development of a **nationwide laboratory network**
- **Reducing vulnerability** of chemical & hazardous materials
- **Cyber security**

Water Security Projects

Multi Use → Homeland Security
Multi Use → Catastrophes: Natural Disasters, Accidents, etc.
Multi Use → "Normal" Operations

Many homeland security-related practices also have other uses.

- Decontamination approaches for use after intentional contamination might also be **useful after natural disasters and industrial accidents**
- **Accessibility to laboratory networks can also support routine monitoring operations**

Decontamination Website

- Provides **background on decontamination activities** during remediation and WSD's mission and priorities for decontamination
- Includes Guidance Documents and Additional References tab with **links to key documents and tools for the Water Sector**
- Includes Laboratory Resources tab with **links to Laboratory Compendium, WLA, WLA Response Plan, ERLN and ICLN**

http://water.epa.gov/infrastructure/watersecurity/emerplan/decon/index.cfm

Outline

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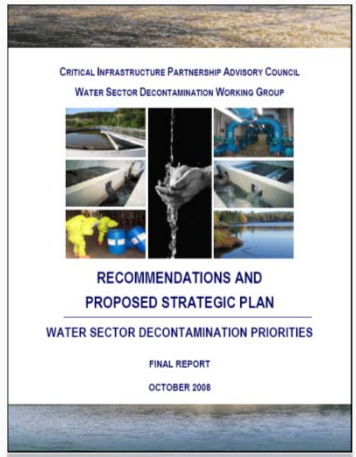
CIPAC Strategic Plan

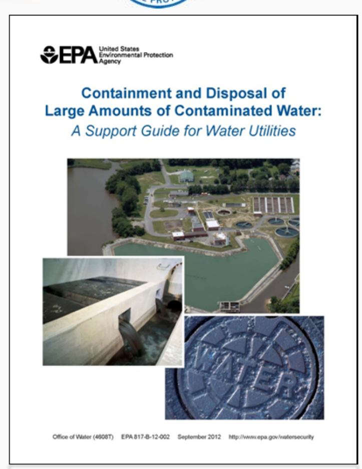
- 2008 CIPAC Recommendations and Strategic Plan report
- Identified 16 priority issues
- Included 35 recommendations for addressing the issues
- Identified potential lead entities to address and act on the recommendations.



http://www.nawc.org/uploads/documents-and-publications/documents/document_ca7f0ed5-0dfe-40ed-afc1-a92a8beb3988.pdf

Disposal Guide

- Serves as a **reference** to assist utility actions related to the containment, treatment and/or disposal of large amounts of water from a contamination event
- Use as a **preparedness** tool



http://water.epa.gov/infrastructure/watersecurity/emerplan/upload/epa817b12002.pdf

What is included in the Disposal Guide?

- **Decision–making flowcharts** for containment, treatment, and disposal of contaminated water
- Options for **containment, treatment, disposal, storage** and transportation of water
- **Information on 69 CBR contaminants** of concern to the water sector

Webcasts

- Recorded webcasts on the **disposal guide** available on the decontamination website
- Provide **direction on use of disposal guide** through example scenarios

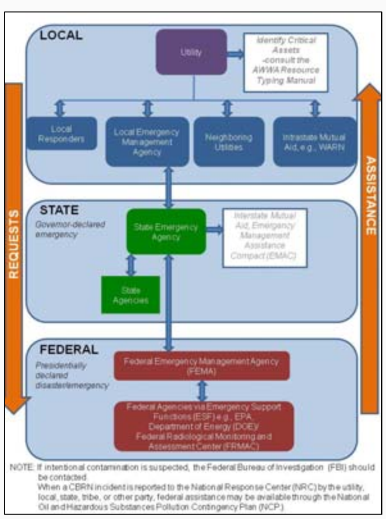
Laboratory Resources for Water Sector to Support Decontamination Activities

- **Factsheet** to help utilities identify laboratory resources during a contamination event
- **Includes a flowchart** with key process steps in identifying appropriate laboratory support

http://water.epa.gov/infrastructure/watersecurity/wla/upload/epa817f12003.pdf

11

How Can Water Utilities Obtain Critical Assets to Support Decontamination Activities?



- A **Factsheet** for utilities for identification of critical assets during pre-incident planning and in response to a contamination event
- Includes a **flowchart** demonstrating the general coordination between Local, State, and Federal Levels

12

How Can Water Utilities Obtain Critical Assets to Support Decontamination Activities?

What is a critical asset?

- Personal protective equipment
- Sampling teams with up-to-date environmental technique training
- Qualified analytical laboratory personnel
- Fate and transport modeling and sampling-design experts
- Data management and documentation specialists
- Decontamination teams capable of verifying decontamination, treating contaminated water, and decontaminating sites or items
- Chemicals for treatment

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Outline

- EPA Homeland Security Roles
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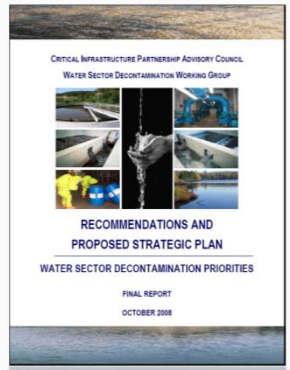
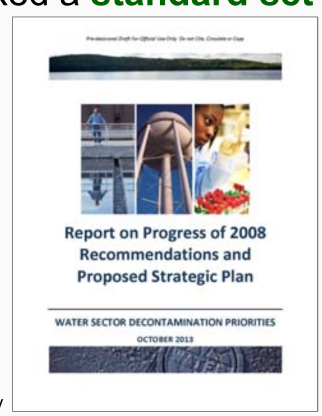
Report on Progress of 2008 CIPAC Recommendations

- Water Sector Decontamination Priorities
- Critical Infrastructure Partnership Advisory Council (CIPAC) **Decontamination Workgroup**
- Strategic Plan – October 2008
  - **Priority Issues (16)**
  - **Recommendations (35)**



Report on Progress of 2008 CIPAC Recommendations

- Presents a **current status** of the work conducted on each recommendation
- All lead agencies contacted and asked a **standard set of questions** such as:
  - – How would you rate the implementation status of Recommendation X in the CIPAC report?
    - Complete / In progress / Not started
  - – What progress has been made toward addressing Recommendation X ?
  - – What products or other outputs have been developed that are relevant to Recommendation X?



Report on Progress of 2008 CIPAC Recommendations

Agencies include:

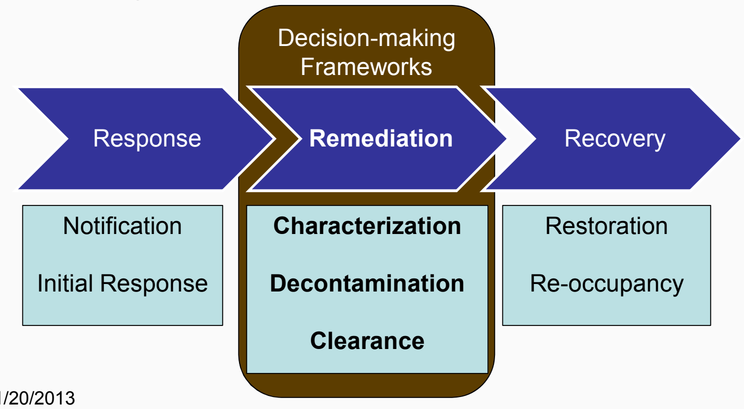
- EPA OW and NHSRC
- Department of Homeland Security
- Centers for Disease Control and Prevention
- US Army Corps of Engineers
- Occupational Safety and Health Administration
- American Water Works Association
- Association of State Drinking Water Administrators
- National Association of Clean Water Agencies
- Water Environment Federation
- Water Sector Coordinating Council

Decontamination Decision-making Frameworks

DRAFT PRODUCT

Decontamination Decision-making Frameworks

- Highlight the critical steps to be taken during the remediation and cleanup for a CBR incident impacting the water sector



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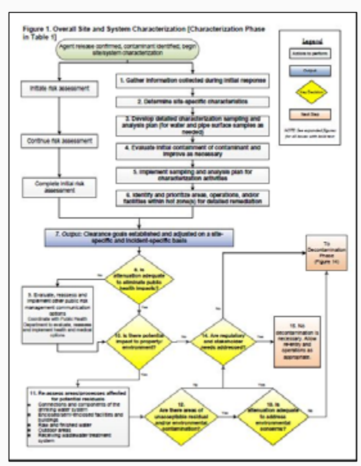
Decontamination Frameworks

- Prepared draft flowcharts and **interactive PDF** for the Decision-Making Frameworks
- Includes **roles and responsibilities**
- Next step: Undergo Workgroup review



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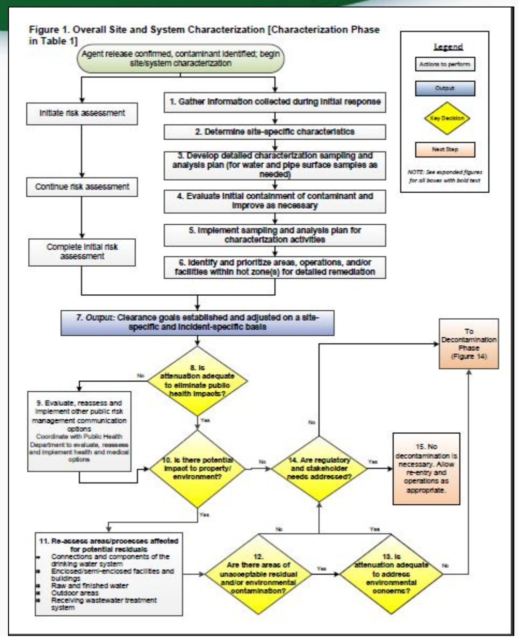
Decontamination Frameworks



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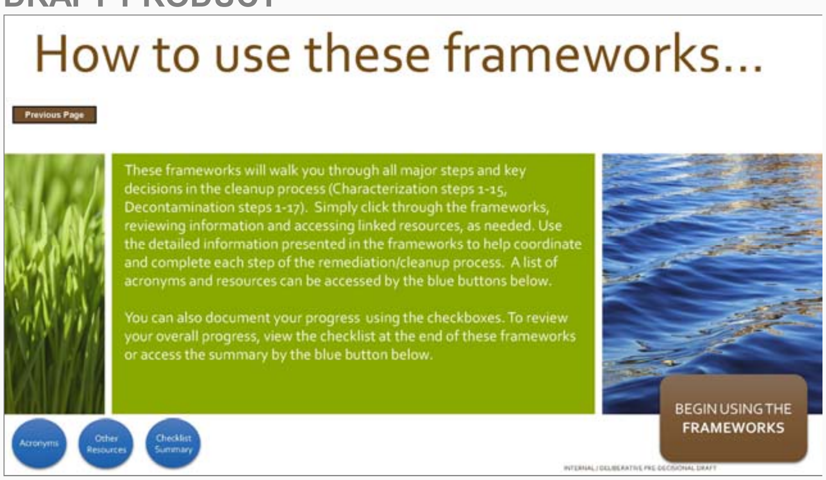
DRAFT Interactive Decontamination Frameworks (cont.)

DRAFT PRODUCT



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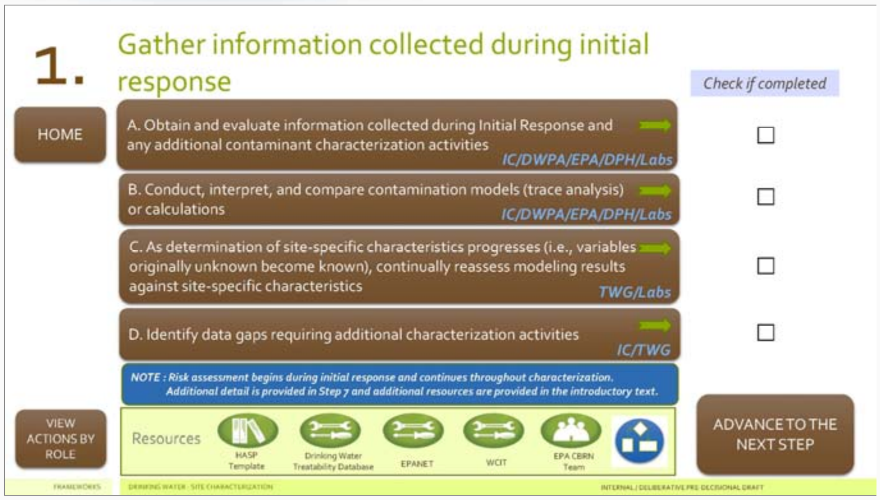
DRAFT Interactive Decontamination Frameworks



Outline

- EPA Homeland Security Roles
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WSD Upcoming Projects

- Additional **webcasts** leveraging decontamination decision-making frameworks
- Decontamination **training and tabletop exercises**
- Update of **WCIT** with decontamination information
- Coordination with: **2013 Water Laboratory Alliance (WLA) Summit**

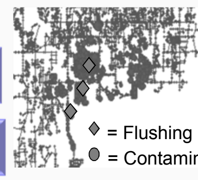
Outline

- EPA Homeland Security Roles
- Decontamination Website
- Available Products
- On-going Projects
- Upcoming Projects
- **Supporting Research by EPA's Homeland Security Research Program**

Supporting Research by EPA's Homeland Security Research Program

EPA Research to Support Water Systems

- Make water systems more resilient
- Mitigate impacts of contamination
- Detect contamination
- Treat water
- Decontaminate infrastructure



Contact Information

Marissa Lynch, U.S. EPA
Office of Ground Water and Drinking Water
Phone: 202-564-2761
E-Mail: **Lynch.Marissa@epa.gov**

Water security website:
http://www.epa.gov/watersecurity/

Decontamination website:
http://water.epa.gov/infrastructure/watersecurity/emerplan/decon/index.cfm

Research website:
http://www.epa.gov/nhsrc

Thursday, November 7, 2013

Concurrent Sessions 4

Chemical Agent Decontamination

Developing Decontamination Tools and Approaches to Address Indoor Pesticide Contamination from Improper Bed Bug Treatments

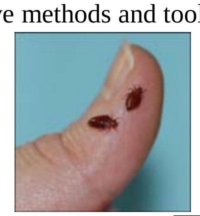
2013 International Decontamination Research and Development Conference

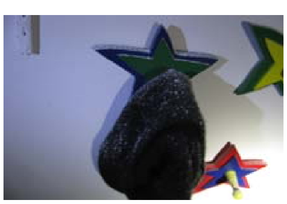
November 7th, 2013

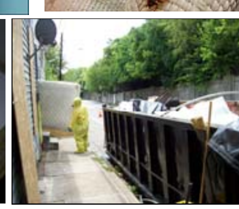
Pesticide Misapplication/Remediation Project

-Improper pesticide use indoors is a ongoing problem resulting in:
- adverse health effects,
- occupant displacement from dwelling,
- property damage and contamination,
- litigation.

-Responding agencies need effective methods and tools to evaluate and remediate indoor settings.







Research

Developing Remediation Tools and Approaches to Address Indoor Contamination from the Misuse of Pesticides for Bed Bug Control

Transdisciplinary Project Team*

- Region 5, Pesticides Section - Amy Mysz
- Office of Research and Development
  - Homeland Security Research Center - Emily Snyder, Lukas Oudejans, Paul Lemieux, Timothy Boe
  - National Exposure Research Laboratory (NERL) – Daniel Stout, James Starr, Haluk Ozkaynak, Kristin Isaacs
  - National Risk Management Research Laboratory – Dennis Tabor
- Office of Solid Waste and Emergency Response
  - Office of Emergency Management, Consequence Management Advisory Team – Jeanelle Martinez

* Technical Support from NERL's Scott Clifton and ARCADIS's Barbara Wyrzykowska

Project Goals

1) **Develop sampling and modeling approaches to evaluate surface residues**
   - to determine if surface residues left after decontamination are below a health-based threshold value
2) **Develop surface threshold values**
   - to determine if remediation is needed
3) **Determine efficacy of decontaminants on surfaces contaminated with pesticides**
   - using decontaminants developed for cleaning chemical warfare agents on surfaces

Goal 1: Sampling and Extraction Methods to Evaluate Surface Residues

- Provides a standard surface sampling methodology for malathion and carbaryl contaminated surfaces

AHHS HARD SURFACE SAMPLING PROCEDURES FOR PESTICIDES

Sample collection kits consisted of :

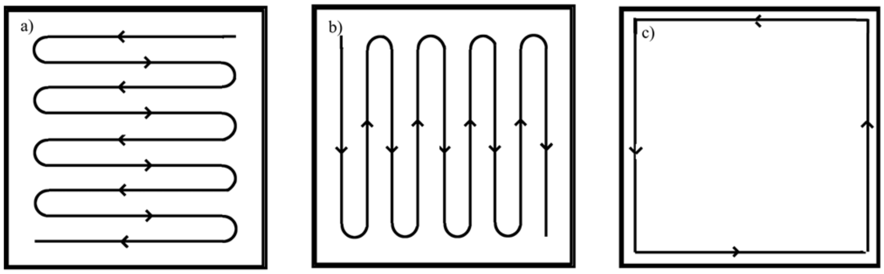
-Nitrile gloves

-two, 6-mL vials of IPA (wetting agent)

-two, 4 in X 4 in surgical gauze sponges (solvent extracted in Hexane and DCM)

-aluminum template (929 cm^2 X 2 = 1858 cm^2)

WIPE PROCEDURE



-A single wetted wipe was used per sample location.

-Two sample locations were wiped at each home.

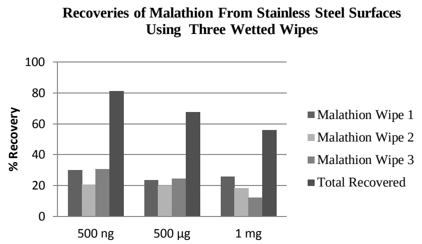
-Samples were aggregated into a single collection jar.

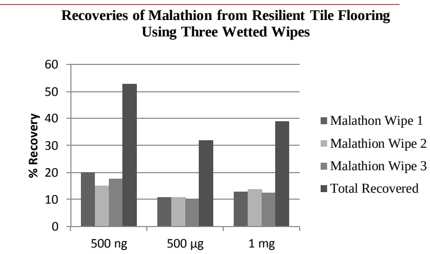
Sampling and Extraction Methods to Evaluate Surface Residues

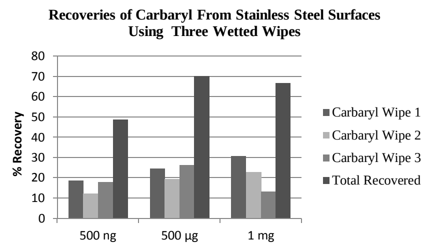
Issues:

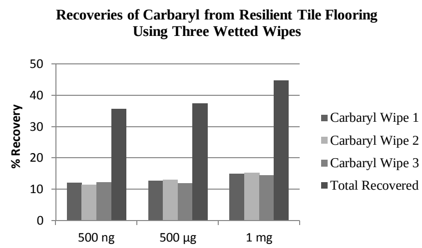
-Methods developed were not validated for malathion and carbaryl.
-The methods were developed for trace level analysis.
-Cheap, validated, standardized, materials available.
-Formulations need to be considered.
-Surface influence on sampling efficiency.

Wipe Sampling, Extraction, and Analysis Results

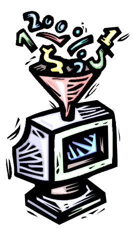








-Surfaces fortified with standard solutions prepared from pure chemical.
-Wetting agent was isopropanol.
-Three similarly wetted wipes.



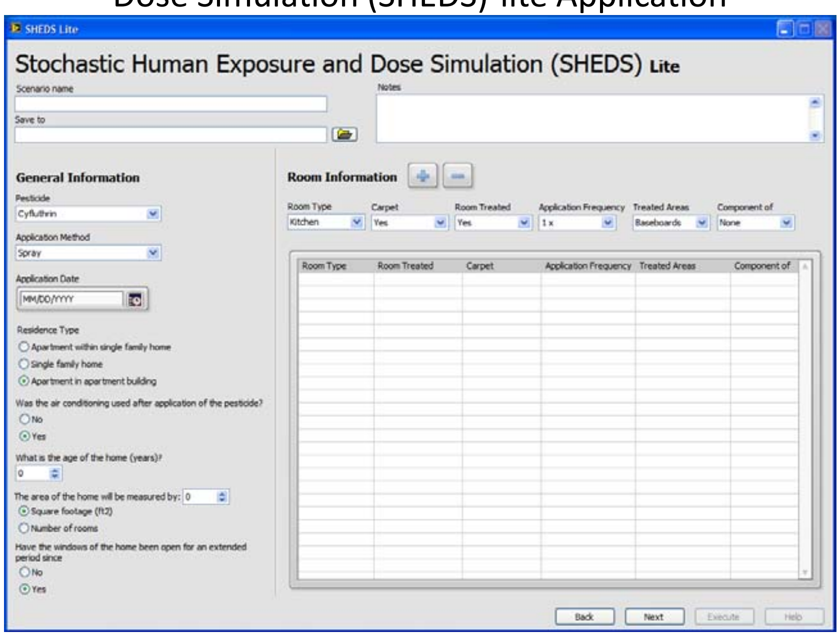
Goal 2: Develop Risk-Based Surface Screening Values

Developing a strategy to calculate a site-specific threshold concentration value using a multimedia chemical fate and exposure model (SHEDS-Lite) with a simple interface that utilizes user-provided wipe sampling data

SHEDS-Fugacity/SHEDS-Lite

- Fugacity-based, compartmental, source-to-concentration module (SHEDS-Fugacity) predicts concentrations of chemical in various environmental media
- Measured wipe sample concentrations can be used as initial conditions for SHEDS-Fugacity; predicted distributions of air and surface concentrations within the home at subsequent points in time can be calculated based on chemical properties and housing characteristics (e.g. estimated air exchange rates, home volumes, room surface areas etc.)
- Exposure distributions can be calculated from media concentrations using probabilistic SHEDS-Lite methods; exposures are based on inhaling contaminated air and touching contaminating surfaces.
- The general probabilitistic SHEDS methodologies are described in the SHEDS-Multimedia documentation at http://www.epa.gov/heasd/research/sheds.html. SHEDS-Lite is a reduced version of SHEDS-Multimedia that is currently in development.

Preliminary Input GUI for Stochastic Human Exposure and Dose Simulation (SHEDS)-lite Application



Challenges with Application of SHEDS-lite to Pesticide Misuse Application

- Tool did not have an existing GUI
- Difficult to balance input needs versus realistic expectations for level of detail available
- Difficult to evaluate model because sampling data frequently lacks the metadata that is needed (location, was sample taken in area where pesticide applied) for this evaluation

GOAL 3: WHAT IS THE EFFICACY OF DECONTAMINANTS ON SURFACES CONTAMINATED WITH PESTICIDES?

Decontamination Testing Laboratory-Scale

- Test 2-4 decontaminants for use against malathion, carbaryl, fipronil, permethrin, and deltamethrin* deposited on building materials (plywood, stainless steel, vinyl flooring)
- Test 1 decontaminant against malathion and carbaryl commercially available formulations
- Analyze for efficacy and toxic by-products

*Standard solutions prepared from pure chemical.

Decontamination Testing Laboratory-Scale Approach

- Contaminated 3 test coupons, 2 positive controls, and 1 procedural blank per pesticide-decontaminant pair decontaminant.
  - Test coupons – decon applied and allowed to sit for 18 hours then extracted.
  - Positive controls set for 18 hours prior to extraction.
  - one 10 µL droplet of 4 mg/mL malathion or 24 mg/mL carbaryl in hexane applied per coupon (simulates misapplication cases)
- A laboratory blank coupon (1 per matrix point) was included.
- Coupons extracted through sonication in hexane (50 mL)
- Used GC-MS for malathion analysis
- Carbaryl extracts reconstituted to H2O:Methanol, 3:7 (V:V) for LC/MS/MS analysis

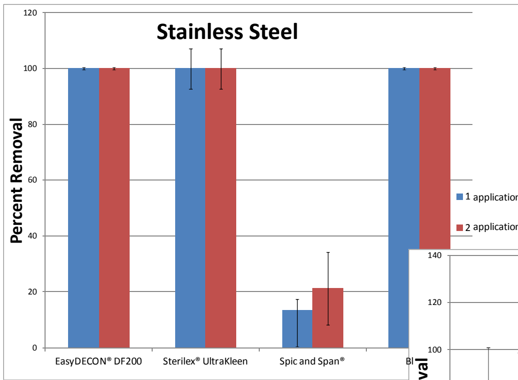
Conditions for GC MS Analysis

Parameter	*Condition*

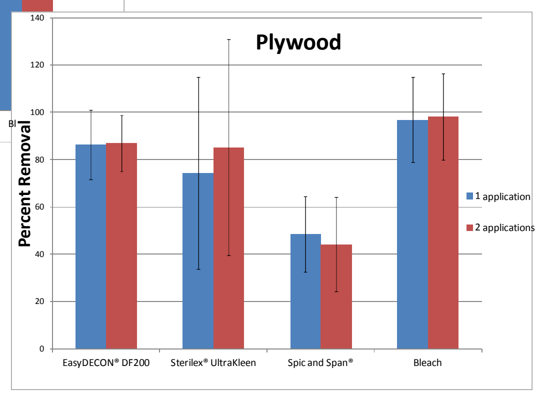
Conditions for LC MS/MS Analysis

Parameter	*Condition*
Mobile Phase	5 mM ammonium acetate in water : MeOH, 3:7. Run time =7 minutes
Column flow rate and injection volume	400 µL/min, 5.0 µL
Ionization	Electrospray
Mode	Negative Ion
Ion pair (Q1/Q3)	219.26/145.04

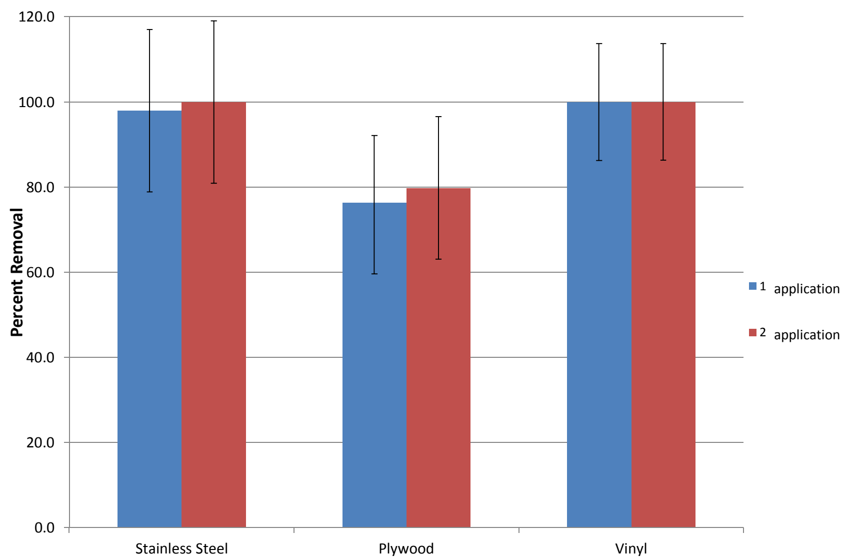
Laboratory Scale Malathion Results



Results :Observe much larger variability in efficacy for the permeable surface which is expected

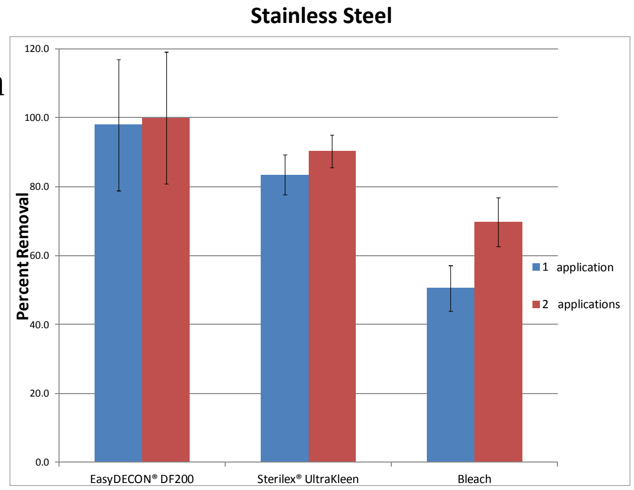


Laboratory-Scale Results
Decontamination of Carbaryl via Easy Decon® DF-200



Issues – Laboratory Scale Surface Decontamination Studies

- Larger variability in decon data for carbaryl on SS than malathion
- Could be a solubility issue

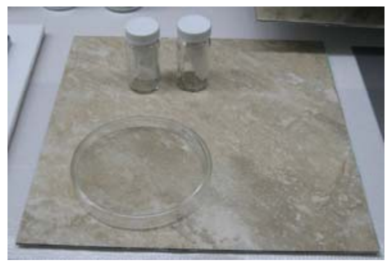


Conclusions

- Wipe sampling, extraction, and analysis
  – Wipe sampling efficiencies vary as a function of concentration for malathion and carbaryl therefore it will be difficult to do quantitative efficacy studies at the pilot scale.
  – As implemented in this project multiple wipes are required.
- Risk based surface clean up values
  – SHEDS-lite combined with fugacity module will result in ability to estimate expected concentrations.
  – The GUI interface tailored to model with user provided input and easy interface.
- Decontamination studies
  – Some of the tested decontaminants were efficacious (best performer varied by surface)
  – Not clear that reapplication significantly improves efficacy (for carbaryl appears to help for some decontaminant-surface combination)
  – Surface type plays a role in efficiency of agent to degrade target pesticides (stainless steel and vinyl easier to decon than plywood).
  – Malathion was easier to decontaminate than carbaryl – could be a solubility issue

Future Work – Pilot Scale Decontamination Testing

- Larger pilot-scale testing – efficacy assessed using residues via surface wipe sampling
  - Will be done for malathion and carbaryl commercially available formulations on two surfaces for one decontaminant
- Qualitatively assess effects on building materials through visual inspection



Disclaimer

- Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government, and shall not be used for advertising or product endorsement purposes.

CHALLENGES IN LEWISITE DECONTAMINATION STUDIES

Harry Stone*, Emily Snyder†, Lukas Oudejans†, Sarah Perkins*, and Autumn Smiley*

*Battelle

†U.S. EPA, National Homeland Security Research Center

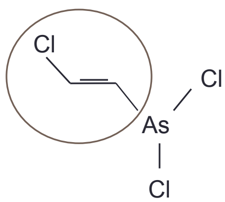
Overview

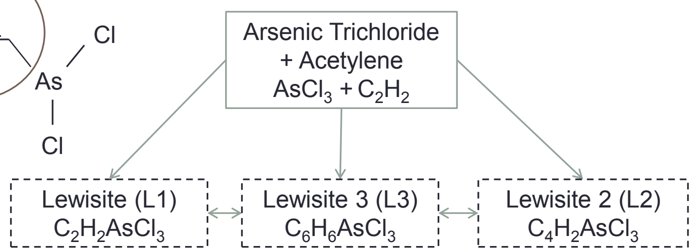
- Purpose
- Lewisite and Byproducts
- Extraction and Analysis
- Approaches and Results
- Summary

Note: Presentation reports the current project status and includes preliminary data that have not been through a full quality assurance review.

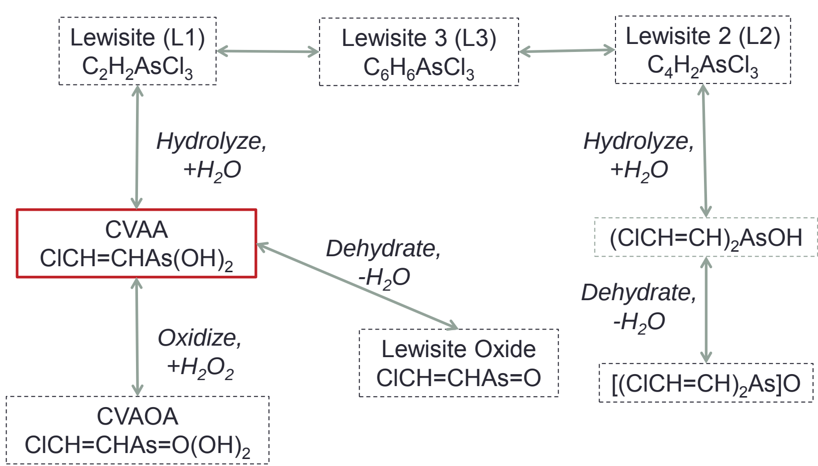
Purpose and Introduction of Agent

- Develop a method for extraction and analysis of Lewisite that can be used to evaluate decontamination efficacy





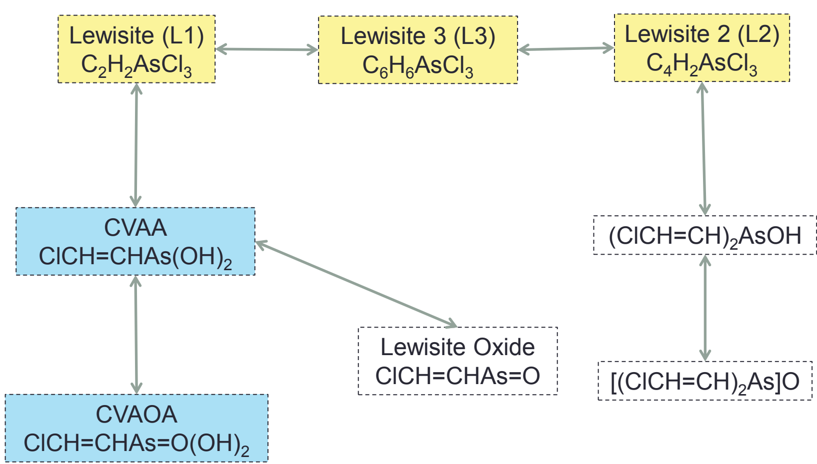
Common Degradation Byproducts



Extraction and Analysis

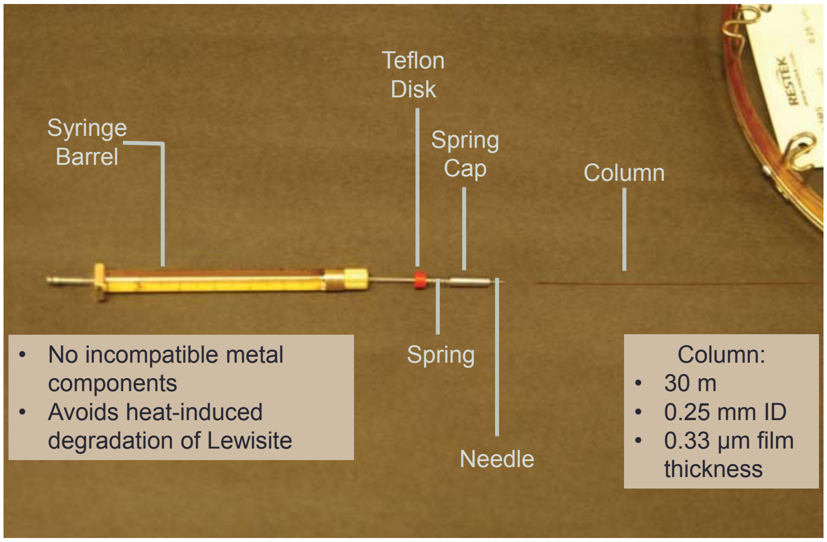
- Coupons: 1.5 x 3.5 cm
  - Sealed concrete
  - Wood flooring
  - Galvanized metal ductwork
  - Glass
- Spike: 1 µL drop per coupon
- Extraction:
  - 10 mL toluene, hexane, or acetone
  - shake by hand 5 - 10 sec
  - sonicate (40 - 60 kHz) 10 min
- Quantify chemical agents in extract
  - GC/MS (L1, L2, L3)
  - Cool on-column GC/MS (L1, L2, L3)
  - Derivatize with butanethiol; GC/MS [$(ClCH{=}CHAs(SR)_2$; $(ClCH{=}CH)_2AsSR$]
  - LC/MS (CVAOA; CVAA)

Common Degradation Byproducts

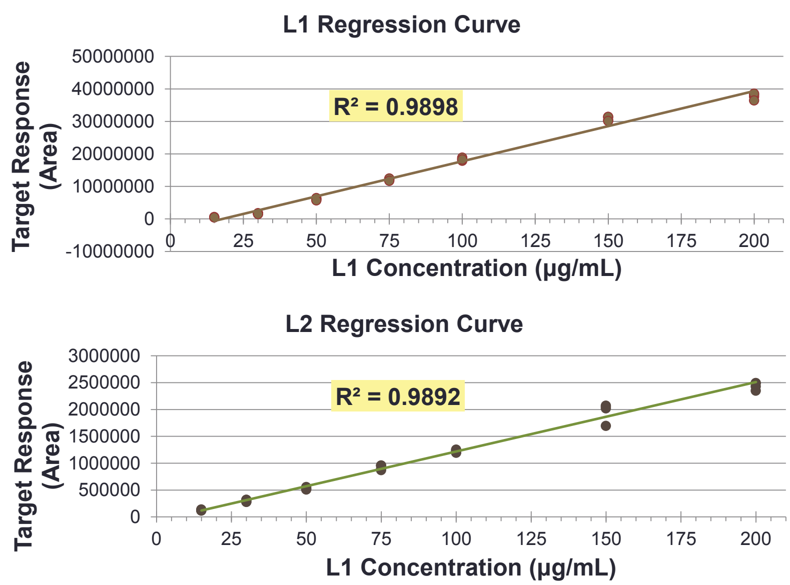


- Yellow: Detected using cool on-column GC/MS
- Blue: Detected using LC/MS

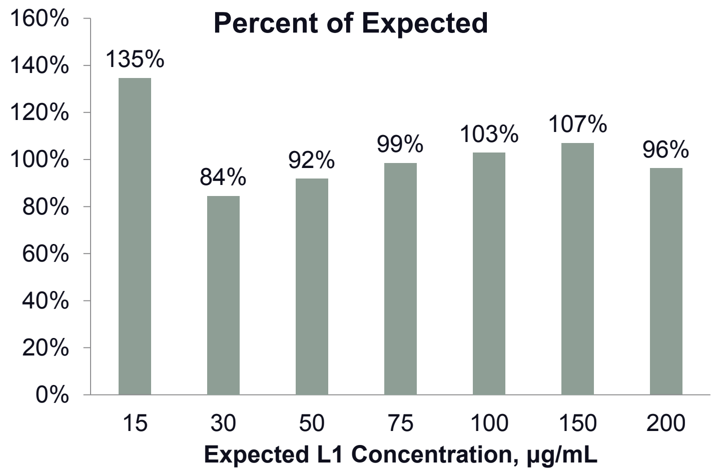
Cool On-Column Inlet (GC/MS)



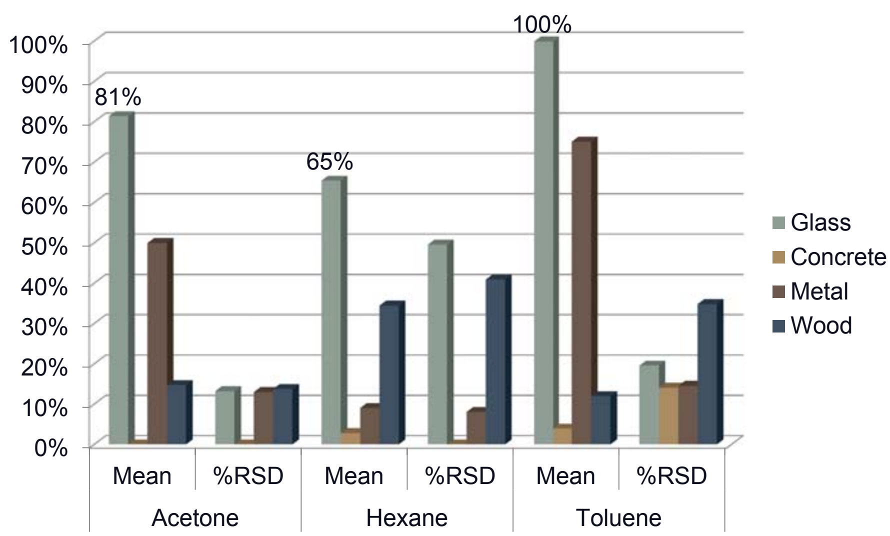
Cool On-Column GC/MS Calibration



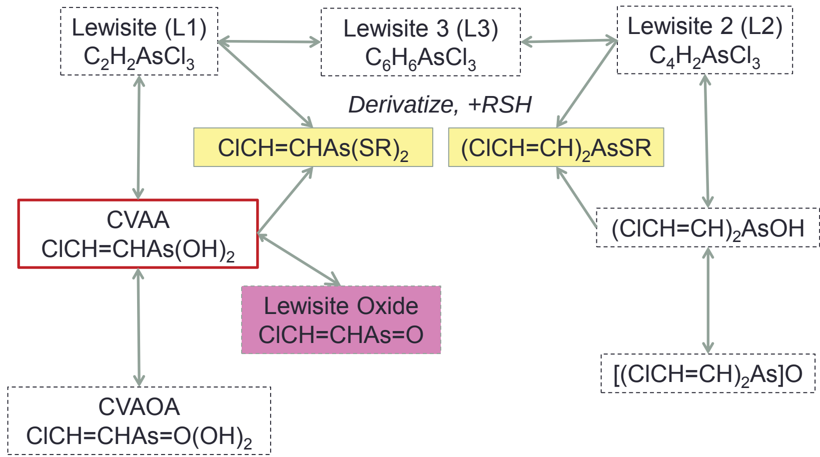
% Recovery of L1 Analyzed By Cool On-Column GC/MS



Extraction Efficiencies by Material and Solvent

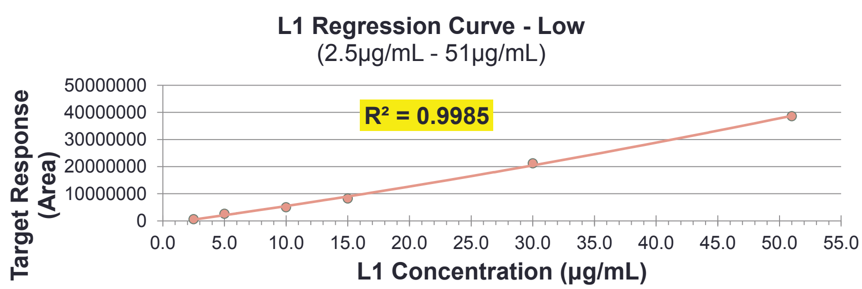


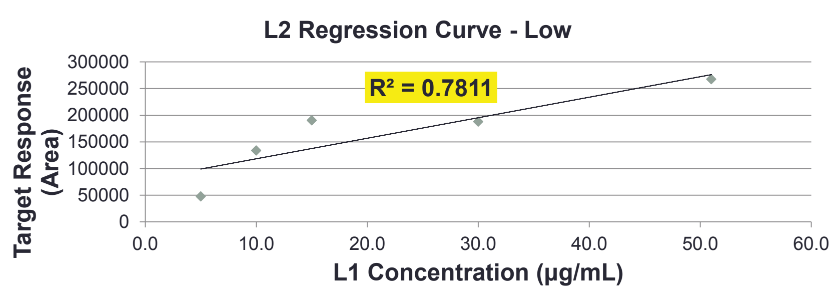
Derivatives with Butanethiol



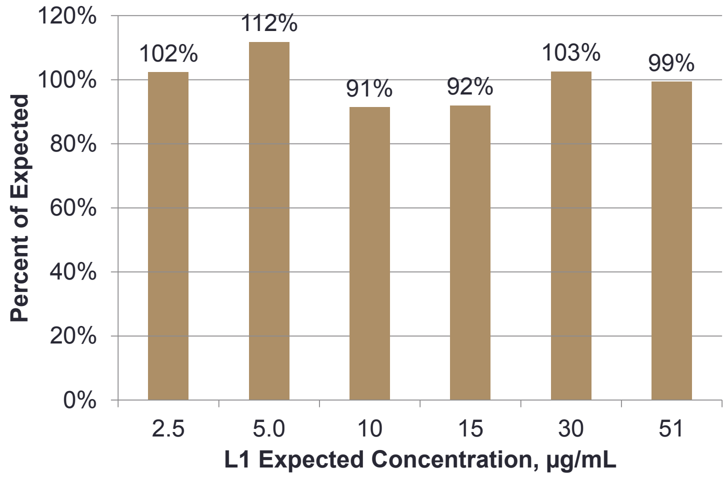
- Yellow: Derivatized products for L1 and L2
- Pink: Can be derivatized but is not soluble in solvent

Derivatized Lewisite Calibration (GC/MS)





% Recovery of Derivatized L1 Using GC/MS



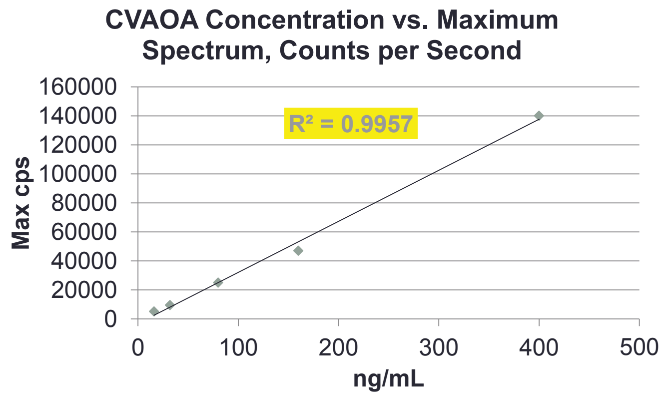
Recoveries and MDL* for Derivatized Lewisite

Sample Source	Average % Recovered, n=10	%RSD	MDL, µg/mL
Solution (no extraction)	78	7	1.3
Extracted from Glass	77	6	1.1
Extracted from Wood	43	17	1.7

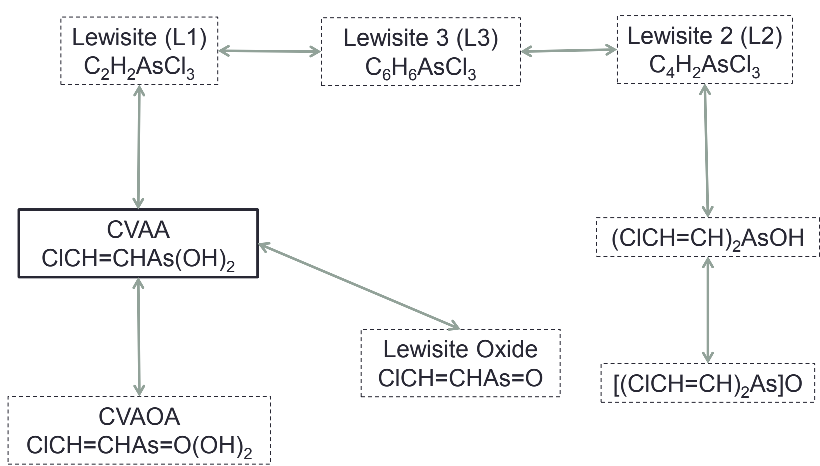
*MDL was calculated following the single concentration design estimator (40 CFR Part 136, Appendix B [1984]):

- Standard deviations of replicate measurements were calculated
- MDL = Student's t-value appropriate for a 99% confidence level and standard deviation estimate with n-1

CVAOA Measured by LC/MS



Common Degradation Byproducts



Future Work – Decontamination and Arsenic Removal Studies

- Determine decontamination efficacies of four solutions for decontamination of identified surfaces contaminated with Lewisite
  - Water
  - Hydrogen peroxide solution
  - Bleach
  - EasyDECON® solution
- Evaluate arsenic removal methods with and without residual decontaminant present
- Use a combination of derivatization followed by GC/MS and LC/MS for residuals and byproduct detection

Summary

- Extraction efficiency for L1 varied by material and solvent combination
- High recoveries of L1 were achieved from glass
- Low extraction efficiencies may be due to physical factors and/or chemical change
- Cool on-column GC/MS measured L1 and L2; can be combined with derivatization and GC/MS to distinguish L1 and L2 from hydrolysis byproducts, e.g., CVAA
- LC/MS can detect CVAA and CVAOA
- Methods are sufficient to extract Lewisite and detect L1 and byproducts at 2.5 µg/mL in extract samples

Acknowledgment and Disclaimer

These are preliminary data that have not been through a full quality assurance review.

The U.S. Environmental Protection Agency, through its Office of Research and Development, funded and managed this investigation through Contract No. EP-C-11-038 Task Order 0007 with Battelle. This document has been subjected to the Agency's review and has been approved for presentation. Note that approval does not signify that the contents necessarily reflect the views of the Agency.

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Questions concerning this presentation or its application should be addressed to Lukas Oudejans, National Homeland Security Research Center, Office of Research and Development, U.S. Environmental Protection Agency, 109 TW Alexander Dr., Research Triangle Park, NC 27711, 919-541-2973.

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United States Environmental Protection Agency

Advanced Absorbent Wipes for personnel and personal equipment decontamination

Dr Stuart Notman

[dstl] 20 November 2013

Ministry of Defence

Outline

- Brief introduction and overall aim
- Experimental methods
- Flat surface experimental results
- Complex surface experimental results

[dstl] 20 November 2013

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Introduction

- Number of technologies have the potential to be used as CWA decontaminants for personnel and personal equipment
  - Wipes
  - Powders
  - Lotions
- Patent literature shows that industry has invested heavily to develop Commercial-Off-The-Self (COTS) wipes
  - Personal care
  - Household cleaning
  - Industrial cleaning

AIM - Determine whether or not modern textile technology could be used as an alternative to fullers' earth

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Methods

- Rotary wiping rig developed
- Wipe turned through 180°
- Aluminium plates, silicone (skin simulant)
- Contamination density 10 g/m^2
- Evaluated decontamination efficacy using
  - 1, 2, 4, 6 and 8 x 180° turns
  - Blot and 1 – 8 x 180 ° turns
  - Blot
- Decontamination efficacy determined from the amount of agent remaining on the plate

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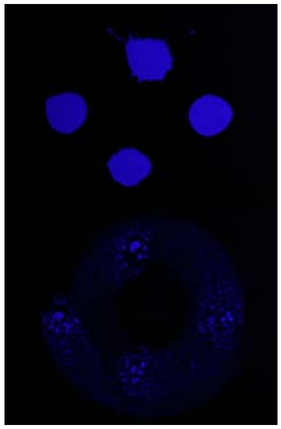
Analytical methods

- Methyl Salicylate (MS) (a sulfur mustard (HD) simulant)
  - Solvent extracts analysed by UV-vis spectroscopy or GC-FID
  - 0.5 %w/w Tinopal added to MS to use an image analysis technique
- HD, GD and VX
  - Solvent extracts analysed by GC-FPD



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Wipes

• Personal care	6
• Household cleaning	10
• Industrial cleaning	11
• Specialist materials	6

- FE pad and FE powder in a puffer bottle

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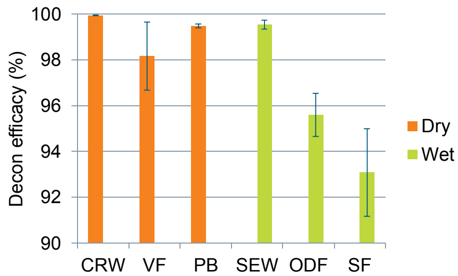
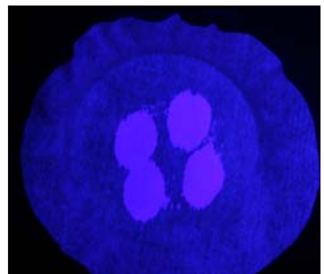
Initial evaluation of six wipes

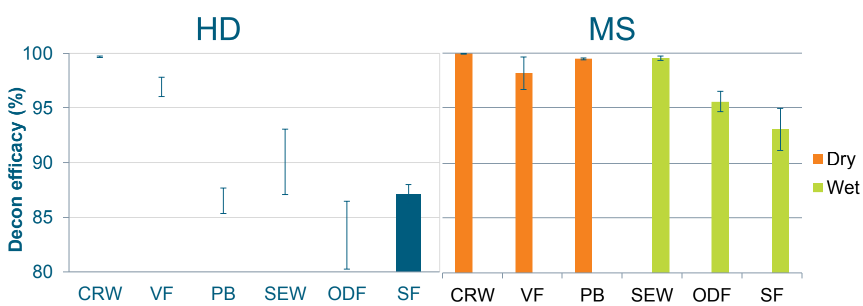
- Six wipes – three personal care wipes and three industrial cleaning wipes
- Selected based on the wipes capacity for absorbing water
- Rotary motion had little effect on performance of selected wipes
- Order of performance (MS) CRW>PB, SEW,VF>ODF,SF





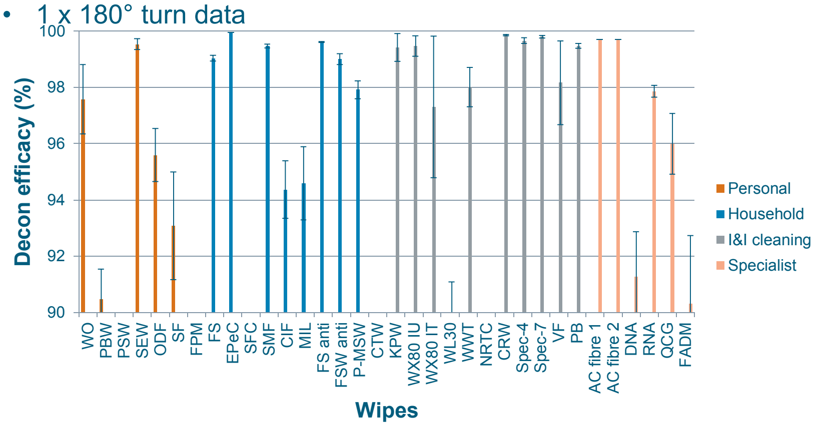
Agent evaluation of six wipes

- Chemical agent HD
- Wipes not as effective against HD as MS
- Order of performance CRW>VF>PB, SEW, SF>ODF



Wipe screening

- Image analysis method used to screen wipes
- 1 x 180° turn data



Development of decontamination process

- Aluminium plates contaminated with MS were used to investigate the affect of different variables on decon efficacy
- Localised saturation can effect efficiency – using two wipes one to blot and a second to wipe – significant improvement
  - Length of blot for the first wipe was also significant
- The effect of pressure is dependent on material of construction and on contaminant
- Addition of solvent to dry wipes apparent improvements were not significant
- Drying out wet wipes showed mixed results
- Drop size had no significant effect on performance of CRW

Agent experiments

- Procedure used – blot 10 s and wipe with clean pad 8 x 180° turns
- To compare performance of the materials
  - Pads of wipes – dimensions of FE pad
- 8 wipes compared to the FE pad – removal of CWA from flat aluminium plates

Wipes
CRW
EPeC
SF-dry
SMF
WX80-iu
AC Fibre 1
AC Fibre 2
KPW

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Agent experiments

- HD
  - FE pad removed 99.9895 % of 10 g/m^2 challenge
  - 4 candidate wipes removed HD to below the Limit of Quantification (LoQ) 99.9997 %
  - 3 wipes were not evaluated using nerve agent
- GD
  - FE pad removed 99.76 % of 10 g/m^2 challenge
  - 3 candidate wipes removed GD to below LoQ 99.997 %
- VX
  - FE pad removed 99.75 % of 10 g/m^2 challenge
  - Only a microfibre cloth performed better than the FE pad 99.89%

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Geometrically complex surface

- Personal equipment list
  - Range of equipment
  - Types of materials
- To be able to compare performance of the different wipes
  - Aluminium plate
  - Manual wiping
- Contamination densities
  - 3 g/m^2
  - 10 g/m^2

Geometrically complex surface

- Removal method required for contaminated FE powder
- At the lower contamination density the FE powder and paint brush was found to be the best option

Removal method	Decon Efficacy (%)	S.E.
Paint brush	84.3	4.1
FE pad	63.9	8.8
EPeC	74.4	4.7

- Dosing single channel

Decontaminant	Channel width (mm)	Decon Efficacy (%)	S.E.
EPeC	1	37.4	9.4
	2	83.9	2.6
FE powder + Paint brush	1	86.7	4.8
	2	98.1	0.5

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Geometrically complex surface

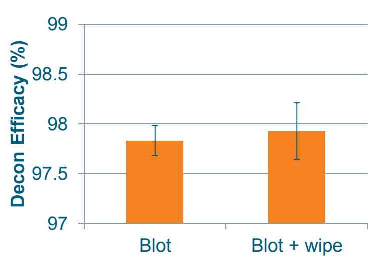
- 10 g/m^2 contamination density

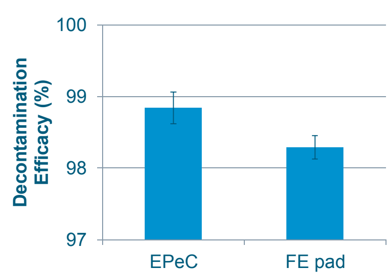
Decontaminant	Decon Efficacy (%)	S.E.
EPeC	85.8	1.23
FE powder + EPeC	46.8	0.12

- Performance of the dual technology option reduced

Silicone skin simulant

- A silicone polymer was used as a skin simulant
- For decon of the silicone it was found that the blot/wipe process was not any better than a blot process
- For 10 g/m^2 contamination density the EPeC wipe out performed the FE pad at removing HD from the surface





Conclusions

We have:

- Developed a selection of processes to identify COTS wipe(s) that are suitable for surface decontamination
- Identified important factors for decontamination of a non-absorbent surface – blot wipe method
- Identified a wipe that performs as well as an FE pad at removing HD, GD and VX from a flat surface
- Developed a complex surface that can be used in assessing decontamination effectiveness relevant to personal equipment

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Questions ?

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20 November 2013

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Thursday, November 7, 2013

General Session 4

Low Tech/Self Help

Assessment of RDD Contamination Removal From Laundering Soft Porous and Bulky Materials

2013 U.S. EPA Decontamination Research and Development Conference, November 2013

Emily Snyder, John Cardarelli, John Drake, Kathy Hall, and Jeff Szabo
(U.S. Environmental Protection Agency)
Karen Riggs and Elizabeth Hanft (Battelle)
Michael Lindberg (Battelle Pacific Northwest Division)

Battelle
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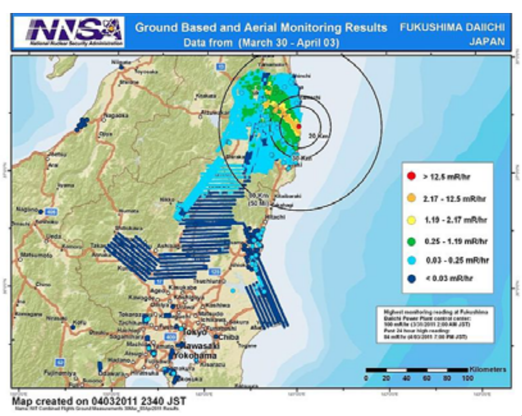
Background

✓ Radiation contamination is possible public threat:
- Release of radiological dispersal device (RDD)
- Accident at nuclear reactor facilities

✓ Protection strategies focus on preventing those who live and work in contaminated areas from being unnecessarily exposed to radiation



2

Existing Guidance

- Current recommendation for handling radioactively contaminated clothing – take off clothing and bag*
- Outside the exclusion zone cleaning activities, such as laundering, will occur
- Washing clothing and other soft porous items may help people living outside of exclusion zone reduce their exposure to radiation

*CDC Centers for Disease Control and Prevention. Emergency Preparedness and Response [online]. Available at: http://www.bt.cdc.gov/radiation/contamination.asp.

Previous Work Objectives

✓ Identify and demonstrate methods for:
  - Deposition of cesium chloride (Cs-137) on material swatches
  - Measuring activity of swatches before and after deposition
  - Measuring residual activity of washing machine used to launder contaminated material swatches

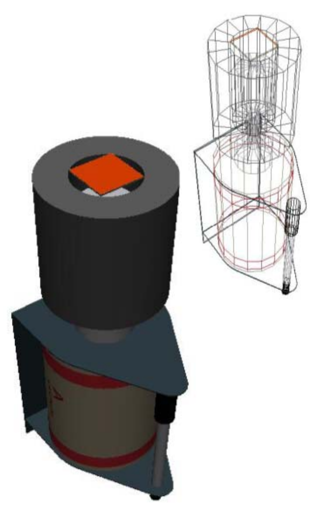
4

Previous Work Objectives

- ✓Determine efficacy of washing to remove radioactive contamination from soft porous materials
- ✓Examine fate of radioactive contamination after washing regular clothing under typical conditions
  - In wastewater
  - Within the washing machine

Previous Work – Method Demonstration

- ✓Cs-137 Application on Material Swatches
  - Consistent across replicate swatches (cotton and polyester) – 3% RSD
  - Consistent across two BEGe detectors – 2% RSD
- ✓BEGe Swatch Detection Limit
  - 0.000185 µCi (20 min counting time)



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Previous Work – Results

Laundering of Contaminated Swatches

Material	Wash/Rinse Temperature	Average* Percent Removal	Average* Decontamination Factor
Cotton	Hot/Cold	94% ± 0.46%	18
Cotton	Cold/Cold	96% ± 0.97%	25
Polyester	Cold/Cold	97% ± 0.28%	30
Cotton**	Cold/Cold	92%	12

**Five replicates*
***Without detergent*

Material Balance

Material	Wash/Rinse Temperature	Average Material Balance
Cotton	Hot/Cold	96%
Cotton	Cold/Cold	92%
Polyester	Cold/Cold	95%

Current Research Objectives

- ✓Build on previous work by using developed methods
- ✓Determine efficacy of washing to remove radioactive contamination from soft porous and bulky materials
- ✓Look at expanded conditions
  - ✓Repeat washing
  - ✓Bulky materials

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Materials and Equipment

✓Material Swatches
- Pre-washed soft porous and bulky materials
- 15 cm x 15 cm
  - Cotton and polyester
- 30 cm x 30 cm
  - Cotton towels
  - Comforter (cotton exterior)

✓Cs-137
- Strong gamma emitter
- Likely candidate for RDD
- Isotope associated with nuclear accidents
- Cesium chloride solution

✓Activity detectors
- Broad energy germanium (BEGe)
- High purity germanium (HPGe) system

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Materials and Equipment (Cont'd)

✓Washing Machine
- Front loading, low volume
- Liquid Tide® HE detergent
- Setup for wastewater collection
- Installed inside radiological containment laboratory

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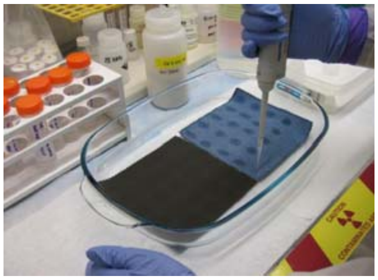
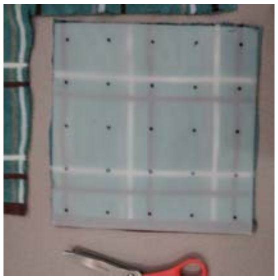
Experimental Procedures

- Material Swatch Contamination
  - Activity measured before and after spiking
  - Approximately <200 pCi before spiking (swatch background)
  - Each test and positive control swatch spiked with ~2 µCi of Cs-137 before laundering





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Test Matrix

Material	Swatch Size	Wash/Rinse Temperature	Other Conditions	# of Test Swatches
Polyester	6 in x 6 in	Cold/Cold	No detergent	5
Cotton	6 in x 6 in	Hot/Cold	No detergent	5
Cotton	6 in x 6 in	Hot/Cold	Include other clothing; Rewash other clothing	5
Polyester	6 in x 6 in	Cold/Cold	Include other clothing	5
Bulky Cotton Towel	12 in x 12 in	Cold/Cold	Detergent	5
Bulky Cotton Comforter	12 in x 12 in	Cold/Cold	Detergent	5

✓ *Quality control samples were laundered with each load*

Quality Control Samples

- ✓ **Positive control** – swatch spiked with Cs-137, and not washed
- ✓ **Procedural blank** - swatch not spiked with Cs-137, and washed with each test swatch
- ✓ **Machine blanks** – swatch not spiked with Cs-137, washed between loads with contaminated test swatches

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Experimental Results

- ✓ Background measurements on co-laundered clothing
  - Not spiked with Cs-137
  - Laundered with polyester material
  - No background radioactive contamination found
  - Detection limit varies based on counting time and geometry

Background Measurements

Clothing Item	Activity (μCi)
Jeans	<6.0E-03
T-shirts	<5.0E-03

Experimental Results – QC Samples

- ✓Positive Controls
  - Contaminated and handled in same manner as Cs-137 spiked test swatches; processed through all procedures except washing (drying after contamination, measurement of radioactivity before and after run load)

Positive Control Sample	Prior Activity (μCi)			Post Activity (μCi)		
Polyester ND/WC*	1.9	±	0.10	1.9	±	0.10
Cotton ND/WC	1.9	±	0.10	1.9	±	0.10
Cotton WC	2.0	±	0.10	1.9	±	0.10
Polyester WC	2.0	±	0.10	1.9	±	0.10
Cotton Comforter	2.0	±	0.14	2.0	±	0.15
Cotton Towel	1.8	±	0.13	1.9	±	0.14

*ND/WC – No Detergent/With Clothing

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Experimental Results – QC Samples

- ✓Procedural Blanks
  - Not spiked with Cs-137
  - Washed with each Cs-137 spiked test swatch
- ✓All post-laundering activities well below 2 μCi spike level
  - Highest values seen in cotton towel swatches which had an average activity of 0.0309 μCi

Experimental Results – QC Samples

- ✓ Machine blanks
  - Not spiked with Cs-137; washed in separate loads run between loads with Cs-137 spiked test swatches
  - Activity <0.00311 µCi
- ✓ Residual contamination in washing machine
  - Previous research
    - After 21 loads - 0.070 µCi
    - After 40 loads - 0.460 µCi
  - Current research
    - After 43 loads - 0.855 µCi

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Experimental Results

Laundering of Contaminated Swatches

Material	Wash/Rinse Temperature	Other Conditions	Average* Decontamination Factor	Average* Percent Removal
Polyester	Cold/Cold	No Detergent	17	94%
Cotton	Hot/Cold	No Detergent	11	91%
Cotton	Hot/Cold	Other Clothing	22	95%
Polyester	Cold/Cold	Other Clothing	36	97%
Cotton Comforter	Cold/Cold	None	35	94%
Cotton Towel	Cold/Cold	None	7.5	68%

**Five replicates*

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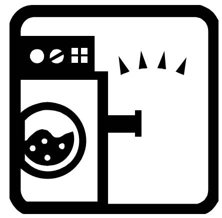
Experimental Results

Activity of Washing Machine Wastewater

Material	Wash/Rinse Temperature	Average Activity for 5 Individual Washes (pCi/mL)	Average Total Activity/ Load (µCi)[a]
Polyester	Cold/Cold	83 +/- 1.9	1.7
Cotton	Hot/Cold	84 +/- 1.9	1.6
Cotton	Hot/Cold	65 +/-2.1	1.2
Cotton[b]	Hot/Cold	12 +/-0.7	0.19
Polyester	Cold/Cold	57+/-2.0	1.1
Cotton Comforter	Cold/Cold	66 +/-2.1	1.4
Cotton Towel	Cold/Cold	34 +/- 1.5	0.76



[a]Based on 20 L collected
[b]Rewashed cotton

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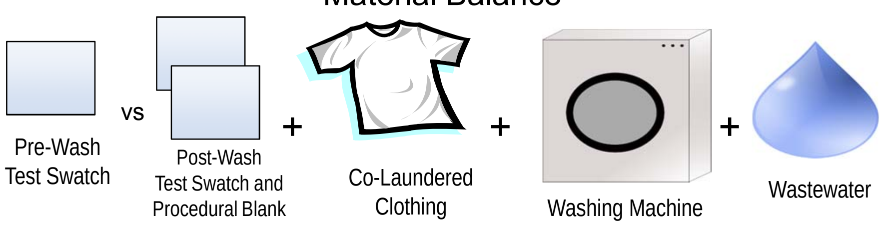
Experimental Results

Material Balance



Material	Wash/Rinse Temperature	Other Conditions	Average Material Balance
Polyester	Cold/Cold	No Detergent	94%
Cotton	Hot Cold	No Detergent	91%
Cotton[a]	Hot/Cold	Other Clothing	100%
Polyester	Cold/Cold	Other Clothing	99%
Cotton Comforter[b]	Cold/Cold	None	77%
Cotton Towels[b]	Cold/Cold	None	74%

[a]Included rewashed cotton, [b]Included remainder of towel and comforter whose activities were not measured

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Conclusions

- ✓These additional experiments confirm earlier results that suggest laundering potentially contaminated clothing might assist people living outside of an exclusion zone in reducing their exposure to radiation

- ✓Some decrease in washing efficacy appears to result from laundering without Tide HE
- ✓Laundering removed more than 90% of the Cs-137 from all material swatches studied except the cotton towel

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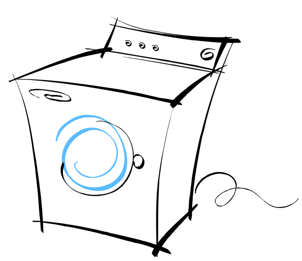
Conclusions (cont'd)

- ✓A second washing improved contamination removal on cotton material swatches
- ✓The majority of removed contamination transfers from material swatches to wastewater
- ✓Laundering contaminated material swatches with noncontaminated clothing resulted in approximately 30% of the Cs-137 ending up in the previously noncontaminated material
- ✓Future research might consider potential risks associated with drying clothing that has been contaminated and washed



Disclaimer

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Evaluation of Compressed Air Dusting and Vacuuming for Radiological Decontamination of Sensitive Equipment

Ryan James and Ryan Stowe, Battelle
John Drake and Emily Snyder,
EPA National Homeland Security Research Center

EPA Decontamination Conference

Research Triangle Park, NC

November 7, 2013

Office of Research and Development
Home and Secur ty Research Program

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Improvised Nuclear Device (IND) Scenarios

- Possibility of IND attacks comes with the reality of fallout/contamination
  - Need for immediate recovery tools
  - Need to minimize dose to 1st responders
- What decontamination approaches would be used?
- How effective are they?

Urban Surface Decontamination

- Decontamination of urban building material surfaces using physical and chemical decontamination technologies

Urban surface coupons used for RAD decon testing

Decon testing using test stand at INL

Example RAD decon technology (DeconGel 1108)

RAD decontamination testing of Wash Aid

EPA
United States
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Agency

Sensitive Equipment Decontamination

- Some types of sensitive equipment necessary for 1st responders in a rescue/recovery scenario
  - Pulse oximeter
  - Handheld radio
  - Cell phone
  - Numeric keypad (simulating a computer)
  - Responder bag
  - Automated external defibrillator (AED)

Representative types of sensitive equipment

EPA
United States
Environmental Protection
Agency

Decontamination Technologies

- High efficiency particulate air (HEPA) vacuum (VAC)
  - Omega HEPA Vacuum, Atrix International Inc., Burnsville, MN
  - 99 cubic feet per minute
  - 110 volt power
  - Carrying case for disposable canister and accessories

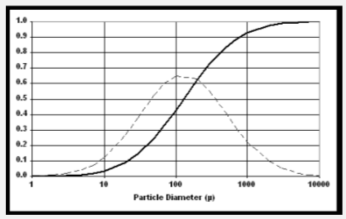

VAC with accessories

- Compressed air duster (CAD)
  - Ultra Duster, AW Distributing, Inc., San Francisco, CA
  - 10 ounce can
  - Contains difluoroethane


Compressed air duster

Technical Approach
Generating Fallout Particles

- Particles must be generated that are similar in size and chemical composition to actual fallout
  - Attempted to simulate the particle size distribution used in Oak Ridge Isotope Generation (ORIGEN) (based upon Nevada Test Site Data) in the radiologically tagged simulated fallout material (RTSFM)



Default PSD for Fallout Model. (Oak Ridge National Laboratory)

Technical Approach

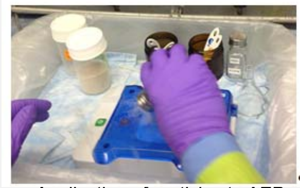
- Radiologically tagged simulated fallout material (RTSFM)
  - Three particle sizes (<150 µm, 150 to 250 µm, >250 µm) allows studying efficacy as function of particle size; similar to fallout sizes
  - Similar to work done in by EPA / Defense Research and Development Canada
  - Each size contaminated with different contaminant: cesium (<150 µm), cobalt (150 to 250 µm), and strontium (>250 µm); selected for detectability
- Contamination method
  - Spike aqueous radionuclide into sized sand, mix well, dry
- Detection
  - ORTEC PopTop Portable Gamma Detector

Collage of particle contamination steps

EPA United States Environmental Protection Agency

Experimental Design

- Contaminate sensitive equipment
  - Target activity of ≥ 0.6 µCi (ranged from 1 to 10 g per sample to ensure detectability
  - Distribute particles evenly across surface of equipment
  - Transported in static-free bags to minimize loss of particles from surfaces
- Measure pre-decontamination activities
  - 100 second measurements of contaminated samples to ensure detectability in shortest feasible time (90 samples)
  - 200 second measurement of post-decon activity to measure removal in reasonable time



Application of particles to AED

Insertion of contaminated handheld radio into bag

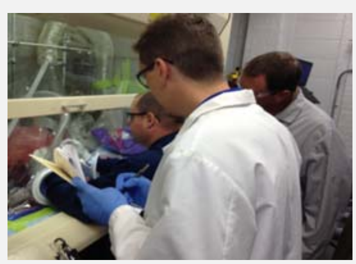
Pre-decon activity measurement

EPA United States Environmental Protection Agency

Experimental Design

- VAC canister located outside of glove bag; hose inserted with opening sealed around hose
- Glove bag vented to prevent glove bag collapse
- VAC used to prevent gross contamination during CAD decontamination

Glove bag in hood prepared for testing

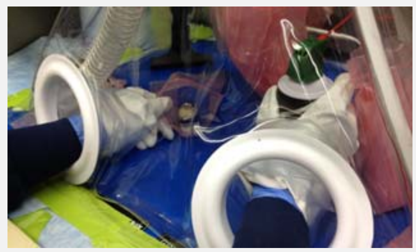


Ongoing decontamination test with QA oversight

Experimental Design

- Decontaminate in glove bag with VAC and CAD
- VAC moved across surface of equipment first in one direction, rotated 90 degrees, and repeated
- CAD - initial "gentle" back and forth flow across surface with capture into bag
- Completed decon with "full-flow" across full surface

Responder bag readied for VAC decontamination



Pulse oximeter readied for CAD decontamination

Experimental Design

- Post-decontamination measurement

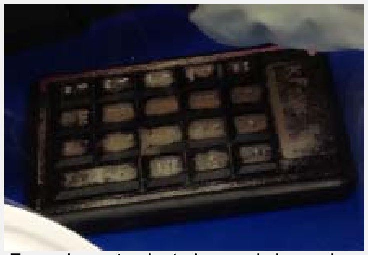
Sensitive equipment samples stored individually in bags and storage bins after contamination and before decontamination; as well as after decontamination and before post-decontamination measurement

"Map" to ensure consistent placement of equipment for gamma spectroscopy

Responder bag during activity measurement

United States Environmental Protection Agency

Visual Decontamination Efficacy


Example contaminated numeric keypad

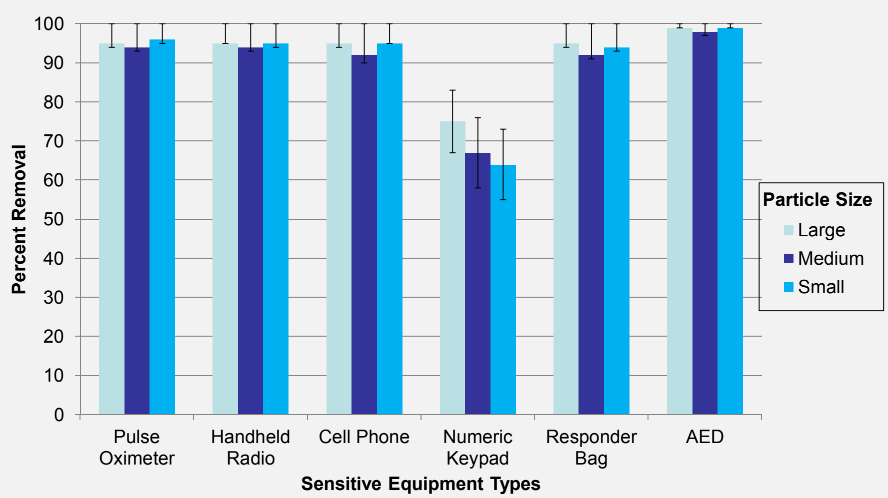

Example decontaminated numeric keypad


Example contaminated AED

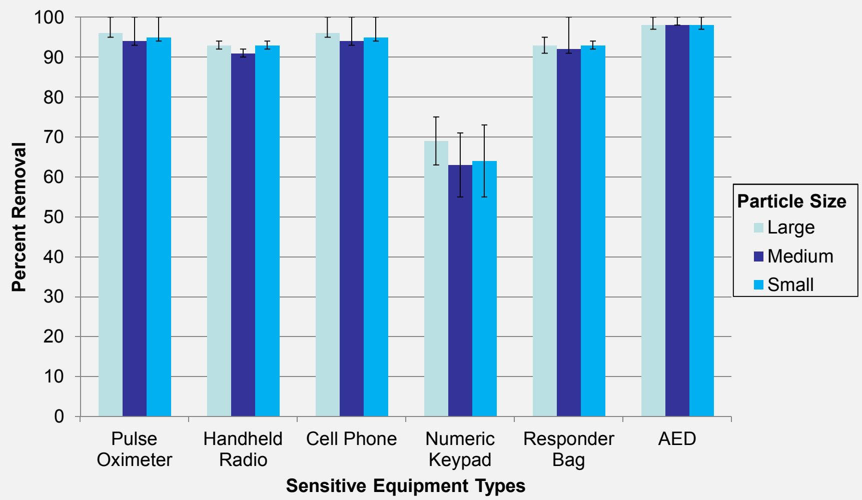

Example decontaminated AED

United States Environmental Protection Agency

Vacuum Removal



Compressed Air Duster Removal



Removal Results

Vacuum (% removal ±SD)

	Pulse Oximeter	Handheld Radio	Cell Phone	Numeric Keypad	Responder Bag	AED
Large	>95	>95	>95	75 ± 8	>95	>99
Medium	>94	>94	>92	67 ± 9	>92	>98
Small	>96	>95	>95	64 ± 9	>94	>99

Compressed Air Duster (% removal ±SD)

CAD	Pulse Oximeter	Handheld Radio	Cell Phone	Numeric Keypad	Responder Bag	AED
Large	>96	93 ± 1	>96	69 ± 6	93 ± 2	>98
Medium	>94	91 ± 1	>94	63 ± 8	>92	>98
Small	>95	93 ± 1	>95	64 ± 9	93 ± 1	>98

Conclusions

- VAC and CAD highly effective across several different technologies
- Except for keypads, average removal was greater than 90%
- Keypads (with open space below keys) had ~ 60-75% removal
- No significant difference between particle size percent removal
- VAC has HEPA filter to enhance personal protection
- CAD has tendency to spread contamination

Efficacy of Sporicidal Wipes on Select Surfaces

Kathryn Meyer, Ph.D.

Jenia Tufts, M. Worth Calfee, Lukas Oudejans

Environmental Protection Agency
National Homeland Security Research Center
Decontamination and Consequence Management Division

Background

- Several wipes are registered with the EPA as effective against *Clostridium difficile* spores
  - immersion or suspension based carrier test
- No quantitative efficacy data with *Bacillus anthracis* or its surrogate(s)
- Current tests don't reflect the activity of these wipes in practice:
  - contact time
  - prescribed wiping action
  - size of "target" area

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Questions

- Can these wipes be used to surface treat anthrax “hotspots”?
- Could these wipes transfer spores between locations?
- Are the prescribed times for inactivation of *C. difficile* applicable for a *B. anthracis* surrogate?

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2-phase Efficacy Testing

1st phase: Small scale – glass Petri dishes	*2nd phase*: Large scale – 14” x 14” material coupons
• Wet (liquid) spores • Surface: 150 mm glass Petri dish • All wipes tested	• Aerosolized (dry) spores • Surfaces: stainless steel, glass, composite epoxy, drywall, low-density polyethylene • Only top 3 performing wipes

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Test design

- 2 approaches
  - Small-scale
  - Large-scale

- 7 Decontaminant Wipes
  - Clorox Germicidal
  - Sani-Cloth Bleach Germicidal
  - Dispatch Hospital Cleaner
  - Steriplex SD
  - Lysol Disinfecting
  - Clorox Disinfecting
  - pH-adjusted Bleach wetted wipe
- 5 Materials
  - Glass
  - Painted drywall
  - Stainless steel
  - Low-density polyethylene
  - Composite epoxy

	Product	Vendor	Active Ingredients	Components	EPA Registration	Contact Time (min)
Sporicidal	**Clorox** Healthcare™ Bleach Germicidal Wipe	Clorox® Professional Products Co.	**Sodium hypochlorite**	Sodium hypochlorite 0.1-1.0%, sodium metasilicate 0.1-1.0%, sodium hydroxide 0.1-1.0%	67619-12	3
Sporicidal	**Sani-Cloth®** Bleach Germicidal Disposable Wipe	Professional Disposables International, Inc.	**Sodium hypochlorite**	Trisodium phosphate dodecahydrate 1-2.5%, sodium hypochlorite <1%	9480-8	4
Sporicidal	**Dispatch®** Hospital Cleaner Disinfectants Towels with Bleach	Clorox® Professional Products Co.	**Sodium hypochlorite**	Sodium hydroxide <0.2%, sodium metasilicate <0.6%, sodium hypochlorite <1.0%	56392-8	5
Sporicidal	**Steriplex®** SD Wipe	SteriScience, Inc.	**Hydrogen peroxide, peracetic acid**	Two separate component solutions: A: silver 0.015%, ethanol 10% B: hydrogen peroxide 22%, peracetic acid 15%, acetic acid 15%	84545-4	5
Disinfecting	**Lysol®** Disinfecting Wipe	Reckitt Benckiser North America	**Alkyl dimethyl benzyl ammonium chloride**	Alkyl (C14 50%, C12 40%, C16 10%) dimethyl benzyl ammonium chloride 0.1-1.0%	777-114	10
Disinfecting	**Clorox®** Disinfecting Wipe	Clorox® Professional Products Co.	**Alkyl dimethyl benzyl ammonium chloride**	Alkyl (C14 60%, C12 5%, C16 30%, C18 5%) dimethyl benzyl ammonium chloride 0.145%, alkyl (C14 32%, C12 68%) dimethyl ethylbenzyl ammonium chloride 0.145%	5813-58	4

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Test methods

- Spores of *Bacillus atrophaeus* (*Bg*) used as surrogate
- Coupon loading
  - ~2 x 10^6 spores / coupon (150 mm Petri dish)
  - ~2 x 10^7 spores / coupon (14” x 14”)

- Efficacy determined by “log reduction”
  - 3 replicate positive control coupons
  - 5 replicate test coupons
  - surface sample + wipe sample used for total log reduction (Task 1)

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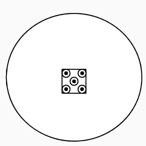
Small scale protocol: ASTM WK32908

1. Inoculate plates with 5 spots of 10 µl each. Allow to dry between 30-90 minutes.



2. Fold towelette in half; rotate towelette 90º and fold in half again. Target final dimensions: ~ 2” x 2”.

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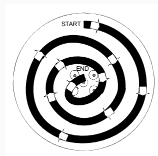
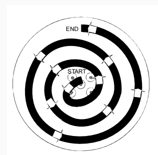
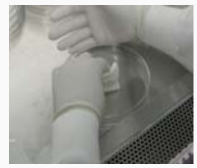
Small scale protocol: ASTM WK32908

3. Wipe surface of sterile Petri plate in 2 passes (1^{st} – outside → in, 2^{nd} – inside → out). Keep surface wet according to time prescribed by manufacturer. Save towelette(s) in 40 ml of appropriate neutralizer (wipe extract).







4. Immediately after the contact time has been reached, add 20 mL of appropriate neutralizer.

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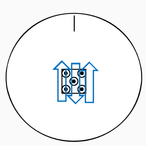
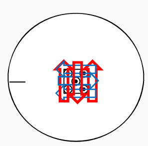
Small scale protocol: ASTM WK32908

4. Using cell scraper, scrape spots 3x with back and forth motions (6 total). Rotate plate ~90°, and repeat scraping.


5. Gently swirl to mix. Transfer to a sterile conical tube.

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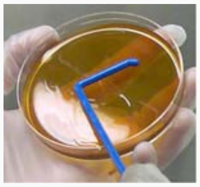
Small scale protocol: ASTM WK32908

6. Add an additional 20 mL of the appropriate neutralizer to the Petri plate, swirl to mix and pool with mixture in conical tube from previous step (surface extract).


7. Plate both the sample extract and wipe extract to enumerate spore counts and determine log reduction.

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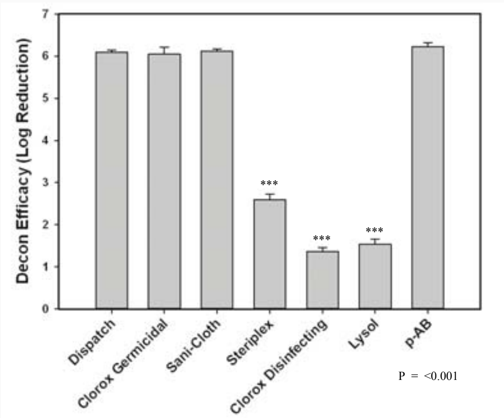
Small scale: RESULTS

Surface Log Reduction



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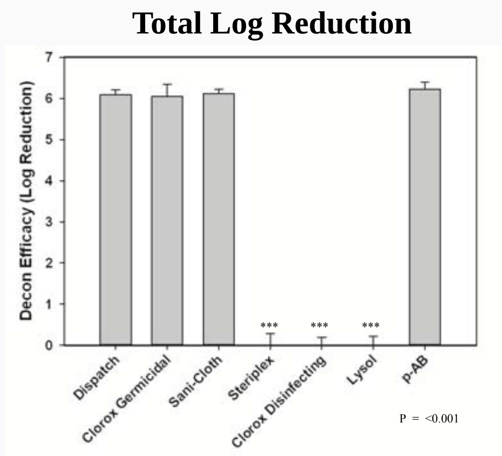
Small scale: RESULTS

Decontamination efficacy test results (± 95% CI) for wipes tested.



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Small scale: RESULTS

Ranking	Test Wipe	Log Reduction
1	Dispatch®	≥ 6.09 ± 0.12
	Clorox® Germicidal	≥ 6.05 ± 0.30
	Sani-Cloth®	≥ 6.12 ± 0.11
4	pH-amended bleach wetted wipe	6.23 ± 0.17¥
5	Clorox® Disinfecting	0.01 ± 0.18
6	Steriplex® SD	≤ 0§
	Lysol®	≤ 0§

≥ indicates no viable spores were recovered following treatment with the wipe.
¥ One CFU observed on one filter plate sample during analysis, four of five samples resulted in no viable spores recovered.
§ Amount of spores recovered exceeds amount recovered from positive controls.

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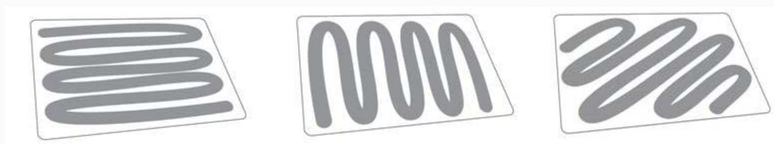
Large scale protocol: 14” x 14” coupon

1. Inoculate coupon using an MDI through aerosol deposition apparatus (ADA). Allow spores to settle for ~18-24 hrs.

2. Fold towelette 2 times. Wipe surface of sterile coupon using sporicidal towelette. With each of the 3 wipe directions, fold towelette inward each time before use. Save towelette in 40 ml of appropriate neutralizer (wipe extract).



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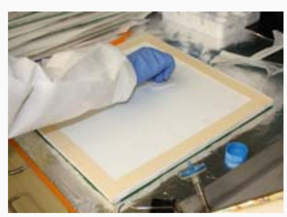
Large scale protocol: 14” x 14” coupon

3. Immediately after the contact time has been reached, sample surface using moistened gauze (surface extract) according to the CDC gauze procedure and same wiping pattern as before.



4. Extract spores from both wipe and surface samples using appropriate neutralizing solution.

5. Plate both the sample extract and wipe extract to enumerate spore counts and determine log reduction.

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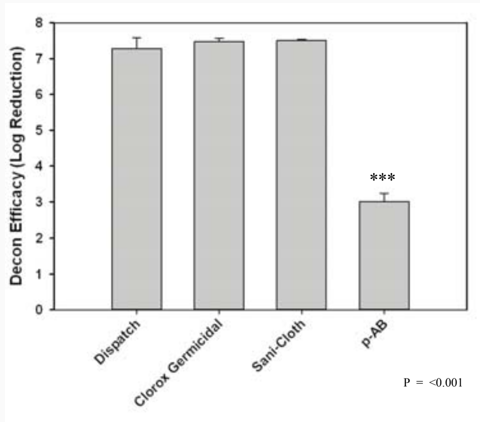
Large scale: RESULTS

Decontamination efficacy test results (± 95% CI) for wipes tested.

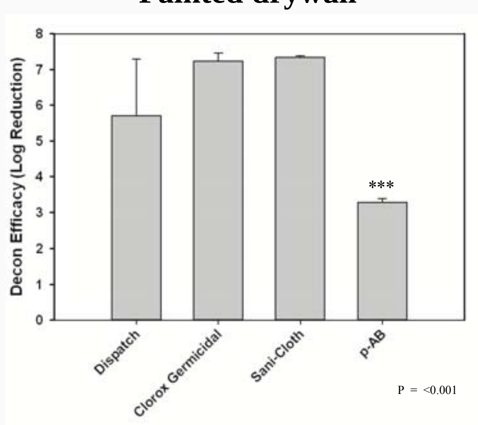
Glass



Large scale: RESULTS

Decontamination efficacy test results (± 95% CI) for wipes tested.

Painted drywall



Large scale: RESULTS

Test material	Clorox® Germicidal	Sani-Cloth®	Dispatch®	pH-amended bleach
Stainless Steel				
Glass	7.47 ± 0.09¥	≥ 7.50 ± 0.04	7.29 ± 0.30¥	3.01 ± 0.23
Composite Epoxy				
Painted Drywall	7.24 ± 0.23¥	≥ 7.34 ± 0.05	5.71 ± 1.59	3.28 ± 0.10
Low-Density Polyethylene				

≥ indicates no viable spores were recovered following treatment with the wipe.
¥ Less than 10 CFU observed during surface and wipe sample analysis of all 5 replicates.

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Summary

- *Bacillus* spore removal/inactivation efficacy varies considerably by active ingredient
  - cloth material/wipe design
- Commercially available disinfecting wipes showed no sporicidal or sporistatic activity
- Comparison of small-scale and large-scale shows log reduction differences for p-AB wetted wipes
  - wipe wetness vs. area

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United States Environmental Protection Agency

Inactivation of Bacillus Spores in Decontamination Wash Down Wastewater using Chlorine Bleach Solution

Vicente J. Gallardo, US EPA

EPA International Decontamination Research and Development Conference,

Research Triangle Park, NC

November 7, 2013

Office of Research and Development
Home and Secur ty Research Program

United States Environmental Protection Agency

Problem statement.
Large quantities of wash water can be generated during remediation of areas contaminated with *Bacillus anthracis* (*B. anthracis*) spores.

How can the water be treated and disposed of in a simple and effective manner?

1 Office of Research and Development
Homeland Security Research Program

EPA United States Environmental Protection Agency

Example:
U.S. Capitol Building Cleanup (2001-2002)

- *B. anthracis* spores in 7 of 26 buildings
- **14,235 gallons of wash water**
- Wash water Sources:
  - –Personnel decon
  - –Equipment/vehicle decon
  - –May contain *B. anthracis* spores
- Inactivation protocol used
  - –Steam sterilization at Fort Detrick, MD and then disposal at on-site treatment plant

2

EPA United States Environmental Protection Agency

US National Response Team Quick Reference Guide

Recommended method for inactivating *B. anthracis* in wash water generated from personnel decontamination

For a given volume of wash water
- Add 10% (by volume) of both household bleach and white vinegar
  - –e.g., 80 liters water, 10 liters bleach, 10 liters of vinegar
- Allows for on-site treatment
- Vinegar added to lower pH to ~7

1 hour contact time

3

Purpose of Study

- Evaluate recommended procedure using real world wash water generated from simulated decontamination activities.
  - –Procedure originally developed for surface decontamination (e.g., counter tops)
  - –Had not been evaluated in water with particulate and organic matter
    - Presence of particulate/organic matter may lower amount of disinfectant available for inactivation
  - –Evaluate in multiple types of wash water
  - –Evaluate using a surrogate for *B. anthracis*
    - *B. atrophaeus* spp. g*lobigii* (Bg)
      - –Bg is more resistant to chlorine than *B. anthracis*
      - –Easily identifiable in wash water matrices

4

Chlorine Basics

- Source of chlorine: household bleach e.g., Clorox®
- Active ingredient: sodium hypochlorite (NaOCl)
- Bleach used in study contained 6 % NaOCl
- 100% bleach = 6% NaOCl = 6 g NaOCl/100 g solution = 60,000 mg NaOCl/liter ≈ 60,000 mg Cl_2/liter
- **6% NaOCl ≠ 6% bleach**
- 10% bleach solution
  - 90 liters of water + 10 liters of bleach
  - Yields 6,000 mg NaOCl/liter or 0.6% NaOCl
- Newer bleach formulations contain higher amounts of NaOCl

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Chlorine Basics (cont.)

- pH of bleach: 11 – 12
- Lowering pH of bleach solution to ~7 increases germicidal properties
  - –pH = 7, hypochlorous acid is more favored
    - ~75% of chlorine species is in form of hypochlorous acid; 25% in form of sodium hypochlorite
      - –Mixture is ~60 – 200 times more germicidal
    - Vinegar is added to produce a pH of ~ 7
  - –Lowering pH too much can yield chlorine gas

6

Disinfection Basics

- Chick-Watson model is assumed
  - $\log_{10}[Bg]_i - \log_{10}[Bg]_t = \Lambda Ct$
    - Λ = Coefficient of specific lethality
    - C = disinfectant concentration
    - t = contact time
    - ($\log_{10}[Bg]_i - \log_{10}[Bg]_t$) known as log reduction.
      - e.g., starting spore concentration 10^7,
      - final spore concentration 10^2
      - $\log_{10}[10^7] - \log_{10}[10^2] = 5$, or a 5 log reduction or 99.999% reduction

7

Disinfection Basics (cont.)

- Plot of log reduction versus Ct should be a straight line
  - (Ct = disinfectant concentration x contact time)
- For a given value of Ct, can predict log reduction
- In water treatment, typical log reduction goal: 2 – 4 log reduction of pathogens, e.g., Giardia cysts, enteric viruses
- For this study, goal was to evaluate process for a 6 log reduction (99.9999% reduction)

8

Experimental Approach

- Generate water from various decontamination activities
  - Mock decontamination of personnel in personal protective equipment (PPE)
  - Washing of floors and other lab surfaces
    - Tap water
    - Tap water with added hardness
  - Car wash/rinse water
  - Storm water
- Evaluate at two temperatures: 20 and 4 ° C
- Wash water typically contained a detergent

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Experimental Approach (cont.)

- Added known amount of spores to a volume of wash water
- Target spore amount was enough to show >6 log reduction
- Add disinfectant, measure viable spores with time
- Disinfectant reaction halted by adding quenching agent
- Evaluated effect of prolonged contact between spores and particulate matter in wash water

10

Early Results with Bleach and Vinegar

- Complete inactivation (greater than 5 log removal) in ~1 minute.
- Conclusion: more rigorous than needed
- Try using lower amounts of bleach and eliminating vinegar
  - Simplifies procedure
    - If wash water has buffering agents, then more difficult to add correct amount of vinegar
  - Results in a less hazardous procedure
    - Minimizes potential of chlorine gas formation

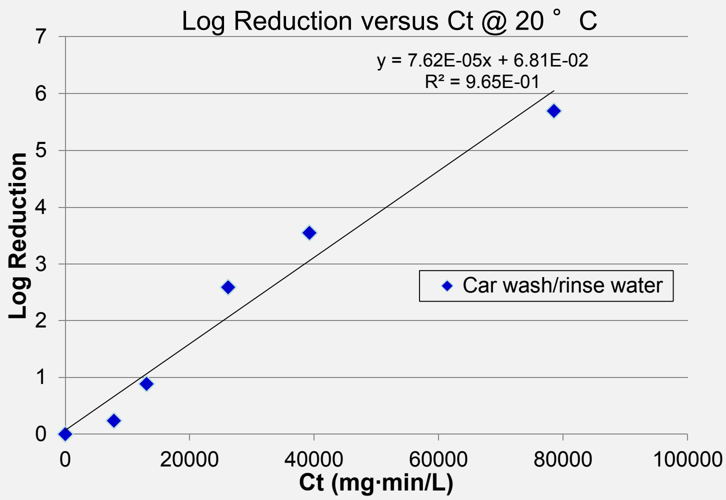
11

Data Presentation

Plot Log Removal versus Ct

Calculate Λ (slope of line)

Calculate time for 6 log removal



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Inactivation of Bg Spores in 5% bleach

Wash Water	Temp. ° C	Time for 6 log kill (min.)	Std. Dev. (n=3)*
Floor wash water (with 1% Alconox®)	20	**11**	*2.9*
	4	**29**	*21.0*
Floor wash water (with 1% Alconox® and added hardness)	20	**6**	*0.2*
	4	**20**	*6.0*
Car wash/rinse water (w/1% Dawn®)	20	**28**	*0.6*
	4	**89†**	*4.1*
PPE wash water with 1% Alconox ®	20	**10**	*3.4*
	4	**12**	*1.5*
PPE wash water with 1% Alconox® and added hardness	20	**5**	*0.7*
	4	**13**	*1.8*
Stormwater runoff	20	**56**	*26.5***
	4	**87**	*13.8*

*n = 3, unless otherwise noted

**n = 5

† Extrapolated value; did not achieve ≥ 6 log removal

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Inactivation of Bg Spores in 5% bleach

Wash Water	Time for 6 log kill (min.)	pH initial	pH final	COD mg/L	TSS mg/L	Alka-linity mg/L
Floor wash water (with 1% Alconox®)	**11**	9.2	9.5	3,530	318	4473
	29	9.3	9.7	3,457	397	
Floor wash water (with 1% Alconox® and added hardness)	**6**	8.8	9.3	3,565	487	4590
	20	8.8	9.3	3,600	530	
Car wash/rinse water (w/1% Dawn®)	**28**	8	10.0	7,097	324	185
	89†	8.5	10.0	6,770	277	
PPE wash water with 1% Alconox ®	**10**	9.3	9.3	2,630	38	4030
	12	9.5	8.6	2,490	78	
PPE wash water with 1% Alconox® and added hardness	**5**	9	8.9	3,061	74	4190
	13	9.2	9.2	3,030	25	
Stormwater runoff	**56**	7.8	10.0	157	418	80
	87	7.7	10.2	144	168	

† Extrapolated value; did not achieve ≥ 6 log removal

Blue highlighted data indicates colder (4° C) temperature

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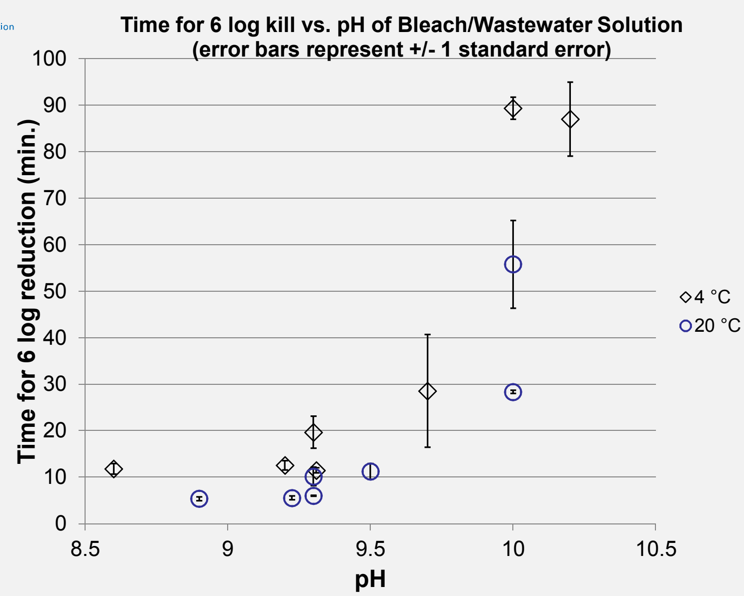

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Other Findings

- Level of chlorine did not change over length of inactivation test
- Prolonged contact time between spores and wash water did not influence time needed for 6 log reduction

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Conclusions

- 10% bleach + 10% vinegar (NRT protocol) is highly effective for inactivating Bg spores
  - May be more rigorous than needed
  - Adjusting pH will be challenging if wash water has significant buffering capacity
  - Potential for chlorine gas formation can be a concern
- 5% bleach with no vinegar is effective for inactivating Bg spores in wash waters tested
  - Colder temperatures will require longer times
- Chlorine demand from wash water constituents was not observed

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Conclusions (cont.)

- Prolonged contact time between spores and wash water did not influence time needed for 6 log reduction
- Inactivation efficiency varied among wash waters tested
- pH of the chlorine/wash water solution varied
  - May influence length of time required for 6 log removal
- No strong correlation between inactivation efficiency and other water quality parameters was observed

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Journal article that summarizes earlier work:

Muhammad, Nur; Gallardo, Vicente J.; Schupp, Donald, E.; Krishnan, Radha; Minamyer, K. Scott; Rice, Eugene, W. 2013. Inactivation of Bacillus Spores in Decontamination Wash Down Wastewater using Chlorine Bleach Solution. *Canadian Journal of Civil Engineering*

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  - Kevin Rhame, EPA
  - Rich Rupert, EPA
  - Dino Mattorano, EPA

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Thursday, November 7, 2013

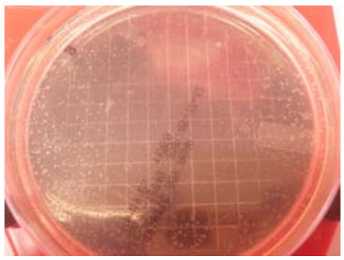
Concurrent Sessions 5

Biological Agent Decontamination

United States Environmental Protection Agency

Decontamination of Soil Contaminated with *Bacillus anthracis* spores

Joseph Wood (EPA)
Morgan Wendling, Andrew Lastivka,
Young Choi, James Rogers (Battelle)



Presented at US EPA Decontamination Research Conference, Research Triangle Park, NC, November 5-7, 2013

United States Environmental Protection Agency

Acknowledgements and Disclaimer

- Acknowledgements
  - –Leroy Mickelson, Dino Mattorano, Craig Ramsey

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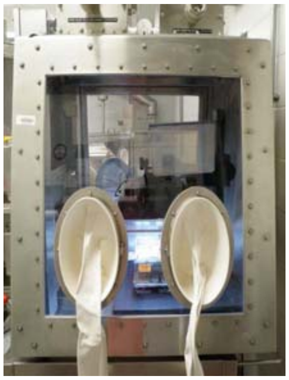
Outline

- Background
- Decon techs evaluated
- Methods
- Results
- References
- Lessons learned



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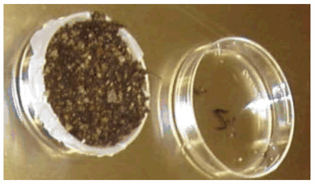
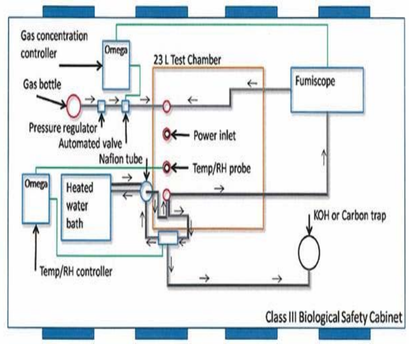
Background

- Remediation efforts could be extensive following an aerosol release of *Bacillus anthracis* (*B.a.*) spores in an urban area and will challenge the capabilities of government agencies and decontamination contractors.
- In such a scenario, many types of materials and environments may need to be decontaminated, including soils.
- Soil materials remain one of the most difficult materials to decontaminate.



Decon Technologies Evaluated

- Chlorine dioxide (ClO_2) gas
- Aqueous ClO_2 solution
- pH-amended (acidified) bleach
- Sodium persulfate activated with hydrogen peroxide
- Methyl bromide
- Metam sodium



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Decon Techs Evaluated (cont.)

- Tests were conducted with varying operational parameters to assess and improve their effect on decontamination efficacy
- Variables tested depended on decon tech., but included:
  - –contact time
  - –number of applications
  - –decontaminant concentration
  - –temperature, relative humidity (RH)
  - –soil depth

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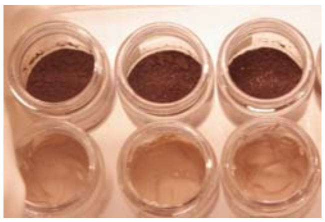
Methods

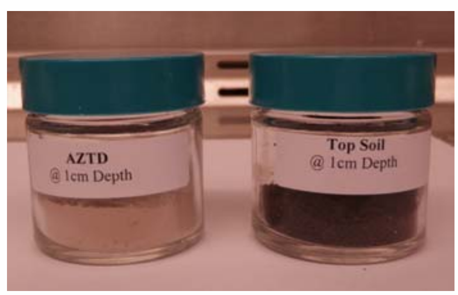
- *B.a.* (Ames strain)
- *Bacillus subtilis* (*B.s.*; ATCC 19659)
- Topsoil
- Arizona Test Dust (AZTD)



Methods (cont.)

Soil Inoculation:

- 1.5 in glass jars filled with sterile soil to a depth of 1 cm
- Samples inoculated with ~1x10^8 CFU of viable *B. a. or B. s.* spores using 100 µL liquid suspension
- Samples allowed to dry in Class III BSC overnight at ambient temperature and %RH
- Positive controls recovered; test samples exposed to decontaminant

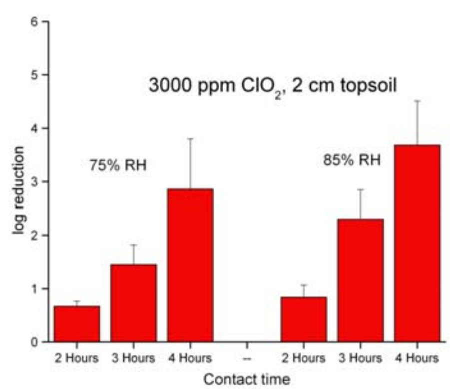


Microbiological Assays and Methods

- Extraction
- Serial dilution and plating
- Incubation
- Colonies enumerated and the CFU/mL determined
- Decontamination efficacy quantified in terms of log reduction (LR)

Results – ClO_2 Gas

- Nearly all AZTD samples completely decontaminated
- Greater than 6 LR for topsoil at 1 cm depth, 2 hour, both RH levels
- 2 cm topsoil much more difficult to decon



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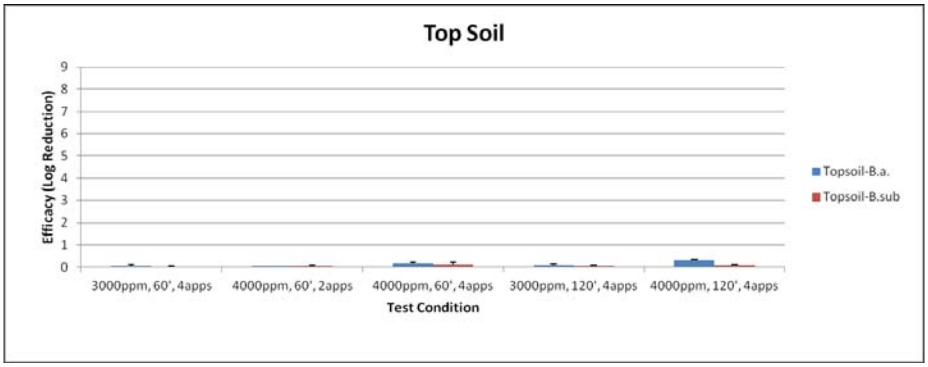
Results – Aqueous ClO_2



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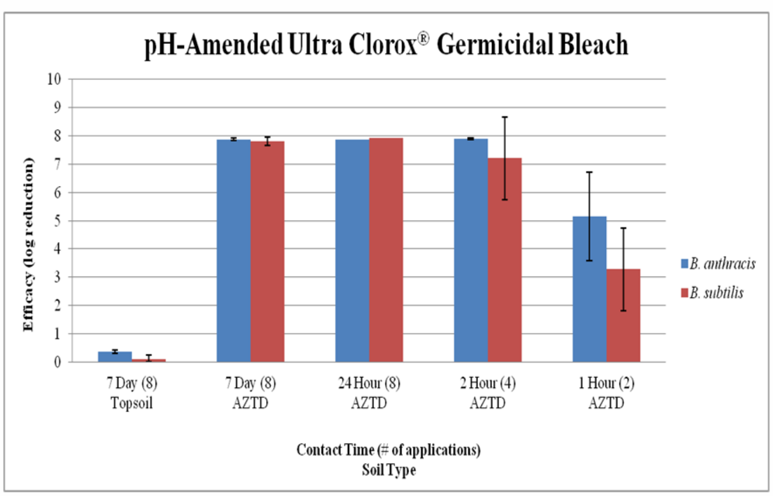
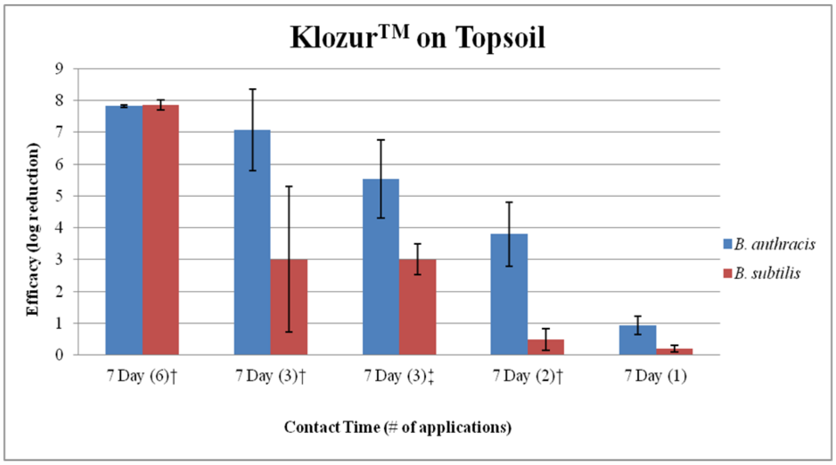
Results – Amended Bleach

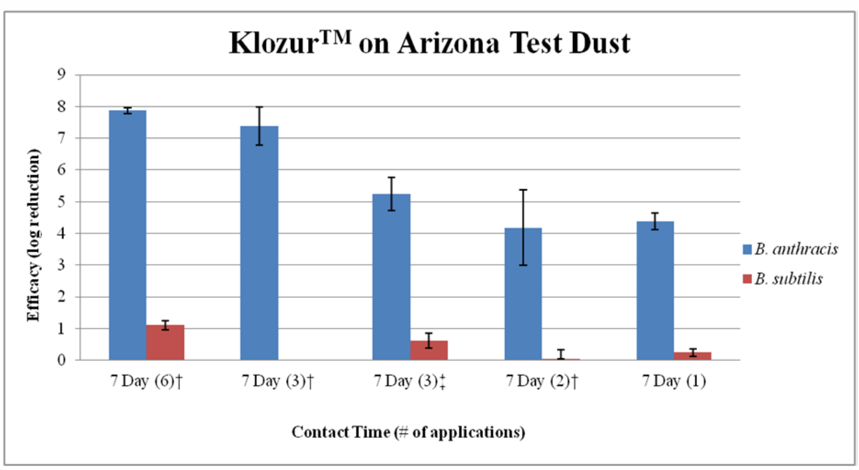


Results – Sodium Persulfate



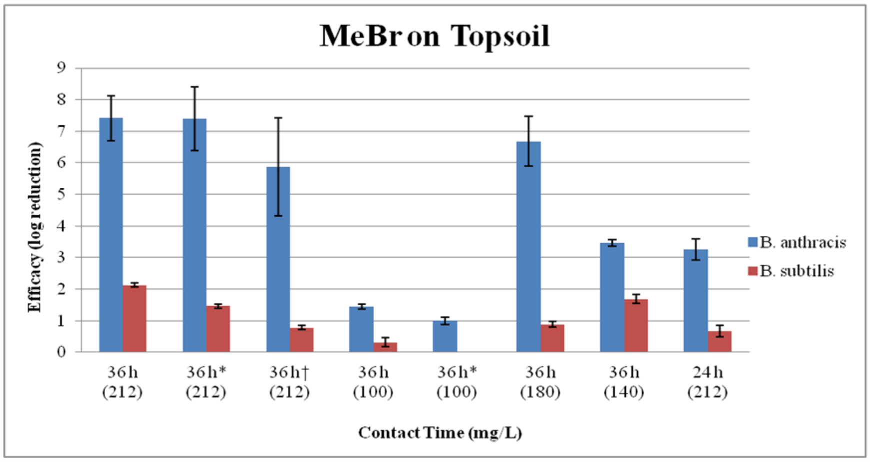
† = The decontaminant was applied every 60 minutes until the total number of applications were reached.
‡ =The decontaminant was applied on days 0, 2 and 4.

Results – Sodium Persulfate



† = The decontaminant was applied every 60 minutes until the total number of applications were reached.
‡ =The decontaminant was applied on days 0, 2 and 4.

Results – Methyl Bromide



* = 2 mL sterile filtered water added to each sample prior to inoculation.
† = samples dried in oven prior to inoculation.

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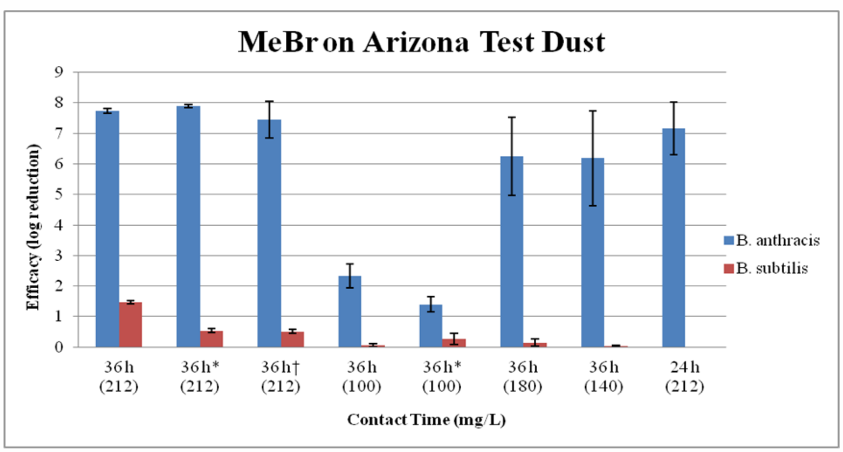
Results – Methyl Bromide



* = 2 mL SFW added to each sample prior to inoculation.
† = samples dried in oven prior to inoculation.

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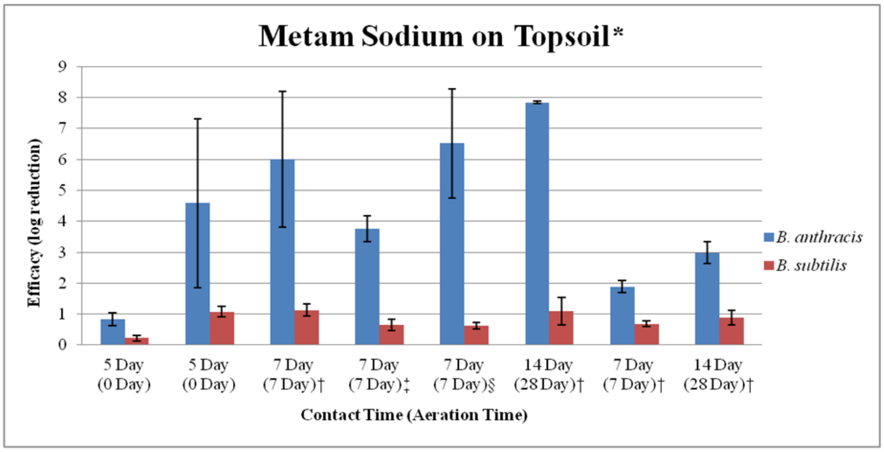
Results – Metam Sodium



* 2 mL SFW added to all samples prior to inoculation
† 1 mL SFW added prior to addition of metam sodium
‡ 2 mL SFW added prior to addition of metam sodium
§ 3 mL SFW added prior to addition of metam sodium

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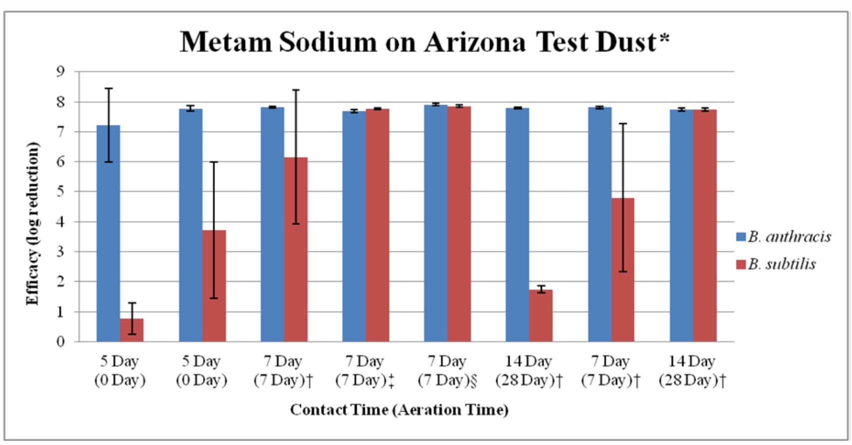
Results – Metam Sodium



* 2 mL SFW added to all samples prior to inoculation
† 1 mL SFW added prior to addition of metam sodium
‡ 2 mL SFW added prior to addition of metam sodium
§ 3 mL SFW added prior to addition of metam sodium

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References

- Poster presented at American Society of Microbiology 2013 meeting
- EPA reports

Lessons Learned

- Decon efficacy: > 6 LR for *B.a.* obtained with all decontaminants studied, on both soil types, except pH-amended bleach and aqueous ClO_2
- Surrogate: *B.s.* not inactivated to a higher degree than *B.a.* in any tests. *B.s.* too conservative a surrogate when using MeBr
- Soil Type: AZTD generally easier to decon, but depends on decontaminant (e.g. sodium persulfate efficacy for *B.a.* similar for both soil types)
- Soil depth: In tests with ClO_2 gas, increasing soil depth significantly impacted efficacy. Further research needed to asses impact of soil depth

Soil sanitation study: Effects of chlorine dioxide in gas and liquid phase on sporicidal efficacy

S. Newman
Colorado State University
Fort Collins, CO
and
C.L. Ramsey, Debra Newman
USDA-APHIS-PPQ
CPHST Lab – Fort Collins, CO

Study objectives

- Determine the soil respiration rates for nine chlorine dioxide formulations
  - Strategic Resource Optimization (SRO) - liquid
  - ICA Trinova – granule formulations
- Determine the sporicidal efficacy of nine chlorine dioxide formulations
  - Liquid suspension of *Bacillus subtilis* spores

Chlorine dioxide description

- Chlorine dioxide (ClO_2) is a synthetic, green-yellowish gas
- Chlorine dioxide is a small, volatile and very reactive molecule
- Chlorine dioxide is an oxidant, or oxidizing agent, sold as a general use disinfectant
- In diluted, watery solutions chlorine dioxide forms a free radical
- Chlorine dioxide is an unstable gas that dissociates into chlorine gas (Cl_2), oxygen gas (O_2) and heat.
- Chlorine dioxide is photo-oxidized by sunlight, and degrades very rapidly
- The end-products of chlorine dioxide reactions are chloride (Cl^-), chlorite (ClO^-) and chlorate (ClO_3^-).

Study factors

- Three chlorine dioxide formulations
  - ClO2 granules + bisulfate activator granules
  - ClO2 granules in permeable sachets
  - ClO2 as liquid + surfactant
- Three rates of ClO2 for each of the formulations

Chlorine dioxide treatments

Treatment number	ClO2 description	Rate (g/tube)	Bisulfate rate (g/tube)
1	Granule	1.5	6
2	Granule	15	60
3	Granule	15	0
4	Gas sachets	3 g of A	3 g of B
5	Gas sachets	6 g of A	6 g of B
6	Gas sachets	9 g of A	9 g of B
7	EB - liquid	600 ppm at 300 ml/tube	Na
8	EB-liquid	600 ppm at 600 ml/tube	Na
9	EB-liquid	600 ppm at 900 ml/tube	Na
10	Autoclaved soil – Negative control	Na	Na
11	Autoclaved soil + B. subtilis spores	Na	Na
12	Untreated control – Positive control	Na	Na

Methods

- Soil columns
  - Acrylonitrile Butadiene Styrene (ABS) tubes
  - resistant to ClO2
- Soil column size - 12” long and 4” inside diameter
  - soil column - filled up to 4 cm from tube top
  - each tube was capped

Soil Preparation

- Potting soil mixed with play sand
  - Mixed at a 75 to 25 parts per volume ratio
  - Potting soil - Fafard – 4-MP
  - Canadian sphagnum peat moss, processed pine bark, vermiculite, and perlite mix.
  - Very high organic matter in soil mix

Potting soil properties

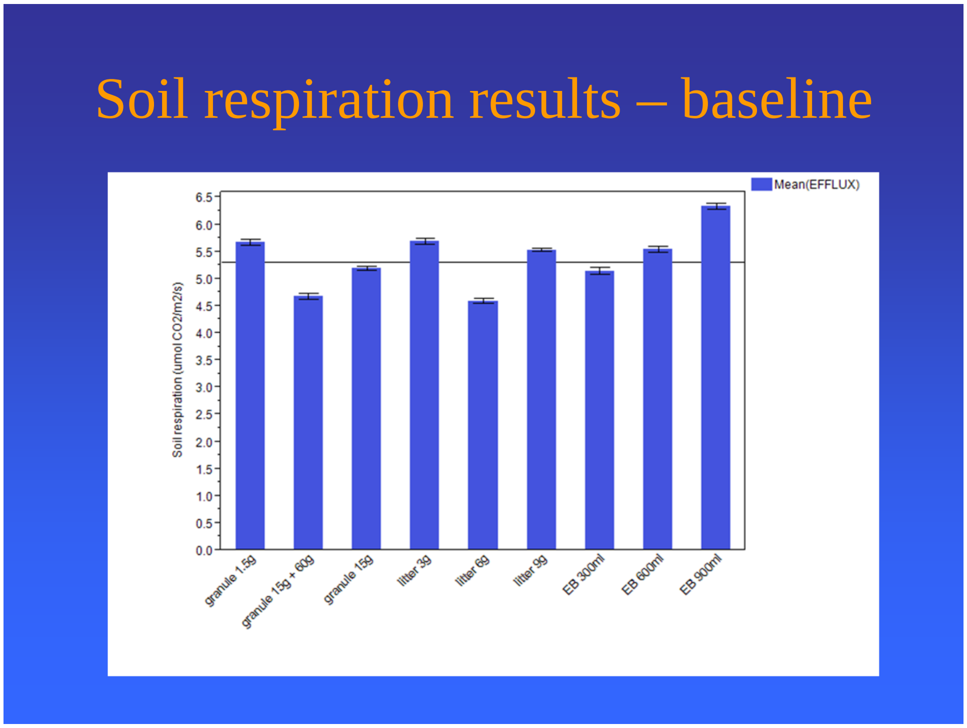
pH	EC	OM	Sand	Silt	Clay	Texture
	mmhos /cm			(%)		
6.1	0.4	11.6	82	0	18	Sandy Loam
6.1	0.4	10.4	78	3	19	Sandy Loam
6.1	0.3	27.8	78	4	18	Sandy Loam
6.2	0.4	7.7	76	0	24	Sandy Clay Loam

Bacillus subtilis efficacy methods

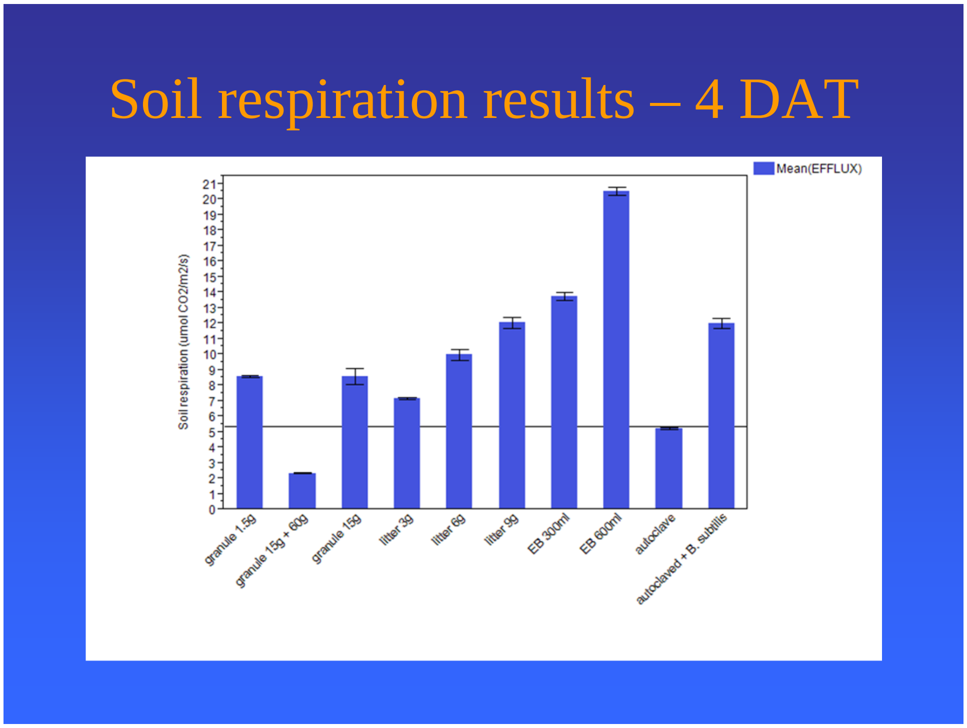
- *Bacillus subtilis* culture
  - MicroChem lab - American Type Culture Collection
- *B. subtilis* spores prepared as a liquid suspension
- Spores were refrigerated to maintain suspension in their spore stage
- 133 ml of *B. Subtilis* added immediately after the ClO2 application

Measurements

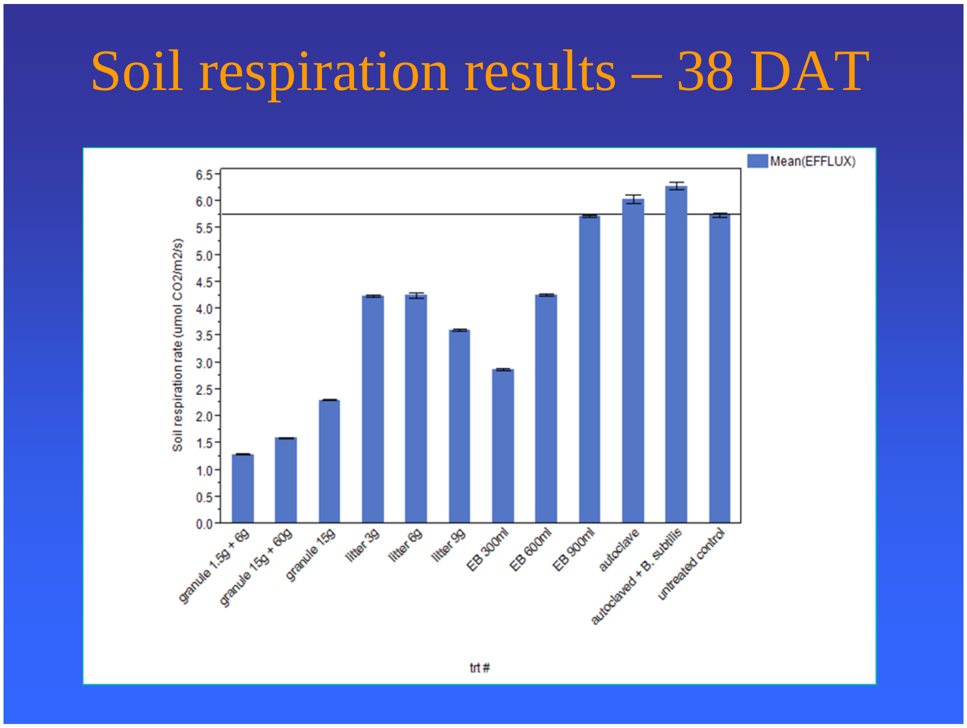
- Soil respiration
  - Measure carbon dioxide flux rate
  - Respiration a function of microbial population and soil decomposition
- Bacillus subtilis sporicidal efficacy
  - Add spore suspension
  - Collect soil at two soil depths (0 – 6cm)
  - Assay samples for viable spore counts

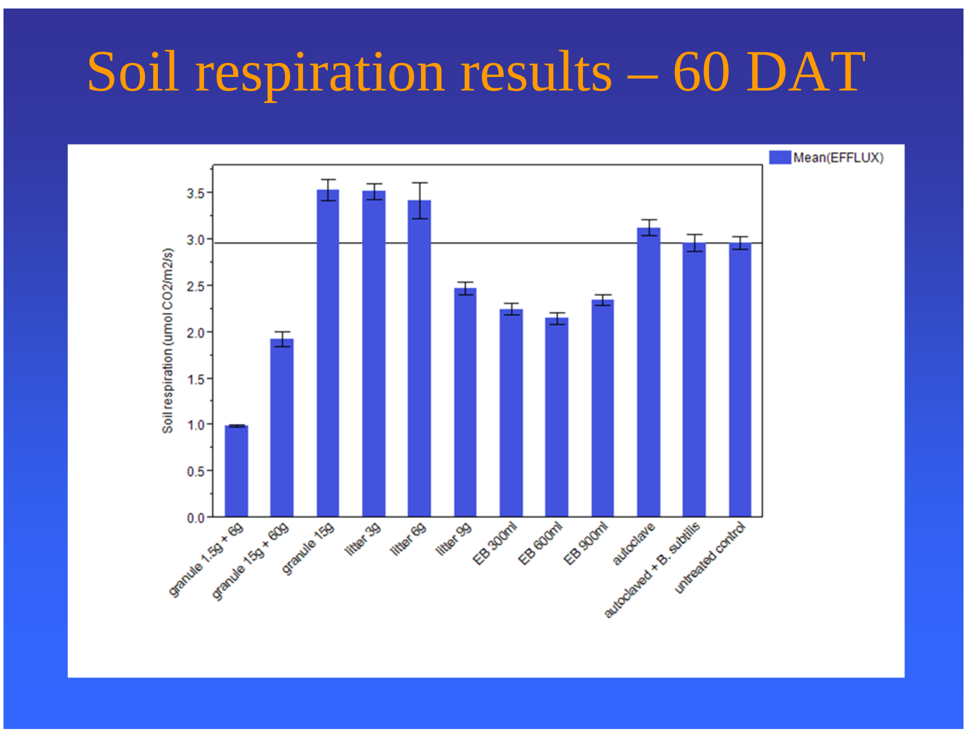


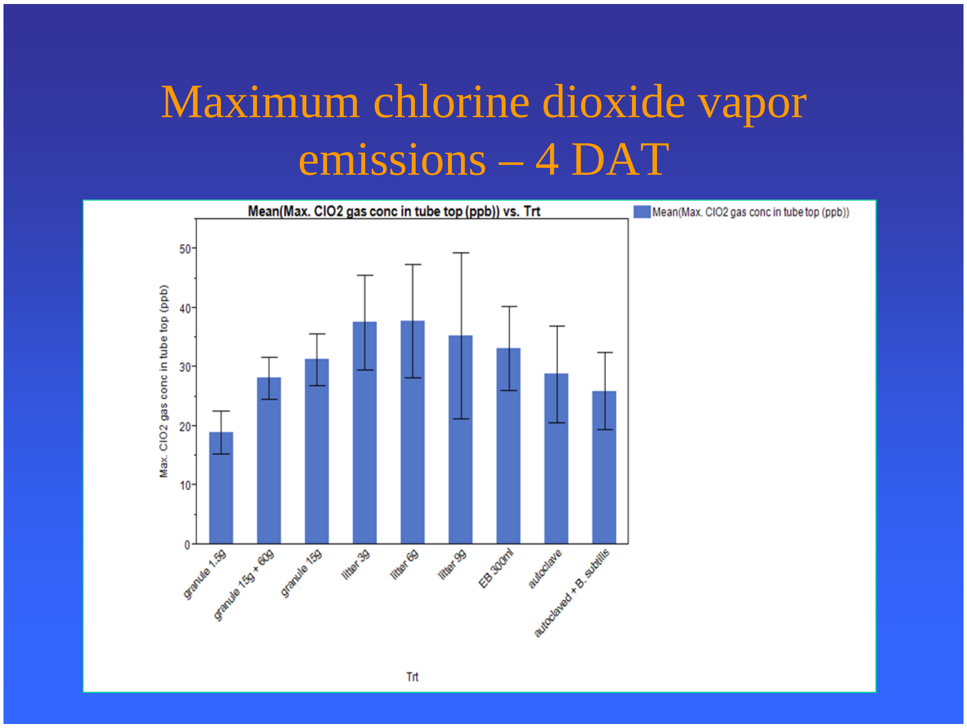
Soil respiration results – baseline
Mean(EFFLUX)
Soil respiration (umol CO2/m2/s)
granule 1.5g
granule 15g + 60g
granule 15g
litter 3g
litter 6g
litter 9g
EB 300ml
EB 600ml
EB 900ml

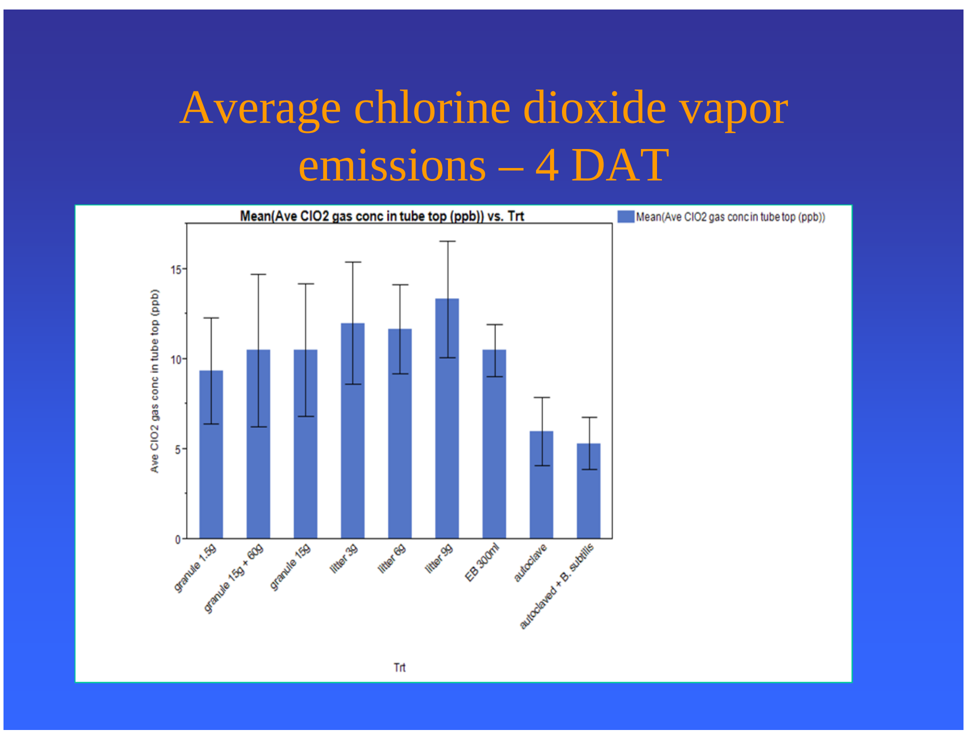


Soil respiration results – 4 DAT
Mean(EFFLUX)
Soil respiration (umol CO2/m2/s)
granule 1.5g
granule 15g + 60g
granule 15g
litter 3g
litter 6g
litter 9g
EB 300ml
EB 600ml
autoclave
autoclaved + B. subtilis

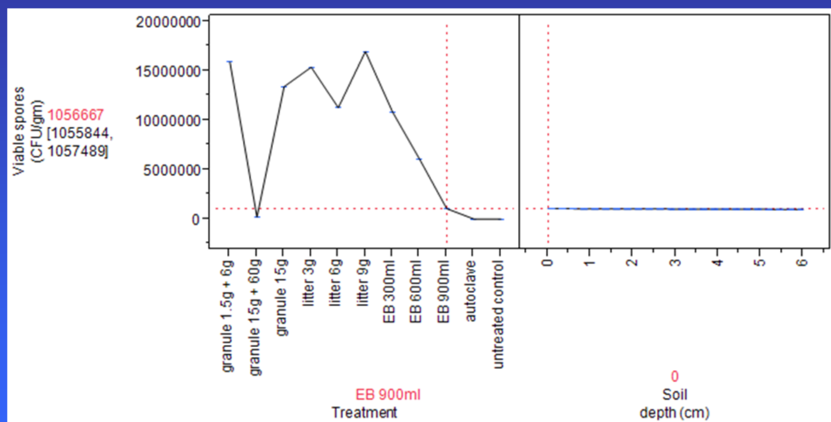

Soil respiration results – 38 DAT
Mean(EFFLUX)
Soil respiration rate (umol CO2/m2/s)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
granule 1.5g + 6g
granule 15g + 60g
granule 15g
litter 3g
litter 6g
litter 9g
EB 300ml
EB 600ml
EB 900ml
autoclave
autoclaved + B. subtilis
untreated control
trt #


Soil respiration results – 60 DAT
Mean(EFFLUX)
Soil respiration (umol CO2/m2/s)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
granule 1.5g + 6g
granule 15g + 60g
granule 15g
litter 3g
litter 6g
litter 9g
EB 300ml
EB 600ml
EB 900ml
autoclave
autoclaved + B. subtilis
untreated control


Maximum chlorine dioxide vapor emissions – 4 DAT
Mean(Max. ClO2 gas conc in tube top (ppb)) vs. Trt
Mean(Max. ClO2 gas conc in tube top (ppb))
Max. ClO2 gas conc in tube top (ppb)
0
10
20
30
40
50
granule 1.5g
granule 15g + 60g
granule 15g
litter 3g
litter 6g
litter 9g
EB 300ml
autoclave
autoclaved + B. subtilis
Trt

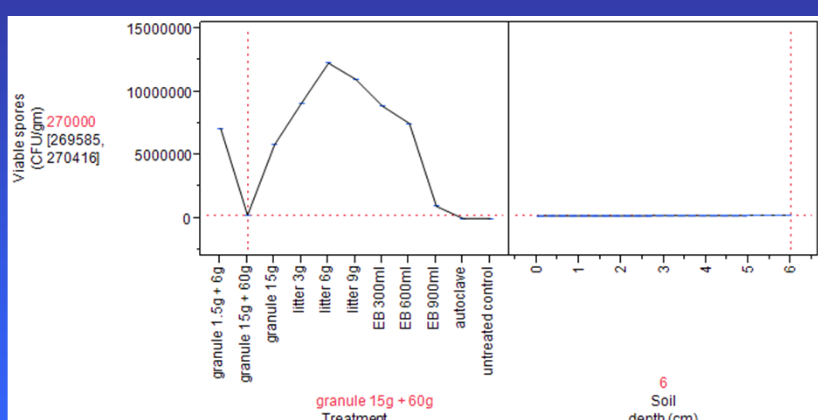

Average chlorine dioxide vapor emissions – 4 DAT
Mean(Ave ClO2 gas conc in tube top (ppb)) vs. Trt
Mean(Ave ClO2 gas conc in tube top (ppb))
Ave ClO2 gas conc in tube top (ppb)
0
5
10
15
granule 1.5g
granule 15g + 60g
granule 15g
litter 3g
litter 6g
litter 9g
EB 300ml
autoclave
autoclaved + B. subtilis
Trt

Viable spores (CFU/gm) by treatment – 63 – 64 DAT



Source	Prob>ChiSq
Treatment	<.0001*
Soil depth (cm)	0.7293
Treatment*Soil depth (cm)	<.0001*

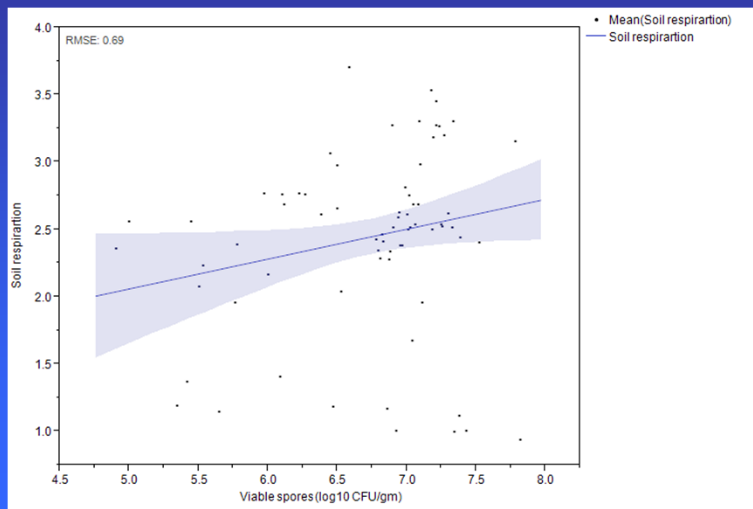
Viable spores (CFU/gm) by treatment – 63 – 64 DAT



Source	Prob>ChiSq
Treatment	<.0001*
Soil depth (cm)	0.7293
Treatment*Soil depth (cm)	<.0001*

Log10 reduction = 24 – 28%

Soil respiration over viable spore counts



Soil respiration and sporicidal efficacy comparison – 60 - 64 DAT

- Soil respiration
  - TriNova granule (1.5g) – 67% reduction
  - TriNova granule (15g) – 35% reduction
  - SRO EB (900 ml/tube) – 21% reduction
- B. subtilis sporicidal efficacy
  - TriNova granule (15g) – 24 - 28% reduction
  - SRO EB (900 ml/tube) – 16 - 20% reduction

Soil and oxidant factors

- Chlorine dioxide factors
  - Distribute ClO_2 evenly across the entire depth of soil in tubes
  - Estimate ClO_2 rates needed to overcome soil organic matter reactivity
- Soil factors
  - Include soil temperature and moisture with respiration data
  - Maintain soil at 10 – 20% soil moisture to encourage microbial recovery

Future studies

- Select target pests that do not require Epermits
- Test soil probe/tube application methods at soil depths down to one meter
  - Place pest sachets at selected soil depths – 12, 24, and 36” deep in soil
  - Use ClO_2 application probes to place ClO_2 at selected vertical and horizontal distances from pest sachet in soil – 2, 4, 6, 8” from sachet
  - Estimate ClO_2 soil placement and distance effects on pest toxicity levels

Future studies

- Repeat applications for both liquid and granular applications in greenhouse soil columns
  - Repeat apply for 3 – 6 times in 14 days
  - Measure soil respiration rates over time to estimate the microbial toxicity effects of each soil application
  - Measure long term (1-3 months) ClO_2 toxicity effects on soil respiration
- Test drip irrigation field methods

Questions

Test method development to evaluate hot, humid air decontamination of materials contaminated with *B. anthracis* ΔSterne and *B. thuringiensis* Al Hakam

Alice A. Young
Naval Surface Warfare Center – Dahlgren
November 7, 2013

Objective

Objective:

Develop a technology using the synergistic action of heat, humidity and time as a biological decontaminant(s) for sensitive equipment without degradation of the functionality of that equipment. Test the limits of decontamination technology.

Example of a Need:

There are no/limited sporicidal decontaminants that can be used on aircraft interior and/or sensitive equipment

U.S. Navy ships use hypochlorite despite >$1trillion annual cost due to corrosion in the U.S.

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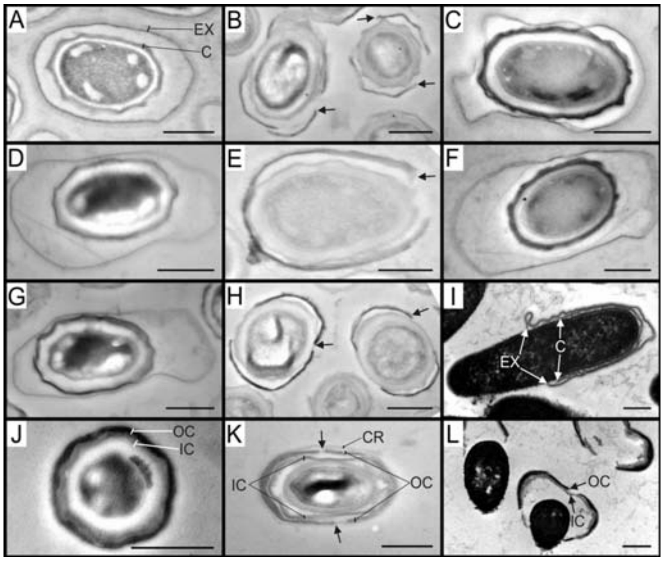
Spores – Healthy, Bleach, Heat-Killed



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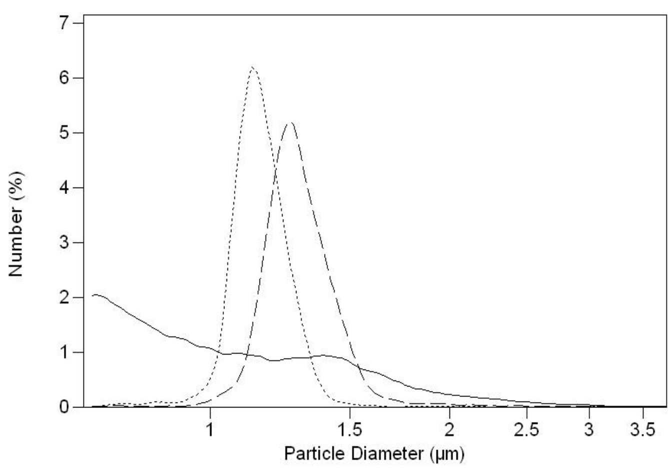
Isolation of Spores as Independent Variable



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Isolating spores as an independent variable

- Single spore preparation method developed for both test strains
- Quantity and Quality Objectives for Test Material
  - Threshold titer of 10^8 spores per mL^{-1}
  - At least 90% phase-bright spores
  - Heat resistance at 65C for 30 minutes
  - Demonstrate Uniform spore size with Coulter analysis

Strain (Number of Independent Preparations)	Titer (spores mL^{-1}) Before Processing (65° C, 30 min)	Titer (spores mL^{-1}) After Processing (65° C, 30 min)	Phase-Bright Spores (%)
B. anthracis **ΔSterne (12)**	**$4.8 \times 10^8 \pm 3.0 \times 10^8$**	**$4.3 \times 10^9 \pm 1.1 \times 10^9$**	**97.6 ± 1.6**
B. thuringiensis **Al Hakam (14)**	**$8.2 \times 10^8 \pm 1.8 \times 10^8$**	**$4.9 \times 10^9 \pm 1.7 \times 10^9$**	**98.0 ± 1.8**

Distribution Statement A: Approved for Public Release. Distribution is Unlimited

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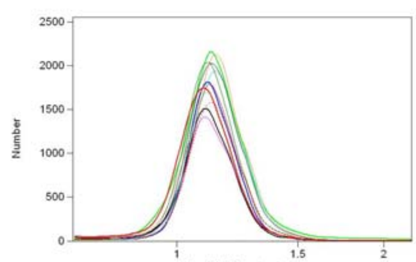
Isolating *B. anthracis* ΔSterne spores as an independent variable



Species – *B. anthracis* ΔSterne	Number	Spherical Diameter (μm)		
		Mean	Median	Mode
10/19/2010 AAY	35,157	1.10±0.14	1.09	1.09
10/26/2010 AAY	46,257	1.16±0.26	1.13	1.12
11/09/2010 AAY	30,800	1.13±0.14	1.12	1.11
11/09/2010 ZAM	26,921	1.11±0.20	1.10	1.09
11/23/2010 ZAM	26,345	1.12±0.19	1.11	1.09
12/03/2010 AAY	35,211	1.16±0.18	1.14	1.13
12/07/2010 ZAM	41,881	1.14±0.15	1.13	1.14
12/14/2010 TB/AAY	38,027	1.12±0.15	1.11	1.11
12/14/2010 DM	38,408	1.14±0.15	1.13	1.11
12/14/2010 ZAM	32,498	1.13±0.14	1.12	1.11
12/21/2010-200 TB/AAY	30,127	1.14±0.15	1.13	1.12
12/21/2010 ZAM	34,198	1.12±0.14	1.11	1.10
Combined	833,044	1.14±0.18	1.12	1.12

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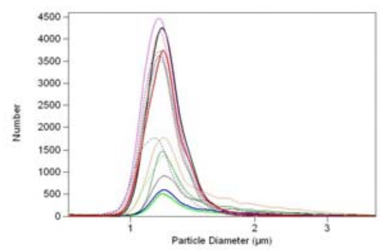
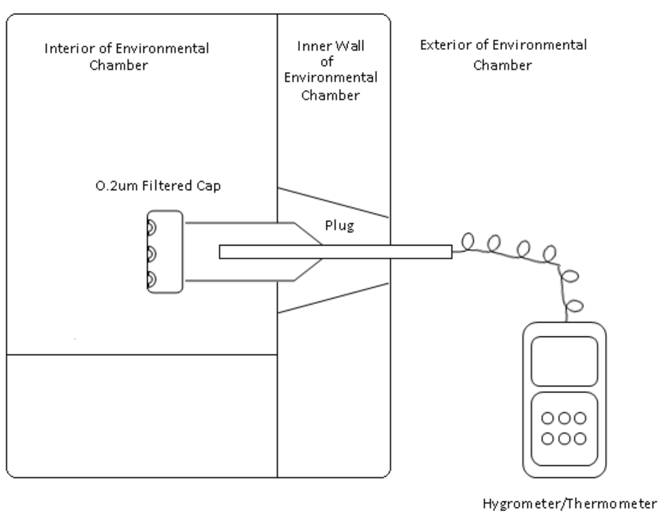
Isolating *B. thuringiensis* Al Hakam spores as an independent variable

Species – *B. thuringiensis* Al Hakam	Number	Spherical Diameter (µm) Mean	Median	Mode
10/19/2010 AAY	76,998	1.23±0.17	1.20	1.19
10/26/2010 AAY	9,264	1.43±0.71	1.25	1.18
11/02/2010 AAY	12,468	1.45±0.71	1.26	1.19
11/02/2010 ZAM	86,499	1.22±0.14	1.20	1.19
11/09/2010 AAY	101,021	1.21±0.17	1.18	1.19
11/09/2010 ZAM	71,097	1.22±0.17	1.19	1.18
11/16/2010 ZAM	47,690	1.53±0.11	1.29	1.20
12/03/2010 AAY	27,918	1.48±0.64	1.27	1.19
12/07/2010 ZAM	24,181	1.63±0.93	1.30	1.19
12/14/2010 TB/AAY	75,728	1.20±0.15	1.18	1.19
12/14/2010 DM	74,948	1.21±0.16	1.19	1.19
12/14/2010 ZAM	37,355	1.43±0.57	1.24	1.19
12/21/2010 TB/AAY	85,737	1.20±0.17	1.18	1.19
12/21/2010-200 TB/AAY	43,160	1.26±0.38	1.16	1.13
Combined	1,560,000	1.28±0.38	1.20	1.19



Validation of Temperature/RH



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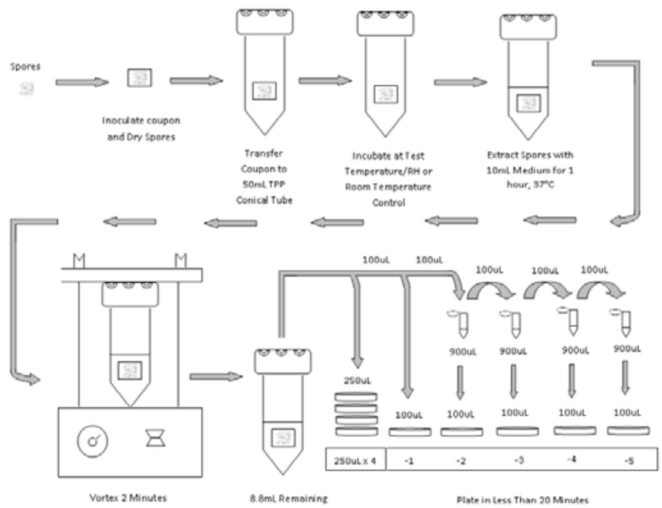
Step-by-Step Decontamination Method



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Biological Experimental Design

Coupon Type	Dried Spores Test	Dried Spores RT	Wet Spores Test	Wet Spores RT	Number for Each Test Run
APC Wiring Insulation	10	10	0	0	20
InsulFab	10	10	0	0	20
Anti-skid	10	10	0	0	20
Nylon	10	10	0	0	20
Plastic	10	10	10	10	40
Total					140

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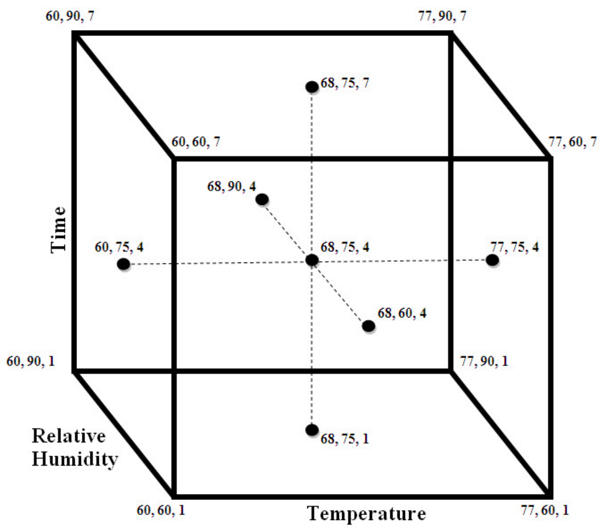
Design of Experiments



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B. anthracis ΔSterne – 1st & 2nd Iteration of DOE

		Relative humidity (RH) and time of decontamination								
		90% RH	90% RH	90% RH	75% RH	75% RH	75% RH	60% RH	60% RH	60% RH
Coupon Material	Temp (° F)	1 day	4 days	7 days	1 day	4 days	7 days	1 day	4 days	7 days
APC	170	0	NA	0	NA	0	NA	6.2	NA	0
APC	155	NA	0	NA	3.1	0.3	0	NA	3.6	NA
APC	140	6.5	NA	0	NA	3.9	NA	7.2	NA	5.3
Wiring insulation	170	0	NA	0	NA	0	NA	6.1	NA	0
Wiring insulation	155	NA	0	NA	0.3	0	0	NA	0	NA
Wiring insulation	140	5.7	NA	0.2	NA	0	NA	7.2	NA	4.5
Nylon	170	0	NA	0	NA	3	NA	7.3	NA	6.3
Nylon	155	NA	4.2	NA	7.1	7	6.6	NA	7	NA
Nylon	140	7.1	NA	6.9	NA	6.4	NA	7.3	NA	6.9
Insulfab	170	0.6	NA	0	NA	0	NA	5.6	NA	0
Insulfab	155	NA	0	NA	0.4	0.3	0	NA	1.4	NA
Insulfab	140	5	NA	0	NA	0.4	NA	6.6	NA	5.5
Anti-skid patches	170	0	NA	0	NA	0	NA	5.6	NA	0
Anti-skid patches	155	NA	0	NA	3.9	0.8	0.1	NA	2.8	NA
Anti-skid patches	140	4.6	NA	0.8	NA	3.3	NA	6.9	NA	5.1
Plastic	170	0	NA	0	NA	0	NA	6	NA	0
Plastic	155	NA	0	NA	6.2	5.1	0	NA	0.3	NA
Plastic	140	7.1	NA	4.5	NA	5	NA	7.2	NA	6.4
Wet	170	0	NA	0	NA	0	NA	0	NA	0
Wet	155	NA	0	NA	0	0	0	NA	0	NA
Wet	140	7.2	NA	2.8	NA	0	NA	7	NA	1.7

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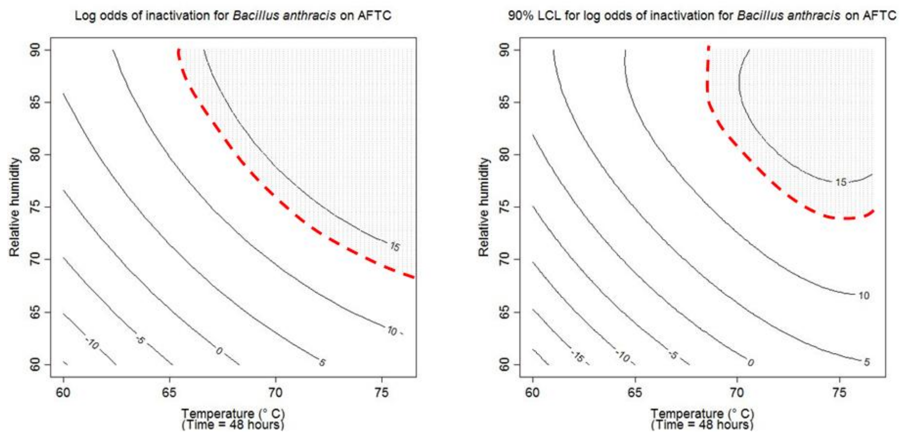
Hot Humid Air Decontamination



2D contour plots for *B. anthracis* ΔSterne on APC at 48 hours of treatment with hot humid air. The solid contour lines are log odds of inactivation. The shaded area on the upper right represents a log reduction of greater than or equal to 6 logs of the fitted equation. The left plot shows average values. The right plot shows the 90% lower confidence limit for the average.

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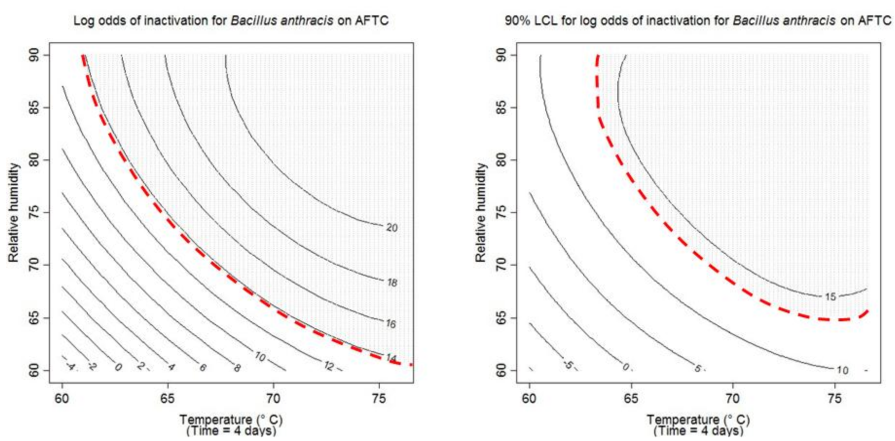
Hot Humid Air Decontamination



2D contour plots for *B. anthracis* ΔSterne on APC at 4 days of treatment with hot humid air. The solid contour lines are log odds of inactivation. The shaded area on the upper right represents a log reduction of greater than or equal to 6 logs of the fitted equation. The left plot shows average values. The right plot shows the 90% lower confidence limit for the average.

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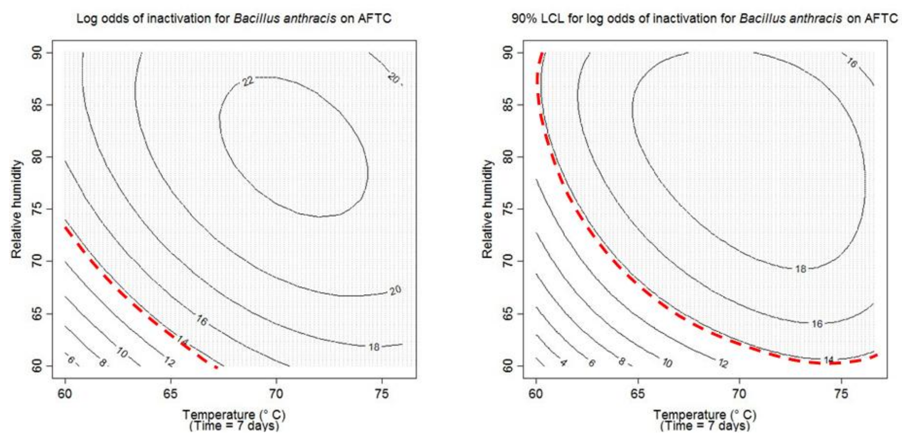
Hot Humid Air Decontamination



2D contour plots for *B. anthracis* ΔSterne on APC at 7 days of treatment with hot humid air. The solid contour lines are log odds of inactivation. The shaded area on the upper right represents a log reduction of greater than or equal to 6 logs of the fitted equation. The left plot shows average values. The right plot shows the 90% lower confidence limit for the average.

Next Step

- Laboratory-Grade – High purity spores
  - Testing completed
  - Isolation of spores as an independent variable
- Field-Grade - Spores + dirt debris
  - Currently being tested
- Crude Preparation or Organic Burden-Grade - Spores + food debris (prime example is agar)
  - Currently preparing to test

- Need:
  - Compare laboratory-grade spores to spores with each of the additives, in order to determine impact of debris and additives for neutralization;
  - Many potential options, so must be selective

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Acknowledgements

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• Materials
Tim Provens and Bill Culhane at Wright-Patterson AFB

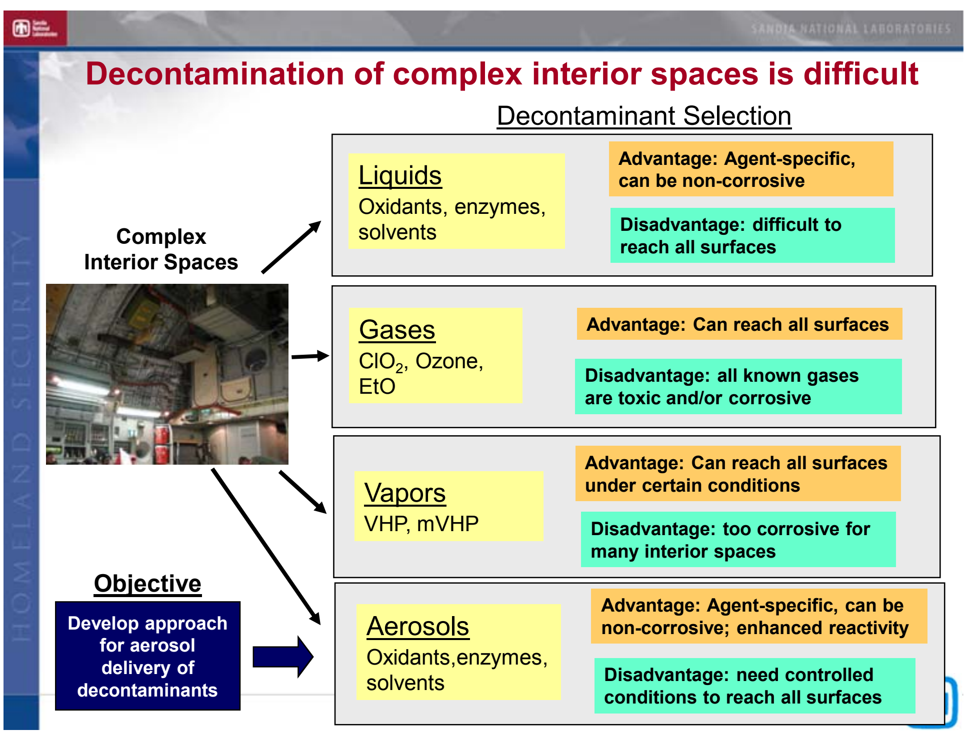
Sandia National Laboratories

SAND2013-9345

Aerosol Delivery of Liquid Decontaminants: A Novel Approach for Decontamination of Complex Interior Spaces

Presented by:
Mark D. Tucker, Ph.D.
Sandia National Laboratories

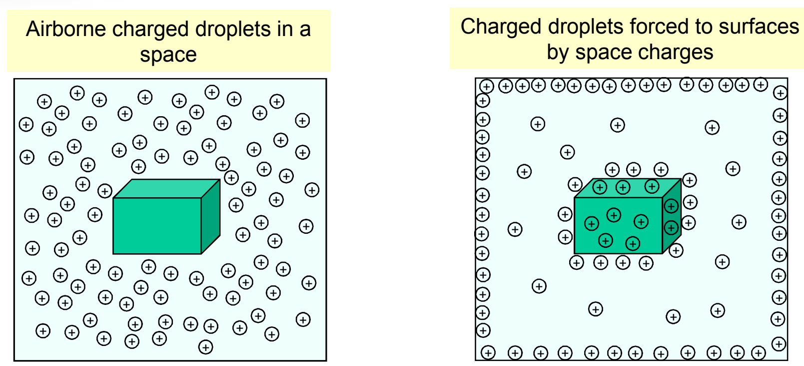
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.



Sandia has conducted a series of three projects focused on the aerosol deployment of liquid decontaminants

- Aerosolized Activated Hydrogen Peroxide Project (AAHP)
  - DTRA-funded
  - Deployment of modified DF-200
- Rapid Germination LDRD Project
  - 2 step process for anthrax spores
  - Deployment of rapid germination formulation followed by mild “kill” formulation
- Aerosol Deployment Project (in progress)
  - Collaboration with Boeing (funded by DTRA)
  - Deployment of any liquid decontaminant based on specific chemical or biological agent

Use of the space charge effect can significantly enhance aerosol transport and surface coverage



For uniform deposition on exposed and hidden surfaces we need:

- **Droplet size small enough to remain airborne during convection to hidden surfaces**
- **High enough droplet charge (charge to mass ratio) to make electrostatic forces dominant**
- **High enough droplet concentration to provide sufficient space charge to drive deposition**

Through modeling and initial experiments, a set of technical objectives for this approach were developed

Required droplet size (diameter): nominally 1 to 5 µm

Required charge: nominally > 10 mC/liter

Required surface coverage: 5 mg/cm^2 in 24 hours

Required input concentration: nominally > 5 g/m^3

Work then progressed to an investigation of various aerosol generators and charging mechanisms to determine if they could meet the technical objectives

Aerosol Hardware Tested (Droplet size, charge, and concentration)

- Electrostatic spray nozzles
- Nebulizers
- Ultrasonic devices
- Electro-spray systems
- Other proprietary devices

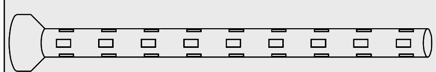
The fundamental aerosol generation capabilities and parameters for a number of commercial-off-the-shelf and emerging devices were evaluated

Surface Coverage and Droplet Penetration Testing

Coupon Placement

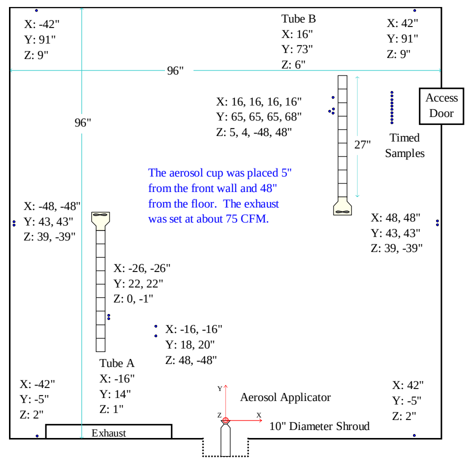
- 8 coupons on the walls.
- 2 coupons on the ceiling and 2 coupons on the floor.
- 2 coupons on top of the platforms supporting the hamster tubes.
- 2 additional coupons at various positions in the chamber.

Hamster Tube Apparatus



- The tube apparatus contained 27 pre-weighed sorbent pads
- The tube was 5.1 cm high by 68.5 cm long.

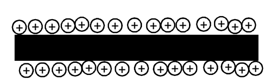
Test Chamber (Plan View)



Surface Coverage and Droplet Penetration Testing

Test Protocol

- Mount sorbent pads in various locations in a test chamber
- Generate aerosol droplets of Sandia DF-200 for various time periods using the selected device
- Remove pads from chamber for weighing to determine aerosol deposition (i.e., B/T ratio)
- Air with the aerosol from the test chamber was pulled through the tube with a fan (i.e., turbulent conditions existed in the test chamber)
- Vary aerosol generation parameters (charge, concentration, droplet size) to achieve best results



$$\frac{B}{T} = \frac{\text{Deposition on Bottom Surface}}{\text{Deposition on Top Surface}}$$

Objective: Achieve a B/T ratio of 1 in all spaces

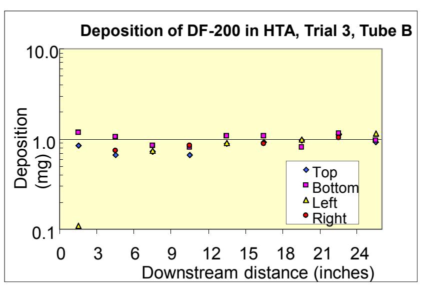
A rotary atomizer was found to be the best device for dispersal of liquid decontaminants

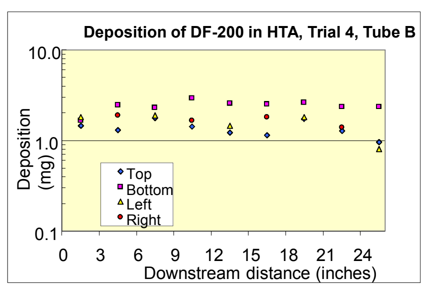
Rotary atomizer for aerosol delivery of decontaminants

Test chamber

Advantages of this technology include: 1) Droplet size (~3-5 μm), 2) Ability to charge droplets, and 3) Uses a mechanical process to create droplets and does not require large volume of air.

Example of experimental results using the rotary atomizer aerosol generation device





Aerosol generation conditions (i.e., charge and concentration) were varied until nearly uniform deposition was achieved on all surface orientations and down the length of the hamster tubes

Following the selection of an aerosol generation device, we investigated decontamination methods using the device

- Application of a modified DF-200 formulation (for both CW and BW agent surrogates)
- Application of a two-step decontamination process for bacterial spores
  - Aerosol dispersal of a germination solution
  - Aerosol dispersal of a mild “kill” solution
- Application of other liquid decontaminants for both CWA and BWA decontamination (collaboration with Boeing – in progress)
  - Peracetic acid
  - Enzymatic

Decontaminant: Modified Sandia DF-200

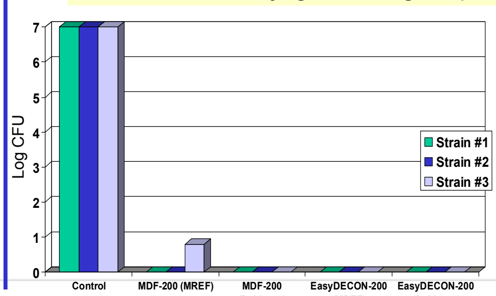
DF-200: An aqueous-based formulation containing ~3.5% hydrogen peroxide

Decontaminant	GD		VX		HD	
	10 Min.	60 Min.	10 Min.	60 Min.	10 Min.	60 Min.
DS2	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
DF-200	>99.9	>99.9	97.8	>99.9	84.8	99.9

Percent decon (stirred reactor tests using EasyDECON™-200 Lot 3829 at 25˚C).

Demonstrated efficacy against CW agents (DoD testing)

Demonstrated efficacy against BW agents (DoD testing)



Residual spores on CARC (SL: 10^7 spores; CT: 30 minutes)

Protocol for Bio-Efficacy Tests

Test Parameters

- *Bacillus globigii* spores on stainless steel biological indicators were used (spore loading: 10^6)
- A constant DF-200 flow rate to the proprietary aerosol-generation device was used
- The trials ran for 120 minutes or 240 minutes
- The exhaust flow was set at 75 CFM
- Only the droplet charge was changed between runs
- Timed samples were collected
- Samples were neutralized with thiosulfate when collected

Liquid coverage of DF-200:

- ***Target for Foam Applications (Surface Decon)***: 5 mg/cm^2 for 30 minutes
- ***Target for Aerosol Applications***: 0.05 to 0.5 mg/cm^2 for 60 minutes
- ***Comparison***: a typical paint application is 10 mg/cm^2 (400 ft^2 per gallon)

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Bio-Efficacy Test Results with DF-200

Sample	Description	Bio-Efficacy Trial		
		38	39	40
Process Data				
	Charge (KV)	Level 1	Level 2	Level 3
	Aerosol Concentration mg/m^3	207.8	76.8	39.6
Log CFU Results				
47-56	Controls (Avg. of 10)	6.32	6.28	6.23
1-12	Wall Samples	0	0	0
13	Top Sample, Stand A	3.42	4.07	0
14	Bottom Sample, Stand A	0	2.64	0
15	Top Sample, Stand B	3.39	3.01	0
16	Bottom Sample, Stand B	5.14	3.31	0
17	Timed Sample (30 min)	4.20	5.70	5.69
18	Timed Sample (60 min)	0	4.15	4.27
19	Timed Sample (90 min)	0	0	4.00
20	Timed Sample (120 min)	0	0	3.44
21	Timed Sample (150 min)	0	0	0
27-46	Hamster Tube Samples	0	0**	0

*Colony Forming Units
**One out of 20 Hamster tube samples showed very mild growth.

Conclusions

- Nearly uniform coverage can be achieved with certain droplet parameters (size, charge, concentration)
  - Spatially (droplet penetration)
  - On all surface orientations
- Excellent kill rates can be achieved even in confined spaces using DF-200
  - Required surface coverage is ~100 times less than foam applications
- Changes in parameters significantly effects results
  - Size, charge, concentration
  - Only a few conditions have been examined
  - Many additional conditions are possible and should be examined
- This method can potentially work with other types of liquid decontaminants

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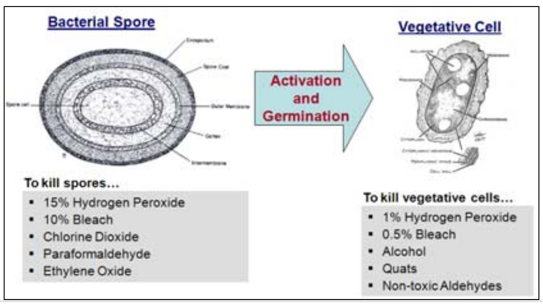
We have investigated a non-toxic, low-corrosivity decontamination method to kill highly resistant bacterial spores in complex interior spaces

- A chemical solution that triggers the germination process in bacterial spores and causes those spores to rapidly and completely change to much less-resistant vegetative cells that can be easily killed.
- Vegetative cells are then exposed to mild chemicals (e.g., low concentrations of hydrogen peroxide, quaternary ammonium compounds, alcohols, aldehydes, etc.) or natural elements (e.g., heat, humidity, ultraviolet light, etc.) for complete and rapid kill.



Aggressive fumigation formulations are currently needed because bacterial spores are extremely resistant.

Initial Test Results

- Our process employs a novel germination solution consisting of low-cost, non-toxic and non-corrosive chemicals.
- We have tested both direct surface application and charged-aerosol delivery of the solutions.

Germination Solution (GS)	Kill Solution (KS)	Time Exposed GS	Time Exposed KS	Log CFU's Remaining
PBS (Control)	None	-	-	6.27
None	3% H_2O_2	-	60 min	6.41
None	6% H_2O_2	-	60 min	6.42
5% of GS Mix in DI H_2O	3% H_2O_2	60 min	60 min	2.55
10% of GS Mix in DI H_2O	3% H_2O_2	60 min	60 min	2.22
15% of GS Mix in DI H_2O	3% H_2O_2	60 min	60 min	1.99
20% of GS Mix in DI H_2O	3% H_2O_2	60 min	60 min	1.59
25% of GS Mix in DI H_2O	3% H_2O_2	60 min	60 min	0
30% of GS Mix in DI H_2O	3% H_2O_2	60 min	60 min	0

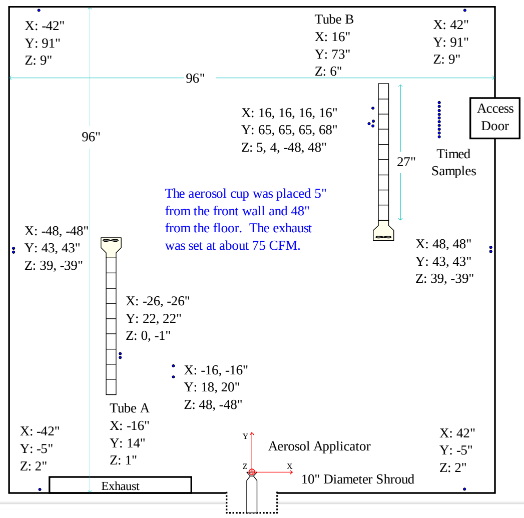
Kill of *Bacillus cereus* spores (an anthrax surrogate) with and without the addition of a germination solution (CFU's = colony forming units).

Coupon Placement for Bio-Efficacy Tests

Coupon Placement

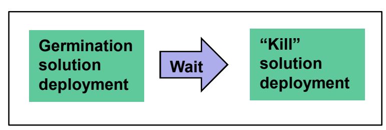
- 8 coupons on the walls.
- 2 coupons on the ceiling and 2 coupons on the floor.
- 2 coupons on top of the platforms supporting the hamster tubes.
- 2 additional coupons at various positions in the chamber.
- 8 timed samples not in the line-of-sight of the aerosol (bio-tests).
- 10 coupons in each hamster tube (bio-tests).
- 10 coupon controls (bio-tests)

Test Chamber (Plan View)

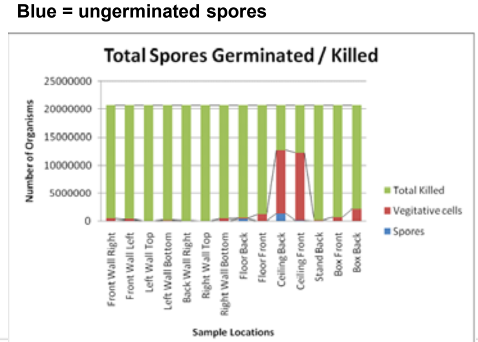


Summary of rapid germination results

Red = germinated spores
Blue = ungerminated spores

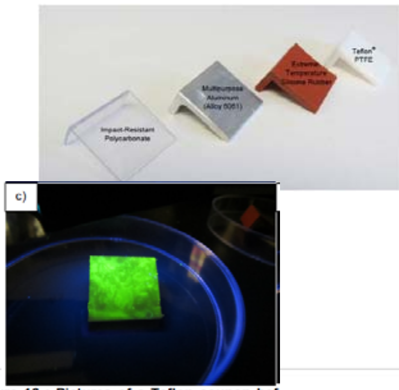


Green = spores that germinated and were killed
Red = spores that germinated and were not killed
Blue = ungerminated spores



Kill solution was 3% hydrogen peroxide

Our current project (in collaboration with Boeing) is using a modified rotary atomizer



- Faster rotational speeds enables smaller droplet sizes.
- Higher and more variable droplet charging has been achieved.
- Decon of both chemical and biological warfare agent surrogates is being evaluated.
  - Steriplex® SD for BW
  - DF-200 for CW
- Coupons are contaminated via aerosol deposition (not liquid deposition).
- Decon on multiple materials and coupon shapes is being evaluated (representative of aircraft materials).
- Evaluation of deposition patterns on material coupons in various orientations.

Conclusions

- A device has been identified and tested that can give nearly uniform coverage of liquid decontaminants on surfaces in interior spaces.
- Two approaches have been evaluated: Direct application of decontaminants and a two-step approach utilizing a germination solution.
- Preliminary methods have been tested that demonstrate high rates of decontamination of BW and CW surrogates.
- Not decontaminant specific.
- Could potentially be used for many types of complex spaces: Aircraft, subway cars, emergency vehicles, etc.
- Could potentially be used in conjunction with other processes (e.g., prior to hot air decontamination).
- Aerosols can also be used for cloud knockdown.

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- Cooperative Research and Development Agreement (CRADA): The Boeing Corporation and Illinois Tool Works – Ransberg Division

Thursday, November 7, 2013

Concurrent Sessions 5

Water and Waste Water Management

Selected Projects of EPA's Homeland Security Research Program for Water and Wastewater Treatment and Decontamination

Matthew Magnuson

2013 EPA International Decontamination Research and Development Conference
11/7/2013

Disclaimer

The U.S. EPA through its Office of Research and Development funded the research described in this presentation. It has been reviewed by the Agency but does not necessarily reflect the Agency's views. No official endorsement should be inferred. EPA does not endorse the purchase or sale of any commercial products or services.

ADVANCING OUR NATION'S SECURITY THROUGH SCIENCE

2

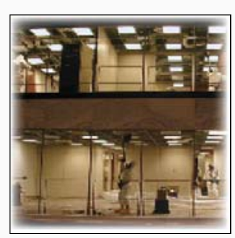
Outline

- **EPA Homeland Security Roles and Water Research**
- **<u>Overview</u> of management and treatment of copious amounts of CBR contaminated water and wastewater residuals**
- **<u>Overview</u> of decontamination and restoration of critical water and wastewater infrastructure**

3

EPA Homeland Security Roles

- Protecting drinking water and wastewater **infrastructure**
- Indoor and outdoor clean-up following an attack, natural disaster, industrial accidents, etc.
  - can use **millions of gallons of water**
  - can **result in even more contaminated wastewater**
- Development of a **nationwide laboratory network**
- **Reducing vulnerability** of chemical & hazardous materials
- **Cyber security**



Water Security Projects

Multi Use → Homeland Security
→ Catastrophes: Natural Disasters, Accidents, etc.
→ "Normal" Operations

For example, decontamination approaches for use after intentional contamination might also be **useful after natural disasters and industrial accidents**, **as well as routine system maintenance.**

Research to Support Water Systems

- Make water systems more resilient
- Mitigate impacts of contamination
- Detect contamination
- Treat water
- Decontaminate infrastructure

6

New experimental facility

Water Security Test Bed

- Distribution system from aged ductile iron pipe with connectors, valves, pumps, hydrants, tanks, etc.
- Investigate chem, bio, and rad detectors, decontaminants, and decon procedures
- 100 x 500 ft under construction at Idaho National Lab

Office of Research and Development
Homeland Security Research Program

7

Outline

- EPA Homeland Security Roles and Water Research
- <u>Overview</u> of management and treatment of copious amounts of CBR contaminated water and wastewater residuals
- <u>Overview</u> of decontamination and restoration of critical water and wastewater infrastructure

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Selected Projects

- **Irreversible wash aid additive for Cs-137 contamination**
  - See Mike Kaminski's talk later in this session
- **Inactivation of Bacillus spores in decontamination wash down wastewater using chlorine bleach solution**
  - If you missed it, see proceedings for Vince Gallardo, 9:15AM Nov. 7
- **Inactivation of bacterial bioterrorism agents in water**
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9

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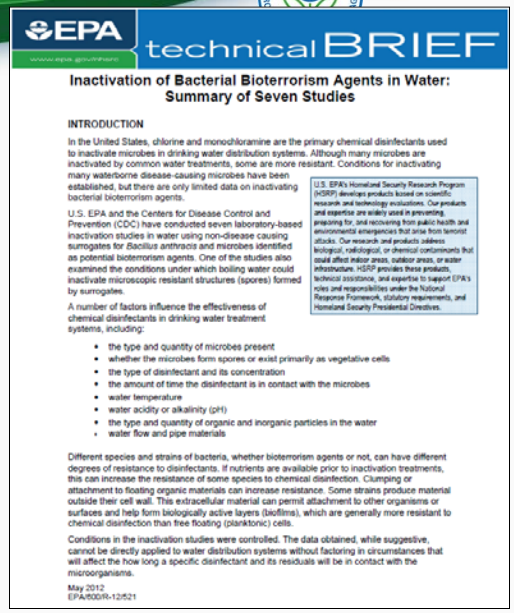
Inactivation of bacterial bioterrorism agents in water

Objectives: Study the effectiveness of inactivation methods of vegetative and spore forms of bacterial bioterrorism agents, including:

- *Bacillus anthracis* Ames and Sterne
- *Brucella melitensis*
- *Burkholderia mallei*
- *Burkholderia pseudomallei*
- *Francisella tularensis*
- *Yersinia pestis*



EPA technical BRIEF

www.epa.gov/nhsrc

Inactivation of Bacterial Bioterrorism Agents in Water: Summary of Seven Studies

INTRODUCTION

In the United States, chlorine and monochloramine are the primary chemical disinfectants used to inactivate microbes in drinking water distribution systems. Although many microbes are inactivated by common water treatments, some are more resistant. Conditions for inactivating many waterborne disease-causing microbes have been established, but there are only limited data on inactivating bacterial bioterrorism agents.

U.S. EPA and the Centers for Disease Control and Prevention (CDC) have conducted seven laboratory-based inactivation studies in water using non-disease causing surrogates for *Bacillus anthracis* and microbes identified as potential bioterrorism agents. One of the studies also examined the conditions under which boiling water could inactivate microscopic resistant structures (spores) formed by surrogates.

U.S. EPA's Homeland Security Research Program (HSRP) develops products based on scientific research and technology evaluations. Our products and expertise are widely used in preventing, preparing for, and recovering from public health and environmental emergencies that arise from terrorist attacks. Our research and products address biological, radiological, or chemical contaminants that could affect indoor areas, outdoor areas, or water infrastructure. HSRP provides these products, technical assistance, and expertise to support EPA's roles and responsibilities under the National Response Framework, statutory requirements, and Homeland Security Presidential Directives.

A number of factors influence the effectiveness of chemical disinfectants in drinking water treatment systems, including:

- the type and quantity of microbes present
- whether the microbes form spores or exist primarily as vegetative cells
- the type of disinfectant and its concentration
- the amount of time the disinfectant is in contact with the microbes
- water temperature
- water acidity or alkalinity (pH)
- the type and quantity of organic and inorganic particles in the water
- water flow and pipe materials

Different species and strains of bacteria, whether bioterrorism agents or not, can have different degrees of resistance to disinfectants. If nutrients are available prior to inactivation treatments, this can increase the resistance of some species to chemical disinfection. Clumping or attachment to floating organic materials can increase resistance. Some strains produce material outside their cell wall. This extracellular material can permit attachment to other organisms or surfaces and help form biologically active layers (biofilms), which are generally more resistant to chemical disinfection than free floating (planktonic) cells.

Conditions in the inactivation studies were controlled. The data obtained, while suggestive, cannot be directly applied to water distribution systems without factoring in circumstances that will affect the how long a specific disinfectant and its residuals will be in contact with the microorganisms.

May 2012
EPA/600/R-12/521

http://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=511103

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Background

- Problem: How to deal with decon waste water, which can represent significant waste management challenges
  - Incinerate water?
  - Haul thousands/millions/billions of gallons long distances to specialty facility?
  - Drain disposal to local wastewater plant?
- Objectives: Investigate Advanced Oxidation Process (AOP) for dealing with large volumes of decon wash water and contaminated water and wastewater to enable drain disposal.

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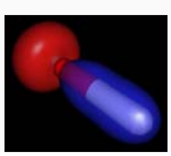
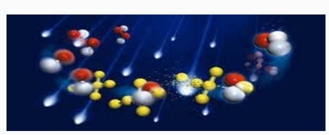
Advanced Oxidation Process (AOP)

- Generate hydroxyl radicals with over twice the oxidizing power of chlorine.
- “Green” -- no chlorinated by-products.
- Several AOP technologies suitable for field use



hydroxyl radical



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Development of Technical Approach

- Workshop with wastewater industry considered requirements for wastewater treatment plant acceptance of AOP-treated contaminated water
  - Biological treatment processes not compromised
  - Receiving waters not affected
  - Infrastructure not affected
- What tests are needed?
  - Monitoring the effectiveness of AOPs in real-time
  - Verification of degradation of target contaminants
  - Protect the microbial community of the biological treatment process
  - Prevent environmental toxicity to receiving water organisms

WERF
Water Environment Research Foundation
Collaboration. Innovation. Results.

Expert Workshop on Toxicity Testing of Water Undergoing Advanced Oxidation Processes Prior to Discharge

Project No. WERF3W11

Workshop Summary Report

December 2011

Water Environment Research Foundation
635 Slaters Lane, Suite G-110
Alexandria, VA 22314-1177
Tel: (571) 384-2100
Fax: (703) 299-0742
www.werf.org
werf@werf.org

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Technical Approach

- Investigate different AOP technologies for the treatment and disposal of drinking water contaminated with toxic chemicals into public sewer (collection) systems
- Perform toxicity tests for wastewater plant organisms and receiving waters
- Designed experiments so results will be useful in assessing impacts of an incident and selecting effective methods for handling contaminated water or wastewater.

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AOP Technologies

Ozone/peroxide

$2\ O_3 + H_2O_2 \rightarrow 2\ OH\bullet + 3\ O_2$

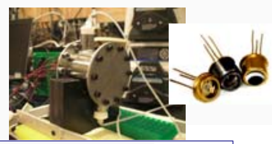
Boron-doped diode electrode

water + electricity → OH• + others

UV/peroxide

H_2O_2 + light → 2 OH•

Mercury lamp system



light emitting diode system

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Toxicity Testing

- Nitrification Inhibition testing
  - Nitrifying bacteria in mixed liquor sample exposed to test samples
  - Rate of decrease of ammonia measured
  - Indicator of toxicity to wastewater biological treatment

- Microtox Toxicity Test
  - Luminescent marine bacteria
  - Indicator of eco-toxicity for the possibility of discharge

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Background

- Problem: OPs, including pesticides and nerve agents, could enter waste water treatment plant (WWTP) during decon operations. If not degraded or removed, they may enter the environment or drinking water supplies through effluent discharge and in land applied sludge.
- Objectives: Examine experimentally the capability of municipal WWTP activated sludge to degrade and remove OP compounds in bench-scale studies

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OP Nerve Agent Exposures

- Iran-Iraq War
- Aum Shinrikyo
  - Matsumoto Sarin Attack
  - Tokyo Subway Attack
- US Soldiers in Iraq
- Civilians in Syria

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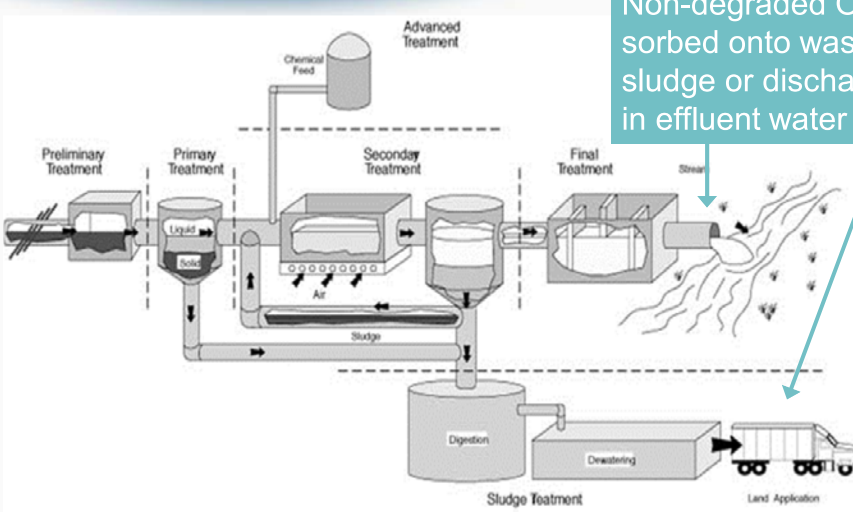
Wastewater Treatment Process

Non-degraded OPs sorbed onto waste sludge or discharged in effluent water



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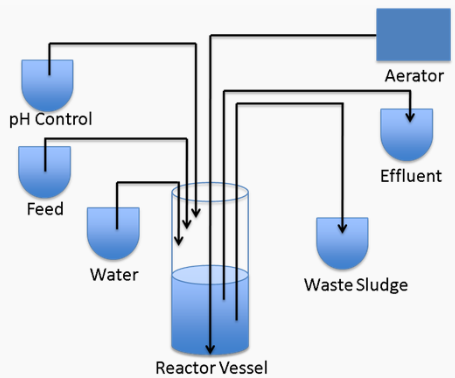
Lab-scale sequencing batch reactors to simulate WWTP



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Outline

- EPA Homeland Security Roles and Water Research
- Overview of management and treatment of copious amounts of CBR contaminated water and wastewater residuals
- Overview of decontamination and restoration of critical water and wastewater infrastructure

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Selected Projects

- State of science review of water system decon.
  - See Jeff Szabo's talk later in this session
- Persistence and removal of CBR contaminants from drinking water pipes studied with USEPA's pipe decontamination experimental design (PDED).
- Impact of CBR contaminated sediments on flushing and decontamination of drinking water storage facilities.
- Decision support tools for responding to water distribution incidents.

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Background

- Problem: Drinking water pipes can sorb contaminants that are introduced either accidentally or by some purposeful means.
- Objectives: Provide data to help decision makers develop a decontamination strategy for contaminated pipe materials

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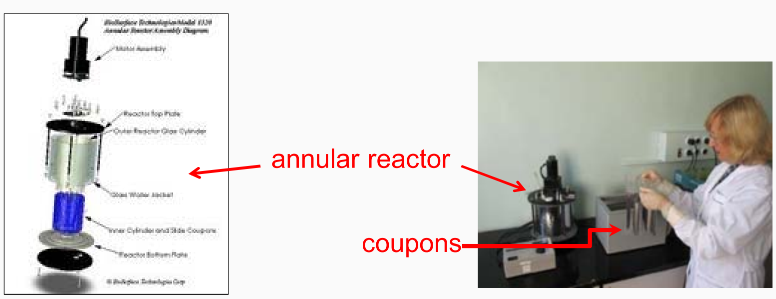
EPA's PDED

Design for realistic studies of persistence and decontamination

- Can be implemented in reproducible fashion across laboratories and for various contaminants and pipe materials
- Conditions within operational drinking water pipes are simulated in annual reactors (ARs)
- ARs contain coupons of pipe materials: copper, PVC, cast-iron, and mortar lined ductile iron
- Decontamination methods: flushing and hyperchlorination.



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- **Impact of CBR contaminated sediments on flushing and decontamination of drinking water storage facilities.**
- **Decision support tools for responding to water distribution incidents.**

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Background

- Problem: Sediments in drinking water tanks can adsorb and act as reservoirs for toxic substances introduced either accidentally or by some purposeful means.
- Objectives: Results useful for assessing impacts of an incident and selecting effective methods for handling contaminated sediments and decontaminating the tanks.

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Approach

Tank cleaning company collecting sediments

Lab contaminant adherence studies

Sediments from different tanks can vary a lot!

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Selected Projects

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Water Security Toolkit (WST)

Objective: Integrate a suite of cutting-edge, automated modeling, simulation, and optimization tools into a user friendly software tool in order to support rapid and effective water utility decision making

WST helps identify:

- Best sensor locations to detect contamination
- **Origin of contamination in network**
- Best sampling locations to confirm contamination or clean-up
- Tanks and/or areas that need to be isolated
- Best injection location of chlorine or other decontaminating agents to neutralize and/or inactivate contaminant
- Region of system that needs public notification
- **Best hydrants to flush out contaminated water**

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Intended Use of WST

- Plan for response to natural disasters and terrorist attacks and compare response actions
  - Develop consequence management plans
  - Inform large-scale exercises/training
- Plan for response to traditional utility challenges (pipe breaks, water quality problems, …)
  - Evaluate implications of different response strategies
- Optimize and implement response actions in real-time
  - Use data from event detection software, sensor stations, field investigations
- Incorporate software tools to create real-time situational awareness tool (future vision)





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Research Collaborators

- Argonne National Lab
  - Mike Kaminski, Ph.D.
  - Carol Mertz, Ph.D.
- Battelle
  - Ryan James, Ph.D.
  - Elizabeth Hanft
  - Mark Benotti , Ph.D.
- US Air Force Institute of Technology
  - Maj. LeeAnn Racz, Ph.D.
  - Lt. Allen Janeckso, M.S.
  - Maj. Edward Walters, M.S.
  - Dr. Michael Miller
  - Dr. Michael Grimaila
  - Maj Tho Tran, Capt
  - Kelsey Duckworth, Capt
  - Michael Spencer, Capt
  - John Richwine, Capt
  - Christopher Bates, Capt
- Research Institute of Hygiene, Toxicology, and Occupational Pathology, Volgograd, Russia
  - Elena P. Vekhter
  - Igor E. Pildus
  - Elena A. Demenkova
- Water Environment Research Foundation
  - Amit Pramanik, Ph.D., BCEEM
  - Daniel M. Woltering, Ph.D.
- Environmental Protection Agency (NHSRC)
  - Scott Minamyer
  - Steve Clark
  - Gene Rice, Ph.D.
  - John Hall
  - Vince Gallardo
  - Jeff Szabo, Ph.D.
  - Terra Haxton, Ph.D.
  - Regan Murray, Ph.D.

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Thank you!

Matthew Magnuson, Ph.D.
Chemist/Acting Associate Director
Water Infrastructure Protection Division
magnuson.matthew@epa.gov, 513-569-7321
Cincinnati, OH

htpp://www.epa.gov/nhrsc

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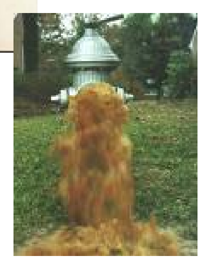
NHSRC Drinking Water Infrastructure Decontamination Overview

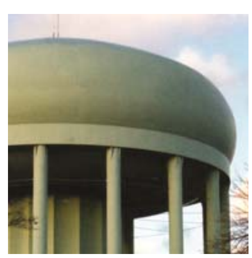
Jeff Szabo
EPA's Homeland Security Research Program

November 7, 2013

Presentation Overview

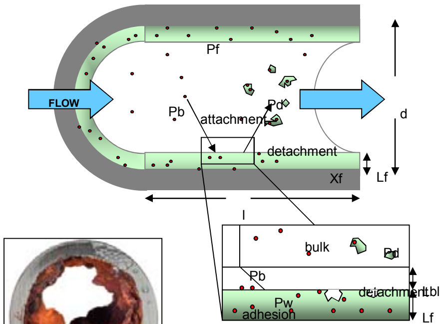
- Summary of the decon scoping report
- The current state of NHSRC's drinking water decontamination research
- Future NHSRC decontamination research with the Water Security Test Bed

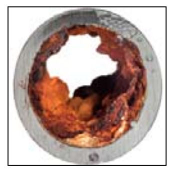




Decon Literature Review and Summary Report

- Decontamination of Drinking Water Infrastructure: A literature review and summary
- Publications from EPA represent the majority of research in some areas
- Provides data for decontamination resources
- Reference key to literature
- **Gap analysis to guide research**



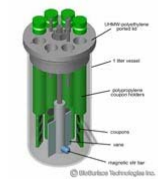


Report Considerations

- Chemical: inorganics (As, Hg), petroleum products, toxins, CWA, pharmaceuticals, organics (chlordane, chloropyrifos, parathion, sodium fluoroacetate and p-dichlorobenzene)
- Biological: spore forming bacteria, vegetative bacteria, viruses
- Radionuclide: cesium, strontium, cobalt
- Infrastructure materials: unlined iron (corroded), cement-mortar lined iron, PVC (plastic), copper
  - Other materials were included if compelling data was identified
- Type of experimental system: how representative of reality is it?

Bench Scale Devices

- Flow cells
- CDC reactors
- Biofilm annual reactors
- Stagnant water pipe
- Homemade designs





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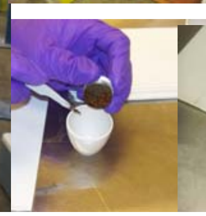
Pilot Scale Water Infrastructure Testing










Report Results Summary

Chemical Agents	•Chemical agents are the broadest category with the least drinking water data •Data available for inorganics (Hg, As), organics (including chlordane) and gasoline •No useful data found on pharmaceuticals, toxins and CWA (no data found) •Validated chemical sampling methods from surfaces is needed
Biological Agents	•*Bacillus* spores are persistent, HOCl effectiveness was limited, ClO_2 is promising. •Effective decon methods for spores could also be used for vegetative bacteria •Little data available for viruses •Specific disinfectants (ClO_2, PAA, ozone, etc.) should be explored further
Radiological Agents	•Most data comes from bench scale experiments or the nuclear industry •Cs, Sr and Co persistence data on cement-mortar and PVC is needed •More research with real radionuclides is needed •Decontamination of Co with acidification was effective •Cs, Sr less persistent than Co, decon with low pH and competing ions proposed

The future of the decon scoping report

- The report identifies gaps in the current literature with respect to contaminant-infrastructure persistence data that is not available
- Suggestions for future decontamination work are presented in areas where persistence is observed
- The report will be updated and reissued periodically as new data is published
- EPA/NHSRC will perform research to fill those gaps
  - We hope others will too
- What kind of work will NHSRC focus on in the future?

Water Security Test Bed (WSTB)

- Located at Idaho National Lab (INL)
- The WSTB is composed of used 8-inch drinking pipe and is roughly oriented in the shape of a loop with a cross in the middle
  - NHSRC's research focus is drinking water contamination
  - The WSTB can support a broad range of drinking water related research
- The goal of this presentation is:
  - Describe the WSTB features and what it will look like in the future
  - Inform you about NHSRC's planned work
  - Promote collaborative research efforts

Where did the pipe come from?

- Drinking water pipe that was in service from the early 1970's until a few years ago
- The pipe was in good condition when it was excavated
- The pipe was partially filled with water, but no major leaks were found

EPA United States Environmental Protection Agency

Pipe material of construction

- Cement-mortar lined ductile iron
- Some pipes are corroded where the lining was worn or broken
- Four and eight-inch diameter pipes were excavated.

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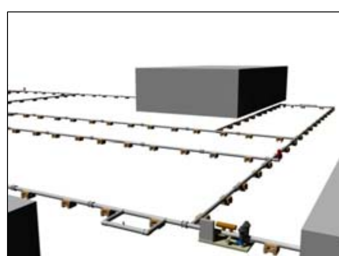
EPA United States Environmental Protection Agency

What will the WSTB look like?

- The pipe will be positioned in a rough loop with lines crossing in the middle
- Pipe will be constrained (braced)
- Service connections will installed
- Water will be pressurized (40 psi)
- Pipe will be elevated and leak containment will be installed
- Pumps will circulate the water (1 ft/sec)
- Water will empty into a flush tank for collection, sampling, pre-treatment and disposal
- Water supply is chlorinated ground water



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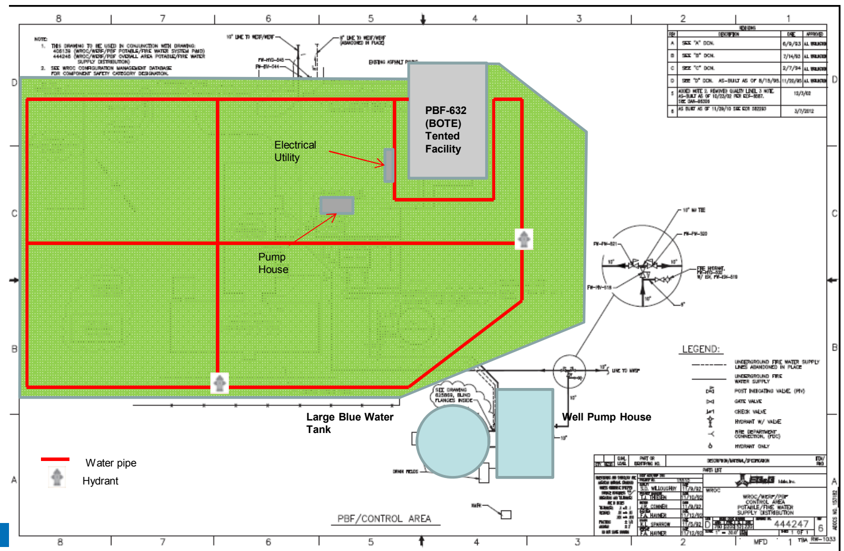
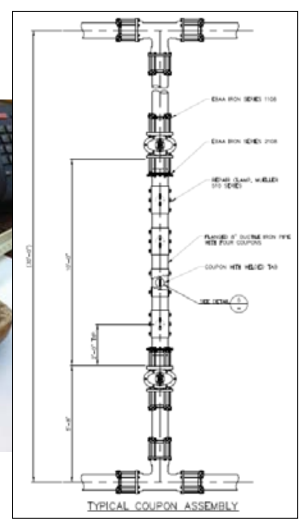


EPA United States Environmental Protection Agency

Sampling interior pipe surfaces

- Many of the samples from the WSTB will be water samples
- Interior pipe wall samples will also be available
- We may have coupon samples in multiple locations around the WSTB
- Coupon extraction procedure will be adapted from pilot scale decontamination studies at EPA



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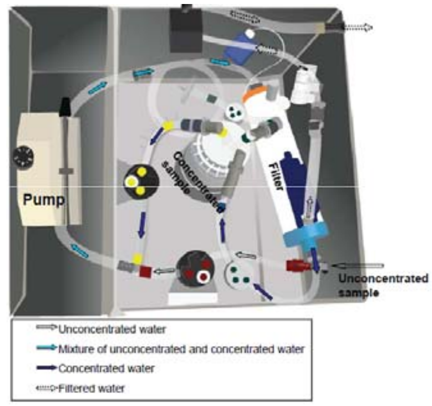
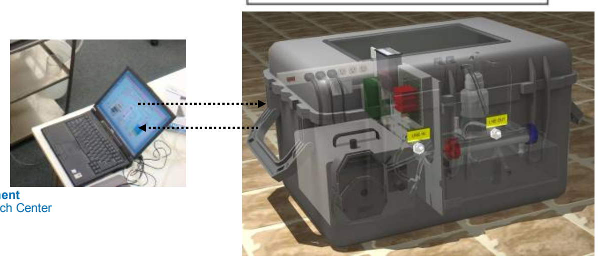
Water Sampling

- Water samples will be common during contamination/decontamination experiments
- For biological samples, we will use the water sample concentrator
  - Uses ultrafiltration to concentrate microorganisms
  - Field portable
  - Easy and cheap to use
  - Built at INL



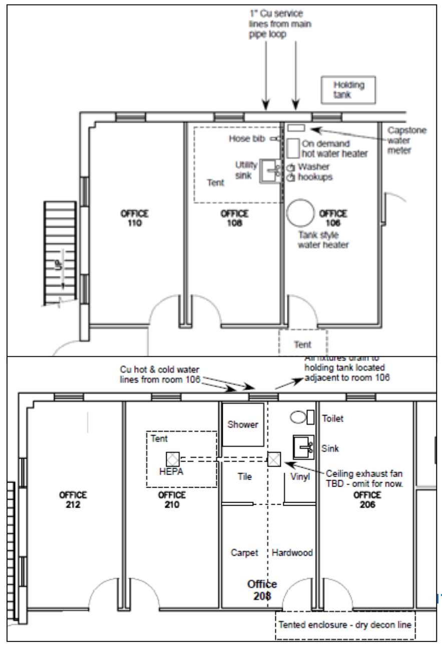


Flushing hydrants and sensors

- The WSTB will be equipped with two fire hydrants, one with automatic flushing
- Sensors will include:
  - Standard water quality sensors (chlorine, pH, turbidity)
  - S::CAN water security panel (light-spectrum based)
  - Hydrant pressure sensors
  - Hydrant RFID tamper alarms
  - Flow meters (standard and specialized)
  - Event detection algorithms (CANARY and S::CAN)

Utility room and bathroom

- Utility room (top picture, bottom floor) will contain:
  - Hose bib
  - Utility sink
  - Hot water heater (tank and on-demand)
  - Washer/dryer connection
  - Water meters
- Bathroom (bottom picture, top floor) will contain:
  - Shower, sink and toilet
  - Vinyl, tile, carpet and wood flooring
  - Exhaust fan
  - Tented enclosure for a decon line



Future Plans

- Tracer experiments are planned for late summer 2014
- Contamination and decontamination experiments in late summer/early autumn 2014
  - *Bacillus* spores and chlorine dioxide will be tested first
  - Surrogate radionuclide experiments are planned for 2015
  - Chemical experiments are planned for 2016 (organophosphate or hydrocarbon)
- Contamination/decontamination experimental protocol will be modeled on our pilot scale work at the Test and Evaluation facility.
- Detection of contaminants with water quality sensors and testing the triggering of novel flushing fire hydrants (summer/autumn 2014)
- Exposure during showering and household plumbing studies (autumn 2014)

Future Plans

- Supervisory Control and Data Acquisition (SCADA) systems
  - A functioning SCADA system similar to what is in place at a water utility will be installed
  - City of Idaho Falls water department is providing technical assistance

- Cybersecurity
  - Are water utilities in the United States aware of the vulnerabilities in their SCADA systems?
  - What commercial tools are available to help protect utility SCADA systems from unwanted intrusion?

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Questions?

Project Coordinator
Steve Clark
202-564-3784
clark.stephen@epa.gov

Sensors/Hydrants
John Hall
513-487-2814
hall.john@epa.gov

Decontamination
Jeff Szabo
513-487-2823
szabo.jeff@epa.gov

Showering Studies
Sarah Taft
513-569-7037
taft.sarah@epa.gov

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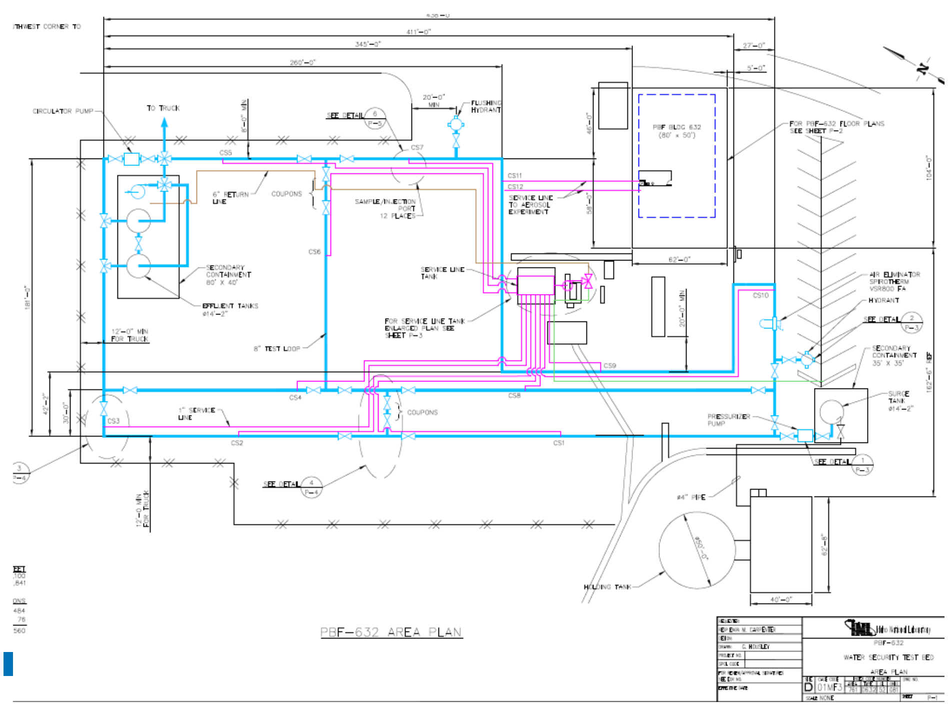
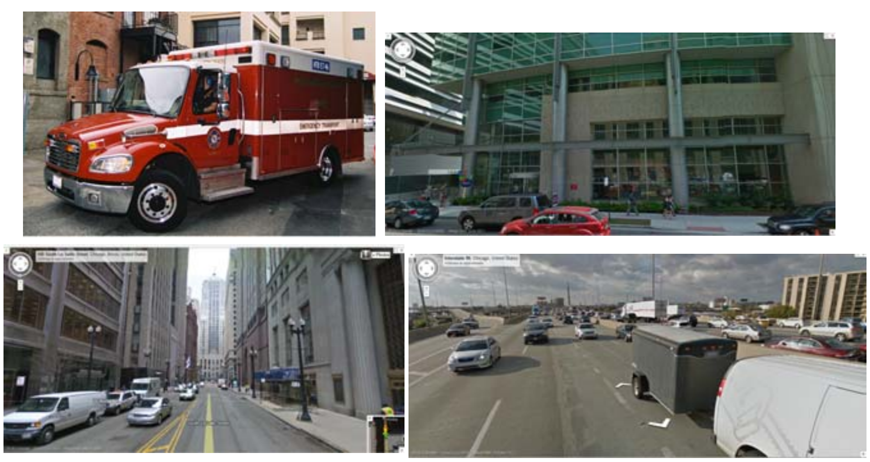


Demonstration of Unit Operations for the Irreversible Wash Aid Additive for Cs-137 Contamination

Michael Kaminski,[1] Matthew Magnuson,[2] Jack Schwalbach,[3] Dennis Barkenmeyer[4]

[1]Chemical Sciences and Engineering Division, Argonne National Laboratory
[2]U.S. EPA National Homeland Security Research Center, Cincinnati, OH
[3]Separmatic Filter Systems, Menomonee Falls, WI
[4]HESCO Bastion Environmental, Inc., Hammond, Louisiana

Irreversible Wash Aid Additive for Cesium

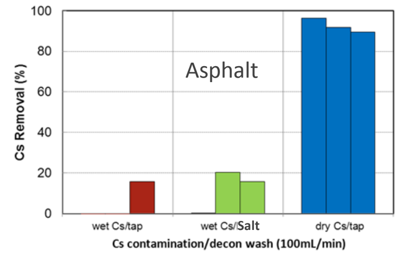


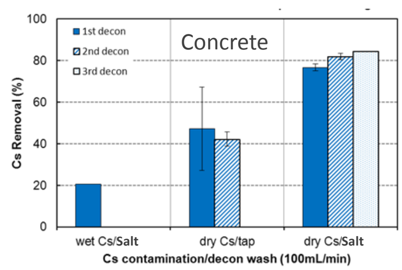
Decontamination Using Wash Aid

Spray decontamination of (Chemical agent resistant coatings (CARC)materials using deionized water (Control) and wash aid formulation

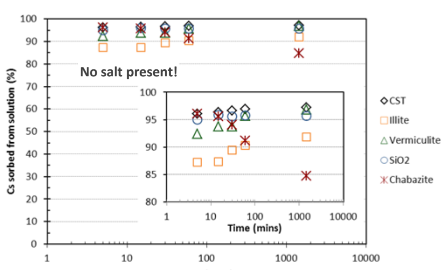
	Decon 1		Decon 2		Decon 3	
Sample	DF	%RE	DF	%RE	DF	%RE
Green (Control)	10.7	89.4	17.9	93.4	25.1	95.75
Green	9.94	89.7	27.0	96.24	38.7	97.34
Tan (Control)	70.7	98.58	160	99.37		
Tan	212	99.4	540	99.78		
Black (Control)	133	99.25				
Black	432	99.73				
Gray (Control)	115	99				
Gray	244	99.59				
White (Control)	31.1	96.52	54.0	98.15		
White	71.1	98.59	168	99.39		

DF=decontamination factor
RE=Removal percentage

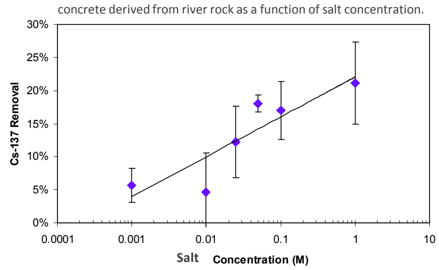


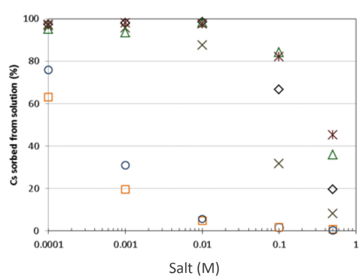


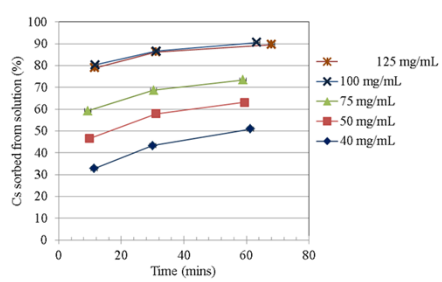
Salt and Sequestering Agents – Kinetics and Equilibrium



Decontamination of Cs-137 (in % removed) from coarse aggregate of concrete derived from river rock as a function of salt concentration.







Wash Aid Formulated On-Site and Distributed

Rapidly Deployable Barriers and Earth

HESCO Barriers Deployed

Construction of the Barrier and Spread of Sequestering Agents

Decontamination and Wash Collection

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9

Slurry Filtration

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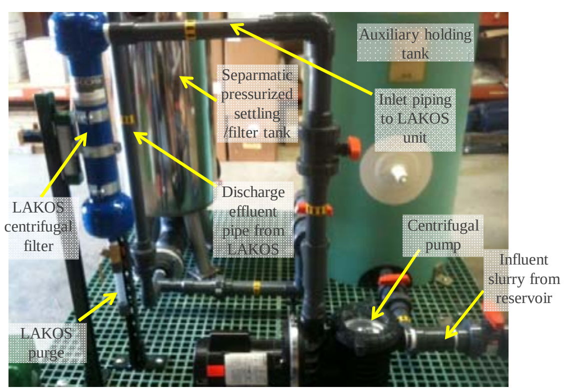
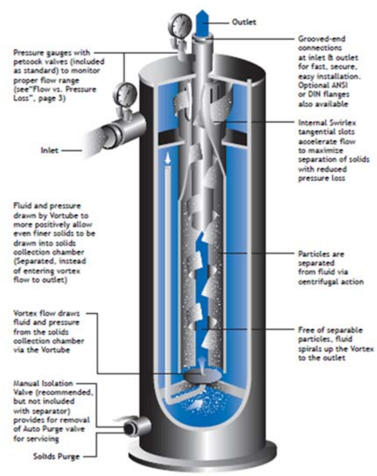
Filter Skid

Solid-Liquid Separators



LAKOS centrifugal separator



Removal and Disposal

The Nautilus Bag™ and the Truck Bag ™ for transporting radioactive packages by Strategic Packaging Systems LLC.

Conclusions and Lessons Learned from Demonstration

- We completed the demonstration without complication.
- The materials arrived as planned and the various partners were well-coordinated under the guidance of Briese and Associates.
- We were able to show the set-up of the system, demonstrate its operations, and assess the additional operations for removal of materials and clean-up of the site.
- From this experience, there were several lessons learned from this demonstration.
  - Logistics
    - Just how do you coordinate and train individuals needed to transport the berm and fill materials and assemble them in a hazardous and radiation area?
    - Where exactly do you set up the berms and how much water is needed to accomplish the mitigation goal?
    - Given the limited footprint in the affected zone, where do you assemble the support equipment (salt and surfactant storage, pumps, filtration trucks, front-loaders, bladder tanks, collapsible tanks, fire trucks, etc.)?

Conclusions and Lessons Learned from Demonstration

- Logistics (continued)
  - Do you permit units to set-up in a radioactively-contaminated zone or do you wash the staging area first and then proceed with mitigation operations at the target zone?
  - Next, it was clear that a more detailed system for reuse of wash water needed to be drafted. This system would need to include monitors to check the water quality before reuse to ensure the absence of radioactivity.
- Separations
  - Slurry intake was not controlled leading to a highly variable solids concentration at the inlet to the LAKOS separator. As a result, the solids concentration was too high in the discharge from the LAKOS (the feed into the Separmatic pressurized, bag filter unit).
  - Extremely high slurry concentrations begs for a series of LAKOS units.
  - Another option is to consider leaving the clay in the reservoir since it settles readily by gravity and simply pull the supernatant wash into the filtration units or collect the wash water in a series of drain tiles. Then, after drawing most of the water you could suction the concentrated slurry into a receiving truck for removal.

Acknowledgments

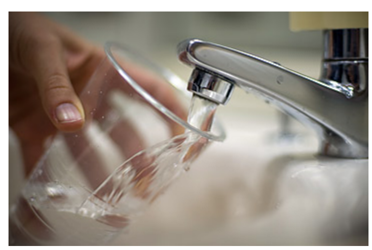
- Work supported by Technical Support Working Group.
- The U.S. EPA through its Office of Research and Development funded in part the research described in this presentation. It has been reviewed by the Agency but does not necessarily reflect the Agency's views. No official endorsement should be inferred. EPA does not endorse the purchase or sale of any commercial products or services.

Radiocesium, radiostrontium and radiocobalt sorption/desorption on components of drinking water distribution systems

Konoplev A.[1], Popov V.[1], Stepina I.[1], Szabo J.[2]

[1]RPA «Typhoon», Russian Federation
[2]U.S. Environmental Protection Agency, USA

EPA International Decontamination Research and Development Conference, North Carolina, Durham November 5-7, 2013



Possible contamination ways:

- *Accidents at nuclear power stations*
- *Leaks from radioactive wastes storage*
- *Acts of terrorism*

2

Objective

investigation the fate of dissolved radiocesium, radiostrontium and radiocobalt deposited on components of drinking water distribution systems for developing effective decontamination techniques and strategies

3

Materials (pipes)

Concrete lined pipe | Iron | Plastic | Copper

4

The experimental setup: closed chemical reactor

5

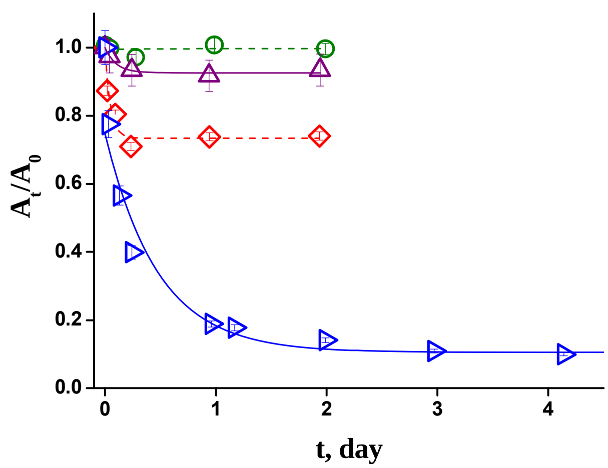
The experimental setup: open chemical reactor

6

Experimental results with a closed chemical reactor

7

The kinetics of ^{137}Cs sorption



○ - plastic, △- copper, ◇- iron, ▷ - concrete lined iron

8

Scheme 1 for desorption experiments

1. Experiments with ^{137}Cs :

Sequential desorption by : tap water, tartaric acid

2. Experiments with ^{60}Co :

Sequential desorption by : tap water, tartaric acid, EDTA, acetic-ammonium buffer

3. Experiments with ^{85}Sr

Sequential desorption by : tap water, tartaric acid

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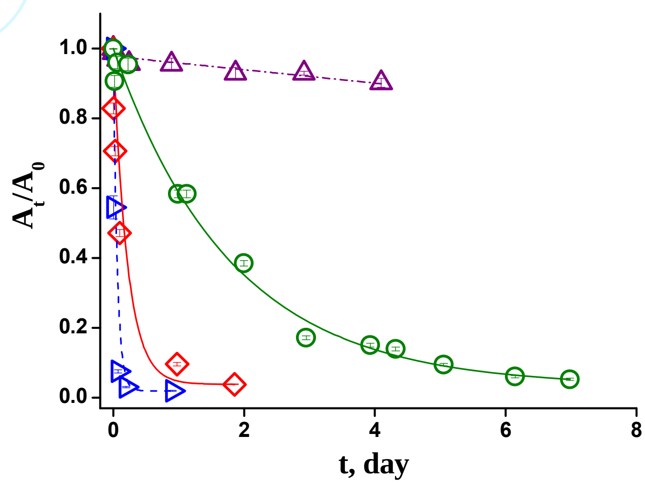
Desorption of ^{137}Cs

Pipe	*Replica-tion*	*Sorption, %*	*Desorption by water, %*	*Desorption by tartaric acid, %*
Plastic	*1*	*2.9*	*2.5*	*-*
Iron	*1*	*29*	*7.5*	*8.4*
Concrete lined iron	*1*	*90.5*	*7.1*	*12.7*
Copper	*1*	*8.3*	*4.3*	*-*
	2	*5.5*	*1.7*	

Values of ^{137}Cs sorption and sequential desorption, % of applied radioactivity

10

The kinetics of ^{60}Co sorption



○ - plastic, △- copper, ◇- iron, ▷ - concrete lined iron

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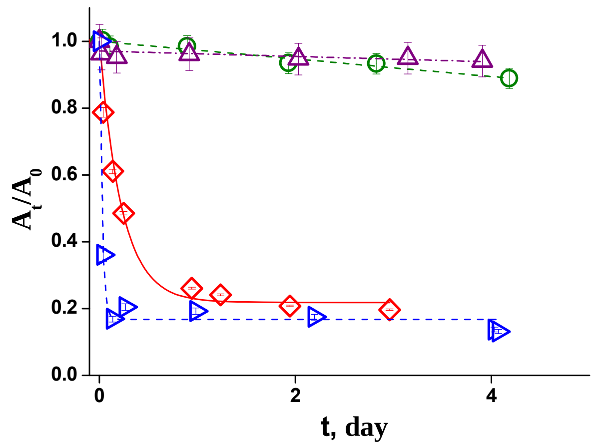
Desorption of ^{60}Co

Pipe	*Repli-cation*	*Sorption, %*	*Desorption by water, %*	*Desorption by tartaric acid, %*	*Desorption by EDTA, %*	*Desorption by acetic-ammonium buffer, %*
Plastic	*1* *2*	*93.5* *94.7*	*1.6* *-*	*91.8* *-*	*-*	*-*
Iron	*1* *2* *3* *4*	*96* *98.3* *93.9* *93.5*	*-* *1.8* *0.64* *-*	*-* *-* *-* *58.6*	*-* *83* *79* *30.6*	*-* *0.7* *-* *-*
Concrete lined iron	*1* *2* *3*	*98* *96* *94.4*	*-* *5.9* *-*	*-* *53.4* *-*	*-* *-* *70.1*	*-* *-* *1.8*
Copper	*1*	*9.8*	*3.2*	*-*	*-*	*-*

Values of ^{60}Co sorption and sequential desorption, % of applied radioactivity

12

The kinetics of ^{85}Sr sorption



13

Desorption of ^{85}Sr

Pipe	Replication	Sorption, %	Desorption by water, %	Desorption by tartaric acid, %
Plastic	*1*	*11.1*	-	-
Iron	*1*	*80.4*	*4.6*	*68.5*
Concrete lined iron	*1* *2*	*88.3* *92.8*	- *2.4*	- *7.6*
Copper	*1* *2*	*5.9* *4.3*	-	-

Values of ^{85}Sr sorption and sequential desorption, % of applied radioactivity

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Scheme 2 for desorption experiments

1. Experiments with ^{85}Sr :

Sequential desorption by : EDTA, KCl, NH_4Cl, $CaCl_2$, acetic-ammonium buffer

2. Experiments with ^{137}Cs

Sequential desorption by : EDTA, $CaCl_2$, KCl, NH_4Cl, acetic-ammonium buffer

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Desorption of ^{85}Sr (scheme 2)

Pipe	Sorption %	Desorption by EDTA, %	Desorption by KCl, %	Desorption by NH_4Cl, %	Desorption by $CaCl_2$, %	Desorption by acetic-ammonium buffer, %
Concrete lined iron	82.2	23.2	8.3	7	0.5	15.4

Values of ^{85}Sr sorption and sequential desorption, % of applied radioactivity

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Desorption of ^{137}Cs (scheme 2)

Pipe	Sorption %	Desorption by EDTA, %	Desorption by $CaCl_2$, %	Desorption by KCl, %	Desorption by NH_4Cl, %	Desorption by acetic-ammonium buffer, %
Concrete lined iron	88.7	23	6.9	50	9.9	1.4

Values of ^{137}Cs sorption and sequential desorption, % of applied radioactivity

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Experimental results with a open chemical reactor

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The values of ^{60}Co surface distribution coefficients K_S and ^{60}Co desorption in the open chemical reactor experiments

Pipe	*K_s, см*	*Desorption by 0.1 M EDTA , % of sorbed activity*
Plastic	*0.39*	*80.5*
Iron	*8.23*	*100*
Iron Concrete	*27.19*	*77.6*

$$K_S = \frac{A_S}{C_{in} S}$$

A_S is the activity of the sorbed radionuclide, Bq; C_{in} is the specific activity of radionuclide in the source solution, Bq/cm^3; S is the inner surface of the pipe, cm^2.

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Additional experiments

1. ***Determination of ^{85}Sr sorption on the components of closed chemical reactor without a pipe***

***Results:** the activity of initial ^{85}Sr solution decreased by 17% for the 5 days . It was shown that reduction in activity is due to ^{85}Sr sorption on the colloids formed in the solution and precipitated on the walls of the container.*

2. ***Determination of radionuclides sorption by the plastic container (open chemical reactor)***

Results:

- *the ^{137}Cs sorption by the container didn't occur for the 18 days of experiment*
- *the activity of initial ^{60}Co solution decreased by 96% for the 4 days of experiment*
- *The ^{85}Sr sorption by plastic container didn't exceed 25% of applied radioactivity for the 11 days of experiment*

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Conclusions

1. *Sorption of radionuclides by pipes (closed chemical reactor):*

•the ^{137}Cs sorption is decreased in number of: concrete lined pipe (91%) > iron pipe (30%) > plastic and copper pipe (3-8%)

•^{60}Co is sorbed by iron and plastic pipes almost completely (95-98%). The ^{60}Co sorption by copper pipe was low

•^{85}Sr is sorbed by iron pipes significantly (80-93%). The ^{85}Sr sorption by copper and plastic pipes was low

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Conclusions

2. *Desorption of radionuclides (closed chemical reactor):*

•For ^{137}Cs decontamination from concrete lined pipe the most effective reagent is 1 M KCl solution, from iron pipe- 0.1 M tartaric acid.

•For ^{60}Co decontamination from iron and concrete lined pipe the most effective reagent is 0.1 M EDTA, from plastic pipe- 0.1 M tartaric acid.

•For ^{85}Sr decontamination from iron pipe the most effective reagent is 0.1 M tartaric acid, from concrete lined pipe- 0.1 M EDTA and 0.2 M acetic- ammonium buffer

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Conclusions

3. Radionuclide sorption and desorption (open chemical reactor):

^{60}Co is well sorbed by the iron pipe with concrete coating. For plastic pipe and the iron pipe without coating the ^{60}Co surface distribution coefficients were lower. Using 0.1 M EDTA solution as a desorbing agent was effective for all types of pipes.

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THANK YOU FOR YOUR ATTENTION!

Thursday, November 7, 2013

General Session 5

Foreign Animal Disease Research

Decontamination of Agricultural Facilities Following a Bioterrorism Attack or Disease Outbreak: Learning from Outbreaks of Low Pathogenic Avian Influenza in Virginia

Gary A. Flory

http://garyflory.com

Gary.Flory@deq.virginia.gov

2013 U.S. EPA International Decontamination Research and Development Conference

Research Triangle Park, North Carolina, U.S.

5 - 7 November, 2013

- Virginia Poultry Disease Taskforce
- Virginia Catastrophic Livestock Mortality Taskforce
- Virginia Agroterrorism Task Force
- Virginia Pandemic Flu Working Group
- Texas VMA, One Health Taskforce

Virginia's Experience with AI

- 1983 – 69 flocks, H5N2
- 1999 – 1 flock, H5N2
- 2002 – 197 flocks, H7N2
- 2007 – 1 flock, H5N2
- 2007 – 1 flock, H5N1

Project Stages:

Managing Mortality, Bedding and Feed

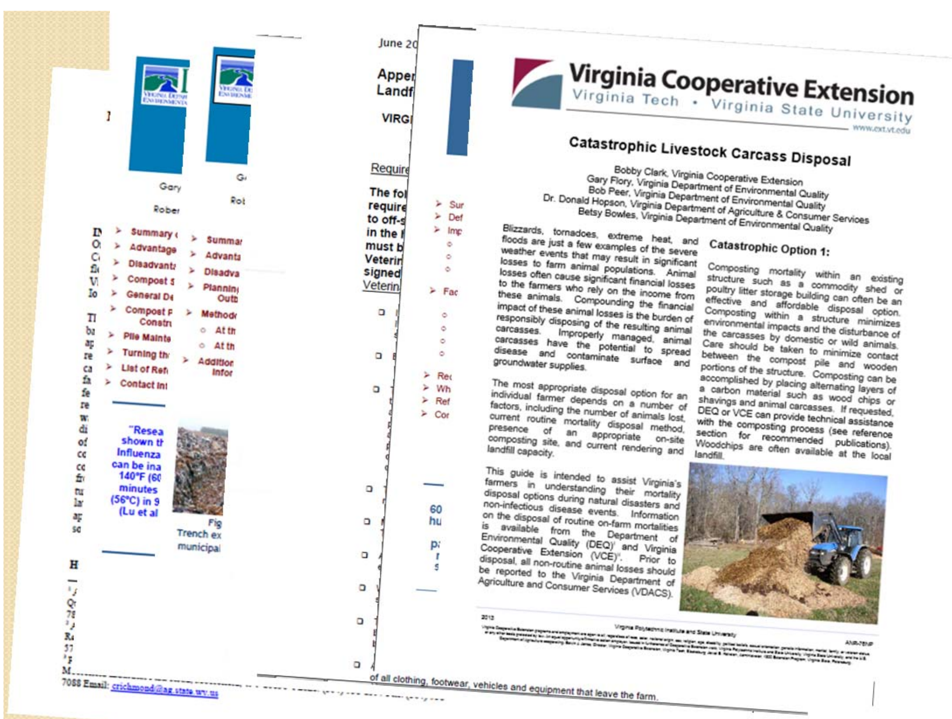
Removing Organic Residues

Cleaning & Disinfection

Moving from Infected to Disinfected

- Dispose of the infected carcasses
- Apply insecticide, close the barns and maintain 100° F for 72 hours
- Leave undisturbed for 21 days
- Remove all residuals such as manure and feed
- Wash all surfaces with soap and water
  - Disassemble equipment as necessary
- Disinfection of premises
- Test for disease agent

Lessons Learned and their Relevance to an Agroterrorism Attack or other Foreign Animal Disease Outbreak


Virginia Cooperative Extension
Virginia Tech • Virginia State University
www.ext.vt.edu
Catastrophic Livestock Carcass Disposal
Bobby Clark, Virginia Cooperative Extension
Gary Flory, Virginia Department of Environmental Quality
Bob Peer, Virginia Department of Environmental Quality
Dr. Donald Hopson, Virginia Department of Agriculture & Consumer Services
Betsy Bowles, Virginia Department of Environmental Quality
Catastrophic Option 1:
of all clothing, footwear, vehicles and equipment that leave the farm.

Let's collaborate!

Gary A. Flory

Gary.Flory@deq.virginia.gov

http://garyflory.com

LinkedIn

Animal Disease Outbreak Emergency Response

Michael L. Mayes
Project Manager
NC Department of Agriculture & Consumer Services
Raleigh, NC

The Project

Large scale Foreign Animal Disease (FAD) Outbreak response

Disposal = Logistical issues

- Transporting
- Permitting
- Disposal Capacities

The Project

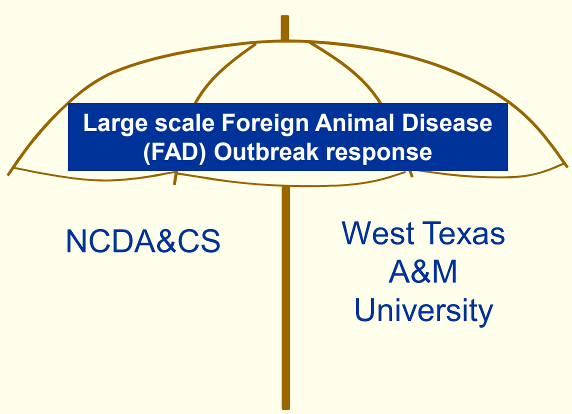
Large scale Foreign Animal Disease (FAD) Outbreak response

- USDA-APHIS / DHS funded grant

- Address response capability gaps

The Project

Large scale Foreign Animal Disease (FAD) Outbreak response



The Project

Large scale Foreign Animal Disease (FAD) Outbreak response

Lead	Focus Area
NCDA&CS	Swine & Dairy
West Texas A&M University	Beef Cattle

The Project

Large scale Foreign Animal Disease (FAD) Outbreak response

Lead		Other Partner States
NCDA&CS	⟷	Iowa Minnesota California Wisconsin
West Texas A&M University	⟷	Kansas Oklahoma Colorado New Mexico

The Project

Large scale Foreign Animal Disease (FAD) Outbreak response

Lead

NCDA&CS

- Iowa
- Minnesota
- California
- Wisconsin

West Texas A&M University

- Kansas
- Oklahoma
- Colorado
- New Mexico

Comprehensive Final Report

National Best Practices

- Transporting
- Permitting
- Disposal Capacities

Transport Parameters

- Regulations

    - CFR 49 Transportation

        - CFR 9 Animals and Animal Products

            - Individual State Regulations

Transport Parameters

- Types of Vehicles

    - Regular render haul?

        -Requirements
        - ✓ Leak-proof
        - ✓ Air-flow reduced/restricted
        - ✓ Pre-treated

    - Other types of transport

Movement Permit Parameters

- Permit Requirements
  - Mandatory information
  - State approval authority
  - How will it be tracked

Disposal Capacity Parameters

- Disposal Capacity
  - Where
  - How
  - Authority

Final Report

- Peer Reviewed

  - Transport, Permit, Disposal
  - Consolidate with W. Texas A&M
  - Report submitted as Recommended Actions

Disposal Calculator

- User inputs

  - Amount of material (or number of carcasses)
  - Select Disposal Locations (or input new one)
  - Select type of vehicle (or input new one)

- Outputs

  - Amount displayed in lbs and tons
  - Is linked to a map service and....
  - Displays number of trips


Conclusion
Large Scale Foreign Animal Disease
(FAD) Outbreak
Questions
Logistical infrastructure impacts
Mike Mayes
NCDA&CS Emergency Programs Division
michael.mayes@ncagr.gov
919-807-4309

Combustion of Contaminated Livestock in a Pilot-Scale Air Curtain Burner

P. Lemieux, J. Wood, W. Calfee
U.S. Environmental Protection Agency, RTP, NC

B. Hall
ARCADIS, Durham, NC

Outline

- Background
- Question to be Answered
- Approach
- Facility
- Test Conditions
- Results
- Conclusions

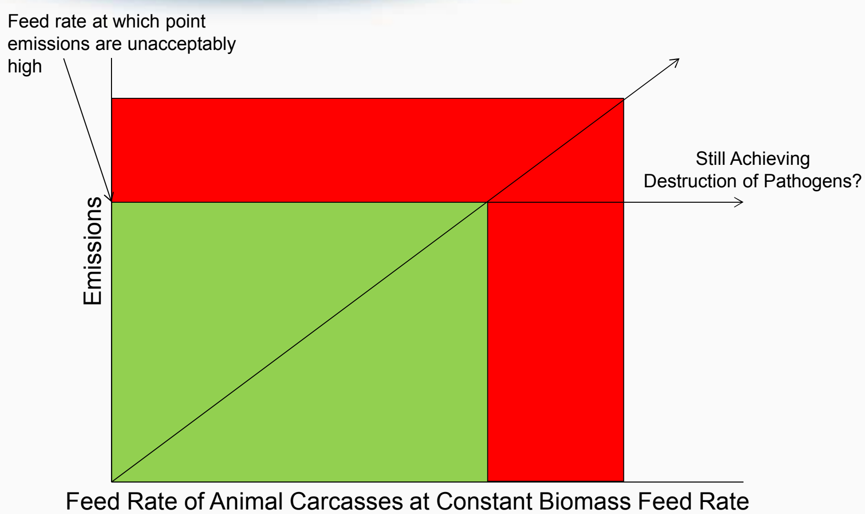
Background

- Air Curtain Burners
  - General Design
    - Open-topped
    - Generator/blower
    - Fixed plenum pointed downward
    - Biomass as aux. fuel
  - Primary Uses
    - Storm debris
    - Animal carcasses
  - Monitoring Approach
    - Opacity of Offgas

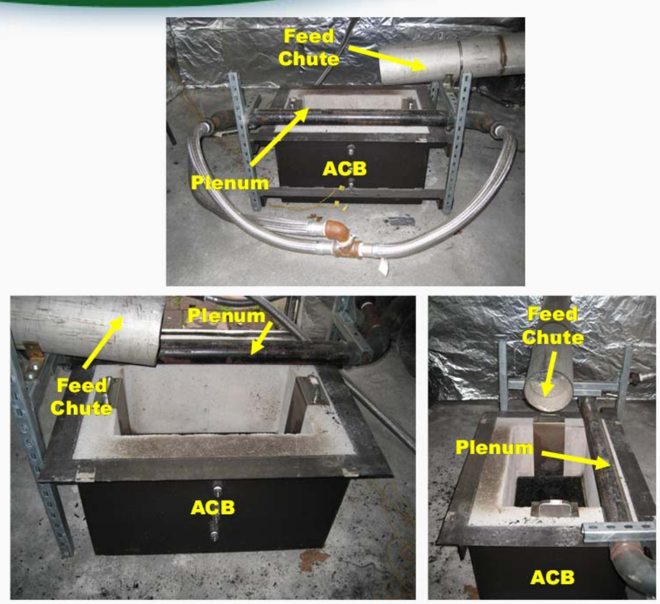
Question to be Answered

- Can ACB air pollutant emissions be used as a conservative indicator of pathogen destruction (i.e., if ACB emissions deteriorate to unacceptable level, is pathogen destruction still being achieved)?

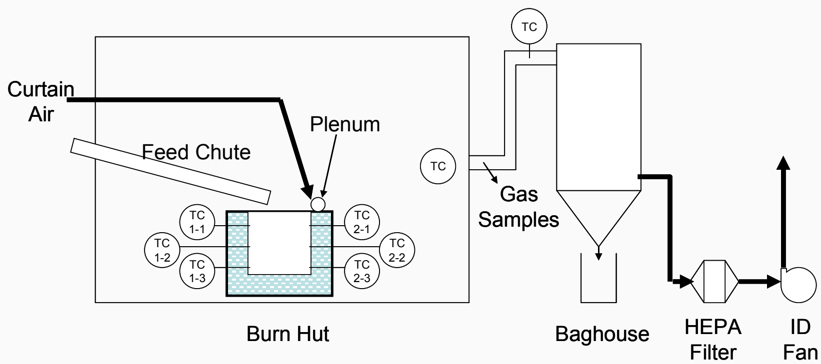
Approach



Pilot-Scale ACB Description



Facility



Feed Material

- Wood
  - 2 x 2's cut into 1-foot lengths
  - 25 lb/hr
- Poultry
  - Whole cornish game hens
  - Fed at varying time intervals (0, 2, 4, 6, 8, 10 min)
- Inoculum
  - 1E6 spores of *G. stearothermophilus* in 10 mL PBS
  - 1 mL of inoculum per bird

Testing Approach

- Scoping tests to identify appropriate baseline conditions (wood, poultry feed rate)
- Tests to identify near-failure conditions at which the ACB still operated, but emissions were significantly higher than baseline
- Tests at baseline conditions (wood:poultry ≈ 2:1) with wood/poultry (1 bird/10 min)
- Tests at near-failure conditions (wood:poultry ≈ 0.66:1) with wood/poultry (1 bird/4 min)

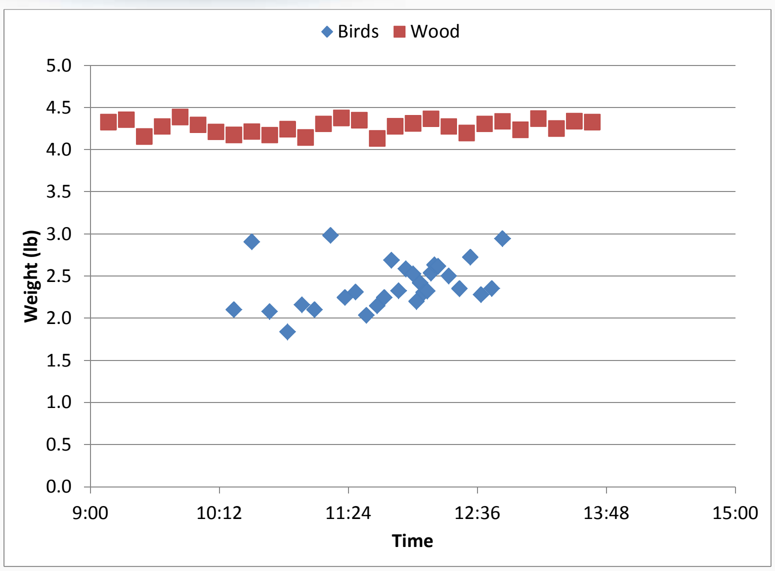
Sampling

- ACB firebox
  - Temperatures
- ACB bottom ash residue
  - Spores (grab sample)
  - Ash and bones analyzed separately
- Burn Hut inside floor sweepings
  - Spores (grab sample)
- Burn Hut inside wall
  - Spores (wipe sample)
- Burn Hut exhaust duct
  - Temperature
  - O_2, CO_2, CO, HC, PM, VOC, PAH
  - Spores (SKC Biosampler)

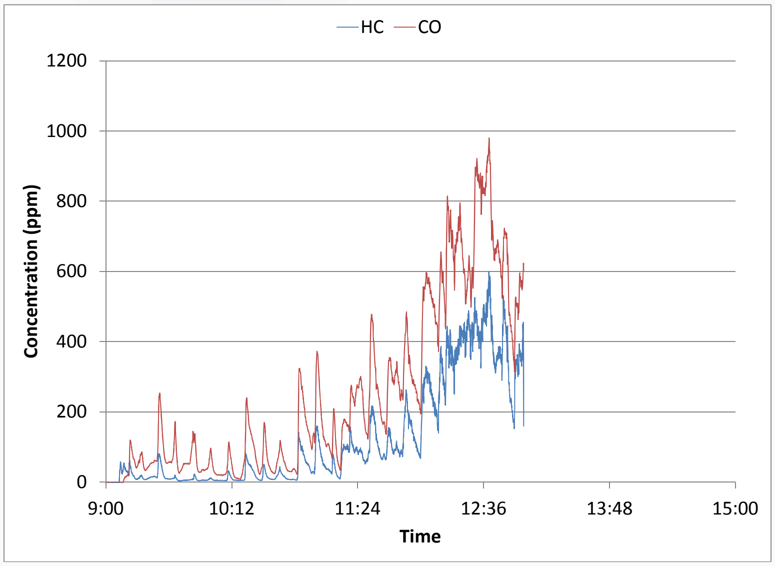
Test Procedure

- Initiate gas monitors; wait for stabilization
- Initiate wood feed; wait for stabilization
- Initiate poultry feed
- Initiate extractive sampling procedures
- Feed wood/poultry for test duration as per QAPP
- Cease extractive sampling
- Cease poultry feed
- Continue wood feed for 1 hr
- Cease wood feed; wait overnight
- Recover ash, floor sweepings, wipe samples
- Decontaminate Burn Hut with Spor-Klenz®

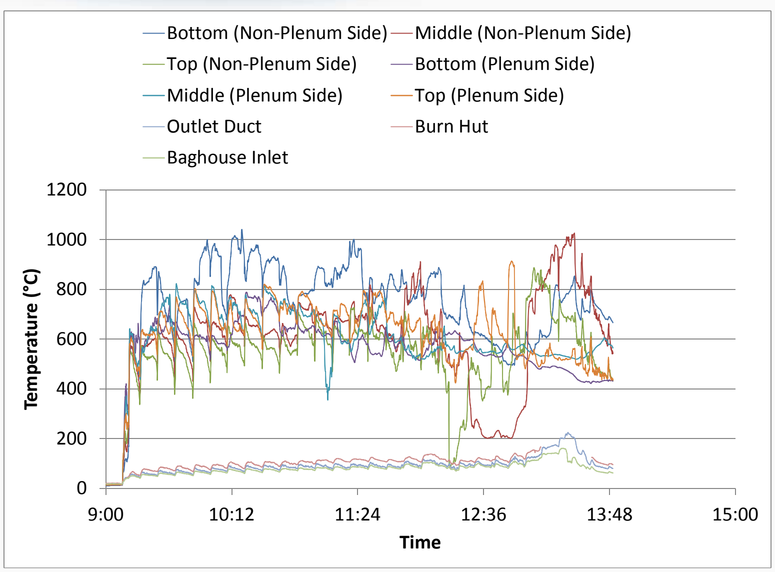
Results: Feed with Varying Feed Rate



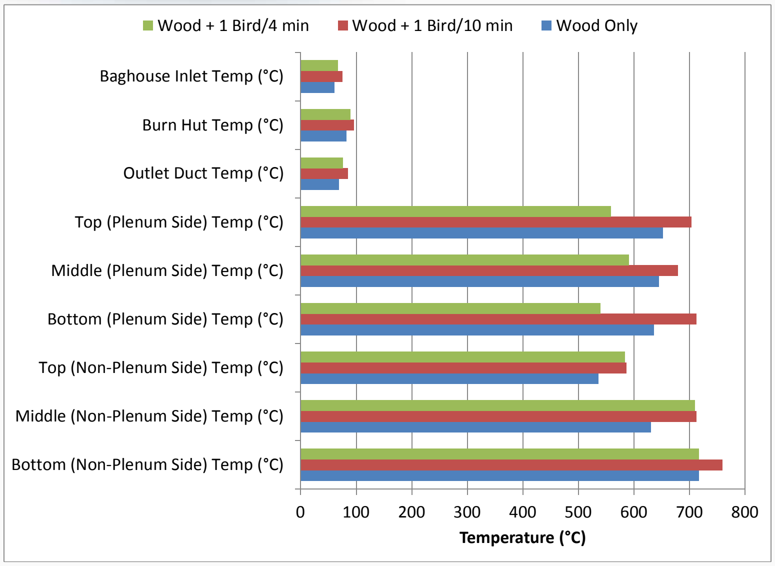
Results: CO and THC from Varying Poultry Feed Rate



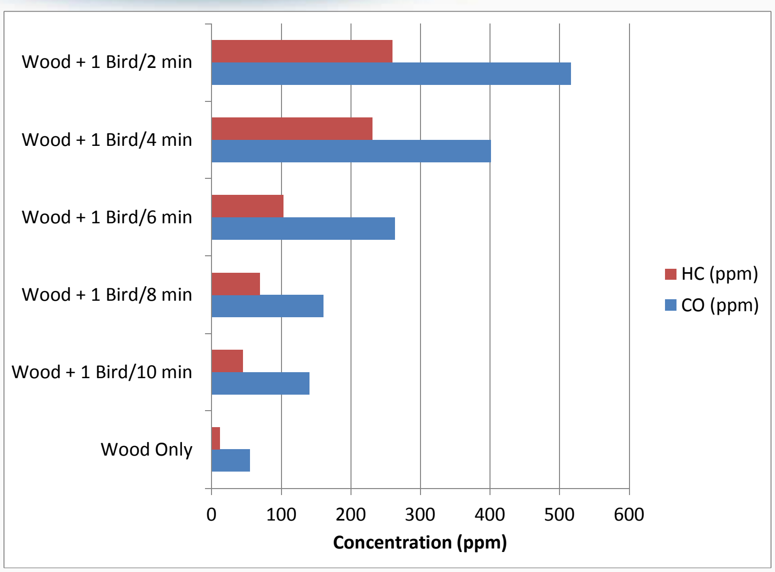
Results: Temperatures from Varying Poultry Feed Rate



Results: Average Temperatures



Results: Average CO and THC



Results: Estimated Emission Factors

Condition	CO (ppm)	HC (ppm)	PM (mg/m^3)	Σ PAH (μg/m^3)	CO (mg/kg total fuel)	THC (mg/kg total fuel)	PM (mg/kg total fuel)	Σ PAH (μg/kg total fuel)
Wood Only	55	12	NA	NA	11,500	3,900	NA	NA
Wood + 1 Bird/10 min	140	45	19	499	18,300	9,200	2,200	57,200
Wood + 1 Bird/4 min	401	231	45	1623	33,900	30,700	3,300	119,900

Results: Emissions of Spores

- Viable spores not detected in the air emissions in any test
- Small amounts of viable spores detected in residual poultry bones (1 of 8 tests)
- Small amounts of viable spores detected in floor sweepings at low poultry feed rate condition (2 of 4 tests) and high poultry feed rate condition (1 of 4 tests)
- Viable spores not detected in the residual ash in any test
- Viable spores not detected in any of the post-combustion wipe samples of Burn Hut walls

Results: Positive and Negative Controls

- Positive Control 1: Injection of inoculum directly into Burn Hut exhaust duct (no combustion)
  - Viable spores found on wall wipe samples
  - 149% recovery of spores in SKC Biosampler
- Positive Control 2: Injection of inoculum directly into Burn Hut (no combustion)
  - Viable spores found on wall wipe samples
  - 96% recovery of spores in SKC Biosampler
- Positive Control 3: Injection of inoculum directly into Burn Hut exhaust duct (with combustion)
  - No viable spores found on wall wipe samples
  - 43% recovery of spores in SKC Biosampler

Conclusions

- No observable difference between the residual viable spore results at the two test conditions
  - No measureable viable spores in the exhaust gases, residual bottom ash, or on the post-combustion wall wipe samples
  - Floor sweeping samples showed positive spore counts on occasional samples, but no statistically quantifiable difference
- Within limitations of the experiments, no measurable quantities of viable spores released from combustion of inoculated poultry even at poultry feed rates that resulted in pollutant emissions at least a factor of five higher than the baseline ACB emissions

Potential Future Work

- Increase inoculum concentration to achieve better quantitation levels of residual spores
- Investigation into use of alternate auxiliary fuels for ACB (e.g., coal)
- Evaluate viral surrogates
- Evaluation of different carcass feedstock
- Full-scale testing in the field

Disclaimer

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