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Environmental Protection
Agency

Report on the 2015 U.S. Environmental Protection Agency (EPA) International Decontamination Research and Development Conference

Office of Research and Development
National Homeland Security Research Center

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REPORT ON THE

2015 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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The 2015 International Decontamination Research and Development Conference would not have been possible without the efforts from the conference organizing committee members Tanya Medley, Amelia McCall, Matthew Magnuson, Jeff Szabo, Marshall Gray, Sanjiv Shah, and Lukas Oudejans. Their contributions to the planning of this conference are greatly appreciated.

Executive Summary

The 2015 U.S. Environmental Protection Agency (EPA) International Decontamination Research and Development Conference brought together scientists, practitioners, and policymakers related to chemical, biological, and radiological (CBR) remediation. For three days at EPA's campus in Research Triangle Park, North Carolina, more than 190 national and international participants representing local, state, and federal government agencies, academia, industry, and public advocacy groups viewed presentations and actively engaged in discussions and a poster viewing session. This diverse audience included experts in detection, environmental emergency response, risk communication, sampling, treatment, decontamination methods, waste management, and decision support tool development related to CBR agents to explore current issues and future directions.

This Executive Summary outlines the events and presentations of the conference, and references more detailed information in the Conference Report. The information is organized by topic: Plenary Session and General Sessions, followed by Concurrent Sessions by topic area, and the Poster Session.

Plenary Session

Dr. Lukas Oudejans, Chairperson of EPA's National Homeland Security Research Center (NHSRC) Conference Organizing Committee, welcomed participants to the conference and provided opening remarks.

Dr. Shawn Ryan, Division Director of the Decontamination and Consequence Management Division (DCMD) of the NHSRC, provided a brief historical perspective of the advances made in the decontamination field in the last ten years. Dr. Ryan applauded the role of the Conference in supporting and sharing those advances among scientists and responders to help with modern decontamination challenges.

Dr. Gregory Sayles, Acting Director of NHSRC, outlined the goals of the Conference, highlighting the importance of bringing together the scientific, regulatory, and response communities to convey the state of the science and continue to foster advances through collaboration. Dr. Sayles emphasized the relevance of this effort in light of recent incidents that have challenged decontamination researchers and practitioners.

General Session 1

Connecting Response and Research Activities

The first section of General Session 1, "Connecting Response and Research Activities," consisted of four presentations outlining how decontamination research can inform response practices. The first and second presentations, given by invited speakers Erica Canzler (U.S. EPA) and Joseph Barbera (George Washington University), focused on relationships and collaborations between researchers and emergency responders. The presentations discussed how available data can be quickly and appropriately interpreted to respond to incidents, and how these data could be incorporated into various testing and training scenarios to better prepare responders. Both presentations stressed the importance of leveraging relationships between researchers, responders, and regulators locally, nationally, and internationally to continue to develop practical applications for research in real-world CBR scenarios. The third and fourth presentations recounted recent examples of responses to ricin and *Burkholderia pseudomallei* incidents in the United States, in which research informed sampling and analysis planning and practices. Early and consistent communication between all involved parties was underscored as a crucial part of each of these real-world incident response processes. **Section 3 of this report provides additional details on these presentations.**

EPA Region 6's Two Recent Bio Responses; Slide 4
John Martin | *U.S. Environmental Protection Agency*

CBR Response Activities and Recovery Handbooks

This "CBR Response Activities and Recovery Handbooks" section of General Session 1 summarized recent CBR responses in two presentations, followed by a third presentation from Public Health England (PHE) showcasing a UK-developed handbook that aids in recovery after an incident. The first presentation outlined the development and application of a "field deployable hydrolysis system" used by the United States Army to safely destroy 600 tons of declared Syrian chemical agents. The second presentation focused on the continued recovery of the large area affected by the Fukushima, Japan, nuclear accident in 2011. The presentation explored available data and techniques to model indoor radiological exposure from various potential sources, and the impact of these findings on the recovery process for the affected regions. The "UK Recovery Handbook for Biological Incidents" was exhibited in the third presentation of this Session. This handbook follows the previous handbooks developed for chemical and radiological incidents and focuses primarily on the cleanup and restoration phases of recovery with the aim of reducing exposure and returning to 'normality.' All handbooks aid decision makers in the development of a recovery strategy. **Section 4 of this report provides additional details on these presentations.**

Field Demonstration and (International) Program Review

The final section of General Session 1, "Field Demonstration and (International) Program Review," consisted of four presentations. The first presentation outlined the benefits of methyl bromide fumigation versus an approach using ethylene oxide and vaporized hydrogen peroxide to respond to *Bacillus anthracis* release. A field demonstration of a patented method of decontaminating entire structures using methyl bromide fumigation was presented. The remaining three presentations focused on programs and international frameworks for defense and response in the United States, Canada, and the United Kingdom.

Canadian Safety and Security Program Project for Infrastructure Mitigation for Rapid Response after a Radiological Incident; Slide 8
Konstantin Volchek | *Environment Canada*

The first of these three presentations showed that in the United States, the Department of Defense is working to improve many technologies that aid in detection and decontamination of agents, including improving resistance of response-vehicle coatings to agents and wide-area anthrax decontamination using germination of spores as a mitigation approach, among others. In the UK, the Government Decontamination Service, with input from other suppliers, has developed a framework process for sampling and analysis, decontamination, and waste management and disposal in response to CBR incidents, including provisions for responder health and safety throughout the process. The fourth and final presentation stressed the importance of developing mitigation techniques to address radiological contamination in the short term to facilitate further and more complete decontamination afterward. Environment Canada, with other collaborators, developed and demonstrated a water-based formulation technology that can be dispersed using fire trucks. **Section 5 of this report provides additional details on these presentations.**

General Session 2 – Data Models, Research Overviews and Remediation Plans

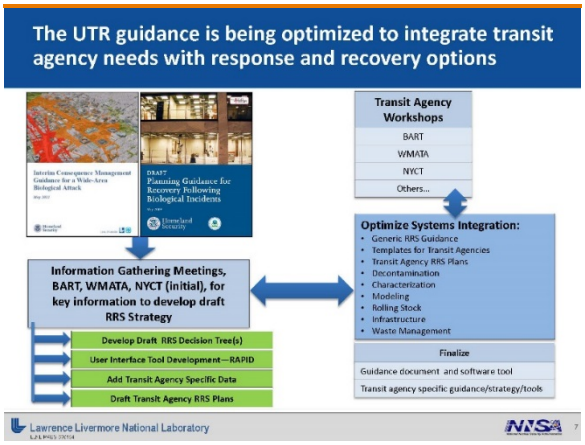
The first presentation in General Session 2 offered an analysis of the data and models used to inform federal response in the United States. Data used in the event of hurricanes and earthquakes were organized, characterized, analyzed for data gaps and compiled into an interactive resource inventory. The second and third presentations provided perspectives on biological decontamination research and remediation plans from EPA and the New York City Department of Health and Mental Hygiene (NYC DOHMH). The EPA's Homeland Security Research Program presentation included recent work in decontamination, including improving demonstration and implementation of fumigants, new application methods for liquid sporicides, and progress with emerging decontaminants. The NYC DOHMH outlined their work, in collaboration with other organizations, to develop a biological incident remediation plan for New York City from incident preparation through recovery and re-occupation of the affected area. In the process, they also detailed important data gaps and challenges associated with decontamination of a city the size of New York. The fourth and final presentation in this session provided an update on available water decontamination strategies, including a report on the progress of the 2008 Critical Infrastructure Partnership Advisory Council Recommendations, resources for water utilities in the event of an incident, an overview of recent decontamination tabletop exercises, and other projects. **Section 8 of this report provides additional details on these presentations.**

General Session 3 – Biological Agent Reaerosolization

General Session 3 featured a presentation that provided an update on the Scientific Program on Reaerosolization and Exposure (SPORE), which explores the relationship between reaerosolization and continued exposure to inform risk-related decision making. **Section 15 of this report provides additional details on this presentation.**

General Session 4 – Decision Support Tools and Guidance Documents

The four presentations given during General Session 4 focused on the resources available to aid decision-makers in the wake of emergencies or incidents. The first presentation focused on availability and functionality of the Prioritization Analysis Tool for All-Hazards/Analyzer for Wide-Area Restoration Effectiveness (PATH/AWARE), which was developed to address CBR scenarios involving weapons of mass destruction. There are plans to expand PATH/AWARE to address hurricanes, floods, and earthquakes in the future. The second presentation provided an overview and short demonstration of the GIS-based Waste Estimation Support Tool (WEST), designed to inform waste management strategies for wide-area contamination scenarios. The next presentation turned the focus to recovery after a specific scenario – an incident involving under-ground transportation. The joint U.S. DHS-EPA Underground Transportation Restoration (UTR) project goals, including developing the first federal guidance to decrease subway restoration down time after a biological event, were outlined. The final presentation explored the potential applicability of data from historical incidents to modern urban response and recovery and the challenges involved. **Section 18 of this report provides additional details on these presentations.**



Developing Biological Operational Response and Recovery Guidance for Rapid Return to Service of Underground Transportation; Slide 7
Robert Fischer | *Lawrence Livermore National Laboratory*

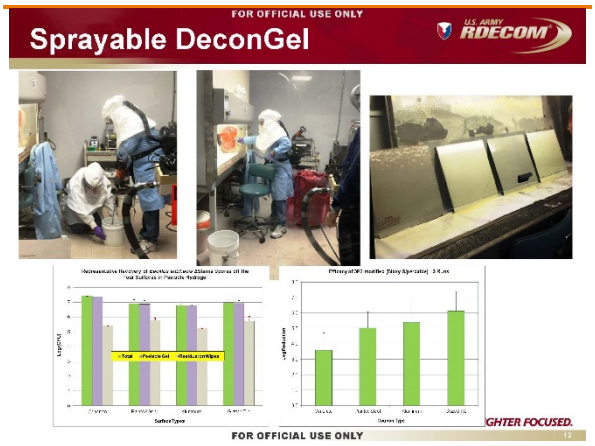
Concurrent Sessions

Sessions were conducted concurrently throughout the duration 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 were a recurring theme while other sessions transitioned between radiological, chemical, water, and waste.

Biological Agent Decontamination

The first Biological session included five presentations that outlined methodologies used for decontamination of areas contaminated by biological agents and the experimental evaluation of various factors affecting the efficacy of these methods. The first of these presentations focused on a relatively nontoxic novel microemulsion decontaminant option for use on chemical as well as biological agents. Performance of the technique for both chemical and biological agents, detector interferences, and material compatibility of the technique were all evaluated. A second presentation expounded on a novel decontamination concept involving use of a viscous hydrogel polymer. Some unique advantages of this approach include a reduction in the amount of hazardous waste, preservation of forensic evidence locked in the gel, and multiple application options for complete coverage of complex surfaces.

A new method of generating chlorine dioxide by photochemically activating chlorite ions was explained in the third presentation. This method was found to have extended benefit over time and was presented as a potential consumer product due to its ease of use and low risk to the operator. The next presentation examined the advantages and disadvantages of various wide-area decontamination methods and presented reason to question the viability of simple "pass/fail" tests for decontamination methods using only small coupons. The fifth and final presentation in this session



Novel Bio-decon Approach – DeconGel; Slide 12
Vipin Rastogi | *U.S. Army, Edgewood Chemical Biological Center*

outlined the results of experimental investigation of the efficacy of methyl bromide fumigation as a decontamination technique under various ambient conditions, on various surfaces, and on various potential surrogate microorganisms for *Bacillus anthracis*. Each of these presentations summarized the outcomes of the experimental testing performed. **Section 6 of this report provides additional details on these presentations.**

Biological Agent Detection

The second Biological session focused on methods and research associated with detection of biological agents. The first of these four presentations described efforts to independently and systematically evaluate various hand-portable biological indicator, immunoassay, and PCR techniques of detection to better inform the first-responder community. The importance of using the best possible rapid-detection techniques in the event of a "suspicious white powder" incident was emphasized. The next two presentations explored the development of rapid viability PCR methods for detecting *Bacillus anthracis* and *Yersinia pestis*. The first of these two presentations offered an overview and historical perspective of rapid viability PCR method development. The second focused on recent efforts to develop a reliable method of detecting *Y. pestis* in water samples and on refining sample preparation protocols to optimize *Y. pestis* cell recovery and growth. The final presentation in this session explored in more detail the challenges associated with obtaining consistent "standard samples" from real-world environments. Established methods of sampling were revisited with proposed revisions that may optimize their use in detection. **Section 9 of this report provides additional details on these presentations.**

Biological Agent Sampling

The third Biological session was dedicated to exploring topics related to bio-sampling, through four presentations. The first of these presentations focused on efficiency of various sampling methods, regarding the number of samples necessary to establish clearance of an area after decontamination. Various tools and sampling techniques were described and evaluated for efficiency of detection. The second presentation discussed current research developing and evaluating a composite sampling method using cellulose sponges. The established method of sponge wiping for surfaces was compared to a new modified method and evaluated for collection efficiency and potential for cross-contamination. A third presentation described work to assess the potential of using commercial robotic vacuum cleaners as sampling as well as decontamination tools. Recovery efficiency and variability due to the sampling pattern were examined experimentally for a variety of flooring materials. The fourth presentation summarized the various laboratory sampling and analysis capabilities that could provide rapid support for a large scale environmental response. **Section 11 of this report provides additional details on these presentations.**

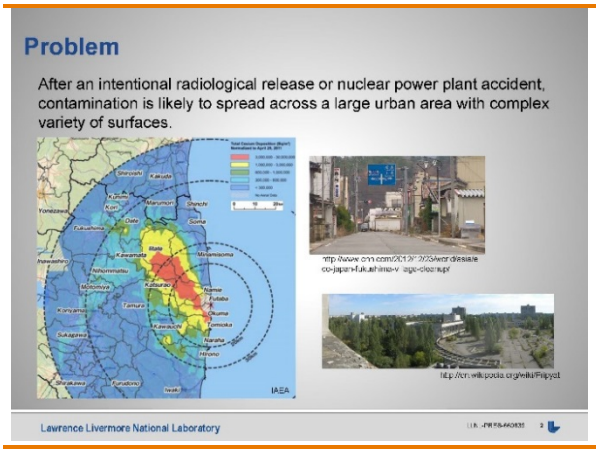
Biological Agent Decontamination Equipment

The three presentations given in the final Biological session focused on equipment used to decontaminate areas contaminated with biological agents. A portable system specially designed to decontaminate vehicles was introduced in the first presentation. The system, redesigned from an original prototype, is operable by a single person and is entirely self-contained, including all runoff and reclaimed liquid. The second presentation examined the efficacy of a mobile pressure washer with and without additional biocides for decontaminating equipment. Many variables, including pressure washing time, presence or absence of grease on the surface, and type of additive disinfectant used were evaluated. The third and final presentation offered results of research on efficacy of a variety of nozzle types used for wide-area spray decontamination. Spray patterns created by different nozzles were evaluated on types of horizontal and vertical surfaces, and results were presented. **Section 13 of this report provides additional details on these presentations.**

Biological Agent Aerosols and Morphology of Spores

The final biological-agent concurrent session examined biological aerosols and spore morphology. The first of four presentations introduced a reaerosolization study method designed to minimize common errors in these types of studies. The study itself examined the differences in reaerosolization of anthrax and its surrogates from common outdoor surfaces like asphalt, concrete, and glass. A second presentation examined the flaws in the usual assumption associated with modeling bodily fluid aerosols: that most droplets fall to the ground with limited evaporation. A more realistic modeling scenario was presented, taking into account the effects of various conditions on droplet evaporation. The third presentation expounded on a study designed to test the reproducibility and consistency of methods used to deposit bacteria on coupons uniformly using aerosols, harvest bacteria, and determine bacterial surface decay accurately. The methods presented are expected to help generate relevant data for post-event planning and response. The final presentation focused on the use of atomic force microscopy (AFM) to examine structure-function relationships of pathogens, specifically the morphology of *Bacillus anthracis* spores. The in vitro use of AFM could fill an analytical gap in the characterization of pathogens and could significantly improve understanding of decontamination methods and approaches. **Section 16 of this report provides additional details on these presentations.**

Radiological Agent Response and Recovery



Radiological Contaminant Stabilization Technologies; Slide 2
Mark Sutton | *Lawrence Livermore National Laboratory*

This session examined response to and recovery from radiological incidents. The first of five presentations summarized the guidance and tools available to radiological first responders. The importance of identifying responder needs through discussion and stakeholder input was emphasized. The second presentation examined technologies designed to contain radiological agents after an incident, which could allow time and consideration for decision makers. That work involved grouping available technologies into tiers, based on their availability and the time needed for deployment. The third presentation emphasized the importance of exploring gross mitigation methods, which would reduce first-responder exposure and reduce resources needed for full decontamination later on. Various techniques on a variety of surfaces were investigated, with more research on the topic forthcoming in the future. A summary of

various available radiological mitigation technologies was given in the fourth presentation. These technologies were to be demonstrated during a DHS/EPA Technology Demonstration for radiological responders in June 2015. The final presentation in this session focused on the importance of developing and implementing early-phase waste management plans. Emphasis was placed on including waste management strategies in the Area Contingency Plan. **Section 7 of this report provides additional details on these presentations.**

Water Infrastructure Decontamination

This session examined the obstacles and solutions associated with decontamination of water and wastewater infrastructure through four presentations. The first presentation gave an overview of selected projects exhibiting techniques of water and wastewater decontamination and restoration and featured a few facilities capable of unique water decontamination and treatment research, including a new water security test bed (WSTB) in Idaho. The second presentation offered a more in-depth look at this WSTB, providing background information and status updates of ongoing research. Both of these presentations stressed the importance of the WSTB and the opportunities it provides to address gaps in water infrastructure protection. The third presentation experimentally examined the persistence of radioactive particles on drinking water pipework to better inform responders about the effectiveness of various decontamination methods. The last presentation also focused on adsorption of particles to sediments that settle in drinking water storage tanks. Samples were collected and analyzed for adherence of various CBR substances. **Section 10 of this report provides additional details on these presentations.**

Water and Waste Water Treatment

The subject for this session was treatment of water and waste water. The first of four presentations provided an overview of selected ongoing research projects designed to make water systems more resilient, to detect and mitigate contamination, and to treat water and water structures. Highlighted projects included investigation of the fate of organophosphates in municipal wastewater treatment systems, prediction of hydrolysis rates of organophosphates, and managing and treating large amounts of CBR-contaminated water and wastewater residuals. The second presentation shared research on the inactivation of vegetative *Bacillus anthracis* in drinking water using free available chlorine and monochloramine. Various conditions were tested, and results were presented. The third presentation addressed the need for development of a deployable CBR water treatment system that would minimize the volume of contaminated effluent generated from the decontamination process. An update of the results, findings, and products developed to accomplish this minimization to date was given. The fourth presentation focused on large-volume contamination events and presented findings from development of a toolbox of strategies for disposal of contaminated water and exploring the challenges that wastewater utilities face when accepting water pre-treated with advanced oxidation processes. **Section 12 of this report provides additional details on these presentations.**

Management and Treatment of Copious Amounts of CBR Contaminated Water and Wastewater; Slide 12
Matthew Magnuson | *U.S. Environmental Protection Agency*

Waste Treatment and Disposal

This presentation addressed management and disposal of waste after an event. Specifically, research was presented on the behavior of biomass-bound cesium in an incinerator environment. Different variables affecting this behavior were examined, and results were presented. **Section 14 of this report provides additional details on this presentation.**

Chemical Agent Decontamination

The four presentations given during this session focused on various techniques of chemical decontamination. The first of these presentations presented findings from the site remediation of a penicillin production facility using chlorine dioxide gas. This successful six-day endeavor, which cost approximately $327,000 USD, was explained in detail from start to finish, including placement throughout the building of fans, humidity generators, and samplers, and sealing the building in preparation for gassing. The second presentation in this session examined the potential use of common household materials and cleaning agents like hydrogen peroxide, baking soda, and rubbing alcohol, among others, to decontaminate VX, GD, and HD without leaving toxic residue on surfaces. These techniques would aid in speeding first response, because necessary materials are easily accessible in large quantities. The Integrated Decontamination Test and Evaluation System was introduced in the third presentation. This test facility enables systematic evaluation of the efficacy of decontamination methods under various sets of experimentally controlled conditions. Survivability of decontamination equipment and gear can also be examined. The final presentation in this session investigated the ability of four solutions to decontaminate materials in response to sulfur mustard, Lewisite, and agent yellow contamination. This bench-scale study examined these solutions for wood, metal, glass, and sealed concrete, and analyzed for efficacy as well as residual byproducts. **Section 17 of this report provides additional details on these presentations.**

Poster Session

An afternoon poster session on the second day of the Conference provided a break between oral sessions with 31 posters representing a range of remediation-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 19 of this report provides additional details on these presentations.**

Table of Contents

Acronyms and Abbreviations

Abbreviation/Acronym	Definition
AAHP	Aerosolized Activated Hydrogen Peroxide (project)
ABCS	Aeromedical Biological Containment System
ABEP	Aboveground Burial Enhanced with Phytoremediation
AFM	atomic force microscopy
ANOVA	analysis of variance
AOP	advanced oxidation processes
ARCIC-FWD	Army Capabilities Integration Center-Future Warfare Division
AST	American Society for Testing and Materials
ATD-GCMS	Automated Thermal Desorber coupled with Gas Chromatography Mass Spectrometer
AWARE	analyzer for wide-area restoration effectiveness
Ba	*Bacillus anthracis*
BaS	*Bacillus anthracis Sterne*
BART	Bay Area Rapid Transit
BDDE	boron-doped diamond electrode
BFC	bioforensic collector
Bg	*B. globigii*
BLAST	Basic Local Alignment Search Tool
BOTE	Bio-Response Operational Testing and Evaluation
Bs	*Bacillus subtilis*
Btk	*B. thuringiensis var. kurstaki*
CA	chloramine
CASCAD	Canadian Aqueous System for Chemical/Biological Agent Decontamination Foam
CBDP	Chemical and Biological Defense Program
CBR	chemical, biological, and radiological
CBRN	chemical, biological, radiological, and nuclear
CD	chlorine dioxide
CDC	(U.S.) Centers for Disease Control and Prevention
CERI	community environmental index
CEUs	continuing education units
CFD	computational fluid dynamics
CFU	Code of Federal Regulations
CJR	combined judgmental and random
CMAD	(U.S. EPA) Consequence Management Advisory Division
COD	chemical oxygen demand
CONOPS	Concept of Operations
COTS	commercial off-the-shelf
CRP	Critical Reagents Program
CRPμTIC	CRP (microbial) Threat Information Center
CRPCD	Conference of Radiation Control Program Directors
Cs	cesium
CsCl	cesium chloride
CT	contact time
CWA(s)	chemical warfare agent(s)
DCMD	Decontamination and Consequence Management Division
DECON	decontamination capabilities
DeconST	Decontamination Strategy and Technology Selection Tool
DFs	decontamination factors

Abbreviation/Acronym	Definition
DG	DeconGel™
DHHS	(U.S.) Department of Health and Human Services
DHS	(U.S.) Department of Homeland Security
DHS S&T	(U.S.) Department of Homeland Security Science and Technology Directorate
DNA	deoxyribonucleic acid
DoD	(U.S.) Department of Defense
DoD-DTRA	(U.S.) Department of Defense - Defense Threat Reduction Agency
DOE	(U.S.) Department of Energy
DOE	design of experiments
DOHMH	Department of Health and Mental Hygiene
DPAT	Decontamination Preparedness and Assessment Tool
DPG	Dugway Proving Ground
DTRA	Defense Threat Reduction Agency
ECL	electrochemiluminescence
EDTA	ethylenediaminetetraacetic acid
EPA	(U.S.) Environmental Protection Agency
ESFLG	Emergency Support Function Leadership Group
FAC	free available chlorine
FAD	foreign animal disease
FDHS	Field Deployable Hydrolysis System
FDNPP	Fukushima Daiichi Nuclear Power Plant
FE	flushing evaluation
FEMA	Federal Emergency Management Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FMD	Foot and Mouth Disease
FNR	false negative rates
FRG	First Responders Group
GAO	(U.S.) Government Accountability Office
GB	Sarin
GD	gross decontamination
GPL	General Population Limit
Gs	*Geobacillus stearothermophilus*
HaMMER ATD	Hazard Mitigation, Materiel and Equipment Restoration Advanced Technology Demonstration
HD	sulfur mustard
HEPA	high efficiency particulate air
HLW	high level waste
HPAC	$H_2O_2/NH_3/CO_2$
HSRP	(U.S.) Homeland Security Research Program
HTB	high test bleach
HTH	high test hypochlorite
HVAC	heating, ventilation, and air conditioning
IBRD	Interagency Biological Restoration Demonstration
IC	Incident Command
ICS	Incident Command System
IDTES	Integrated Decontamination Test and Evaluation System
IND(s)	improvised nuclear device(s)
INL	Idaho National Laboratory
IWWA	Irreversible Wash Aid Additive
JBADS	Joint Biological Agent Decontamination System

Abbreviation/Acronym	Definition
JPM_P	Joint Program Manager, Protection
JSTO	Joint Science and Technology Office
L	Lewisite
LAW	low activity waste
LC/MS	liquid chromatography/mass spectrometry
LDH	lactate dehydrogenase
LED	light emitting diode
LFI	lateral flow immunoassays
LLNL	Lawrence Livermore National Laboratory
LOD	limit of detection
Lst	lytic enzyme lysostaphin
MB	methyl bromide
MCHM	4-methylcyclohexanemethanol
MDI(s)	metered dose inhaler(s)
MDWG	Modeling and Data Working Group
MeBr	methyl bromide
MRSA	methicillin-resistant *Staphylococcus aureus*
MTTP	multiservice tactics, techniques, and procedures
NGS	next generation sequencing
NHSRC	(U.S. EPA) National Homeland Security Research Center
NIES	National Institute for Environmental Studies, Japan
NIMS	National Incident Management System
NMR	nuclear magnetic resonance
NPP	nuclear power plant
NUSTL	National Urban Security Technology Laboratory
NYC DOHMH	New York City Department of Health and Mental Hygiene
NYCT	New York City Transit
OCSPP	(U.S. EPA) Office of Chemical Safety and Pollution Prevention
OD	optical density
OEM	(U.S. EPA) Office of Emergency Management
OHS	(U.S. EPA) Office of Homeland Security
OP	organophosphate
OPCW	Organization for the Prohibition of Chemical Weapons
ORCR	(U.S. EPA) Office of Resource Conservation and Recovery
ORP	oxidation and reduction potential
OSC(s)	(U.S. EPA) On-Scene Coordinator(s)
OSCAR	Ordering System for CRP Assays and Reagents
OSTP	(U.S. White House) Office of Science and Technology Policy
OW	(U.S. EPA) Office of Water
OWM	(U.S. EPA) Office of Wastewater Management
PAGs	(U.S. EPA) Protection Action Guidelines
PATH	prioritization analysis tool for all hazards
PC	personal computer
PCR	polymerase chain reaction
PDA	potato dextrose agar
PDED	(U.S. EPA's) pipe decontamination experimental design
PDEDP	(U.S. EPA's) Persistence and Decontamination Experimental Design Protocol
PE	persistence evaluation
PFOA	perfluorooctanoic acid
PHE	Public Health England

Abbreviation/Acronym	Definition
POTW	publicly owned treatment works
PPD	Presidential Policy Directive
PPE	personal protective equipment
PPM	parts per million
Psi	pound(s) per square inch
PUV	pulsed UV
PVC	polyvinyl chloride
Q&A	questions and answers
QSPR	quantitative structure property relationship
R4	recover, recycle, reuse, remanufacture
R&D	research and development
RCM	radiological contamination mitigation
RCRA	(U.S.) Resource Conservation and Recovery Act
RDD(s)	radiological dispersion device(s)
RE	recovery efficiencies
RH	relative humidity
RNRR	Radiological/Nuclear Response and Recovery
rpm	revolutions per minute
RV-PCR	Rapid Viability Polymerase Chain Reaction
SAIC	Science Applications International Corporation
SBIR	Small Business Innovation Research
SDS	sodium dodecyl sulfate
SMEs	subject matter experts
SNL	Sandia National Laboratories
SPORE	Scientific Program on Reaerosolization and Exposure
TaCBRD	Transatlantic Collaborative Biological Resiliency Demonstration
TARMAC	Targeted Acquisition of Reference Materials Augmenting Capabilities
TEER	transepithelial electrical resistance
TIC(s)	toxic industrial chemical(s)
TOC	total organic carbon
TRF	time resolved fluorescence
TWG	technical working group
UC	unified command
UCC	Unified Culture Collection
UKRHBI	U.K. Recovery Handbook for Biological Incidents
USACE ERDC	U.S. Army Corps of Engineers Engineer Research and Development Center
USAF	U.S. Air Force
USDA	U.S. Department of Agriculture
USDA-APHIS	USDA-Animal and Plant Health Inspection Service
UTR	underground transportation restoration
UV	ultraviolet
VHP	vaporous hydrogen peroxide
VX	O-ethyl-s-(2-diisopropylaminoethyl) methylphosphonothiolate
WARRP	Wide-Area Recovery and Resilience Program
WEST	(U.S. EPA) Waste Estimation Support Tool
WMD	weapons of mass destruction
WPL	Worker Population Limit
WSD	(U.S. EPA) Water Security Division
WTP	water treatment plant
WV	West Virginia (United States)

1. Introduction

This report summarizes presentations and discussions from the "2015 U.S. Environmental Protection Agency (EPA) International Decontamination Research and Development Conference," held May 5–7, 2015, at the U.S. EPA Conference Center in Research Triangle Park, North Carolina. The technical content of this report is based entirely on information and discussions from the conference.

The conference consisted of 58 speaker presentations organized into four general sessions and five concurrent sessions. A poster session showcasing 31 posters was held on the second day of the conference. Approximately 200 conference participants represented federal, state, and local government agencies and laboratories; international organizations (six countries in addition to the United States); academia; and the private sector.

This report highlights the opening session of the conference and summarizes each presentation given during the conference. Each presentation summary includes the abstract provided by the speaker and an overview of the 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 chemical, biological, and radiological decontamination, and water and wastewater management as follows. Poster session abstracts are located at the end of the report (page 75).

- Section 2 summarizes the opening session.
- Section 3–19 contain the abstracts and question-and-answer summaries for nearly 60 presentations given over the course of the three-day conference, as well as abstracts for the posters presented on Day 2. The presentations are organized according to the agenda.
- Appendix A provides the meeting agenda.
- Appendix B lists the conference participants.
- Appendix C includes presentation slides for speakers who approved them for distribution.

2. Opening Session

Dr. Lukas Oudejans, Chairperson of the EPA/NHSRC Conference Organizing Committee, welcomed participants to the conference and provided opening remarks. He thanked members of the organizing committee for their effort in planning the conference and provided an overview of the conference format.

Dr. Shawn Ryan, Divison Director, EPA/NHSRC/Decontamination and Consequence Management Division (DCMD), thanked Dr. Oudejans and the other organizing committee members. Dr. Ryan discussed advances in the decontamination research community over the last ten years driven, in part, by the efforts of this conference. He specifically mentioned the advances in sampling/cleanup devices and surrogate spores that are improving decontamination capabilities as well as addressing remediation. He expressed his enthusiasm for learning more over the course of the Conference.

Dr. Gregory Sayles, Acting Director, EPA/NHSRC, reiterated the accolades to Drs. Ryan and Oudejans, as well as the other organizing committee members. Dr. Sayles thanked all attendees for their participation and the international registrants for enduring the long travel. He explained that the purpose of the conference is to bring together researchers who are looking to push the boundaries of research, policymakers who will develop guidance, and the field teams implementing the work. Dr. Sayles encouraged speakers to convey the state of the science and attendees to reflect upon challenging incidents that continue to occur. Dr. Sayles introduced Erica Canzler, Director, EPA Chemical, Biological, Radiological, and Nuclear (CBRN) Consequence Management Advisory Division (CMAD), which is a group that manages assets to aid in cleanup responses and provides guidance to other responding organizations.

3. General Session 1
Connecting Response and Research Activities

Auditorium C-111

Presentations and Questions and Answers (Q&A) moderated by Shawn Ryan and Leroy Mickelsen | *U.S. EPA*

Science and Environmental Response Decision Making: Examples of Research Supporting Field Operations
8:30 am

Erica Canzler, Invited Speaker (presenter) | *U.S. Environmental Protection Agency*

Abstract

No abstract available.

Questions, Answers, and Comments

- [no questions]

Emergency Response Research, Development, Education & Training: A Researcher-Responder Perspective
9:00 am

Joseph Barbera, Invited Speaker (presenter) | *George Washington University*

Abstract

Technical emergency response, especially in the extreme urgency and/or novel context, is very complex and difficult. Research to improve response must include both the technical elements ("what needs to be done") and the application elements ("how to do it in the time urgency, uncertainty and austerity of the emergency context"). These are commonly two very different areas of research expertise, and unless carefully considered and integrated, the gap can result in suboptimal and even dangerous solutions. Conveying the necessary education (knowledge) and training (skills and abilities) creates an additional element that must be carefully developed to assure operational level of competency in the emergency responders.

Dr. Barbera has participated in research and development of specialized emergency response resources for almost three decades. He will highlight insights gained from developing response resources and systems that have been used in actual response. Interface between technical developers, response managers and practitioners, and training systems will be examined. Research and development strategies and tactics are presented for discussion.

Questions, Answers, and Comments

- [no questions]

Lessons Learned from Three Recent EPA Ricin Responses

9:30 am

Mike Nalipinski (presenter) | *U.S. Environmental Protection Agency*

Abstract

This presentation will provide multiple lessons learned from recent responses by EPA EPA On-Scene Coordinators (OSCs) to ricin in Mississippi, Wisconsin, and Oklahoma. The transition from law enforcement to local public health followed by their request for EPA assistance will be discussed. Challenges associated with characterization sampling, decontamination approaches, and clearance analysis will be discussed. Of particular interest, the analytical approaches used at the three example sites will identify how the various responses were successfully completed with affected properties returned to normal operation.

Questions, Answers, and Comments

- Q: Were the surfaces cleaned and rinsed before you applied the bleach?
- A: We used bleach because it was easy and readily available; in some cases there was some HEPA vacuuming, but not in others. Bleach needs sufficient contact time, in the absence of organic matter, to effectively render the ricin inactive. In the case with the table in the home in Wisconsin, the table was clean, so we bleached it and let the bleach evaporate. For porous materials, for example, a rug, it should be soaked in bleach, but the waste that is generated needs to be disposed of. There's no *one* answer. Bleach needs enough contact time to kill the ricin, and the organic load must be factored in, and if waste is generated, there needs to be a plan for disposal.
- Q: Were there any aerosols you could have used? For example, would chlorine dioxide have inactivated the ricin?
- A: There are, but considering the small areas associated with these responses, we didn't need a large operation when bleach will suffice. If it had been a more extensively contaminated area, we would have looked at other options.
- Q: In all four incidents, was the ricin used crude or purified?
- A: All of the ricin was pretty crude.
- Q: Did you consider involving cell or animal assays? Because the methods used don't tell you if ricin is active or inactive.
- A: I'm sure we thought about that; I wasn't intimately involved in all of these examples. The message of this presentation is that all of these analytical procedures are evolving, and you need to know all of your available options.
- C: I believe time resolved fluorescence (TRF) is a test for activity of ricin, and was performed in these cases.

EPA Region 6's Two Recent Bio Responses
9:55 am

John Martin (presenter) | *U.S. Environmental Protection Agency*

Abstract

This presentation will briefly discuss EPA's role and activities during a recent biological event in Covington, LA. The event was in relation to a potential select agent outbreak, Burkholderia psuedomallei, from the Tulane National Primate Research Center. Responding agencies included CDC, USDA, EPA, and numerous state agencies. EPA supported this response through development of a sampling plan that was implemented by Tulane employees. Pro and cons of various decontamination options were provided and will be discussed in this presentation.

Questions, Answers, and Comments

- Q: It sounds like there is a U.S. Department of Agriculture (USDA) employee infected with *Burkholderia*; is she continuing to spread the disease?
- A: No; they discovered the antibodies in her system due to exposure approximately 15 years earlier on a trip to Australia. There was a second employee with a positive test, but there were many incidents of false positives, which have to be reported and followed up.
- C: When EPA was coming up with decontamination strategies for field cages, we asked U.S. Centers for Disease Control and Prevention (CDC) what assays we could use, but they didn't do the research on *Burkholderia*. Researchers came up with the answer, in another example of research folks helping out during the throes of a response. It worked very effectively in this case.
- Q: If this happened in a bigger city, do you think it would play out similarly? Is it a transferrable lesson learned? How much would variability between locations affect the response?
- A: There are yeses and noes to that. CDC operates nationally, they don't have regional representatives, and they would take charge. Some USDA responders are local, but most were national and they would likely respond nationally. The state of Louisiana is probably different from other states in its response approach, especially in this event; there are variable political factors, and each state would probably be a little different. I've been doing response work for 28 years, operating under national contingency plans and other Stafford Act triggered responses, and this represents a gap between those two national response plans, because in this circumstance EPA doesn't have very much authority and it was unlikely that FEMA would be activated, but still it was an enormous environmental question that needed to be answered. The chain of command would most likely be different and sometimes complicated, but you have to trust all responders to share response objectives and to take responsibility in addressing those objectives.

4. General Session 1 (cont.)
CBR Response Activities and Recovery Handbooks

Auditorium C-111

Moderated by Marshall Gray and Chris Gallo | *U.S. EPA*

Destruction of Syrian Chemical Agents and the Field Deployable Hydrolysis System (FDHS)
10:45 am

Brian O'Donnell (presenter) and Amy Dean | *U.S. Army, Edgewood Chemical Biological Center, Chemical Biological Applications & Risk Reduction Unit and Joint Program Executive Office for Chemical Biological Defense*

Abstract

This briefing will cover several topics associated with the destruction of the Syrian Chemical Agent and pre-cursor materials stockpile to include:

- Technology Selection, FDHS Design, Fabrication, and System Attributes;
- Operation of the FDHS on the Cape Ray; and
- Successful Decontamination, Monitoring, and Sampling which led to the Return of the Cape Ray to Service.

The technology selection discussion of the presentation will cover the initial problem set, the timeline and limitations for destruction, the methodology for evaluating technologies, and the formulation of a complete solution set. The presentation will cover the changing destruction paradigm that occurred over 2013 and how the FDHS modular design was adapted to suit the operational environment and end state. The construction of the FDHS on the Cape Ray will be discussed to include the Cape Ray's attributes for performing the mission, and how the Cape Ray had to be retrofitted to allow for the operation of the FDHS and the number of personnel needed for the operation on the Cape Ray. The briefing will cover the overall destruction operation on the Cape Ray to include DF and HD operational experiences.

This briefing will also discuss the application of decades of decontamination and closure methods from the former production facilities, stockpile destruction facilities, and non-stockpile equipment to the Cape Ray FDHS. Through the application of a comprehensive program for contamination mapping, deconstruction and demobilization, decontamination, analytical sampling and unventilated monitoring the Cape Ray was returned to the Maritime Administration for unrestricted future use.

Questions, Answers, and Comments

- Q: How much did those tanks cost?
- A: I don't know the cost, but cost was not an issue given the problem. There was concern for supply of the metals, but the Pentagon was ready to jump in to provide us the materials.
- Q: What type of personal protective equipment (PPE) did you use for persons checking for leaks, and for the tanks?
- A: We had a detailed health and safety plan. While checking the tanks, most of us always had masks on because the biggest concern was the inhalation hazard, and if we saw a leak during visual inspection, we would don appropriate PPE before continuing.
- Q: What happened to waste that was left in Finland and Germany?
- A: I'm pretty sure that both companies with the disposal contracts used incineration. The United States couldn't be involved with that work because those contracts were led by the Organization for the Prohibition of Chemical Weapons [OPCW]. The U.S. could only get involved if OPCW asked us to get involved on behalf of the country. In-state waste was disposed of in Texas through an existing U.S. Army contractor.
- Q: How was the ship decontaminated after the operation?
- A: For the most part, mopping the decks with water was enough. We also conducted headspace sampling (luckily the deck where we operated was closed in) and clear them for the General Population Limit [GPL]; or we took wipe samples and tested those. In general, it was not a problem.

Indoor Contamination from the Fukushima Nuclear Power Plant Incident

11:10 am

Atsushi Tanaka (presenter), Taeko Doi, Haruhiko Seyama, and Yasuyuki Shibata | *Center for Environmental Measurement and Analysis*
Mai Takagi and Shoji F. Nakayama | *Center for Environmental Health Sciences, National Institute for Environmental Studies, Japan*

Abstract

After the Great East Japan Earthquake on March 11, 2011, a sequence of accidents of the Fukushima Daiichi Nuclear Power Plant (FDNPP) occurred. A large quantity of radionuclides was released from FDNPP mainly on March 15 and 20. Radionuclides deposited in the northwestern direction from the first emission caused severe

contamination in Fukushima. The plume in the second emission ran to the south-southwestern direction and reached Metropolitan region. It caused belt-shaped contamination zone in Ibaraki and Chiba prefectures (Joso area). Our institute, National Institute for Environmental Studies (Japan) (NIES), is located at the edge of contamination zone. The activities for Cs-137 observed at NIES was 3.8E0 Bq/m3 on 15 and 7.0E0 Bq/m3 on 20-22 March. At present, the activity for Cs-137 in Fukushima is below 1E-3 Bq/m3. The activity in the atmosphere decreased ten thousandth or more. In considering indoor contamination with radionuclides, the status of air ventilation when the radioactive plume passed over is the key factor. Unfortunately, the earthquake and tsunami wave damaged the air-tightness of the houses in and around Fukushima area.

We have collected indoor dust samples from vacuum cleaners of collaborators. A geometric mean for Cs-137 in Joso area in 2012 campaign was 1480 Bq/kg (n=250) showing a good log-normal distribution. Geometric mean for Fukushima samples was 25000 Bq/kg (n=26). Several kinds of tests were applied for the characterization of radiocesium in the indoor dust. The radiocesium was enriched in small particles (<53 um). However the activity in the coarse particles was the largest because the coarse particles (>2 mm) were mass dominant. By washing coarse particles with water (containing 1ppm of stable Cs), we obtained three fractions; fluffy cotton-like particles, solution and fine particles washed out. The concentration of radiocesium in the fine particles was higher than that in original dust. Cotton-like particles were less abundant in radiocesium. Up to 68% of radiocesium was water-soluble. In contrast, the solubility of radiocesium in soil particles was quite low. The cotton-like fibers gathers fine particles containing radiocesium which can be regarded as unintended decontamination process. Not all radiocesium in the dust was derived from track-in of soil particles.

We also found that daily cleaning with a vacuum cleaner and wiping with wet cloth decreased radiocesium level in the indoor dust. It motivates the people especially evacuees to improve their own indoor radiation environment by the cleaning.

Questions, Answers, and Comments

- Q: What happens to the household waste, including dust, that's been captured by vacuum cleaning? Is there a special disposal area?
- C: I can partially answer this question. In Japan, if waste contains below 8,000 µC per kilogram radioactivity, then you can dispose of it into municipal landfills. According to Dr. Tanaka's presentation, it seems that it probably doesn't exceed this amount of radiation, so that is probably the case in this scenario.
- Q: With regard to effectiveness of cleaning: U.S. residents don't take off their shoes before entering a home. For this reason, if dust is the main issue, then if the incident happens in the U.S., the indoor scenario might be worse than in Japan because there is a tracking issue. Filtration is another issue. In Japan they don't use heating, ventilation and air conditioning (HVAC); they use window unit air conditioners or other options. We don't know the impact of the HVAC and wearing shoes indoors on the scenario. So the question for Dr. Tanaka is: have you ever checked effectiveness of cleaning on tatami (Japanese flooring that is different from typical US carpet)? Was the vacuum effective on this type of flooring? What kind of wipe testing did you do? Did you compare dry vs. wet wiping?
- A: With regard to the first question: recovery of floor-type differences is shown in the presentation. Due to the mesh-like porous make-up of tatami, some powder passes through the material, so there is lower recovery than U.S. carpet, I think. I have not compared wiping methods because it depends on the type of wall being tested. Some walls are porous or almost sandy, and smear tests on sandy walls peel off the sand itself and so cannot be appropriately compared.

Returning to Normality. The UK Recovery Handbook for Biological Incidents (UKRHBI)

11:35 am

Thomas Pottage (presenter), Clare Shieber, Stacey Wyke, Sara Speight, and Allan Bennett | *Public Health England*
Stacey Wyke | *Centre for Radiation, Chemicals and Environmental Hazards, Public Health England*

Abstract

The release of biological agents, both accidental or deliberate, can result in outbreaks of infection and may also lead to contamination of the environment, which may require restrictions and access controls to the contaminated area (i.e. farm, hospital or water supply) until the affected environment is declared safe to use or re-enter. Public Health England is developing a biological recovery handbook as an information resource and technical guidance document for governments, local authorities, and others involved in the clean-up and recovery phase following a biological incident (both through intentional release and naturally occurring). 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) and is due for publication in 2015.

The UK Recovery Handbook for Biological Incidents (UKRHBI) project began with an extensive review of the literature on environmental persistence of micro-organisms and on their resistance/susceptibility to decontamination techniques (i.e. liquid chemicals). The literature review will be used to inform the technical guidance, decision-aiding framework, check-lists, and recovery options that are being developed as part of the UKRHBI. Following the approach taken for the chemical and radiation recovery handbooks, environments will be addressed separately within the UKRHBI and stakeholder groups convened to comment on the practicability of the recovery options recommended within each environment (food production systems, inhabited areas, and water management systems). Information on previous incidents and the efficacy of recovery options has also be obtained as part of the literature review. Additionally, the project involves a retrospective study (online survey followed up by a telephone interview) to capture experiences from incidents that are not well reported, these will be collated and distilled into the UKRHBI, and presented in an easy to understand format for non-experts and experts alike (i.e. checklists and colour coded tables).

The handbook has already been adapted and implemented to assist with recovery from flooding in the UK, February 2014. This document has been published by PHE and is openly available for use by first responders and the public. It is envisaged that the UKRHBI will facilitate decision makers access to expert opinion and scientific advice by presenting this information in an easy to use format, and assist the recording of decisions made during the recovery process (i.e. why were decisions made to implement various clean-up techniques). The UKRHBI will be openly available, therefore providing a resource that will also be useful for training and preparedness activities.

Questions, Answers, and Comments

- Q: In the inhabited areas, did you work on any tube or train scenarios?
- A: We haven't, but we have incorporated types of transportation into what areas we looked at and have taken into account which types of surfaces (for example, sensitive or resistant surfaces) would most likely be contaminated in those scenarios.
- Q: You have a mix of retrospective and current science. How do you go through the analytics to determine when to replace a method based on what's working better now than it has in the past?
- A: Retrospective studies go directly into the database, and we can also write directly to the authors and gather more information. We had many talks about how to present those data, especially when there are contradictory data on a given method. We try to use a few checkpoints so we can make sure the data are mostly normalized and we have disregarded inappropriate data. We continue looking at new and emerging techniques and publications.

5. General Session 1 (cont.)
Field Demonstration and (International) Program Review

Auditorium C-111

Presentations and Q&A moderated by Sarah Taft and Mario Ierardi | *U.S. EPA*

Methyl Bromide Fumigation: *Bacillus anthracis* Inactivation, Emissions Containment, and Conservation of Sensitive Materials

1:00 pm

Leroy Mickelsen, Shannon Serre, Worth Calfee, Joseph Wood, and Marshall Gray | *U.S. Environmental Protection Agency*
Rudolf Scheffrahn (presenter) and William Kern | *The University of Florida*
Neil Daniell | *CSS-Dynamac*
Tim McArthur | *ARCADIS*

Abstract

In 2002 gaseous methyl bromide (MB) was shown to be sporicidal to *Bacillus anthracis* (Ba). Since then, research on MB efficacy and containment has progressed and current study is a culmination of these efforts. In December 2013, 87 wood and 87 glass coupons each containing ca. 1 x 106 colony forming units of Ba Sterne, were placed in 22 locations inside a 1,400 m3 conference building in Davie, Florida. Additional twelve-coupon sets (six wood, six glass) were prepared for early extraction (16, 24, 32, and 40 hrs) from the building. Ducting was used to connect two 2,500 kg charcoal vessels to the structure. The structure was then sealed under tarpaulins and fumigated with MB at 28°C and 83%. After 48 hours, the building was duct-aerated which forced the MB-laden building air through the charcoal vessels before atmospheric release at an exhaust stack. During the four-hour aeration, the MB concentration decreased from 55,000 ppm to <150 ppm with maximum stack release of 156 ppm. Ambient air monitors, run continuously during the fumigation and aeration, detected small leaks near the tarpaulin ground seal. During the fumigation/aeration, there were no sustained elevated MB levels >0.5 ppm at any of the five monitoring sites located ca. 30 m from the building. No colony forming units of Ba were detected on coupons fumigated for more than 16 hours. A single wood coupon from 16-hour set yielded ca. 2 x 103 cfu. Although there was a lingering odor in the building for several days post-fumigation, there were no visible or functional effects to the structure or its contents including computers and router, LCD monitors and projector, kitchen appliances, or HVAC. This operational study increases EPA's resiliency and capacity for response to Ba or other biological incidents. Furthermore, a health and a guidance document was developed from this study which reviews the tactical use of MB as a fumigant for inactivation of Ba.

Questions, Answers, and Comments

- Q: So did you go back and recalculate if you had used methyl bromide [MeBr] in the decontamination of the mail facility in Virginia, what the cost would have been?
- A: You can calculate it pretty easily; the methyl bromide itself probably would have cost about 70,000 dollars. I would guess it would have been under 1 million dollars with MeBr, so about 1/9 of the $8.6 million cost for decontamination of the mail facility, without having to use ethylene dioxide and its yellowing effects on the surrounding area.
- Q: With regards to the testing where you produced humidity: are you accounting for locations that may not be very humid?
- A: Yes, that's why we chose that type of humidifier. Heating can also get more sophisticated. It's certainly doable. We were planning an exercise in California with that in mind; fans, of course, circulate heat and humidity to keep equilibrium during fumigation. You can also use insulating tarpaulins if you have the budget for it.
- Q: Did you say what the starting concentrations on the coupons were?
- A: Most of them were around one million spores per coupon; 1x10^6. And we had one failure at 16 hours when were down to two thousand.

- Q: Do you consider MeBr overkill for a poultry house, after the birds have been removed? Right now we have avian influenza in poultry houses, and there may or may not be remaining litter and manure inside the houses. Is this overkill?
- A: It's not overkill, but because MeBr has become so regulated, it's become very expensive. In the past it was used for salmonella and other things but it's now a lot more difficult and expensive, and there's also the ozone depletion concern (though the ocean produces about 4-5x the amount we use in the world), so we have to comply with those regulations.
- Q: How long were the spores on the surface of the coupons before they were decontaminated?
- A: A couple of weeks from when they were deposited to putting them in the building. They had controls to account for loss of titer between deposition and when the fumigation was done and they saw no loss; these are very hardy spores that can live for a couple hundred years if nothing is done.
- Q: I think my question pertains more to whether or not the spores were allowed to penetrate into the material, because you mentioned that MeBr is penetrating; so I am wondering if the spores were left there long enough to penetrate the surface of the coupons and that MeBr was also able to penetrate and reach those spores.
- A: They used liquid inoculation, so the liquid pulls the spores into the substrate, and once it dries, the spores don't move any more. I don't know how far in they go, but in a normal aerosol release of a weaponized formulation, they probably wouldn't penetrate. The molecules of MeBr are much smaller than a spore; they're about 5 million times smaller, so the beauty of MeBr is that it will penetrate farther than spores on most surfaces.
- Q: How does the MeBr actually kill the spores?
- A: I'm not a microbiologist, I'll be the first to admit, but spores have a complex coat of proteins around them, and I'm assuming that somehow MeBr probably diffuses and hits a few vital proteins that inactivate the spore by methylating those enzymes so they're no longer functional.

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

1:25 pm

Charles Bass (presenter), Glenn Lawson, William Buechter, and Mark Morgan | *Defense Threat Reduction Agency*

Abstract

The 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 six efforts:

1. Support joint programs for the fielding of equipment and sensitive equipment decontamination.
2. Support a U.S. Air Force (USAF) demonstration: Joint Biological Agent Decontamination System (JBADS) which is based on hot, humid air and focused on large airframes.
3. Facilitate the development of improved, easy to decontaminate coatings.
4. Develop and demonstrate novel, low-logistical burden approaches to wide-area decontamination of *B. anthracis* spores.
5. Improve decontamination processes for decontamination of personnel and mass casualties.
6. 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: On the Joint Biological Agent Decontamination System (JBADS): how are you going to test the avionics after you've soaked the plane for three days to make sure it still works?
- A: We had the Air Force crew there and they went through the maintenance cycles at the demonstration. The crew was able to bring it up to pre-flight levels, which includes a function check of the avionics, and that was considered successful. Military avionics are designed to handle temperatures from -55 deg C to 125 deg C. As long as the avionics are powered-off, the maximum decontamination temperature of 82 deg C is not considered an issue.
- Q: To go from germination to get to the vegetative state, isn't it going to be a certain percentage that just never…
  A: There are persistors, and there are lots of reasons why that occurs. We are trying to look at how you can collect this at the cellular level; we need approaches that disrupt the spore coat to enable better access to the cortex and cell. We also need approaches that inhibit the alanine racemase to promote germination at lower concentrations of L-alanine.

UK Government Decontamination Service – Framework Assurance

1:50 pm

Suzanne Young (presenter) | *Department for Environment, Food and Rural Affairs*

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 which focus on capability assurance, gap analysis and the closure of capability gaps.

A brief overview will be given of the role of GDS, which will focus on 1) the framework of specialist suppliers, 2) the methods used to assure the framework suppliers have the required capability during CBRN recovery, and 3) development of an assessment tool to assure the health and safety of those suppliers and how this will be utilised in future evaluations with suppliers. In particular, this procedure includes consideration of supplier adherence to relevant regulations and legislation and that they can operate safely in a hazardous environment. At each stage of the procedure there are links and appropriate referrals to legislation highlighting all aspects that are a legal requirement to complete or adhere to and what is considered to be best practice. Whilst it is acknowledged that the US legislation will be different, the principles could be readily adapted to reflect this. The process considers a pre-qualification questionnaire, the suppliers' adherence to the risk assessments and method statements and also the practical understanding of the health and safety aspects of the practical evaluations. It will also consider the adaptability of the suppliers in the face of unexpected challenges. The assessment tool will provide a consistent third party external and internal validation of the suppliers.

Questions, Answers, and Comments

- Q: How many suppliers do you have, and who is funding them to maintain all these capabilities?
- A: Suppliers are listed on a slide of the presentation. Those are the suppliers listed currently on our framework, and we're about to initiate procurement for a new framework. We don't pay suppliers any retainer for being on the framework, and there's no guarantee that they'll get work from the framework for incidents. However, the work we do with them is funded to be able to carry out the exercises. But they don't have guarantee of income from that.
- A: We've got biological, chemical, and radiological suppliers. They're in alphabetical order on the slide.
- Q: Are you allowed to share how long these contracts will go for and how you place a value on them?
- A: The framework is for a four-year period. This one will end next year [2016], and we are going through the process now of setting up procurement for next framework.

Canadian Safety and Security Program Project for Infrastructure Mitigation for Rapid Response after a Radiological Incident

2:15 pm

Matthew Magnuson and Sang Don Lee | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
Konstantin Volchek (presenter), Wenxing Kuang, Pervez Azmi, Vladmir Blinov, and Carl E. Brown | *Environment Canada, Canada*
Jaleh Semmler | *Canadian Nuclear Laboratories, Canada*
Pavel Samuleev and David G. Kelly | *Royal Military College, Canada*
Stephen Sunquist and David Clarke | *Ottawa Fire Services, Canada*

Abstract

Mitigation – defined here as removal of gross contamination – can be used to quickly reduce levels of radioactivity in areas impacted by a radiological release, thereby enabling responders to accomplish their tasks more safely, effectively, and for longer periods of time. Mitigation doesn't necessarily result in a thorough cleanup which uses specialized techniques and procedures, but it can be done as early as possible after the radiological release by using readily available equipment and materials. Environment Canada, US EPA, and their partners have been developing mitigation technologies to remove and capture a number of radionuclides from contaminated materials. The ultimate goal is to provide responders with a toolbox of mitigation technologies that may be applied to the unique challenges of specific radiological contamination incidents, particularly those that contaminate large areas and generate large quantities of solid and liquid wastes. Incidents to which these technologies might be applied include those involving radiological dispersion devices, improvised nuclear devices, and large scale nuclear power plant accidents.

The presentation covers work to date including in-house studies and technology demonstration trials through the Canadian Safety and Security Program. Some of the technologies developed will be included in an upcoming demonstration scheduled for the summer of 2015 in the US that will involve several mitigation approaches. Technology benefits, limitations, and future development activities are presented and analyzed from both research and end-user's viewpoints.

Questions, Answers, and Comments

- Q: I agree with you, I think the decontamination factors (DFs) you're seeing are extremely high. When the spray is put on the building, is it allowed to "set"?
- A: Our protocol was generated based on lab tests. We applied contaminants to the wall, then we waited for several time periods, starting with half an hour, to see what happened. The data shown here show what happens after two hours of exposure. We used a controlled environment with relatively low humidity. In general, we found that it would take an extra several days before we saw a decrease in efficiency.
- Q: Can you tell us what you plan on doing with the resulting solution that comes down from doing a building wash?
- A: We will build berms around a building to control the waste water. Once it is generated, we will work with waste management companies that will deal with that issue. The formulation we use is fairly environmentally friendly, but obviously in a real-life situation, there are always factors you can't account for. The waste containment will be part of the demonstration.
- Q: Is there any possibility of application in humans or pets?
- A: We have not tried it ourselves, because we don't have the necessary license to deal with humans. I would guess that the components that are present in our formulation are very benign and wouldn't cause harm to skin; I would guess they could be used for those applications.

6. Concurrent Sessions 1
Biological Agent Decontamination

Auditorium C-111

Moderated by Sanjiv Shah and Benjamin Franco| *U.S. EPA*

Development of Microemulsion Decontaminant Against Chemical and Biological Agents

3:00 pm

Lee Hwi Ang (Presenter), Linda Ang, Yoke Cheng Tan, George Ming Horng Ng, Gek Kee Loh, Meiyun Lim, Hwee Teng Low, Jasmine Liu Yun Ng, and Eunice Soo Hoon Sim | *DSO National Laboratories*

Abstract

A microemulsion decontaminant, ME21, has been developed in-house for the decontamination of biological and chemical warfare agents. It is a relatively non-aggressive formulation consisting mainly of water, solvents, surfactant, and an oxidising active ingredient. Extensive trial studies validated the effectiveness of ME21 against a wide spectrum of nerve and blister agents as well as *Bacillus anthracis* spores. This unified chem-bio decontaminant will reduce the logistical challenges of having to use multiple decontaminants to cover a wide spectrum of chem-bio threats. In addition, ME21 can be deployed in the form of spray or aerosol with common off-the-shelf dispensing systems for surface and interior decontamination applications.

In this presentation, the considerations and challenges involved in the development of ME21 will be shared. The assessment of its decontamination effectiveness against chemical warfare agents (as surface and vapour threats) and *Bacillus anthracis* spores, including the methodology and the decontamination efficiency data, will be reported. In addition, operational considerations critical to the success of decontamination operations, such as the chemical compatibility of this decontaminant with selected materials of interest and cross-interference with selected chemical agent detector technologies, will also be presented.

Questions, Answers, and Comments

- Q: After you mix the ME21, how stable is it?
- A: About six hours for maximum efficiency.
- Q: Would it be possible to tell us what the active ingredient is? Or is that proprietary?
- A: I can share that; it's hydrogen peroxide-based.
- Q: Could you conjecture what would have happened if you had use non-painted concrete?
- A: I believe there should not be significant difference in the efficiency. We did a control study using water as a decontaminant which showed that the chemical agents penetrated to a large extent and were not removed by the water, but ME21 was able to extract the penetrated agents.
- Q: Did you look at toxic byproduct formation?
- A: Yes, we performed a preliminary screening for known degradation products, paying particular attention to toxic ones. Among the degradation products observed, there were no toxic byproducts. For Lewisite, however, our preliminary screening did not reveal any known degradation products.
- Q: Where are you taking your research next? What is the largest scale you've done?
- A: This development was small scale; the largest scale we tested was with a 10 L spray. Potentially, a larger sprayer could be used to increase the area of decontamination. The next step is talking to military users to try to transition into military operations.

Novel Bio-decon Approach – DeconGel

3:25 pm

Vipin K. Rastogi (presenter) and Lisa S. Smith | *BioDefense Branch, R&T Directorate, U.S. Army, Edgewood Chemical Biological Center*
Markos DasaKalakis and Garry Edgington | *CBI Polymers, Inc.*

Abstract

Bioterrorism events on a large scale are expected to result in contamination of building interiors/exterior of fixed sites assets. Current doctrine for decontamination of such contaminated assets include use of fumigants, such as chlorine dioxide (CD) or vaporous hydrogen peroxide (VHP) or use of 10% bleach to decontaminate environmental surfaces. Two adverse issues related to current doctrine include spore re-aerosolization and significant generation of hazardous waste in case of bleach use.

Through collaborative effort with CBI Polymers, Inc., optimization and re-formulation of base DeconGel is being investigated through Department of Homeland Security's UTR (underground transportation restoration) program. In this program, development and application of a novel technology, DeconGel™ (DG), has been explored. DeconGel is a hydrogel, developed by CBI Polymers, Inc. to decontaminate surfaces contaminated with radiological materials. The hydrogel is modified by the addition of sporicidal chemistry and tested for its efficacy in decontamination spores of *Bacillus anthracis, ΔSterne*.

Results from this collaborative effort clearly demonstrate and lend a strong support for the effectiveness of the unmodified DG in its ability to sequester spores off the surfaces (>99.9% or 3-4-logs). The modified DeconGel was highly effective in both spore sequestration and its kill (>6-logs). The results will be presented to show decontamination of surfaces relevant to underground transport system by the modified DeconGel. This technology offers unique advantages over the current doctrine in minimizing the spore re-aerosolization with an added benefit of no hazardous waste generation. Future work in pursuing efficacy of base gel and modified gel formulation against CW agents will be important in developing a safe and effective technology against CBRN threat materials.

Questions, Answers, and Comments

- C: For the base gel without the sporicides in it, you were able to recover and culture spores. It might be a more efficient way to do sampling than the sponge wiping. So, the DeconGel in its original state might be a great way to do assurance sampling.
- C: That's true, especially for surfaces that are complex and three dimensional. A colleague of mine has submitted a research proposal, and that's precisely the issue she's going to be investigating: The use of base gel as a sampling method for preservation and seeing how long spores survive.
- Q: So, with the base gel, what sort of removal did you get from the materials?
- A: Roughly five to six log spores. Of the residual spores, we recovered about four logs on the surface; we used wipes in this case.
- Q: Can you speculate on the poor recoveries for stainless steel and hard nonporous materials where you typically see the highest recoveries?
- A: This is purely speculative: Paint is acting as a porous surface, so spores are somehow encapsulated or attached to the paint such that the gel is not able to retrieve them. Aluminum was a real surprise, but under a microscope, aluminum has a very corrugated surface. The funny thing is with concrete; we were able to get 100%.
- Q: If you inoculate the gel itself and do liquid extraction, how much do you get back?
- A: You are asking if we were to spike the gel itself; we haven't done that, but the fact that we get over six log recovery from the gel means that recovery is in the 40-60% range. Different materials are showing a range; it's more a function of the surface, not the gel.
- Q: Although you have four relevant coupons selected, have you considered glass or other surfaces?

- A: These surfaces were chosen after extensive discussion with the program manager on which surfaces are common to trains, cars, and underground transportation. The list is long, but with constraints of funding, these are the four they chose. It will be nice to test other surfaces.
- Q: How do you decontaminate the peeled gel?
- A: We put the gel in 50 mL tubes containing 20 mL of extraction buffer, and we hydrate the gel at 37 degrees for about two hours, and that is enough to soften and liquefy the gel.
- How much gel is used? What is the cost?
- C: A five gallon pail is $640.
- A: For four 12 x 12 panels, we prepared two liters of gel, but used less than half of that. If we had an even larger surface, we could have easily used two liters of gel.
- Q: When you spray the formulation, is it still peel-able?
- A: Yes.
- Q: Do you think it would be beneficial to add a sporicidal agent to the gel?
- A: That's what we're doing. There is an active component sporicidal chemistry added to the base gel, and that's how we're able to lock in and kill the spore.
- Q: What's the agent?
- A: The company is in the process of patenting this technology. I can tell you that one of them is peroxide-based. I can't reveal the actual components, but I'll be happy to once they have filed the patent.
- Q: Spraying did not work as well as wiping, but spraying will be most efficient in terms of coverage over time. Why did you have less promising results from spraying? Did you look into other nozzles or application equipment?
- A: When you spray the polymer gels, some viscosity changes have to be made. When we receive the gel, it's almost semi-solid, so we have to really break into the viscosity by using a mud mixer for 15-20 minutes, and then we add components including water to it. One difference can be the changes in viscosity, and that is still some work that needs to be done. We tested only one type of spray. It's a commercial unit that costs about $5,000 that worked well. We did not have time or resources to test different spray equipment.
- Q: If you were to rehydrate the gel, could you reuse it for a second application?
- A: We toss it, so I don't know. I think too much water is added to reuse it, so my answer would be no.
- Q: What if you use the gel and then it rains?
- A: It would probably rehydrate and become a gooey glue type material. Suppose I spray on an outside surface and it rains, the gel film will rehydrate itself, so I think you have to wait for it to dry for it to be removed as a film.
- Q: Have you established a thermal range of the gel?
- A: No, these experiments were all performed under ambient conditions. We have not tested under different temperatures.

New Advanced Oxidant Generation Method for Large Area Biological Decontamination

3:50 pm

Brian France (presenter) and William Bell | *TDA Research, Inc.*

Abstract

During a DHS-funded SBIR Phase I project, TDA developed an advanced oxidant generation system to respond to an attack with biological agents. Specifically, this technology is capable of decontaminating anthrax spores on building exteriors and interiors, and other surfaces. We describe an innovative bio-agent decontamination technology that is particularly suitable for decontamination over wide areas. This technology has demonstrated efficacy against chemical warfare agent simulants and anthrax surrogates. This decontaminant formulation produces sustained, effective, low level oxidant concentrations that are effective for extended periods (hours to days). The decontaminant does not require special application equipment and has a long shelf life and the ability to be rapidly shipped on commercial air transport. This dual-use technology is currently being developed by TDA

and our partners for both commercial and national security applications, thus ensuring it will be available to meet the needs of the Federal On-scene Coordinators during a biological remediation event.

Questions, Answers, and Comments

- Q: Did you measure the concentration of chlorine dioxide after you photoactivated? What is the parts per million (ppm) generated?
- A: If you keep it in there and make sure it's not reacting with anything, we find a couple hundred PPM; it's not nothing.
- Q: You mentioned the surface must be wet for the product to work. How long should the surface be wet for it to work? How do you measure wetness?
- A: Wet is wet; there is a water film on the surface. These data show an eight-log reduction after 15 minutes and a six-log reduction in under an hour.
- Q: Have you tested any other microbes? Some of the more common bacteria?
- A: We only looked at anthrax surrogates, but we would like to look at other organisms.
- Q: Does it require photoactivation before or after application?
- A: It needs to be photoactivated after it is applied. For example, if you need to apply it to a runway, you would run a truck down the runway, and it would not become activated until it was exposed to the light.
- Q: Were efficacy calculations based on applied amount or recovered amount?
- A: We looked up the populations we could recover from the sponge sticks. We used the amount that was applied to determine efficacy.
- Q: Do you know what the overall dose is because you mentioned that you have a time release? Have you looked at it with any interferences like organic loadings because I think the test is in inorganic?
- A: Primarily inorganic. We've done a little more work with some potting soil mixtures that we would like to work with that are going to have a lot more organic loading, but at this point we have not done those experiments. Loading levels do turn over; we've seen photocatalytic turnover more than what you've put down on the surface.
- Q: Are you looking into remediation products that can kill spores in surfaces? Have you done studies to see how safe the product is?
- A: Chlorine dioxide is pretty short-lived. So, it is pretty reactive and goes away. What you end up dealing with is chloride salts from as safety standpoint, and these concentrations are quite low. As far as looking at the product for other things, yes we are looking into marketing this product for remediation; absolutely.

Decontamination of Large Spaces –Scopes and Limitations

4:15 pm

Marek Kuzma (presenter), Jaroslav Cerveny, and Dusan Pavlik | *Laboratory of Molecular Structure Characterization, Institute of Microbiology of AS CR, Czech Republic*
Petr Kacer | *Department of Organic Technology, University of Chemistry and Technology, Czech Republic*

Abstract

Decontamination of large spaces (airports, government buildings, hospitals, etc.) is a modern problem without a satisfactory solution. These places can be targets of terrorist attacks, and have potential for fast spread of infectious diseases, because of their high strategic importance and/or high concentration of people. There are several different technologies for decontamination of biological pathogens using liquid and gaseous decontamination media. Technologies based on a gaseous medium are more suitable for application in large areas compared with liquids ones. They can be easily applied with minimized involvement of personal.

The most important gaseous decontamination agents are formaldehyde, ethylene oxide, chlorine dioxide, and hydrogen peroxide vapors (VHP). All of these methods, however, carry some drawbacks and limits for their use. There is no ideal decontamination agent, which would be highly efficient, have a rapid onset, be affordable,

compatible with indoor-materials, have low toxicity, be safe and easy to handle, have a long shelf life, and be odorless.

Chlorine dioxide and VHP are the most frequently mentioned for use in large areas. Formaldehyde is known for its carcinogenicity and formation of difficult-to-remove residues, while ethylene oxide is flammable and makes explosive mixtures with air so its applications are limited either to processes under reduced pressure or in a mixture with halogenated hydrocarbons. One of the risks of ClO2 application is its considerable toxicity. The most commonly reported VHP disadvantages are derived from the fact that hydrogen peroxide vapors are a readily condensing medium. The condensate is highly corrosive and it requires extended aeration time at the end of the decontamination cycle. Moreover, some studies describe the failure VHP technology deployment in larger spaces. Based on our experience, we expect that the cause of this failure could be insufficient concentrations in the target area. But in general, we assume VHP to be the most appropriate decontamination technology for large spaces.

Our research is focused on the further development of decontamination technologies, mainly VHP. The efficiency of the process is influenced not only by hydrogen peroxide concentration but also by other conditions of the decontamination process, such as moisture level, the length of the process, morphology of decontaminated surface and its contamination. Our research is aimed at assessing the influence of these parameters on the decontamination process.

Acknowledgement: The authors thank the Technology Agency of the Czech Republic (Grant No TA02011185) for financial support.

Questions, Answers, and Comments

- [no questions]

Methyl Bromide Decontamination of Indoor and Outdoor Materials Contaminated with *Bacillus anthracis* Spores

4:40 pm

Morgan Wendling (presenter) | *Battelle*
Joseph Wood and Leroy Mickelsen | *U.S. Environmental Protection Agency*

Abstract

EPA's Homeland Security Research Program, with support from Battelle Memorial Institute, investigated the decontamination efficacy of methyl bromide (MeBr) for the inactivation of *Bacillus anthracis* (*Ba*; causative agent for anthrax) Ames spores on indoor and outdoor materials. Laboratory tests were also conducted with other spore-forming microorganisms (*Bacillus subtilis* [Bs], *Geobacillus stearothermophilus* [Gs], Ba NNR1Δ1, and Ba Sterne) to assess their potential as representative surrogates for Ba Ames, for use in field studies and additional lab-based investigations. Indoor and outdoor materials included: glass, ceiling tile, carpet, painted wallboard paper, bare pine wood, and unpainted concrete. Decontamination efficacy was quantified in terms of log reduction (LR), based on the difference between the number of bacterial spores recovered from positive control coupons and test coupons. Tests were conducted at varying temperatures, relative humidity (RH) levels, MeBr concentrations, and contact times to assess the effect of these operational parameters on decontamination efficacy. Twenty tests were conducted with MeBr, with target concentrations of either 212 or 300 milligrams per liter (mg/L). Target temperatures during testing ranged from 22 to 32 °C, the target RH was either 45 or 75%, and contact times ranged from 18 to 72 hours.

Testing showed that a contact time of 36 hours was required to achieve > 6 LR of Ba Ames on all materials when fumigating at 212 mg/L, 22 °C, and 75 % RH. However, only 18 hours of contact time were required to achieve > 6 LR of Ba Ames on all materials when the MeBr concentration was increased to 300 mg/L and temperature increased to 27 °C.

With regard to potential surrogates, the data show that Gs is less resistant than Ba Ames, while every test conducted with Ba NNR1Δ1 showed it was more resistant than the Ba Ames. Tests with Ba Sterne strain showed a higher degree of inactivation when compared to Ba Ames when fumigating at 45 % RH. However when fumigating at 75 % RH, Ba Sterne was more resistant than Ba Ames.

This study demonstrates the important role that RH plays when fumigating with MeBr. There were no tests in which >6 LR of Ba Ames was achieved on all materials when fumigating at 45 % RH, and that increasing the MeBr concentration, temperature, or contact time generally did not improve decontamination efficacy at this RH. In contrast, when fumigating at 75 % RH, increasing the MeBr concentration, temperature and contact time did generally improve efficacy.

The results of this research may be useful in the development of guidance to aid in deployment of MeBr fumigation after a wide-area release of Ba spores. It also provides data to assist in the selection of an avirulent surrogate for Ba Ames when using MeBr, for use in future field studies and additional lab-based investigations.

Questions, Answers, and Comments

- C: I have a couple comments; very nice research. Methyl bromide was not outlawed in 1984, and there's still no reduction in its use for quarantined fumigation. Although soil fumigations have decreased, there's still about 10,000 metric tons required in the world for international trade. Also, the St. John Virgin Island incident was gross negligence with Methyl bromide.
- Q: Can you explain why the glass was so difficult to decontaminate? Did you look at the quality of the spore preps?
- A: I don't know; normally glass is the easiest to decontaminate. Yes, for each test, all materials were inoculated at the exact same time.
- C: I thought the glass and wood results were interesting as well, and on Thursday you will see some re-aerosolization studies where glass had more adhesion than other surfaces. In those tests, we're assuming that the more hydrophilic surfaces were tending to hold the spores more, and that may have something to do with it. But, it's interesting that you were having a similar result.
- C: When you get to an endpoint where you have 6-7 log reduction, if it is an issue with recovering spores and their adhering, you can go to grow/no grow situations.
- A: We could, but we didn't have an issue with recovery because with our positive controls we were recovering greater than seven logs.

7. Concurrent Sessions 1
Radiological Agent Response and Recovery

Classroom C-113
Moderated by Jeff Szabo | *U.S. EPA*

Providing First Responders with Scientifically Based Tools, Easy-to-Understand Protocols, and Actionable Guidance for Radiological Response and Recovery

3:00 pm

Benjamin Stevenson (presenter) | *Department of Homeland Security Science and Technology Directorate, First Responders Group, National Urban Security Technology Laboratory*

Abstract

This presentation will introduce attendees to the Radiological/Nuclear Response and Recovery (RNRR) Research and Development (R&D) portfolio, the objectives and purposes of its projects, and the first responder technology priorities and operational needs Department of Homeland Security Science and Technology Directorate (DHS S&T)

aims to meet. It will also serve as an introduction for more detailed presentations on the various technical tasks associated with the DHS S&T and Environmental Protection Agency (EPA) partnership to develop an electronic app to assist first responders in mitigating radiological hazards and managing waste.

In 2013, the First Responders Group (FRG) initiated a R&D portfolio seeking to improve state and local agency capability in the area of RNRR. The RNRR R&D portfolio focuses on projects that increase local and state capability during a radiological emergency. Specifically, through R&D, FRG wants to increase the capability to save lives through mitigating the hazard of radiation, managing complex incident data, and minimizing the impact of the incident on individuals, families and businesses. Because of the "no-notice" nature of a radiological/nuclear incident, federal support would not be immediately available. For a period of time early in a radiological response first responders would rely on their own technical resources to perform critical missions and operations.

The RNRR R&D portfolio includes many ongoing projects that focus on scientific-based guidance for initial response operations, technology improvements for radiological modeling and dose calculation products, and research on virtual training for improved decision-making. These projects seek to put the tools and technology responders need to effectively respond to a radiological incident directly into their protocols and operational procedures and increase their capabilities to respond to the first minutes, hours and days of a radiological emergency.

One project in S&T's portfolio is a partnership with the EPA to develop an electronic app that will provide first responders, both online and offline, with reference information and operational guidance on contamination containment, gross decontamination and early phase waste management strategies following a radiological incident. Multiple interagency documents identified the need for additional radiological hazard management and mitigation strategies to guide state and local agencies through the challenges of decontaminating an area impacted by a radiological incident. Though primarily a research endeavor, the EPA will put this research and technology development into an electronic app that will be easily accessible and useful to all first responders.

Questions, Answers, and Comments

- Q: How do you take this tool out and do what you need to do to have an informed conversation?
- A: We expect it will be rolled out through the EPA regions and maybe FEMA regions. It wouldn't be me talking about the application, but rather the field coordinators talking about it in the moment. Rollout is not complete yet, but I think we need to roll out to the field coordinators for EPA and the FEMA regions. We want to get it out there so that a conversation happens between municipal and state governments and the people they would actually be dealing with. That would be an informed conversation that will help in the response.
- Q: The protective action decision support tool—is that pulling into the information that was developed for the EPA PAGs (Protection Action Guidelines) and just putting it into a tool that first responders can use?
- A: I should have added a caveat to the presentation. The actual technology objectives that we listed here aren't verbatim the projects that we executed. They were the recommendations of the implementation strategy. I'm in the process of reaching out to FEMA and the U.S. Department of Energy (DOE) to talk about what models and tools exist and also how to optimize what has already been built for the first responder audience that we're trying to represent here from a science and technology perspective. Some of the stuff is still in the process of getting scoped. We consider it technology foraging—that is, finding out what tools and models exist and then figuring out with decision support or protective action decision support it's really an optimization of the timing of the message and what it's designed to imply. You need to build a tool with an understanding of when it's used, who uses it, and how it's used. There's a lot of work that still needs to be done for everyone to get on the same page in terms of the timing and the use.
- C: This is a follow-up to the first question. Another approach to note is that the app is not a new stand-alone program that requires a whole new rollout and user base. It will be attached to existing models and tools that first responders are already using on a regular basis.

- Q: Is the intention of this app to get very specific on what to do or to describe general principles on containment in different situations with different environments?
- A: The goal is to be more general. The goal is going from everything is an option to whittling down using decision-tree logic and you can audit as well. Similar to the Handbook from Public Health England presented earlier it is meant to allow users to click through screens to determine options. It is not meant to be super specific, but it is designed to suggest what the best options are—the ones that are most cost efficient and most effective—and provide additional information on how to implement a particular strategy. It allows the user to focus on options to facilitate an informed conversation.

Radiological Contaminant Stabilization Technologies

3:25 pm

Mark Sutton (presenter), Dianne Gates-Anderson, and Norris (Kip) Harward | *Lawrence Livermore National Laboratory*
Sang Don Lee | *U.S. Environmental Protection Agency National Homeland Security Research Center*

Abstract

After an intentional radiological release or nuclear power plant accident, contamination is likely to spread across a large urban area. Re-suspension and tracking of particulate contamination may create containment issues and further exacerbate remediation activities. There is a need for stabilization technologies and/or methodologies to reduce resuspension and tracking of contaminants to minimize the effect on human health and the environment. Stabilization technologies should be available in large quantities, and be quickly and easily deployable. Wetting of particles with water (e.g. by misting or fire-hosing) is the most widely available, quickly deployable approach, yet it can lead to detrimental effects later on when the area is remediated for re-use, especially for soluble contaminants (e.g., Cs-137) on porous surfaces. For instance, wetting may result in destructive decontamination methods being required, and thereby in significant waste generation and remediation costs. Traditional containment technologies, such as fixatives have been widely tested, but are typically not available in the quantities needed within the first 48 to 72 hours after a radiological release.

EPA's Homeland Security Research Program is currently collaborating with Lawrence Livermore National Laboratory to evaluate the binding properties (fate and transport), dose attenuation (public and worker health), stability and minimization of waste consequences (environmental protection) for non-traditional radiological stabilization technologies such a fire retardants and dust suppression technologies (e.g., wetting agents other than water and chloride salts typically used in road and mining facility dust suppression). These materials, not previously tested for use on radiological contamination, may provide rapid availability on a larger scale than traditional, specialized nuclear stabilization technologies. Laboratory-scale studies using Cs-137 and outdoor field-testing at LLNL's unique Site 300 test facility using surrogate particles will determine whether such non-traditional containment technologies are feasible solutions for preventing resuspension. The work will culminate in a demonstration event June 23-24, 2015.

This work was performed under the auspices of the US Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-667517.

Questions, Answers, and Comments

- C: This is one area of application for materials and equipment, but we shouldn't be focusing on this for first responders and it's not the first responders' job. Focus seems to be on tools for first responders, but they wouldn't use this approach.
- C: Agree this is not a tool for first responders, but we want to educate them so they don't make the situation worse (e.g., apply water to radioactive cesium (Cs) contamination) that would make future decontamination more difficult.
- Q: What is the plan for the spent clay once it is on the surface? Will it be removed for decontamination or left there?

- A: We use fire retardants. Some are clay-based, some are guar gum-based. They stay for the near term and then are removed.
- Q: Would they be washed off with water?
- A: Not necessarily as that might release the cesium.
- Q: Are there multiple types of flame retardants? The color is just an additive?
- A: Correct, we don't care about the color. The point is the fire fighters already know how to use and deploy flame retardants so no training is required. Also, it's available in large quantities.
- Q: Are there different kinds of flame retardants?
- A: Yes, but most are phosphate-based, so usually just a different type of phosphate and whether it's premixed or water needs to be added. Essentially, they are the same, and there is one main supplier.
- Q: Is it true that the fire retardant is biodegradable and since it's is phosphate, it will decompose to fertilizer?
- A: Yes, that's true, but although it's good for plants, it's not good for fish.
- Q: Do you have to remove some dirt also?
- A: Not necessarily, if the cesium doesn't migrate into soil.
- C: Cesium half-life is 30 years.
- Q: From the perspective of FEMA regional office talking to states, is it accurate that whatever we put down we'll need to pull up plus 2 cm of dirt and vegetation?
- A: Cesium lands on the surface as a particle. If it dissolves, it will migrate into the soil, but if you get to it before it dissolves, it will not migrate into soil.
- Q: So then we just need to take the top 2 cm of soil?
- A: Yes, but maybe not even that much, maybe more like 1 cm or a ½ cm. It's insoluble dust, so if you get to it before it dissolves, not much dirt must be removed.
- C: There is some research that plants may take up cesium.
- Q: What fluorescent particles did you use?
- A: We used PDT-06 from Risk Reactor Inc. fluorescent particles. We need something we can see and something that we can distinguish from natural particulate matter.
- Q: Do you know what it's used for?
- A: It is used by health physicists to help teach people how to do decontamination. It's the same idea as florescent materials used to teach kids how to wash their hands.

Toward Best Practices for Gross Decontamination Methods in a Radiological Response

3:50 pm

Michael Kaminski (presenter), Carol Mertz, and Nadia Kivenas | *Argonne National Laboratory*
Matthew Magnuson | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

After a malicious release of radioactive material via a radiological dispersion device (RDD) or improvised nuclear device (IND), large urban areas may be contaminated, compromising the life-saving and property-preservation efforts of first responders and law enforcement officials. In addition, some public services (e.g., drinking water and wastewater treatment, electrical power distribution, transportation, etc.) may be disrupted. In such an incident, it may be important to deploy "gross decontamination" (GD) efforts in certain areas in order to restore first responder activities and public services as quickly as possible. GD is decontamination that is conducted with the goal of reducing contamination levels, though the reduction may not meet final cleanup levels. Nevertheless, during GD, the speed and scale at which methodologies can be deployed and completed may be of similar importance to overall contamination reduction. Further, appropriately selected GD technologies may positively impact effectiveness, speed, and cost of decontamination technologies for longer term recovery; inappropriate GD may have the opposite effect.

The development of the Irreversible Wash Aid Additive (IWWA) process for cesium contamination was reported at the EPA International Decontamination Conference in 2013. The process for radioactive cesium GD 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 to aid with transport and disposal. The wash solution is designed to be easily disseminated by first responders using educators and nozzles already used by firefighters to distribute foaming agent.

This presentation will discuss efforts to support science-based "best practices" for responders enabling them to perform GD as effectively as possible in the early phase of a response to an RDD or IND using readily available equipment and supplies. It will build on and expand previous research on cesium GD by adapting the cesium IWWA system for mitigation of radioactive strontium contamination. In these pursuits, we have collected data on the effectiveness of decontamination techniques using simple salt solutions and sequestering agents. We will discuss the results of benchtop decontamination experiments using small coupons as well as plans for scale-up testing of the overall technique. Scale up experiments will also incorporate the lessons learned from a previous demonstration of the cesium IWWA technique.

Questions, Answers, and Comments

- Q: In the beginning of your presentation, you showed a truck going into the bermed area. Does water get onto the berm materials?
- A: We designed the berm materials to be either permeable or impermeable. For flood applications, they are impermeable—they are trying to contain flood waters, but they do have a geotextile fabric that will allow water to percolate. One of the ideas we originally had was to contain the vermiculite clay within the berm. As you collect the water, the clay within the berm would act as a filtration tunnel and allow the water to percolate through the berms, and then we could capture the waters downhill. The idea was this would be the initial (and probably quite effective) decontamination of cesium from the waters. However, because of the high quantities of salt and presence of surfactant, we started to think that we need to capture the waters because there is no way to monitor them after releasing them. The idea was we need to capture the waters as part of a full monitoring system.
- Q: Speaking of monitoring, your idea of capturing, filtering, and reusing the water, what do you do to monitor the water as it comes through? Is adding clay enough to remove radioactivity in the water?
- A: Yes, it can be enough if you have enough stages. You don't want to do it in one mixing stage because that is inefficient, but if you have enough tanks to go through multiple tanks you will eventually knock down the dose to some level that passes criteria and can then be put into a storage tank. You can also use a combination of clay and earth. If you need to deploy quickly, you might not have the luxury of using clay solely and might need to use something that is more easily available like earth. The partition coefficient values will be lower with earth, but it can still be effective with enough stages. This may require more space and a bigger footprint for the decontamination; there are a lot of logistics to work out.
- Q: You compared data for chelating agents and for the salts. The salts were superior, but what was the concentration used for salts versus the chelating agents?
- A: We used 0.1 M salt and 0.15 M for chelating agent. The problem is that the chelating agent wants to bind to a salt, so if you are already giving it all the salt it can handle then you have really rendered the chelating agent useless. I think that is the problem here. We want to follow up to determine if there is a synergy. We may have overwhelmed the chelating agent, and we are only talking about the ability of the salt essentially, but the chelating agent may still have a role here. Maybe it allowed us to knock down the salt by a factor of 10 or 100, and then we would see the same effects. We may find that the chelating agent improves the decontamination and might make it easier to deploy. But what do we do with the contained waters with the chelating agent; uncertain if it will make it more difficult. We're not sure.
- Q: Did you control the pH?

- A: Yes, good question. Initially we thought we were too acidic so we neutralized the chelating agents to bring within a pH range we thought would work better. That is when we saw the better results. We may be able to use the pH swing to make recovery better.
- Q: Do the berms need to be on level ground or can they cope with variation?
- A: Variation is okay. They are deployed in flood water containment situations They do handle bumps, but if there is a drop off you will need to end the berm and start a second berm.

Full-Scale Demonstrations of a "Toolbox of Options" for Radiological Incident Mitigation Technology
4:15 pm

Ryan James (presenter) and Ryan Stowe | *Battelle*
Sang Don Lee and Matthew Magnuson | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

During June 2015, EPA's National Homeland Security Research Center (NHSRC) will demonstrate five wide area radiological decontamination technologies (including strippable coatings, gels, and chemical foam technologies) on an urban building. Decontamination technologies are applied to remove the contaminants from surfaces by physical, chemical, or other methods to reduce radiation exposure level. In addition, NHSRC is teaming with the Department of Homeland Security (DHS) to demonstrate several radiological mitigation technologies including building and vehicle wash technologies, as well as high and low-technology particle and liquid containment technologies. Radiological contaminant mitigation technologies are measures taken to reduce adverse impacts of radiological contamination on people and the environment, and facilitate such purposes as restoration of first responder services and critical infrastructure.

The purpose of the demonstrations is to showcase and provide education about a "Toolbox of Options" for radiological decontamination, gross decontamination and containment technologies. Not all options will be applicable to specific incidents or available at specific sites when needed. Some technologies will be more effective but less available. Some less effective but more available. Local planning, coordinated among all responsible agencies, is necessary.

Both demonstrations will be conducted using a 75 year old brick building and surrounding area (including parking lots) in Columbus, OH. No radioactive contaminants will be applied during either demonstration, as the objective is to duplicate and implement realistic operational conditions for these technologies. Surrogate contaminants such as particle tracers may be used in several demonstrations as required. Example information that will be obtained includes decontamination rate and mitigation and containment capacity, user friendliness of each technology, the required utilities (electric, water, etc.) for each technology, skill of worker required for use of each technology, and the cost of the application. Documentation will include notes recorded by the technical staff on the demonstration observation forms and digital photographs and/or video. The condition (color, texture, integrity, etc.) of each building material present on the structure along with all structural components such as gutters, windows, doors, etc. will be carefully examined and documented. All condition observations prior to the application of the technology will allow for a comparison of the condition following the removal of the technology from the structure. The demonstration outcomes will be published in a technical report and video.

Both technology demonstrations, including the radiological decontamination technologies, will be demonstrated during June 2015. The decontamination technologies will be used in a scaled-up setting with application to at least 100 square meters over multiple stories. Contaminant mitigation technologies will be demonstrated on the building as well as on vehicles. Example technology application techniques/accessories include an articulating boom lift, boatswain chair repelling, stand-alone surface material structures, high-volume foam applicators, fire truck foam applicator, a vehicle wash tent for vehicles up to a semi-truck, particle tracers to simulate radiological contaminants, and high and low technology liquid containment approaches. All demonstrations are open to

individuals, organizations, and local, state, federal, tribal, and international governments who may be involved with implementing or planning radiological incident response.

Questions, Answers, and Comments

- C: It's great to see that these technologies are being used in real environments, but given that the building is scheduled for demolition, this might be a missed opportunity to see what the long-term consequences of these technologies might be.
- Q: Could you preserve some pieces of the building for long-term stability?
- A: Yes, perhaps we could preserve some of the materials and bricks.
- Q: You mentioned some 10 foot by 10 foot wall demo that was done at Idaho National Laboratory (INL). Was that real radioactive?
- A: Yes. One of pictures showed the setup that we've used for the last eight years to mimic on a medium scale. It allows us to mimic an actual radiological event on a medium scale.

Early-Phase Waste Staging for Wide-Area Radiological Incidents

4:40 pm

Paul Lemieux (presenter) | *U.S. Environmental Protection Agency, Office of Research and Development*
Rachel Sell | *Battelle*

Abstract

The U.S. Environmental Protection Agency (EPA) is working with the Department of Homeland Security Science and Technology Directorate (DHS S&T) to strengthen the Homeland Security Enterprise by performing a project to support first responders for radiological and nuclear incidents. This project focuses on four tasks: (1) methods for radiological contamination mitigation (RCM) via "containment" which prevents the resuspension and subsequent dispersion of radiological particle contamination, (2) methods for radiological contamination mitigation via "gross decontamination" which physically removes radiological contaminants from impacted areas of interest, (3) methods of early phase staging and storage of radiological waste, and (4) development of a software application that could help facilitate early decision-making regarding containment, decontamination and waste storage/disposal during a wide-area radiological incident.

This presentation focuses on methods of early phase staging and storage of radiological waste (task 3), with the intent to provide first responders and other decision-makers with recommendations and best practices (or "operational guidelines") for initial waste handling and staging that could be implemented in the early phases of a response to a wide-area radiological incident. Waste staging can be defined as the process by which space is allocated for sorting waste into different waste streams, isolating radioactive waste in order to keep it from contaminating non-hazardous waste streams, and storing waste until capacity becomes available. These incidents could include nuclear power plant (NPP) accidents as well as detonation of radiological dispersal devices (RDDs), otherwise known as "dirty bombs," or Improvised Nuclear Devices (INDs).

Although waste management is typically viewed as a function associated with later phases of the response and recovery, waste will start being generated almost immediately after the initial contaminating incident and as a result, "pre-incident" waste management planning to include early phase staging of waste is needed. Waste management decisions made by first responders during the early phase of the response may impact waste management options available later in the response/recovery process as well as impact the overall cost and timeline of the recovery to come. Pre-incident waste management planning could have an even broader audience during the incident involving waste management decision-making.

Questions, Answers, and Comments

- C: I understand the need and drive to create a "menu" of things that local responders can decide upon, but there are some states in this country that don't have the radiological expertise to make these

decisions, let alone the counties and the municipalities. Somebody is going to have to bite the bullet and say this is a minimum standard, and it needs to be the Federal government. It's just a minimum standard, but if you give them a menu and you don't give them a minimum, they are going to decide on a minimum. You are going to run into the trouble we are trying to avoid which is creating more problems.

- C: I agree with you. We need to work closely with U.S. Department of Homeland Security (DHS) to roll these various things out to give the people who make these decisions the ability to know what they don't know.
- C: When considering whether waste will go to a local U.S. Resource Conservation and Recovery Act (RCRA) site or a low level repository I think you have learned that you also need a mix of local sites especially if it's going to a west compact facility. Especially in eastern states, as we learned in PA, some waste must be taken locally before any waste is accepted out west. Beyond cost, there must be regional political acceptance before the west will accept waste. This is a politically sensitive issue.
- C: Yes this has been a recurring theme from some of the workshops. The western states have opined that if Pennsylvania wasn't going to take a significant quantity of material and do something with it within their state, the Governor of Utah might close the facility to everyone.
- Q: You had talked about building a second landfill quickly, and this has some tie-ins for staging. Can you talk about that?
- A: Yes, if the private sector would not accept materials in their landfill they may still be willing to operate another landfill built by locals or government and created specifically for an incident. They might be willing to handle the materials in this way without risking their own business assets.
- C: Suggest taking a look at how waste was handled from the Joplin tornado. They had a big problem handling the debris that was mostly harmless aside from some asbestos. It took weeks including several days just to work through the landfill issue partly due to the local geology and geography. We spent a lot of time trying to find places and open spaces even though Joplin is not a big metropolitan area, we still had difficulty.
- C: Yes it's a huge issue and there's also a stigma attached to accepting waste. With the Deep Water Horizon, there were landfills that were taking waste like this the day before the incident and after the incident, they wouldn't have anything to do with it.
- C: Legal agreements with land owners can be difficult to overcome—we sometimes had to walk away.
- C: This highlights the importance of trying to figure out these issues before an incident occurs to determine potential pitfalls and partners.
- Q: How does the concept of R4—recover, recycle, reuse, remanufacture—apply here? It can stimulate a capital component. Was there any discussion or understanding of that in your assessment?
- A: Yes, this is one of the reasons we need enough space in the staging area so that you can separate non-contaminated materials and help reduce the volume of waste. Recycle and reuse is in play for these incidents, although there is still stigma attached. It contributes to lowering cost. Note that $3 billion in tipping fees doesn't include the cost for sending a train or truck to Utah. Imagine how many trucks you would need if they only haul 20–30 cubic yards each.
- Q: What is the state-level attitude like?
- A: Most states recognize that it is a big problem and that we're all in it together. That is not to say there won't be some issues when an incident occurs. It will often become a regional problem. Many cities are near a border and waste can easily go into a neighboring state.
- Q: For biological disposal, you indicated that you wouldn't mix organic waste with some of these contaminants because of the generation of gas and the possibility of leachate production and venting. Do you have the same concern for radioactive materials? Do you still need to segregate the organics from the inorganics for that reason?
- A: Yes, it is best to separate wastes so you can use the appropriate strategy to handle it. Some organics can be sent to an incinerator if you can remove cesium, and this will reduce volume significantly. Metals may be more amenable to being washed, decontaminated, and then can be recycled. In a lot of radiological release situations, you will have ability to separate materials relatively easily outside the area where the release occurred. It is relatively easier to separate materials in this type of incident compared to debris from a hurricane or earthquake.

8. General Session 2
Data Models, Research Overviews and Remediation Plans

Auditorium C-111

Moderated by Lukas Oudejans and Mike Nalipinski | *U.S. EPA*

Systems Analysis of the Data and Models Used for Federal Emergency Management

8:15 am

Ellie Graeden (presenter) | *Gryphon Scientific*

Josh Dozor and Eric Soucie | *Federal Emergency Management Agency*

Abstract

Informed decision-making is key to successful emergency management. New data resources and modeling tools have led to a rapid expansion in the amount of information available to decision-makers during emergency management, but this information is not always available when and in the format it is needed. To address this gap, we have inventoried the data and modeling resources required to support both senior-level and operationally-relevant decision making across the federal interagency during all phases of emergency management for nuclear detonation, hurricane, and earthquake scenarios. In support of the FEMA-led Modeling and Data Working Group (MDWG), appointed by the Emergency Support Function Leadership Group (ESFLG), we have gathered information from over 200 in-person interviews with senior policy advisors, emergency managers, and technical subject matter experts to identify and characterize the data and modeling resources available. Through an iterative process, we have developed an ontology to characterize the resources and collated resource metadata in a database with a simple graphical user-interface that provides ready access to the inventory. Network analysis has been used to define linkages between the resources and their users with the results identifying the interagency relationships required to support information sharing for emergency management. These results have also been used to identify gaps and redundancies in the data and modeling resources available to inform emergency planning and response. This inventory and analysis is the first of its kind and will ultimately enable the entire emergency management community to identify and access the resources available to support decision-making during planning and response to disasters.

Questions, Answers, and Comments

- Q: Is FEMA looking at using the modeling and data inventory to evaluate models or to designate a "model run of record" to be sure everyone has the same outputs?
- A: I am not a FEMA representative, but I speak to what they have been discussing and what the Modeling and Data Working Group (MDWG) is working on. The inventory itself is not a source to access the model or data itself, but there is contact information for how to get it. You cannot actually get datasets or models through the inventory; it's a library. The goal is to provide information about what datasets and models are available, how to access them, and to describe how they are used at the federal level for emergency management. FEMA is not attempting to tell everyone what data or models they should be using for their mission; no one agency is an expert in all of these fields. By counting agency-level usership for each dataset and model, we are effectively allowing users to vote on those datasets and models that they find most useful. While there are limits to that method, it the most empirical way we could perform the analysis.
- C: For the heat map with all the models called out and considering biological scenarios, I recognized a challenge and think it may be misleading to take an all-hazards approach. The datasets and models used to support biological scenarios are not captured in this map. Hurricanes are frequent; users are going to be using a standardized subset of tools that can be described as they are here. Maybe distinguishing between all-hazards datasets and models and what other tools you would potentially need for specific scenarios would be good. Specifically, using all-hazards approaches may not be effective for on-scene responders for biological scenarios.

- A: The maps that you are looking at are hazard-specific. On the event characterization side, these models are very event-specific. It is really only when you look at the decision support and mission-specific tools that address different emergency-support functions that you can distinguish between scenario-specific or all-hazards effects. There are no models that are consistently used for biological scenarios, because every biological scenario involves a different agent that is going to act differently within the population. FEMA is interested in looking at biological scenarios next, *because* it is a fundamentality different type of scenario and very different types of datasets and models are needed.

An Overview of EPA Homeland Security Research Program's Biological Decontamination Research
8:40 am

Joseph Wood (presenter), Shawn Ryan, Worth Calfee, Lukas Oudejans, Shannon Serre, Marshall Gray, Sangdon Lee, and Leroy Mickelsen | *U.S. Environmental Protection Agency*
Jenia Tufts and Katherine Meyer | *Oak Ridge Institute for Science and Education*

Abstract

One area of EPA's Homeland Security Research Program (HSRP) includes the evaluation of decontamination technologies to inactivate biological agents on various materials and in challenging environments. This research program is conducted by EPA's National Homeland Security Research Center engineers and scientists, in close partnership with end-users from EPA's Office of Emergency Management, Office of Resource Conservation and Recovery, and Regional Office On-scene Coordinators.

The goal of EPA's bio-decontamination research is to develop and improve upon capabilities to address environmental contamination with biological organisms, in order to inform end-user remediation strategy decision making. Objectives of the research include assessment and evaluation of decontamination efficacy as well as the engineering aspects of implementing such technologies. Efficacy refers to understanding how well a decontamination product or method inactivates the target biological agent (e.g., *B. anthracis* [Ba] spores) on different material types as a function of operating parameters and environmental conditions. Studies of engineering aspects of decontamination include assessing the impact of the decontamination on the materials (including sensitive equipment or high value/historical items) and methods enabling implementation in the field (e.g., containing a fumigant).

The emphasis in recent years has been to increase the nation's decontamination capacity to handle a wide area release of Ba. One approach toward meeting this goal has been to find efficacious conditions for decontaminants that are easier to implement, such as using fumigants at lower temperature, relative humidity, and concentration (but perhaps longer contact time). This would facilitate the use of such decontaminants by contractors and possibly homeowners ("self-help"). Examples of decontaminants being assessed for this simpler application approach include chlorine dioxide gas, methyl bromide, and hydrogen peroxide vapor.

Liquid sporicidal chemicals such as peracetic acid and hypochlorous acid/hypochlorite based decontaminants (e.g., pH-amended bleach, Canadian Aqueous System for Chemical/Biological Agent Decontamination (CASCAD) foam) have been found to be effective in inactivating Ba spores on a number of materials, and have been typically applied by spraying. HSRP is currently investigating other methods to apply these sporicidal liquids that may enhance decontamination capacity or provide niche uses, such as fogging, wipes, immersion, and gels/foams.

Additionally, the research program is investigating widely used agricultural pesticides, structural fumigants, and other chemicals (e.g., in-situ advanced oxidants used for soil remediation) to determine their effectiveness against Ba spores. Examples demonstrated to be effective in laboratory testing include methyl bromide, methyl iodide, metam sodium, and sodium persulfate.

The HSRP has generally focused on Ba, however, decontamination research for other biological agents such as *Yersinia pestis* and vaccinia virus has also been conducted. Potential surrogates (generally non-pathogenic spores)

are often included in these studies, to assess the surrogate's suitability in representing Ba for use future decontamination studies. The ability to use appropriate surrogates enhances the scale at which work can be accomplished, often improving the direct applicability of the research to use in the field. Research typically begins with small scale laboratory tests, and then depending on results, may move to pilot-scale or eventually full-scale field tests.

Some of the more important findings from the EPA's bio decontamination research program from the past few years will be highlighted during the presentation.

Questions, Answers, and Comments

- Q: Having experienced this in the past, are you examining the economics of these simpler approaches?
- A: There was some cost-analysis done as part of the Bio-Response Operational Testing and Evaluation (BOTE) project but, in general, no. Some others may have looked at that.
- Q: Have you considered the wide-area decontamination aspect of this and the cost of it? For example, if the EPA campus was contaminated, what approach would you be using to eliminate the problem?
- A: I don't know, I think there would be a team of experts and on scene coordinators, U.S. Office of Emergency Management (OEM) folks and researchers would probably get together and talk about it and try to figure out the best way to decontaminate.
- Q: Would the materials you mentioned be applicable to a wide-area application? And would you prefer one to the other?
- A: Yes, it depends, some decontaminants work better than others on different materials, for example, hydrogen peroxide vapor doesn't work very well on concrete. Chlorine dioxide works very well, but it is highly oxidative and damaging to a lot of materials at the high levels.
- C: That is really an operational question and that would go back to: what are priorities for cleanup? What are the available decontamination technologies? What are your waste disposal options? What are your political pressures? What are your resources? What Joe presented was a toolbox that we can use to answer and prioritize those types of responses. I think the key points are area-wide contamination and *anthracis* but, in yesterday's presentations, we used these cleanup technologies for ricin, *Burkholderia*, Ebola. So these methods have daily applicability to these unique scenarios we are working with once or twice a year. This is preparing us for daily activities as well as high-impact low-probability events. These researchers are starting to say "off-the-shelf", which is great because as responders, we need access to materials quickly.

New York City (NYC) Department of Health and Mental Hygiene (DOHMH) Environmental Remediation Plan for Biological Incidents

9:05 am

Shannon Serre (presenter), Paul Lemieux, and Leroy Mickelsen | *U.S. Environmental Protection Agency*
Donna Edwards | *Sandia National Laboratories*
Kobria Karim, Laurie van Vynck, and Colin Stimler | *New York City Department of Health and Mental Hygiene*

Abstract

EPA's Consequence Management Advisory Division (CMAD) is working with the NYC Department of Health and Mental Hygiene (DOHMH) and Sandia National Laboratories to develop a remediation plan for DOHMH. The work group is comprised of people from several EPA offices including OEM, NHSRC, U.S. EPA Office of Resource Conservation and Recovery (ORCR), U.S. EPA Office of Chemical Safety and Pollution Prevention (OCSPP), OW, Office of Homeland Security (OHS), and OSCs from Regions 2, 3, and 5. In addition, representatives from various NYC agencies and the state of New York are helping with the development of the plan. The plan will provide guidance for the remediation, clearance and re-occupancy of private and public properties in the event of an intentional release of *Bacillus anthracis* (Ba). The concepts and processes developed can be leveraged in the event of the release of biological agents other than Ba. The plan includes general guidance for government/regulatory entities and stakeholders; personnel health and safety plans; technical guidance including decontamination

strategies and tactical procedures (supported by tools), sampling strategies and plans, clearance criteria and procedures, waste management plans; roles and responsibilities; and guidance for establishing technical working groups and environmental clearance committees. The goal is to develop a plan that can be modified and used for developing bio-response plans for other municipalities.

NYC represents many technical, logistical, and political challenges, including buildings that are predominantly high-rise structures and the largest subway system in the country. In a wide-area release of *Bacillus anthracis*, these types of structures and facilities will be difficult to decontaminate. As part of the development of this plan, a sub-group of the team performed an inspection of a 33-story high-rise building to obtain information on how to fumigate a high-rise building as well as to inventory the materials in the building. The materials in the building may be affected by the sampling or decontamination process and there may be compatibility issues with the materials and decontamination method selected, which will increase the amount of materials requiring disposal further adding to the waste stream. Other sub-groups tackled issues unique to subway remediation and another tackled the issues of the management of the enormous quantities of waste that might be generated in such an incident.

The development of this plan and the discussion of the many issues involved will help to facilitate an effective and coordinated response for a biological terrorism event that can serve as a model for other municipalities across the country.

Questions, Answers, and Comments

- C: This is more complicated research. A lot of credit goes to Shannon, because there are a lot of people involved. One thing we've learned is how the gap in planning exists; we learned that from each other. To get a plan requires intense coordination at federal, state, and local levels. Your thoughts?
- A: That's one thing we can encourage them to do, strongly: to talk to their colleagues in the state as well as the internal city agencies, but whether or not they do is up to them. This is a leaping point for them to jump in and start facilitating this, but they're also dealing with other issues like the Ebola response. We realize situations are going to pop up for them as well, and they are trying to do this on the side. Hopefully nothing happens soon, but if it does, they have this information and they have us. All we can do is strongly encourage them.
- Q: What other federal agencies would be planning if an incident happened tomorrow? What would other federal agencies' roles be and who would design the guidance document or path forward for cleanup?
- A: We have not worked with any other federal agencies on this; this is mostly for bio-decontamination, which would be our role and responsibility.
- C: We have not worked with any other federal agencies on this; we are mainly focused on decontamination sampling.
- C: The National Urban Security Technology Laboratory [NUSTL], our laboratory in SoHo, could offer you some staging and connection because I don't see New York Fire or Police Departments on there. We've had a longitudinal investment in this since 2008, and I know you're connected to the core documents, like planning guidance for recovery from biological incidences. But I think there are some additional conversations we could have, so I would like to commit to you that we should try to build a liaison because we are covering the same ground.
- Q: I am curious to know, since this is such a complicated situation to try to work in all of the challenges with various agencies: have you considered computerized modeling for types of scenarios or situations to better plan for things if something should occur?
- A: We try to define a scenario up front, but there are always a million different variables to account for, so we try to make plans scalable to account for variables that are out of our control. There are a lot of models out there – a lot of subway models – to use if an incident happened. We try to assemble all the tools to make a decision for a specific scenario that would pop up. One of the things we battle with is "how do you define a building?" Or "how do you define a region?" What does it include? So we developed specific definitions applicable to this plan. A model would have been easier, but we haven't done that.

Water Sector Decontamination

9:30 am

Marissa Lynch (presenter) | *U.S. Environmental Protection Agency, Office of Water*
George Gardenier | *Oak Ridge Institute for Science and Education, U.S. Environmental Protection Agency*
Matthew Magnuson | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

Drinking water and wastewater systems face major challenges when confronting a contamination incident—whether accidental or intentional. The challenges include not only isolating and treating contaminated water, but also decontaminating the storage, treatment, and distribution infrastructure to enable recovery and return to service.

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 tools that can be adapted to specific incidents as appropriate. To address the needs of the Water Sector, EPA's Water Security Division (WSD) has developed tools and other resources that can aid water utilities and responders in their decision- making analysis.

In collaboration with other EPA Program Offices such as the Office of Research and Development/National Homeland Security Research Center (NHSRC) and the Office of Wastewater Management (OWM), WSD has worked with water utilities to finalize development of the Decontamination Preparedness and Assessment Tool (DPAT). The tool walks the user through the three pertinent phases of remediation and cleanup, namely characterization, decontamination, and clearance. The tool highlights key decision points and options to help return a water system to service.

WSD is also in the process of rolling out a series of decontamination tabletop exercises, the first of which was initiated in 2014 and included representatives from drinking water and wastewater utilities, water sector trade associations, local and state departments and agencies, federal agencies, and other partners. The goals of the exercises are to:

- Define critical decontamination issues for utilities and identify options utilities have to address these issues,
- Understand the roles and responsibilities of stakeholders and response partners and how coordination will occur through the Incident Command System, and
- Identify key resources to inform decision-making for decontamination efforts.

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

The presentation will also highlight other potential products currently under development to enhance preparedness, such as the work WSD is performing in collaboration with NHSRC, other federal agencies and water sector organizations.

Questions, Answers, and Comments

- Q: For these cities that have combined waste water systems: how do you see that from your perspective, and what gaps do we have to close?
- A: Working with New York City with Mario Ierardi (EPA) and helping him address some of the waste water concerns; a lot of these utilities are dated (very dated), so subjecting them to some of these biologicals could disrupt their daily operations and change a waste water facility into a hazardous waste facility. There are people in our division that can shed more light on that. It's a big problem for these utilities and provides a potential gap that will probably be faced continuously.

- Q: If you take your tabletop on the road, would you come to Kentucky? How much did you get from the Charleston MCHM [4-methylcyclohexanemethanol] spill about a year and a half ago?
- A: Sure, we can go on the road! We've reached out to states to obtain CEUs [Continuing Education Units] for the operator to make it a learning process so they can keep their licenses up to date.
- A: The utility (American Water) led the response to the distribution system contamination incident and the State DEP led the response to the spill in the river. The State Primacy agency oversaw the utility's response, and in general approved the plans proposed by the utility. EPA (Region III, U.S. EPA Water Security Division (WSD), and NHSRC) provided technical support to the utility and State Primacy Agency during the response and recovery efforts for the distribution system contamination incident. EPA OSCs were on the ground to support the response to the spill into the river. However, they were not in charge. CDC provided a "screening lever" that was used to inform the remediation target. However, neither the state nor the utility were compelled to use it. Later in the response, the utility and state decided to use a much lower remediation goal.

9. Concurrent Sessions 2
Biological Agent Detection

Auditorium C-111
Moderated by Worth Calfee and Shannon Serre | *U.S. EPA*

Independent Testing of Hand Portable Biodetection Equipment

10:15 am

Rachel Bartholomew (presenter), Cindy Bruckner-Lea, Richard Ozanich, Alejandro Heredia-Langner, Beth Hofstad, Janine Hutchison, Kristin Jarman, Andy Lin, Angela Melville, and Kristin Victry | *Pacific Northwest National Laboratory*

Abstract

Background: Pacific Northwest National Laboratory (PNNL) has been tasked by the Department of Homeland Security (DHS) to assess hand portable commercial-off-the-shelf (COTS) biodetection technology with the end goal of transitioning information and technology to the first responder community and other end users. Methods: As part of this effort, PNNL has developed a cost-effective statistically-based test plan and is evaluating hand portable biodetection technologies for the application of screening suspicious powder samples for *Bacillus anthracis* and ricin. We are evaluating a wide range of technologies including polymerase chain reaction (PCR) detection systems and immunoassays for biothreat detection, as well as other methods for screening potential biothreat samples (protein tests, DNA tests, ATP tests, and FTIR). Preliminary Results: Specificity testing of five PCR instruments with inclusivity (13 strains) and exclusivity (18 strains) *Bacillus anthracis* DNA indicated that three of the instruments (FilmArray, RAZOR, and T-COR 4) achieved a minimum probability of detection of 0.95 with 95% confidence when tested at 2,000 genome equivalents per milliliter. All of the platforms (PCR, immunoassays, protein tests, DNA tests, ATP tests, and FTIR) were evaluated with 22 commonly encountered suspicious powders in triplicate to assess potential interference. Results demonstrate that the biological indicator tests (protein, DNA, ATP, and FTIR) are useful screening tools and provide expected positive results for organic, biological, or protein containing powders. Most of the immunoassay and PCR biodetection systems (agent-specific technologies) gave true-negative results for all powders (as expected). However, limited unexpected (and undesirable) false-positives occurred with some of the technologies. The results of testing with *Bacillus anthracis* spores and ricin preparations will also be presented. Conclusions: Biodetection technologies vary in their performance as well as their cost, size and ease-of-use. Specific end-users and Concept of Operations (CONOPS) will dictate technology attributes and performance requirements. This effort provides the first responder community and other end-users with objective information to guide appropriate instrument procurement and optimal use in order to improve response to biological events.

Questions, Answers, and Comments

- Q: What is the powder that you used for your evaluation test?
- A: We have 22 environmental powders. We have things like yeast, dipel dust, salts, acetaminophen, Tums, and chalk. First responders also gave us things that they found.
- Q: Is there any plan to look into the limit of detection for this?
- A: We have, but for the sake of time and brevity, I took that out of my presentation. We have done limit-of-detection (LOD) studies. On several platforms, we were not able to meet manufacturer LOD. With the PCR platforms that wasn't the case; we could get well below LOD.
- Q: Which American Society for Testing and Materials (AST) subcommittee are you working with?
- A: E54, Homeland Security.

Rapid Viability PCR Method for Detection of *Bacillus anthracis* Spores: Overview and Historical Perspective 10:40 am

Sanjiv Shah (presenter) | *U.S. Environmental Protection Agency*
Staci Kane, Gloria Murphy, Teneile Alfaro, and Sonia Létant | *Lawrence Livermore National Laboratory*

Abstract

Rapid Viability Polymerase Chain Reaction (RV-PCR) method for detection of live *Bacillus anthracis* spores from surface and water samples was collaboratively developed in a multi-year effort by the National Homeland Security Research Center (NHSRC) of the US EPA and the Lawrence Livermore National Laboratory (LLNL) of the US Department of Energy. The method was developed in direct support of the Environmental Response Laboratory Network (ERLN) established by the EPA's Office of Emergency Management (OEM). The RV-PCR method integrates high throughput sample processing, rapid broth culture, and real-time PCR to detect low levels of *B. anthracis* spores in the presence of challenges including high levels of dead *B. anthracis* spores, high levels of live, non-target bacterial cells and spores, and other interference matrices. The method was developed and optimized for air filter, water, and different surface sampling tools including wipe, sponge-stick, vacuum filters, and vacuum socks. Ultimately, the method was evaluated and further optimized for detection of *B. anthracis* spores in post-decontamination samples using the spores exposed to complete and partial kill conditions with pH-amended bleach, vaporized hydrogen peroxide, and chlorine dioxide. During Phase I of the Bio-Response Operational Testing and Evaluation (BOTE) field exercise that disseminated spores of the *B. anthracis* surrogate, *Bacillus atrophaeus* subspecies globigii (BG), the performance of the RV-PCR method was verified and compared with the traditional plate culture method. Both pre- and post-decontamination surface samples were analyzed. Overall, the RV-PCR method provided rapid results that were 95% (250/262 samples) consistent with the results obtained with the traditional plate culture method. The RV-PCR method could be used with the same accuracy as traditional microbiological culture-based methods in the future if a wide-area anthrax incident should occur. More importantly, however, the RV-PCR method, based on its current manual version, can allow for five to six fold higher sample analysis throughput than the traditional culture method.

Questions, Answers, and Comments

- Q: The sponge stick didn't work very well in terms of getting a shift in the contact time (CT) value. So, are you recommending using wipes in the future or something else?
- A: We go by what is best for the end users in the field. So, there are two things here. We need to do more work to increase the recovery of spores in the samples, and then also increase the incubation time to 15-18 hours.
- Q: I'm surprised when you look at your time zero, the spores come out with no detectable CT value. Are you doing something to try to get deoxyribonucleic acid (DNA) out of the spores? How are you doing your spore prep? I don't understand how you get no CT value.
- A: First, it all depends on how you prepare your spores. Secondly, you are talking about taking 1 mL out of 3.5 mL containing 10-99 spores, very small quantities. Only 5 microliters from a total of 200 microliters elution volume of the DNA extracted from such a small number of spores will usually not give any polymerase chain reaction (PCR) CT value.

Development of a Rapid Viability PCR Method for Detection of *Yersinia pestis* in Water Samples

11:05 am

Staci Kane (presenter), Teneile Alfaro, and Anne Marie. Erler | *Lawrence Livermore National Laboratory*
Sanjiv Shah | *U.S. Environmental Protection Agency*

Abstract

In previous collaborative efforts between the EPA and LLNL, Rapid Viability Polymerase Chain Reaction (RV-PCR) methods have been developed and thoroughly evaluated for *Bacillus anthracis* spores in surface and environmental samples, with RV-PCR methods showing comparable results to the gold-standard culture method even though confirmed results were generated in about one-third the time. The 10-spore level was consistently detected in the presence of background debris and high levels of live, non-target cells/spores or dead target spores. Since the US EPA is also tasked with responding to contamination by other biothreat agents including vegetative cell pathogens, RV-PCR protocols for *Yersinia pestis* cells were developed and evaluated for pre-wetted wipe and water samples, where cells may be expected to remain viable. Low detection limits were achieved (10 – 100 cells) even in the presence of chemical interferences (humic acid, iron) and indigenous microbial backgrounds (native reference dust). *Since Y. pestis* has a longer doubling time than *B. anthracis,* confirmed results were obtained with 24 hr incubation (compared to 9 hr for *B. anthracis*) although this compares favorably to ~ 72 hr for traditional plate culture-based analysis. *Y. pestis* cells at the 10 CFU level were consistently detected by RV-PCR in backgrounds of live non-target organisms (104 – 105) and dead target cells (104) killed by isopropanol treatment, which kept cells and DNA intact. Longer incubation times (> 24 hr) may be required for detection of the 10-CFU level in ≥ 105 dead target cell backgrounds. Approaches to concentrate *Y. pestis* cells from water samples prior to RV-PCR analysis including immunomagnetic separation showed promise. Together the results demonstrated that the RV-PCR method could provide more rapid, while equally accurate results and enable higher throughput analysis for *Y. pestis* contamination compared to the traditional plate culture-based approach.

Questions, Answers, and Comments

- Q: Sanjiv Shah, US EPA, mentioned that they were using sponge sticks; have you used a sampling method for wiping, and is there a difference in how much you can get from the surface between the sponge, wipe, and swab?
- A: We have not looked at recovery from surfaces using different devices. The method worked well with gauze wipes but here we added *Y. pestis* cells to wipes rather than recovering cells from surfaces.
- Q: What other organisms are you going to look at after this?
- A: *Burkholderia pseudomallei* would be interesting given recent events.

Sample Preparation Considerations for Detection of Biological Threat Agents in Complex Environmental Matrices

11:30 am

Richard Winegar (presenter) | *MRIGlobal*

Abstract

Technologies to detect biological threat agents are continuing to evolve at a rapid pace, with analytical sensitivities approaching the single-cell/single-molecule-level. Despite these advances, significant barriers for their use in field applications exist. A significant factor is the lack of corresponding technical advances in sample preparation methods for complex environmental matrices. Often there is a mismatch between the bulk and complexity of the collected samples and the microfluidics and purity requirements of the detection platform. With genomic approaches increasingly used to complement or replace PCR-based detection, new considerations are required for both sample processing and analysis.

As a contract research organization, MRIGlobal often develops, tests, and evaluates technologies for sample collection, preparation, and analysis. To ensure candidate technologies will meet user needs, we must integrate requirement and constraints of the entire workflow (from initial collection through data analysis and interpretation). A key element of this process is developing a workflow concept that describes all elements of the intended use: the nature of the environmental matrix; sample collection devices; types of threat agents; logistical constraints for sample processing and analysis (power, size, ruggedness, throughput, ease of use); compatibility of sample processing outputs with detection inputs; requirements for detection output (sensitivity, specificity, qualitative or quantitative, level of characterization). After several iterations based on end-user feedback, the finalized workflow concept provides a framework for preparing and executing an integrated development and validation plan. In this presentation we will discuss the various considerations for workflow concepts and examples of integrated development approaches.

Questions, Answers, and Comments

- Q: There are many parties trying to sell genome sequencing-based detection of biological agents, and say that they can give results in five hours. Many of us know what it takes. If you get a sample in hand, it will take at least five days, not five hours; what is your feel for that? If you are given a wipe or sponge stick sample, how long would it take, and what's the complexity?
- A: We can do it in about 30 hours: two hours for extraction, three hours for library prep, 24 hours for the sequencing, and maybe two hours for bioinformatics. However, that is dependent on the organism of interest being present at a sufficiently high level, and it's also based on having a fixed list of the targets of interest. On some of our projects that we're interested in, we may have a list of 20 different organisms, and we'll have a referencing genome library to which we map all the sequence reads. So, you currently can't do it in five hours, but you probably also don't need three days; the actual time required will depend on the exact nature of your sample and what you are interested in analyzing.
- Q: Could you apply lessons learned now and from the sample prep to legacy cases where we've had anthrax contamination, and could it be done to yield new insights on the extent of contamination? And corollary to the public health cases that did not emerge?
- A: I don't know how much material is available for those kinds of things. This doesn't directly answer your question, but I know in the pre-genomics era, when we were involved in analysis, if we had genomic approaches it definitely would have helped considerably because we had to develop very refined PCR assays based on small differences between the threat strain as compared to generic *Bacillus anthracis*, and to have been able to do whole genome analysis would have been quite helpful. As far as the collection methods, I've encountered so many approaches to collection and sample prep. In some protocols, there isn't really an intrinsic spore lysis. So, often there will be a sample collection, you'll vortex the sample in buffer, and then put the extract directly in PCR, so you won't have the maximum sensitivity. But, it's sort of all over the map as far as what people have used. That is part of why DHS is funding this validation work, because they wanted an integrated approach where there is validation data behind it, and if we have to deal with it in the future, hopefully everyone won't be running around with their own analyses; there will be a concerted approach.

10. Concurrent Sessions 2
Water Infrastructure Decontamination

Classroom C-113
Moderated by Marissa Lynch | *U.S. EPA*

Decontamination and Restoration of Critical Water and Wastewater Infrastructure

10:15 am

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

Abstract

Selected results for the EPA Homeland Security Research Program (HSRP) projects for decontamination of water and wastewater infrastructure after chemical, biological, and radiological (CBR) contamination will be briefly presented. "Infrastructure" refers to the physical components of water and water systems – pipes, pumps, valves, etc. Treatment of contaminated water and wastewater is discussed separately in the presentation "Selected Projects of EPA's Homeland Security Research Program (HSRP) for Water and Wastewater Treatment and Decontamination." Please contact the presenter for more details on the individual projects described below. Some of these projects are also the subject of separate presentations at this conference.

1. **State of science of water system decontamination.** Three peer-reviewed journal articles are now available that summarize the publically available research on decontamination of drinking water infrastructure. Each article is separately devoted to chemical, biological, and radiological contaminants, respectively.
2. **Persistence and removal of radionuclide simulants from drinking water pipes studied with U.S. EPA's pipe decontamination experimental design (PDED).** Options for decontamination of radionuclides are elucidated from their non-radioactive equivalents.
3. **Impact of CBR contaminated sediments on flushing and decontamination of drinking water storage facilities.** This research is focused to better understand 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 to develop response action plans. It also evaluates response techniques in water distribution systems using computerized simulation studies. Hydraulic models for these studies are refined through incorporation of real-time water system operational data.
5. **Unique facilities for infrastructure decontamination research.** Describes research at unique pilot- and full- scale facilities, as well as mobile treatment platforms. For instance, full-scale decontamination work at the Water Security Test Bed at Idaho National Laboratory.

Questions, Answers, and Comments

- Q: We talked yesterday about the WV response. Were there any issues with that incident for decontaminating pipes?
- A: Yes, there were a lot of issues that came up with decontaminating the pipes. EPA Region 3 led the effort and consulted with both U.S. EPA Office of Water (OW)/Water Security Division and NHSRC on technical issues surrounding decontaminating pipes, analysis of water, and other related technical issues.
- Q: Are you still doing work with the model River Spill to determine travel time of the plume?
- A: River Spill [currently known as ICWater] is a current product that was funded by EPA and other groups and developed by Science Applications International Corporation (SAIC). It was used in the West Virginia (WV) response via the DTRA [Defense Threat Reduction Agency] reach-back capability. They are able to run the model and provide travel times. It was an unfortunate opportunity that demonstrated that the model does in fact work well enough to predict the arrival of the plume downstream and water utilities were shut off all along the Ohio River in response.
- Q: Does it happen often that you get a biological contamination in the water distribution system?

- A: Biological contamination is a common concern. Many water systems test for coliform bacteria daily. This contamination can occur from low levels of residual disinfection in the water distribution system providing an opportunity for coliforms and perhaps pathogens to grow. People might be surprised to learn that pathogens can live in water systems even with chlorine. More recently, there was a harmful algal bloom in the Toledo area that made the news last summer and is another example of a biological incident.
- Q: Are there any examples of an accidental biological contamination for something other than coliform? A: Yes, periodically there have been biological incidents, particularly in smaller systems where they may not maintain their systems as well. There was an incident with *Salmonella* in Colorado. The biggest one in recent memory was a *Cryptosporidium* outbreak in Milwaukee that unfortunately resulted in fatalities from ingesting *Cryptosporidium*. Things like these do happen, unfortunately with some regularity. They are often a result of accidents or poor system maintenance. For example, water tanks on top of apartment buildings may be open and birds fly in and can cause contamination. It's difficult to say how many smaller scale incidents have occurred, but several have made the news [some are mentioned above].

The Water Security Test Bed – A Pilot Scale Test Bed for Water Infrastructure Decontamination

10:40 am

Stephen Reese (presenter) and Michael Carpenter | *Idaho National Laboratory*
Jeff Szabo and John Hall | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

The US Department of Energy's Idaho National Laboratory and the US EPA's National and Homeland Security Research Center have collaborated to construct a first of its scale water security research and testing center. The center develops and tests methods and technologies for securing and decontaminating drinking water distribution systems. Contaminants can be introduced into a water system due to natural (weather or geological) events, accidents (e.g., petroleum contamination due to an industrial accident at a refinery), or intentional (terrorist) acts. The focus of the Water Security Test Bed is on four areas of water security vulnerability: biological, chemical, radiological, and cyber security.

In 2014, the initial phase of the apparatus was constructed. ~450 feet of 8-inch cement mortar lined ductile iron pipe was laid out in an "L" as an above ground test bed. The pipeline features two hydrants, three 1-inch corporation stop connections that function as sampling ports, water quality instrumentation, secondary containment, and a section of pipe featuring twenty 1-inch diameter removable coupons. Coupons made from pipe materials other than cement mortar lined, ductile iron can be inserted to test those materials' response to the contaminant or decontamination method being tested. In 2015 and out years, additional 8-inch piping and 1-inch service connections are planned. The completed test loop as envisioned will feature ~2100 feet of 8-inch piping configured in a loop, which can be segregated into four sub loops. Additionally, ~2800 feet of 1-inch service lines will be added, along with supply and effluent storage tanks, pumps to pressurize and circulate the loop, and automated controls for the system. Continued expansion of the system will be linked to the level of involvement of government and industry partners.

Initial testing, conducted in autumn 2014, included studying biofilm growth in the water main, and dispersal of a biological agent in the piping system followed by subsequent decontamination. Future studies will focus on a variety of potential chemical, radiological, and biological contaminants, as well as cyber vulnerabilities in the automated controls of the piping system. The system and its capabilities are described, and the results of initial testing are presented.

Questions, Answers, and Comments

- Q: Will the shower re-aerosolization studies include estimates of vulnerability and loading and delivery of a dose that would be of a concern or just for proving the aerosolization happens?
- A: Sarah Taft (EPA) is the best person to answer this. I'm not sure what her plans were or if this is something she plans to look into further. The concern is the showerhead can allow the spores to be suspended and inhaled, which is more lethal than ingesting them. Essentially in the BOTE building, we could mock up a residential bathroom and pipe service connection.
- C: It's building on two studies including one on showering and exposure and one where she applied the framework for exposure to a shower setting.
- Q: There are two types of pipe material including steel and copper. Do you also use concrete?
- A: No, the main line is cement mortar-lined ductile iron pipe and the small service connections are built out with copper. They could also be black plastic. The one coupon section is polyvinyl chloride (PVC) and the rest of it is cement. We are able to test all different types of components.
- Q: Did you measure the thickness of the biofilm?
- A: Absolutely, this is why we used the old reclaimed pipe so it would be more representative of the real world. Some of the pipes were remarkably clean despite being in service for decades, but some had carbuncles and rust bubbles that formed over time unlike a new pipe.
- Q: You mentioned over the course of the experiment the concentration went from 110 mg/L of chlorine at the start to 11 mg/L. Was this a flowing experiment? Where was the marker point at the beginning and the end as to where the decrease occurred or did it sit there and decay?
- A: Once the chlorine dioxide was distributed throughout the pipe system via flow, flow was stopped, and the chlorine dioxide sat in the pipeline for 24 hours. The measured values of 110 mg/L and 11 mg/L were at the start and end of that 24 hour hold period.
- C: The way the experiments were set up, we did an injection of the bacillus spores and there was flow going on in the pipe, letting the spores come in contact with the pipe surface. Once spores showed up in the downstream end of the pipe, we injected chlorine dioxide and there was flow going down the pipe and once the pipe was fully flooded with chlorine dioxide, we stopped the flow, so the contact was stagnant. The main takeaway is that from the perspective of contamination, we have done lots of work in a pilot-scale system, but we wanted to bring it up to something more realistic. The slide he showed where the bacillus spores stuck to the pipe surface – we really learned there that things that work great on our pilot-scale systems and in the lab just didn't work as well in the field as much as we had hoped. The whole point of this is to try to understand what works on the field scale. We will be going back in a few weeks to redo the contamination based on what we know so we can do it better.
- Q: If you inject rad material in there, it would be very interesting to see how it bonds on pipes. Do you have sufficient sections of pipes that you can play with so you can characterize the types of films? Can you go into the real test pipe and pull out sections?
- A: There is one 15-foot section in the pipe that is PVC with drilled out holes that allows for different pipe materials to be tested. They can be pulled out at various intervals.
- C: As a followup, you could do this for other pipe sections as needed – replace a section of pipe with a PVC section with coupon taps drilled out. It's something to think about.
- C: One of the reasons why we haven't built the whole system is because we are looking for partners to see what they need, and then we can tailor the rest of the system to meet their needs.

Radiological Contaminant Persistence and Decontamination in Drinking Water Pipes

11:05 am

Ryan James (presenter) and Elizabeth Hanft | *Battelle*
Jeff Szabo and John Hall | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

The objective of this work was to evaluate the absorption, persistence, and possible decontamination approaches of non-radioactive cesium, cobalt, and strontium on concrete-lined and/or polyvinyl chloride (PVC) pipe using the EPA Persistence and Decontamination Experimental Design Protocol (PDEDP). The PDEDP uses annular reactors (AR) to simulate conditions within operational drinking water pipes. The work included five components. Surface contamination and surface extraction method validations were first performed to confirm that pipe coupons could be contaminated with simulated radiological contaminants from a bulk solution and that simulated radiological contaminants could be extracted from the coupon surfaces. Additionally, persistence evaluation (PE) and flushing evaluation (FE) steps were performed by applying shear to Bg-contaminated concrete-lined and PVC coupon surfaces by setting the AR inner cylinder rotation to 100 revolutions per minute (rpm) (shear similar to flow in a 6 inch pipe) for the PE and as high as 250 rpm for the FE. Lastly, chemical cleaning agents were tested by exposing contaminated coupons to several different chemical cleaning approaches. Prior to contamination of pipe coupons, a biofilm was grown on all of the coupons.

The surface extraction method validation confirmed that simulated radiological contaminants could be extracted from both concrete and PVC surfaces after direct contamination. For example, the recovery of cesium from the concrete coupons was 18% ± 4% and from the PVC coupons was 95% ± 17%. The surface contamination method validation confirmed that concrete and/or PVC coupons could be reproducibly contaminated with simulated radiological contaminants by exposing them to a solution of contaminated water. As an example, for concrete, 3.1 µg of cesium were contaminated onto four coupons with a relative standard deviation of 30% and for PVC, 16 µg were contaminated onto four coupons with a relative standard deviation of 12%.

The results from the persistence evaluation are summarized indicated that cesium was not persistent on concrete or PVC pipe materials, cobalt was very persistent on concrete, but less persistent on PVC, and strontium was persistent on concrete, but not on PVC. Furthermore, results from the decontamination evaluation indicate that flushing was not effective for cobalt or strontium on concrete, ethylenediaminetetraacetic acid (EDTA) was an effective chemical cleaning agent for cobalt on concrete, and tartaric acid was an effective chemical cleaning agent for cobalt on concrete, but it formed a yellow precipitate on the surface of the coupons. Lastly, ammonium acetate and calcium chloride were both observed to be moderately effective as chemical cleaning agents for strontium on concrete. Because none of the contaminants were persistent on PVC pipe materials, no chemical cleaning agents were evaluated on PVC pipe materials.

Questions, Answers, and Comments

- Q: The concentrations of cesium, strontium, and cobalt are an order of magnitude higher than you would ever expect. It's almost 10 times higher than high level nuclear waste. How can this translate to drinking water, which is orders of magnitude lower in concentration?
- A: We wanted to contaminate the pipe surfaces by mass transport through the aqueous solution, not spiking the surfaces directly. To reach measurable levels in a reasonable amount of time, very high concentrations were required. We recognize the concentrations used were not plausible for most contamination scenarios.
- C: Yes, the concentrations of the contaminants that we used here were very high. We wanted to start high to make sure we could see something on the coupons to evaluate decontamination. This is analogous to disinfection work conducted by EPA where we start with concentrations of organisms that are in the 10^6 to 10^8 range so that you can see log reductions. These are concentrations you wouldn't expect from a microbial standpoint, but you want to be able to see log reductions.

- Q: I have a question on some of the chemical decontamination methods with respect to strontium. You were seeing that some of the strontium seemed to be growing back in after a few days. Did you do any kinetic studies on lifetimes of the complexes you were forming with chelating agents and possibly if they were re-releasing strontium back onto the surface?
- A: No, we didn't do that, but note that chemical chelating agents were filled into the annular reactor and then the reactor spun in them, so there is possibility of "resuspension," but we didn't study this in depth.
- Q: Did you do anything to keep biofilms growing as they would in a normal pipe? How did you differentiate for the type of pipe, that is, the relationship of the contaminant to type of pipe and the way the biofilm acted?
- A: Good question. We didn't investigate this. This is another area of possible exploration; the issue of biofilm especially as it pertains to mimicking biofilm from an actual pipe on a simulated pipe. Once we had grown them, we put them in the annular reactor and went forth with regular drinking water. There is certainly an impact on the health of the biofilms, but we mainly hoped they stayed on the surface.
- Q: When you grow the biofilms on the coupons, are they just on surface?
- A: We submerged the entire coupon so biofilm is grown on all sides of the coupon. However, only the face of the coupon is exposed to the contaminant.
- Q: Was the biofilm thin enough to see through? You are probably losing strontium onto the concrete. It is probably absorbing all the strontium onto the concrete. This may be why you aren't seeing anything on the biofilm and then when you do the reaction and you see strontium persist.
- A: Yes, you could see through the biofilm.
- C: The biofilms were grown at EPA for practical reasons to accelerate the biofilm growth. There are a lot of ways to grow biofilms, and this was intended to save time. You can also do a real time growth. There is no one right way to do it—both ways have advantages.
- Q: You tested on non-radioactive strontium. Is there any way to confirm the test results on radionuclides?
- A: Yes, it's feasible, and there is the potential for each of these scenarios to go in that direction.
- C: In terms of real radionuclides, EPA has done some work with a Russian lab where we used real water pipes and exposed them to radioactive cesium, strontium, and cobalt and looked at persistence and decontamination.
- C: We have noticed in past work that how long you leave strontium in contact with pipe materials can have a big influence on how long it persists. Short-term exposure of about an hour followed by flushing water will remove most of it. However, if you leave in contact for a much longer period it may become irreversibly bound. We have seen this with bench-scale systems especially with concrete and heavily corroded iron.

Adherence of Contaminants to Drinking Water Storage Tank Sediments

11:30 am

Jeff Szabo, Scott Minamyer*, John Hall, and Matthew Magnuson | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
Ryan James | *Battelle*
*retired

Abstract

This study evaluated the adherence of four target contaminants onto sediments that were collected from drinking water storage tanks located across the United States. The target contaminants for this study were non-radioactive cesium (Cs-133), the insecticide lindane, Escherichia coli, and *Bacillus anthracis Sterne* (BaS), an avirulent strain.

Experimental Design. Between 2012 and 2014, twenty-five sediment samples were collected from drinking water storage tanks in 12 different states and were named by their state of origin. The eight samples with a sufficient

amount of sediment were used for contaminated adherence testing with each of the four contaminants. Background levels of each of the four target contaminants were measured prior to the adherence experiments to establish baseline concentrations before introducing the target contaminant. Before beginning the contaminant adherence experiments, the physical and chemical properties of the sediment samples were determined in order to provide for the possibility of correlating contaminant adherence and sediment characteristics in the future. Sediment characteristics included particle size, pH, total exchange capacity, total organic carbon, and organic matter. Individual solutions of contaminated drinking water of each target contaminant were prepared at pH 7.5 and pH 8.5. Aliquots of the sediment samples were then placed in centrifuge tubes and the contaminated drinking water was added to the tubes. These samples were rotated for 16 hours (cesium and lindane), or 6 hours (E.coli and BaS spores) to enable adherence. Following rotation, the supernatant was analyzed to determine the amount of contaminant partitioning from the solution to the sediment.

Results. Across all the samples collected, cesium sediment adherence percentages ranged from 5% for one Tennessee sample to 88% for the Arkansas sample. Lindane sediment adherence ranged from 7% in the Tennessee sample to 88% in one Ohio sample. More than 50% of the E.coli adhered to all of the sediments studied except for two samples. The largest extent of E.coli sediment adherence occurred in the Arkansas sample with 99% and 100% adherence at pH 8.5 and 7.5, respectively. In general, the BaS adhered more readily to the sediments than the E.coli. The adherence percentages for BaS ranged from 31% for one North Carolina sediment, to 100% for the Arkansas samples. However, most BaS sediment adherences were greater than 90%. The pH differences in the contaminated drinking water did not consistently impact the adherence results.

Questions, Answers, and Comments

- Q: Were any areas of the sediments or biofilms anaerobic?
- A: We didn't address that in this study. I would expect that a lot of sediment sitting in a tank would be anaerobic at the bottom. Drinking water biofilm tends to be thin so unlikely to be anaerobic, but we would expect an anaerobic zone in thicker biofilms formed near wastewater.
- Q: It seems like the sediments could serve as a sink for the contaminants preventing them from getting to the end user. In this case, would you want to remove the sediments?
- A: Yes, the sediments could be a sink, but we are also worried about resuspension from sediments into water and causing the contaminants to be carried around the distribution system. We also wanted to understand better how to handle contaminated sediments when cleaning up after a contamination.

11. Concurrent Sessions 3
Biological Agent Sampling

Auditorium C-111
Moderated by Tonya Nichols and Lawrence Kaelin | *U.S. EPA*

Efficient Sampling Strategies to Minimize Number of Samples Needed for Clearance

12:45 pm

Brett G. Amidan (presenter), Alexander M Venzin, and Landon H. Sego | *Pacific Northwest National Laboratory*

Abstract

A Government Accountability Office (GAO) investigation following the 2001 anthrax incident concluded that validated sampling methods and statistical sampling plans were needed to provide confidence that there is no contamination when all sample results are negative (GAO, 2005). This conclusion strongly reinforces the need for characterized, validated sampling plans to effectively respond to bio threats and ensure public safety. Sampling plans are an essential element when characterization or clearance is required for a contaminated or possibly contaminated area (referred to as the decision area). Generally, sampling plans that make no assumptions about

the contamination or the decontaminant will require many probabilistic (random) samples to be taken, in order to obtain a high amount of confidence that a high amount of the decision area is clean (no contaminant found). When characteristics about the contamination and/or decontaminant are understood, then assumptions can be made and statistical methodologies can be produced which will use those assumptions to drive down the number of samples needed to clear the decision area.

PNNL has been developing methods and tools that help the domain expert make defensible assumptions about a contamination scenario, resulting in fewer samples needed to make confidence statements. This presentation will discuss one of those methods, the stratified sampling method. This is an extension of the CJR (combined judgmental and random) method. It allows the user to divide the decision area into heterogeneous strata with each stratum having an estimated probability of still being contaminated after decontamination. An approach called "Lines of Evidence" can be employed to help with the stratified sampling method. This approach can be used to take into account many factors like decontamination efficiency, air sampling results, and surface material to help determine the probability of a stratum still being contaminated after decontamination. Using these lines of evidence along with the stratified sampling method drives down the number of samples necessary for clearance. This presentation will discuss the methodologies and show examples of how they can be applied.

Questions, Answers, and Comments

- Q: The combined looks great on paper, but have you put it to the test to see if the subject matter experts (SMEs) are able to achieve the same probability as random, and have you compared that to a layperson's input?
- A: That would be a really good game to play. We have the INL studies that occurred. We did combine random judgmental sampling, but all the samples came back negative. So, it worked.
- Q: On the post-sample compositing, do you do eight sponge sticks per bag?
- A: It's all in one bag. After you sample the four different locations with four different media, you put them all in into the bag and process them. We did 16, too, and 16 looks really promising if you put them in one at a time and mash them.
- C: Just to clarify, it was sequential, so not all the sponges went in one bag. You put one sponge in, process it, and remove it.
- Q: So, that was my question: when you composite with one sponge stick and did one analysis, you saved time on the front end and the back end. When you composite just the sponge stick on the back end, theoretically you're just saving time on the analysis. But, if you're doing sequential, then there goes your time savings, right?
- A: There's still more time in the processing, but not in the analysis part. If that's your bottleneck, then it's a good solution.
- C: If you have one hot sample and nothing in the others, you run the danger of diluting your sample to where it might be below an action level.
- C: We never had that problem. We went down to five colony forming units (CFU) per coupon.
- C: It's the same volume that you're working in.
- Q: Just sponges? You didn't use wipes?
- A: Just sponge sticks.
- Q: Can you combine your two compositing methods? For example, one sponge, four sides, and then composite multiples of those later and have a combination of the two tickets?
- A: The only issue is that at these low levels, you lose something when you run one medium across four or eight locations, but you could combine those and not lose anything in that process. In that case, you could take four and four as 16 samples.

Composite Sampling of a *Bacillus anthracis* Surrogate with Cellulose Sponge Surface Samplers from a Nonporous Surface

1:10 pm

Jenia A. M. Tufts (presenter) and Kathryn M. Meyer | *Oak Ridge Institute for Science and Education*
Michael Worth Calfee and Sang Don Lee | *United States Environmental Protection Agency, National Homeland Security Research Center, Office of Research and Development*

Abstract

A series of experiments were conducted to explore the utility of composite-based collection of surface samples for the detection of a *Bacillus anthracis* surrogate using cellulose sponge samplers on a nonporous stainless steel surface. Two composite-based collection approaches were evaluated over a non-porous surface area of 3716 cm2 (four separate 929 cm2 areas). The CDC method was compared to a modified protocol where only one surface of the sponge sampler was used for each of the four areas composited. Differences in collection efficiency compared to positive controls and the potential for contaminant transfer for each protocol were assessed. The impact of the loss of wetting buffer from the sponge sampler onto additional surface areas sampled was evaluated. Statistical tests of the results using ANOVA indicate that the collection of composite samples using the modified sampling protocol is comparable to the collection of composite samples using the standard CDC protocol ($p = 0.261$). Most of the surface-bound spores are collected on the first sampling pass, suggesting that multiple passes with the sponge sampler over the same surface may be unnecessary. The effect of moisture loss from the sponge sampler on collection efficiency was not significant ($p = 0.720$) for both methods. Contaminant transfer occurs with both sampling protocols, but the magnitude of transfer is significantly greater when using the standard protocol than when the modified protocol is used ($p<0.001$). The results of this study suggest that composite surface sampling, by either method presented here, could successfully be used to increase the surface area sampled per sponge sampler, resulting in reduced sampling times in the field and decreased laboratory processing cost and turn-around times.

Questions, Answers, and Comments

- Q: If you're sampling in one location and moving to another, are you putting the sponge stick back in the original container and then sampling another location? Are you proposing to do close by areas where you just walk over and sample the next area?
- A: We just moved to the next area with that sponge stick, but it was a small laboratory setting.
- C: For con ops, the idea is to sample within one decon unit. If you get a positive, it doesn't matter if it's here or there. So, it would be within room; the sampler would probably be walking with the stick, never putting it back up. So, one hallway, one room is what we're calling one decon unit.
- Q: Have you thought about what reproducibility would be if your surrogate had contained an exosporium? I saw you were using *B. atrophaeus*. If the target is *anthracis* and having an exosporium, and the differences adhere to material, and have you thought about that as a second phase of this work?
- A: We certainly could use another surrogate; *thuringiensis* has an exosporium. The surrogate used in this study is consistent with the surrogate used by the CDC for their validation study of the analysis method. Since we were comparing the a CDC sampling protocol with our modified protocol, we felt that using the same surrogate used by the CDC would allow our results to be more easily compared with previously published data using this method. It would be interesting to compare the *B. globigii* (*Bg*) results with the results from another surrogate, but that wasn't the focus of this research.
- C: Right, because you're looking at extraction efficiency. So, if you're trying to develop a method for improved extraction efficiencies.
- C: We're looking at sample collection efficiency, not extraction efficiency.
- C: So, at the time, we did not have *thuringiensis* in our metered dose inhalers (MDIs) and most of our sampling work is moving toward using *thuringiensis*.
- C: Right, just for a second phase, I was wondering if you're moving into that.
- C: I think we're moving into using *thuringiensis* more now that we have it in our MDIs.
- C: You also included in your studies the loss of moisture from sponge sticks; what did you observe?

- A: That's correct. We sampled across one surface coupon, weighed the sponge to see what the moisture loss was; and then sampled two coupons, then weighed, and so on. We repeated that three times over four coupons so that we could determine what the moisture loss was from the sponges during sampling.
- Q: Was there a significant effect?
- C: There did not appear to be any effect.
- C: Since this was on stainless steel surfaces, it was non-absorbent

Potential Use of Robotic Vacuum Cleaners to Sample Biological Contamination

1:35 pm

Thomas Pottage (presenter), Susan Paton, Katy-Anne Thompson, and Allan Bennett | *Public Health England*

Abstract

Vacuum cleaning robots offer a potential alternative to traditional sampling performed by personnel following a biological release. The advantages of robotic sampling are to reduce personnel exposure and increase controlled coverage of contaminated areas. A study has been carried out to assess the effectiveness of four commercially available robots in sampling wet disseminated spores in an artificially contaminated environment.

Three representative flooring types were used in this study: Laminate, PVC, and carpet, and each flooring type was assessed in triplicate. Clean flooring was laid in a 2m2 area in an environmental chamber. One central square of the flooring was contaminated with spores in a class III microbiological safety cabinet using an artists' airbrush containing 150ml of a 5.0 x 107 spores/ml solution of B. atrophaeus (BG2601/11/A) in 100% IPA, operated at 2 bar (30psi). The robots were each introduced and allowed to operate for 10 minutes, then sealed in bags and their sample collection points (bins, tanks, and filters) assessed for percentage collection of spores. Air samples were taken during each run and bagging, as well as surface sampling of the flooring and robot to assess cross-contamination.

Results were calculated by comparing numbers of spores recovered from flooring or robots, to numbers of spores added to the contaminated tile, to give a percentage. Results show that across the 3 flooring types, collection efficiencies and limits of detection were dependant on the flooring type. Collection was highest and detection limits lowest from the smoothest surface, laminate, followed by the hard but rough PVC, followed by soft, porous carpet. The Moneual MR6800-M3 had the highest collection efficiency of all at 17% from laminate, the iRobot Scooba 390 collected the most from PVC (7.3%), whereas the iRobot Roomba 770 collected the most from carpet (0.2%). Cross-contamination to clean areas of flooring (averaged across robots) was seen to be highest on carpet (0.233%), and least on PVC (0.049%). Results show that carpet is the most difficult surface to sample, and that different robots may be suitable to different flooring types and situations. Although additional work is required, these results show that using robotic vacuum cleaners is a potential safer alternative to the use of human sampling teams in a biological release event.

Questions, Answers, and Comments

- Q: When you're trying to collect the samples from carpet, did you consider temperature and humidity?
- A: The room was maintained at a certain temperature, but humidity wasn't accounted for. It ranged from 50-70% humidity.
- C: Yes, because when you vacuum in winter with static and drier conditions, which could affect efficiency.
- Q: Did you expand your study to investigate the recovery from used carpet tiles?
- A: We only had time to look at the new carpet tiles. We didn't look at any used tiles. The actual efficiency might increase a bit more with used carpet as the fibres would be flattened and contamination could be more present on the surface.

- Q: We have a difficult time using robots in the field; responders raise questions about reliability. For example, how do we know that when we deploy the robots to the unknown place, how much area it's going to sample or decontaminate, if we don't know how much area has been treated or sampled?
- A: In terms of this study, it was really just sort of a looksee to see if we could take this forward to develop these kinds of protocols, but there is that issue that you hit with contamination; you would know roughly where it was, so you could go back and sample afterwards. In the UK, we've used more targeted sampling. There's still a lot of work to be done before you can use these robots in the field, but you potentially could do much larger areas more systematically than a person.
- Q: Do you know how much of the four meter square you actually covered?
  A: We put paper on the floor and attached a marker to roombas to track where they went, but of course after each pass the algorithm changes its path. So, you have to trust that the correct area was sampled on the first pass. We could use the floor tracings and cover them.

Sample Analysis Laboratory Capabilities to Support Large Scale Environmental Responses

2:00 pm

Joseph Bogan Jr. (presenter), Jeanette Coffin, and Peggy Lowary | *MRIGlobal*

Abstract

MRIGlobal supports a 24-hours-a-day, 7-days-per-week, 365-days-per-year Environmental Sample Analysis Program for the detection of biological agents in the National Capital Region. The mission of this Program is to "Provide requisite laboratory and scientific expertise to support the need to rapidly recognize, respond and recover from a biological attack on personnel and infrastructure critical to maintaining the continuity of Government and business operations."

This Program has operated without interruption since establishment in early 2002. In total, nearly 950,000 samples have been tested to date with zero system false positives. The Program currently tests ~100 samples per day for multiple biological threat agents with proven surge capacity to >400 per day over multiple weeks. Routine sample analysis result turn-around-times (TAT) range from 2-72 hours depending on the urgency of the result and level of sample interrogation required.

Analytical laboratory methods and protocols are based upon a model developed and approved by the US Government and utilize a "Tiered" analytical approach specific for each biological. The analysis involves nucleic acid detection, protein/toxin detection, and classic microbiology for screening, as well as a suite of confirmatory methods. All analysis is conducted according to established formal Standard Operating Procedures (SOPs) under internal and external quality assurance programs. The laboratory methods are accredited to the International Organization for Standardization (ISO) 17025 and have been used to analyze over 9,500 Quality Assurance and 1,500 Proficiency Test samples.

All staff working on this Program possess Department of Defense (DoD) secret clearances. Staff, schedules, equipment, and reagent/supply inventory are configured for surge support. Requisite staff possess the necessary CDC Select Agent/USDA permits, as well as DOT training required to receive, use, and ship restricted materials. The laboratory facility operates within an infrastructure with redundant power, analytical equipment, and means of communication, and includes a BSL-3 laboratory registered with the Centers for Disease Control and Prevention (CDC).

Associated with this Environmental Sample Analysis Program is a robust Research, Development, Testing, Evaluation, and Validation arm that has transitioned several analytical methods into operational use over the past decade, greatly improving the robustness of the Program's capability and the confidence in the results it produces.

MRIGlobal believes that this Program could help support the EPA's Environmental Response Laboratory Network (ERLN) mission.

Questions, Answers, and Comments

- Q: When you were discussing getting away from diffusion assays, to determine antibiotic susceptibility, you mentioned targeting the Cipro marker. As I know you are aware, the presence of a gene doesn't equal expression or bioactivity. So, how do you handle that?
- A: We handle that by running the gold standards in the background. If we have a tool, we put it in the toolbox and help that move forward, but the gold standards are running in the background. The use of the Next Gen Amplicon Sequencing to determine antibiotic susceptibility (for known Cipro resistance markers) is much faster than diffusion assays. It allows clients to, at the very least, lean forward in their response posture if there is a positive result (identified Cipro resistance marker) and take low regret actions in preparation for positive results with the gold standard methods.
- Q: PCR as a screening method, what kind of detection limits do you see? Is there a concern that PCR is typically less sensitive than some of the other methods?
- A: I can't really talk about the LOD. Method level LOD's (Sample Prep and PCR assay components) are as much about the sample prep methods as they are about the PCR assay. There are certain standards for PCR assay level LODs that you expect and that can be tested early in assay/method validation to down select the appropriate PCR assays. The sample prep component is a whole other variable that can have a significant impact on the method level LOD. We tried an automated magnetic bead-based method, but we couldn't get the method level sensitivities that we wanted and had with a manual silica column-based method for some organisms, so we simply transitioned the manual silica column-based method to a liquid handler. In theory, culture is more sensitive than PCR for some organisms, but in high background environments and/or for slow-growing organisms, PCR is often more sensitive and the preferred method.
- Q: On your sequencing, I saw that it looks like you are doing Basic Local Alignment Search Tool (BLAST); is that the only type of analysis that you're doing to look at your sequencing data?
- A: We developed a custom bioinformatics pipeline/Standard Operating procedure using the CLC Bio Genomics Workbench.
- Q: I have a logistical question: Every lab manager I've ever talked to says, "I have 24/7, 365 search capacity." Can you store all those samples for six months? Can you do this for two weeks? Do you have to maintain regular laboratory operations, and how do you exercise this? DHS just went through that for Ebola; we could do it for a few days or weeks, but long-term labs have needs and processes. I'm just wondering if you guys have considered that. When we do our public health emergencies, we understand that we'll get diagnostic PCR that we can run in hospitals and through the LRN and that will drop down to capacity, but a sustained environmental sampling process could be zillions of samples.
- A: It is 24/7, 365 day per year operation that supports daily sample analysis. There are some periods that there's less staff, but there are people there all the time. We try to help the clients condense their samples coming in at certain times of day to help with staff levels because there's a cost impact driven by the staffing level. At the peak, we were running 400 per day. Currently, we are running about 200 samples per day. While running 200 samples a day, we were able to support a surge event of up to 400 per day for just over two weeks. We are fortunate that many of the staff that support our method development and validation efforts for the 24/7, 365 day per year operational programs originally supported the daily sample analysis component of the24/7, 365 program. So, we can tap this staff to support surge events, as well as staff at our other facilities. So far it's worked very well, but we understand that some of the scenarios we're talking about such as NYC could be thousands of samples.

12. Concurrent Sessions 3
Water and Waste Water Treatment

Classroom C-113
Moderated by Hiba Ernst | *U.S. EPA*

Management and Treatment of Copious Amounts of CBR-Contaminated Water and Wastewater

12:45 pm

Matthew Magnuson (presenter) | *U.S. Environmental Protection Agency, National Homeland Security Research Center, Water Infrastructure Protection Division*

Abstract

Selected results for the EPA Homeland Security Research Program (HSRP) projects for treatment of water and wastewater for chemical, biological, and radiological (CBR) contaminants will be summarized. "Treatment" refers only to the contaminated water and wastewater. Decontamination of water infrastructure -- the physical components of water and wastewater systems, e.g. pipes, pumps, valves, etc. -- is discussed separately in the presentation "Drinking Water Distribution System Decontamination Research in EPA's Homeland Security Program." Please contact the presenter for more details on the individual projects described below. Some of these projects are also the subject of separate presentations at this Conference.

1. **Investigation of advanced oxidation processes (AOP) for treatment and disposal of contaminated water contaminated into public sewer (collection) systems.** Designed in consultation with the wastewater industry, this work studies to the ability of AOPs to break down chemical contaminants to make the resulting wastewater suitable for public sewer discharge, i.e. without interfering with "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. Also examines the ability of activated sludge to recover from short- and long- term exposure to OPs.
3. **Minimization of radiological aqueous waste from washing.** Describes approach and technology for the double edged challenge of removing radionuclides from surfaces via washing with water while simultaneously minimizing the volume of contaminated that cannot be recycled or disposed of.
4. **Prediction of hydrolysis rates of organophosphorus compounds.** Discusses efforts to overcome computational chemistry challenges in the ab initio prediction of hydrolysis rates of organophosphorous compounds, with the ultimate goal of developing a quantitative structure property relationship (QSPR) to assist in developing treatment strategies for contaminated water.
5. **Acceptance of bio-contaminated waste water by POTWs.** Assist wastewater plant operators in making decisions about whether and how to accept wastewater contaminated with pathogens into their collection and treatment systems.

Questions, Answers, and Comments

- Q: For organophosphates, did you look at enzymatic degradation?
- A: This study was all based on abiotic processes, so just acid, basic, and neutral hydrolysis processes. There is a lot of literature about enzymatic degradation, but not covered by this study.

Survivability and Disinfection of *Bacillus anthracis* Vegetative Cells in Drinking Water

1:10 pm

Lisa S. Smith (presenter) and Vipin Rastogi | *U.S. Army Edgewood Chemical Biological Center*
H.D. Alan Lindquist, Jeff Szabo, and Gene Rice | *U.S. Environmental Protection Agency*

Abstract

The US-EPA is the lead Federal Agency for protection of the drinking water infrastructure sector and conducts research on the detection and characterization of contaminants, response, and mitigation of these contaminants. All of these activities are dependent on how long an introduced agent survives in the water system under varied conditions. The persistence of anthrax causing *Bacillus anthracis* spores in water and in the environment is well documented. However, the persistence of vegetative cells of *B. anthracis* is not well characterized. This issue is particularly important because one of the wide-area decontamination options is augmented germination followed assumed rapid decay of vegetative cells.

In this study, laboratory-scale experiments were designed to assess the persistence of vegetative cells of *B. anthracis* (strain ΔSterne) in dechlorinated water as a function of temperature and nutrient co-contamination. Survivability was determined in dechlorinated tap water and water that contained diluted microbial growth media at two temperatures. The results show that vegetative cells, in general, survive much longer than two weeks, especially in the presence of organic material/nutrients, and that a small fraction of these vegetative cells spontaneously differentiate into spores. Both temperature and organic material/nutrients play a role in the viability of the *B. anthracis* vegetative cells.

With respect to disinfection, 2-mg free available chlorine (FAC) was effective in disinfection of vegetative cells in chlorine-demand free water at pH 7 and 8 and at 5 and 25 ºC. The cell death effected by FAC was more rapid at 25 C relative to that at 5 ºC. Disinfection of vegetative cells by 2-mg chloramine (CA) was carried out in phosphate buffer at pH 8 at both temperatures 5 and 25 ºC. CA disinfection was also more rapid at 25 ºC. In all disinfection studies, presence of spore population in the cell preparation largely contributed to the variability in cell death kinetics.

Questions, Answers, and Comments

- Q: How do you see this being transferred into a real water system where you have other surfaces?
- A: I would say it could be done pretty easily because they do use free available chlorine (FAC) in water systems. I would assume that as we found the pH does matter.
- C: With regard to the water systems, we did some work on decontamination processes before we looked at germination. Instead of just disinfecting spores that were stuck on water infrastructure that germinate and then are disinfected we disinfected the vegetative form which is much more sensitive. The issue that comes up is what if that stuff is floating down the water column for a while. Would it make it very far? Conventional wisdom assumes that it's a vegetative cell and it will be gone right away. What they're showing here especially with the monochloramine is that is not necessarily the case, which was somewhat of a surprise. This matches what we've seen with monochloramine and spores—it's not a good disinfectant.
- Q: Do you know the mechanism of action for disinfection?
- A: The FAC disrupts the membrane. It's the same for monochloramine, but it's slower.

Deployable Treatment of Decontamination Effluents

1:35 pm

Jonathon Brame (presenter), Victor Medina, and Jeffery Stevens | *USACE ERDC Environmental Laboratory*

Abstract

The Army maintains extensive decontamination capabilities (DECON) to mitigate chemical, biological, and radiological (CBR) attacks. However, the Army currently has no capability to treat and/or recycle the effluent from its aqueous based decontamination operations. This effluent is extremely hazardous and poses major handling, logistical, political, and liability burdens.

An effective on-site effluent treatment approach would allow for a more rapid return to operational readiness after an attack and provide better civilian support capabilities in homeland defense scenarios. Furthermore, issues with environmental exposure from downstream or groundwater impacts would also be removed. Currently, there is not any readily available treatment approach for this wastewater. This issue is an Army-wide problem, cutting across multiple Army organizations and centers and is likely also an issue for non-Army organizations tasked with decontamination.

DECON can also represent a logistical challenge, particularly for large attacks. The 2013 Unified Quest, Deep Futures war games, which were conducted by the Army Capabilities Integration Center-Future Warfare Division (ARCIC-FWD) with the purpose of developing concepts of future wars and military conflicts that may affect the Army, focused on military operations affected by large and dispersed chemical attacks (ARCIC-FWD 2013a, b). The findings indicated that water supply for DECON would be potentially problematic. Furthermore, logistics would be affected by the need to remove contaminated effluents. Therefore, this project will focus on developing treated effluent that is suitable for reuse in the DECON stream, and eventually suitable for onsite discharge with no restriction.

The project is taking a two-pronged approach to addressing this problem. We will utilize currently available membrane technologies with the goal of developing a modular treatment system that can move into field testing within 3 years. We will also simultaneously explore novel treatment systems and technologies, including graphene and graphene-oxide treatment, reactive membranes, hypochlorite generation and other advanced oxidation and targeted contaminant removal treatments. This presentation will present the rationale of our program, outline our overall plan, and give results that we have obtained to date.

Questions, Answers, and Comments

- Q: Are you going to move into investigating non-traditional threat agents?
- A: Yes, we decided to start with only chemical agents, but we have considered looking at some non-traditional threat agents and perhaps using carbon nanotubes
- Q: Have you considered looking at non-liquid options (i.e., dry decon)?
- A: No, we haven't looked at that as it is outside our mission at the Environmental Laboratory of the U.S. Army Corps of Engineers Engineers (USACE) Research and Development Center (ERDC). We do have significant expertise in water treatment technologies, so that has been the focus.
- C: You mentioned working with EPA to come up with safe effluent concentrations, but for some of the things you are dealing with those concentrations might not exist. I would think the war fighters would be nervous not knowing if the water they are being sprayed with is absent any contaminants.
- C: That was a big sticking point in our original funding. No matter how well we think we're treating it, we won't ever reuse water that is sprayed on a human. Liability-wise this is an issue.
- Q: Are the graphene oxide filters commercially available?
- A: Some places will sell graphene oxide films, but they are not able to sell them as filtration devices. There is one commercially available called Purforene that is supposedly a graphene oxide film filtration unit, but it's not available yet. It's been promised for a while.

- Q: What's the relative advantage of using graphene oxides that stack up on top of each other compared to graphite? Is there a difference in permeability or spacing of the layers?
- A: There are some differences with hydrophobicity. Also, depending on the oxidation level of the graphene that can change the layer thickness and how much space is available for water to make its way through.
- C: One thing that might help on water levels are some new methods that are in development that may reduce water consumption by a factor of four.
- C: It's an army-wide focus to save water at every level of operation.
- Q: It seems like you're making an assumption that contamination will be really high all the time. Have you thought about ambient types of decontamination agents that you can let sit out such as chlorine oxide?
- A: Depending on the hazard, that may be the only option—to let it sit out regardless of what it is. For some things that may be sufficient, but for others you may need more advanced treatment.
- Q: What is the operating pressure for graphene?
- A: We haven't explored it yet, but in our initial test we ran at pressures similar to reverse osmosis, which is very high, and that was more pressure than necessary. However, we need more than just the head pressure from the waters.
  C: We need to look at the thermodynamics of whatever material is being used.

Advanced Oxidative Process Treatment of Heavily Contaminated Water for Drain Disposal and POTW Acceptance

2:00 pm

Rebecca Phillips (presenter) | *Oak Ridge Institute for Science and Education Research Participation Program*
Ryan James and Mark Benotti | *Battelle*
Matthew Magnuson | *U.S. Environmental Protection Agency, Homeland Security Research Program*

Abstract

In light of continuing concern regarding water contamination from intentional and unintentional incidents – such as criminal/terrorist acts, industrial spills, or natural disasters – three advanced oxidation processes (AOPs) are investigated for the treatment of contaminated water prior to release into the environment or disposal to a wastewater treatment plant: O_3/H_2O_2, UV/H_2O_2 and electrochemical using a boron-doped diamond electrode (BDDE). AOP technologies generate hydroxyl radicals (OH•), oxidants with a higher oxidizing potential than either chlorine or ozone. The BDDE system also generates a mixture of other oxidants as well, depending on the influent characteristics and the electrolyte utilized.

The three AOPs are compared based on their abilities to degrade a variety of contaminants with known OH• reaction rates. The contaminants include herbicides, pesticides, flame retardants and other potential contaminants of interest. The selected contaminant concentrations (parts-per-million) simulate those found in water contamination events and wastewater applications. Results illustrate that contaminants at these concentrations may behave differently than microcontaminant concentrations reported in much of the drinking water AOP literature.

In addition to comparing contaminant reduction achieved by each technology, the AOPs are compared based on the difference in pre- and post-treatment microbial toxicity, a parameter not often reported for many contaminant classes. Two toxicity assays are utilized to determine microbial toxicity: Nitrification Inhibition, which uses activated wastewater sludge to indicate potential toxicity to wastewater treatment processes; and Microtox toxicity sensing, which uses luminescent bacteria to indicate potential eco-toxicity to receiving waters.

Although the active oxidant in each AOP is expected to be mainly hydroxyl radicals, results for several contaminants demonstrate that the three AOP treatments may yield different toxicity results, in addition to

different reaction rates. Taking propanil as the example, the O_3/H_2O_2 AOP exhibited the fastest parent compound degradation of all three AOPs, but also yielded an increase in toxicity during the treatment time. The UV/ H_2O_2 AOP exhibited slower parent compound degradation but showed a reduction in toxicity for the propanil, while the BDDE AOP performance and resulting toxicity were very dependent on the electrolyte utilized during treatment. Contaminant degradation rates followed the general trend: O_3/H_2O_2 rate > UV/ H_2O_2 rate > BDDE rate for most contaminants and technologies. The toxicity results associated with the technologies, however, did not always follow this trend.

Both toxicity and contaminant reduction resulting from AOP treatment will be presented for the contaminants studied. This will facilitate the comparison of conventional AOPs, like UV/H_2O_2 and O_3/H_2O_2, with the emerging BDDE AOP. The toxicity assays will provide operationally relevant information that is not evident from the amount of contaminant destruction alone. These results may impact utilities' operations when selecting AOPs for contaminant treatment within their systems.

Questions, Answers, and Comments

- Q: Did you look into modifying pH levels?
- A: We did think about pH and wanted to look into it, but ended up investigating the electrolytes (for the boron doped diamond electrode (BDDE) system) instead. At this time we realized that the chloride electrolyte produced way too much chlorine to be useful. The pH was a consideration we weren't able to explore. Based on our observations, the electrolytes themselves may have participated in reactions, so pH adjustment and/or adding a buffer may have altered the system. The pH adjustment without buffer may not have been adequate either, as the pH changed during treatment for the BDDE reactor.
- Q: I noticed you used clean water. For the ultraviolet (UV) to work, you can't have a significant turbidity level, but in some of these wash downs you might have high turbidity which might inhibit the UV. Did you consider this?
- A: That's part of why we are looking into the high total organic carbon (TOC) water, hoping that will help. We did start looking into wash water matrices and gray water matrices, but were unable to find a good recipe.
- C: You hear people talking about separating what the UV is really doing compared to the peroxide by itself. Also compared to the combination and how it works with your particular matrix.
- A: We did test all of the chemicals with just the UV light and just the peroxide to make sure it wasn't just one or the other that was doing all the work.
- Q: Did you analyze all the degradation products? From our experience, malaoxon is much more toxic than malathion, for example.
- A: We did do some analysis for aldicarb and propanol. For the most part, by-products were outside the scope of the work. For propanol, we also sent out TOC samples.
- C: TOC would not change a lot.
- C: Some preliminary results did show some TOC degradation.
- Q: Did you analyze other advanced oxidation processes (AOP) methods with perfluorooctanoic acid (PFOA)?
- A: We did, but this is still in progress and the results are not shown here yet.
- Q: What is the relative cost per volume treated from each of these systems?
- A: We have not costed them yet. For UV on a cost basis, we have a partner project using UV light emitting diode (LED). There is a poster on this but I don't believe it has costing information yet either.

13. Concurrent Sessions 4
Biological Agent Decontamination Equipment

Auditorium C-111

Moderated by Matthew Magnuson and Lawrence Kaelin | *U.S. EPA*

Portable Decontamination System for FAD and CBR Response

4:00 pm

Bob Henderson (presenter) | *Integrated Solutions for Systems Inc.*

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 Vehicle Wash Tunnel system provides a reliable, easily deployable, autonomous vehicle wash system that can rapidly disinfect small and large vehicles as well as farm and other specialty equipment. At full capacity, a single tunnel can process over 100 standard size vehicles 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 (40 ft.) and long (80 ft.) lengths. Both are available in single and dual lane versions. All portable variants include an inflatable shelter and are transportable in a small trailer and can be deployed by two to four people in approximately 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

- Q: Since you've got a bladder for 3,000, how much did it take to clean and disinfect one tractor trailer?
- A: Roughly 130 gallons per vehicle with multiple passes, but all that's programmable. Keep in mind we're recycling those fluids, so we're filtering them out. Some of the fluids are lost when the truck drives out, of course, but we reclaim most of it and add more water.
- Q: Is the system computerized so you can change all the nozzles to soak for one pass or another function for another pass?
- A: That's right; based on the type of response you're trying to get, you can make trades between efficiency and speed. The best case scenario would be running three trucks a day with plenty of time; I would make five or six passes. The worst case scenario would be trying to get people out of the city and sprayed off; you may just do one pass. So, we can dial all of that into the software.
- Q: Can you comment more on how you decontaminate in cold weather? How to prevent the decontaminant from freezing? When you're trying to rinse, how do you prevent ice from building up on the vehicle?
- A: We do three things, and it depends on the temperature. If temperature is just under freezing, we are recirculating water, and putting propylene glycol in there. If it's really cold, then we'll put more

propylene glycol in the water (about 20%-25%). We'll recirculate the water, and also have large heaters that heat the shelter and keep water from freezing. The most extreme version is an optional kit that circulates fluids through water heaters and heats the shelter.

Equipment Decontamination with Disinfectants and Mobile Pressure Washer with Water Containment Mat

4:25 pm

Craig Ramsey (presenter) | *USDA-APHIS*
Steven Newman, Debra Newman, and Paul Freebury | *Colorado State University*

Abstract

This project was a cooperative agreement between USDA-Animal and Plant Health Inspection Service (USDA-APHIS) and Colorado State University. The goal of this project was to field test a mobile equipment decontamination system that includes a water containment and recycling system followed by a disinfectant application to the equipment. The decontamination study was conducted in May 2014 at the Colorado State University research farm in Fort Collins, CO. The overall objective of the study was to determine the effects of pressure washing followed by a disinfectant spray on sporicidal efficacy of *Bacillus subtilis* spores. The specific study objectives were to: 1) determine the effect of power washing the coupons at 0, 5, and 10 seconds on sporicidal efficacy after application to inoculated steel washers; 2) determine the efficacy of six ElectroBiocide additives on sporicidal efficacy; 3) determine the effects of time of exposure on sporicidal efficacy, after ElectroBiocide formulations have been applied to the sample coupons for 5, 10, and 15 minutes; 4) determine the effects of an "organic challenge" on sporicidal efficacy using white grease painted on the selected washers; and 5) determine the effects of Virkon-S and Accel on sporicidal efficacy on washer samples.

The study results show that sporicidal efficacy increased as the pressure washing time and disinfectant contact time increased for the six ElectroBiocide treatments. All four study factors had significant two way interactions with the other factors, which precluded making generalized conclusions. Axle grease results suggest that the grease acts like a solvent for the spore coats, which would dislodge them or detach them from the waster surface so that they could be more readily removed with pressure washing. The interaction model predicted that ElectroBiocide + glycerol at 1% had the highest sporicidal efficacy with a log10 reduction of 5.4, with 10 second pressure wash, 15 second disinfectant contact time, and the grease application. This same treatment had a predicted viable spore count of 43.1 Colony Forming Units (CFU)/2" steel washer. In contrast, the average log10 reduction estimate shows that ElectroBiocide + Reign at 10% had the highest efficacy with a log10 reduction of 4.7. Visual observation of the standard errors for the sporicidal efficacy means showed that pressure washing and axel grease strongly reduced the variance in efficacy results. In other words, pressure washing and axel grease provided more consistent or uniform efficacy results. Future field tests will include additives mixed at higher concentrations, longer pressure washing times, and spore samples inoculated on wool fabric.

Questions, Answers, and Comments

- Q: Given the range of biopathogens that can and cannot be safely pressure washed, I'm wondering in terms of the guidance here for the anthrax; the worker didn't have a mask or any protections, and some of the suggested recommendations were to have an even closer impact. So, I'm wondering how you will approach that dynamic as you go about your research portfolio.
- A: I don't know; that's a good question. We were trying to really take this into the real world. What I was really worried about was the aerosols leaving the mat, so we were trying to work up a tent with collapsible curtains like the wash tunnel. I never thought about PPE for the actual sprayers; you would probably have to wear a mask.
- C: I raise it only because I asked CDC in the context of Ebola and decontaminating planes or boats, and if we had to decontaminate a boat what would we do, and they said, "Whatever you do, don't hit it with a pressure washer." The next thing I knew in Texas they're going around hitting some of the apartment

complexes with a pressure washers. So, I think it's a new area of science that we don't have a lot of data on.

- A: At 2,000 pounds per square inch (psi), there is a lot of aerosol; you get wet just standing five or six feet away from it.
- C: We published work on pressure washers here at EPA and we did do aerosol samplings, and we did show that spores can be liberated from surfaces using pressure washers and even backpack sprayers.
- C: What was the conclusion in terms of risk to the personnel?
- C: There would be significant risk to personnel, but we assumed they would have PPE.

Post-Conference note from presenter:

The Q&A questions and answers were addressing two different decontamination scenarios. The presentation was focused on equipment decontamination for agricultural pathogens and pests with no human health risks. The questions that were raised concerned high risk human pathogens (*B. anthracis* or Ebola). The two scenarios are very different and would require different decontamination methods. Everyone would agree that decontamination of high risk pathogens would require the use of high level PPE and containment of the pathogens. The high powered pressure washing that was discussed may not be a good approach for cleaning inside facilities or transport vehicles. The choice of decontamination methods, including pressure washing, will depend very much on where and what is being cleaned (e.g., outside cleaning of field equipment, or inside facilities on walls and surfaces) and whether the pathogen is a high risk human pathogen or a low risk agricultural pathogen.

Spray Equipment Selection for Wide Area Application of Decontaminants

4:50 pm

Richard C. Derksen (presenter) | *U.S. Department of Agriculture, ARS Application Technology Research Unit*
Erdal Ozkan and Mike Sword | *The Ohio State University*
Martin Page | *U.S. Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory*

Abstract

Deliberate or accidental dispersion of biological hazards into the built or natural environment could pose a significant health threat that requires fast, flexible, and adaptable responses. Some biohazards are known to be particularly persistent and resist decontamination. Development of an environmentally-friendly, non-corrosive, and potent decontamination system requires consideration of a means to transport the decontaminant that will maximize effectiveness. Mission parameters dictate the choice of application equipment to mitigate the effects of a biohazard dispersed over a wide area. However, equipment selection is also determined by the timing of the application, active ingredient concentration in the formulation applied, amount required to be deposited on the target, distribution of material on the target, as well as environmental conditions such as temperature, relative humidity, and wind direction and velocity. In the application process, decontaminants have to pass through the pumping system, pipes, valves, connectors, and nozzles which can impact the efficacy of products because of the stresses and heat generated during the transport process. The type, size, orientation, and number of nozzles used to deliver spray material affect the uniformity of product distribution which can ultimately affect how effectively the toxin or contaminant will respond to treatment. The design of the delivery system will also affect the effective treatment capacity which impacts how quickly an area can be treated and how many times vehicles cross areas needing treatment.

Currently, there are no published guidelines available on how to utilize agricultural equipment to decontaminate facilities, or any other public or private structures, roads, right-of-ways, or grounds with biological control measures. The objective of this project was to identify equipment for a large-scale response that can be integrated onto standard platforms of choice. Given the high-volume applications required, nozzle evaluation required modification of existing testing standards for treating ground terrain. A 15-ft spray bar, fitted with impact nozzles,

created flexibility to treat horizontal swaths up to 75-ft with acceptable variations in deposit in the swath. A single-nozzle system normally used for treating wide swaths of terrain without a spray bar was selected to provide treatment on vertical surfaces up to 20 ft. A commercial spray patternator was modified for vertical spray pattern assessments to cope with high-volume applications. The equipment recommendations are simple and robust, have scalable capability, and are able to decontaminate an outdoor area, encompassing a variety of contaminated vertical and horizontal surfaces.

Questions, Answers, and Comments

- Q: I was under the impression that some of the tractors were driverless. Was this intended to be a driverless system to avoid some of those issues with PPE like we talked about?
  A: Autonomous vehicles were not part of the requirements; they are still experimental.

14. Concurrent Sessions 4
Waste Treatment and Disposal

Classroom C-113
Moderated by Jeff Szabo | *U.S. EPA*

Field Demonstration of the "Aboveground Burial Enhanced with Phytoremediation" (ABEP) System as a Tool for Managing Animal Carcasses Following an Agroterrorism Attack or Disease Outbreak

4:00 pm

Gary A. Flory and Robert W. Peer | *Virginia Department of Environmental Quality*
Robert A. Clark | *Virginia Cooperative Extension*

Abstract

The food supply represents a high-risk vulnerability for every nation. The food and agricultural sector of the US economy, for example, contributes as much as $1 trillion to the Gross Domestic Product and accounts for an estimated 15 percent of the total workforce. The economic impact of an act of agroterrorism or a naturally occurring outbreak of foot & mouth disease (FMD) in the United States has been estimated at $20.8 billion. The response to the 2001 outbreak of FMD in the United Kingdom and the 2010 outbreak in South Korea cost an estimated $12.7 billion and $2.7 billion respectively.

Environmental impacts from carcass disposal were a significant concern in both the United Kingdom and South Korea. A study published in 2001 by the United Kingdom Department of Health looked at the specific hazards present during FMD carcass disposal efforts and the associated pathways. Potential hazards associated with burial include: *campylobacte*r, *E. coli*, *Listeria*, *Salmonella* B, *anthracis*, *Cryptosporidium*, *Giardia*, *Clostridium tetani*, *C. botulinum*, *Leptospira*, *Mycobacterium*, TB v. *bovis*, *Yersinia*, prions for BSE, Scrapie, disinfectants, detergents, and hydrogen sulfide. Hazards of open burning include particulates, SO_2, NO_2, nitrous particles, fuel-specific chemicals, metal salts, PAHs, dioxins, prions for BSE, and Scrapie.

Despite a history of costly, ineffective, and environmental damaging carcass disposal efforts, large animal carcass disposal methods have advanced little in the last decade. Although vaccination will likely play a more prominent role in future disease management efforts, an outbreak occurring in 2015 will likely be managed with the same carcass disposal techniques used in previous decades and will likely result in the same economic, health and environmental impacts. Now, more than ever, first responders need new options for disposing of carcasses.

The purpose of the Aboveground Burial Enhanced with Phytoremediation (ABEP) project is to optimize, evaluate, and operationalize the ABEP system as an alternative to existing large animal carcass disposal methods. The system design includes a shallow trench excavated into native soil to a depth of approximately 28 inches and lined with 10 mil polyethylene. About 12 inches of soil is returned to the lined trench and animal carcasses are placed

in a single layer within the trench. Excavated soils are subsequently placed back in the trench forming a mound on which the phytoremediation layer is established. Finally, the perimeter of the mound is trenched to prevent the intrusion of surface water into the system.

The presentation will highlight preliminary results from the field demonstration project conducted in the Shenandoah Valley of Virginia and will evaluate the following potential benefits over existing mortality disposal methodologies:

- Simple, low-technology, design allows implementation with minimal training;
- Low execution cost;
- Relatively rapid to install;
- Shallow trench depth and plant uptake of decomposition fluids minimize environmental impacts and allow implementation in more diverse geologic settings;
- Reduces the potential for disease spread by keeping carcasses on the infected farm and minimizes the need for external inputs;
- Plant species can be varied to suit regional and seasonal condition;
- Flexibility to implement as a temporary or permanent solution;
- Carcasses could be excavated for permanent disposal (incineration, landfilling, composting) after initial disease eradication efforts;
- ABEP mounds could be regraded and revegetated after complete carcass decomposition;
- Can be implemented to manage natural disaster as well as Foreign Animal Diseases; and
- Flexibility for global application.

Questions, Answers, and Comments

- This speaker was unable to attend the meeting.

Capture of Cesium from Combustion of Contaminated Biomass Using Sorbent Injection

4:25 pm

Paul Lemieux (presenter) and Sang Don Lee | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
William Linak | *Environmental Protection Agency, National Risk Management Research Laboratory*
Chris Winterrowd | *ARCADIS*

Abstract

In the aftermath of a radiological contamination incident in an urban setting, there is the potential for the generation of significant quantities of contaminated biomass waste. These wastes are likely candidates for incineration as a means of volume reduction. Cesium-137 (137Cs), in the form of cesium chloride (CsCl) is a common radionuclide that might possibly be used in a radiological dispersal device, and has been shown to be the predominant long-term contaminant in the urban and residential contaminated areas in Japan following the 2011 Fukushima nuclear power plant accident.

Cs presents challenges in combustion systems due to its volatility and high solubility in water. Although high-temperature combustion systems cannot destroy metal constituents, these environments may induce metal transformations. Volatile metal species, including Cs, vaporize readily within combustion environments. This saturated vapor may subsequently nucleate and condense downstream of the combustion zone, forming a fume of ultrafine particles. These condensed particles, because of their submicron size, are difficult to collect in air pollution control systems. Emissions of particulate-bound radioactive isotopes, such as 137Cs, from combustion systems are highly undesirable, and the presence of chlorine often exacerbates the metal volatility. Moreover, as the incineration residues are disposed of in landfills, chlorinated and sulfated metals may exhibit increased water solubility and subsequent leachability in landfill environments.

This presentation reports on a study to examine biomass-bound Cs behavior and transformations. The goal of the study was to determine if combustion modifications, including addition of aluminosilicate sorbents into the post-flame regions of practical incinerators and combustors, could be used to reactively convert biomass-bound Cs into easily collected non-leachable forms. Initial results from combustion of Cs-doped corncob flour with injection of kaolinite powder showed approximately 65 % capture of Cs in the supermicron particle size fraction associated with the aluminosilicate sorbent.

Questions, Answers, and Comments

- Q: Are they doing waste incineration of radioactive material from Fukushima in Japan?
- A: Yes, they are looking at incineration and likely doing it; they have limited landfill capacity, so they already incinerate most waste. This research might help them reduce the risk of getting radioisotopes into the air.
- C: Japan is studying the corrective effect discussed here.
- Q: You used non-radioactive cesium chloride—is that the most common form?
- A: It is one of the major projected sources to be used in a dirty bomb because the commercial food irradiators already use this form; it's easy to obtain and already in usable form. Cesium from nuclear power plants is varied in its salt composition and might not be cesium chloride.
- Q: Will the chloride compete with sites for cesium to sorb to?
- A: The presence of chlorine might lower the capture from 85% to 65%, but it's hard to say. The amount of cesium chloride is relatively small. Chlorine is already in the biomass especially for the corn. We chose between something that was easy to feed and something that might potentially confound the data—we went with something that was easier to feed.
- Q: How strongly does cesium bind to the biomass matrix?
- A: We don't know the answer to this question. We were looking at what would happen if biomass got hit from aerosol or deposition. In Japan, plants may have pulled cesium from soil into tissues. We didn't look at cesium chloride in the plant matrix; rather plants were soaked and dried. We didn't have a way to incorporate cesium into the plant matrix.

15. General Session 3
Biological Agent Reaerosolization

Auditorium C-111
Moderated by Lukas Oudejans | *U.S. EPA*

Understanding Reaerosolization and Exposure: What happened to "SPORE"?

8:00 am

Marshall Gray (presenter) | *U.S. Environmental Protection Agency*
Donald Bansleben | *U.S. Department of Homeland Security, Science and Technology Directorate*
John Koerner and Angela Weber | *Department of Health and Human Services*
Sari Paikoff | *Department of Defense*

Abstract

In 2011 the interagency Scientific Program on Reaerosolization and Exposure ("SPORE") was formed between the Department of Homeland Security, Science and Technology Directorate; the Department of Defense, Defense Threat Reduction Agency; Department of Health and Human Services, Assistant Secretary for Preparedness and Response; and the EPA, National Homeland Security Research Center. EPA was designated as the interagency lead to develop and implement a program to inform response and recovery decisions related to reaerosolization of *Bacillus anthracis* (Ba) spores.

Initial program action included resolving the fundamental question of whether reaerosolization in an outdoor urban environment was a possible human exposure issue. If so, are there appropriate test surrogates for Ba? What forces are needed to initiate reaerosolization and do those forces differ among various surfaces? Is there variability among different spore preparations? If reaerosolization occurs, how long will it persist? Can we predict the fate and transport of spores in the outdoor environment? How does this information influence response and recovery actions, including medical countermeasures and more?

The purpose of the session will be to present the work completed to-date, current program plans, and proposed future efforts.

Questions, Answers, and Comments

- C: On the issue of fomite transport: we are funding some work (it hasn't started yet) looking at clothing on people as transport mechanisms for spores. We are looking at transportation scenarios for example, in subways or on trains, trying to identify the risk of having spores shed from people's clothing.
- A: Surface area of hair is another consideration.

16. Concurrent Sessions 5
Biological Agent Aerosols and Morphology of Spores

Auditorium C-111
Moderated by Joseph Wood and Michael Boykin | *U.S. EPA*

Comparison of Reaerosolization of Anthrax and Surrogates from Common Outdoor Surfaces

8:30 am

Alfred Eisner (presenter), Laurie Brixey, and Ryan Stokes | *ALION Life and Environmental Sciences*
Russell Wiener and Marshall Gray | *U.S. Environmental Protection Agency*

Abstract

Bacillus anthracis (Ba) and many other biological agents can potentially reaerosolize after a release, but there is a lack of quantitative information that can be used to predict the reaerosolization risk to the public. The US Department of Defense (DOD), Department of Homeland Security (DHS), Department of Health and Human Services (DHHS), and Environmental Protection Agency (EPA) partnered through the Scientific Program on Reaerosolization and Exposure (SPORE) to compare reaerosolization of Ba to reaerosolization of other biological agents commonly used as surrogates. The main goals of this research were to quantify Ba spore reaerosolization from selected outdoor surfaces and to determine the suitability of *B. thuringiensis var. kurstaki* (Btk) and B. globigii (Bg) as surrogates for Ba in reaerosolization research.

The test variables selected were spore type (Btk, Bg, and Ba [Ames strain]), spore deposition method (wet and dry), jet velocity, surface material (asphalt, concrete, and glass), and roughness level within each surface type. The authors designed and constructed chambers for wet and dry deposition of spores onto surface materials and two identical small wind tunnels for conducting controlled reaerosolization experiments. Computational fluid dynamics (CFD) modeling was used in the design process of the deposition chambers to achieve good uniformity of the surface coating of spores. The design of the wind tunnels was also aided by CFD modeling of particle transport under the influence of a slotted jet traversing over the surface of a coupon. The wind tunnels were designed to minimize transmission losses of reaerosolized spores by incorporating a unique flow transition unit leading to four filters for spore collection.

Reaerosolization tests using surrogate spores (Btk and Bg) were conducted at the US EPA facility in Research Triangle Park, NC, USA. Replicas of the deposition chamber and small wind tunnel were constructed and sent to

the US DOD facility at Dugway Proving Ground (DPG), UT, USA, where tests using Btk and Ba-Ames spores were conducted in a Biosafety Level 3 laboratory according to the same procedures used at EPA. Reaerosolization data for both wet- and dry-deposited Btk were compared between the EPA and DPG laboratories. The data from the two laboratories showed no statistically significant differences between reaerosolization of Btk and Ba-Ames spores for either wet or dry deposition, validating the equivalence of experimental equipment and methods at EPA and DPG. Bg spore reaerosolization was 79% lower than the average for Btk and Ba-Ames. Wet-deposited spores reaerosolized significantly less than dry-deposited spores under the same experimental conditions. The results also showed more spore reaerosolization from concrete than from asphalt or glass under the same experimental conditions.

Questions, Answers, and Comments

- Q: What kind of spore prep did you use? Were each made the same way? Do you plan to use the spores prepared in a synthetic medium and compare the spores prepared in a natural medium?
- A: That's a very good question. I know that attention was paid to the propagation medium. In terms of prep, the spores were triple-washed before they were delivered to us. The prep may be important because the propagation medium, for example, contains ions, so when the wet drop containing spores lands on the surface, the presence of ions can create a "double layer," which can produce repulsive forces. So, this is important when it comes to potential detachment. This was rather lengthy work. As far as I know, the procedure for producing spores was always consistent. I think that *B. thuringiensis var. kurstaki (Btk)* prep was different from *Bacillus anthracis (Ba)* prep for spores; I can't really give you the details at this point. We have found that one of the reasons why *Bacillus globigii (Bg)* was the least adequate is because *Bg* particles tend to create clumps that are difficult to break. The chunks are three-dimensional, and there's no way one can generate a single layer of *Bg* spores on the surface.

Evaporation and Transport of Bodily Fluid Aerosol Droplets

8:55 am

Jonathan Thornburg, Quentin Malloy, Jerome Gilberry, James Hanley, and **Howard Walls (presenter)** | *RTI International*

Abstract

Background

Numerous researchers have determined the typical droplet aerosol generated by a coughing or sneezing person, such as an Ebola infected patient, has a size distribution spanning 1 to 500 um, with a mass median diameter of approximately 100 um. The apparently large size of the expelled droplets normally leads to the assumption that rapid gravitational settling to surfaces will occur. However, confined spaces with the proper environmental and ventilation conditions, such found in the Aeromedical Biological Containment System (ABCS), may cause aerosol droplets to transport farther than assumed. The expelled aerosol droplets evaporate and their airborne residence time increases substantially before eventually depositing on a surface. The droplets may even evaporate to a diameter that will remain airborne. An understanding of the aerosol droplet evaporation rate as a function of initial diameter, environmental conditions, and ventilation characteristics is important for designing the proper personal-protective equipment, collective protection, isolation systems, and surface decontamination CONOPS.

Methods

We used published aerosol equations to calculate droplet evaporation and transport. The equations accounted for impurities in the aerosol droplets, and aerosol dynamics in the Stokes and non-Stokes regimes. Expected values for temperature, RH, and air velocity within a ABCS in flight were used as data inputs. We modeled cough events at 1 m or 1.5 m above the floor to simulate someone lying on a litter or standing, respectively. Horizontal air velocities in the direction of airflow of 250 cm/s and 13 cm/s were selected. The temperature was 72°F, and the RH was 50%. We assumed an empty ABCS to simplify the modeling approach. When calculating droplet surface deposition and transport, RTI did not consider the presence of litters, equipment, or other personnel.

Results

Preliminary modeling results identified the drop sizes that will evaporate to minimum diameter before depositing on a surface. At 250 cm/s and 1 m height, the maximum drop size that will evaporate to a cluster of biological agent before traversing a horizontal distance of 3 m is 26 µm. Cough droplets between 26 to 155 µm will completely traverse 3 m before traveling 1 m vertically and depositing. Cough droplets larger than 155 µm will vertically travel 1 m and deposit on the floor before traversing 3 m. At 13 cm/s and 1.5 m height, all droplets smaller than 80 µm will evaporate before depositing onto the floor. The 80 µm droplet will traverse a horizontal distance of 1.4 m before depositing.

Conclusions

Our modeling showed coughed, sneezed, or expelled droplets may travel a significant distance before depositing onto a surface or remain an aerosol under the proper conditions. However, a caveat is that we modeled a simple scenario to understand the scope of the potential evaporation and deposition. Different release scenarios, air turbulence, environmental conditions, and ventilation characteristics will change the airborne residence time of the droplet and affect the time available for droplet evaporation or deposition onto horizontal surfaces. We recommend scenario specific droplet evaporation and transport modeling to develop the proper PPE and decontamination CONOPS.

Questions, Answers, and Comments

- C: Several years ago at EPA, we conducted work using…We found that body heat can create a natural convection effect. Considering that…The most limited assumption is the assumption of …air flow. The coughing or breathing.

Development and Evaluation of Methods to Extract Aerosol Deposited Bacteria from Indoor Surfaces to Determine Bacterial Environmental Decay

9:20 am

Ian M. Gut (presenter), Ryan A. Bartlett, John J. Yeager, Shanna Ratnesar-Shumate, Paul A. Dabisch, and David K. R. Karaolis | *National Biological Threat Characterization Center, National Biodefense Analysis and Countermeasures Center*

Abstract

Following identification that an indoor environment has been contaminated with a biological agent, the subsequent public health and decontamination decisions require knowledge of the environmental persistence of the agent. The goal of this study was to develop methods for depositing bacterial agents onto operationally relevant indoor surfaces via aerosol, qualify methods for the sampling and enumeration of agent on surfaces, and determine agent decay on surfaces as a function of humidity. A specialized aerosol deposition chamber was constructed and methods were established for reproducible and uniform aerosol deposition of bacterial onto coupons representing four indoor surfaces: glass, unpainted galvanized steel, laminate and industrial carpet. Moreover, the engineered aerosol deposition chamber facilitated the control of relative humidity (10 – 70% RH) following particle deposition to mimic the conditions of indoor environments. Following development of the aerosol deposition methods, liquid extraction and culture based enumeration methods were developed to quantitate the viable bacterial on coupons. These methods were optimized and subsequently qualified for intra- and inter-operator reproducibility, sensitivity, specificity and precision. The extraction and enumeration methods were shown to be highly sensitive, operator independent and reproducible for all surfaces. The qualified bacterial enumeration methods were used to verify the functionality of the test system for decay studies and evaluate *Y. pestis* persistence as a function of surface type at 21°C and 40% RH. The surface decay rate of *Y. pestis* was greater than 40 %/min with a D-value (time required for a 90% reduction in the bacterial population) of 2-7 min for all surfaces. Statistical analysis determined that observed decay rates were not influenced by surface type. The date suggest that at typical indoor temperature and humidity, a 6-Log reduction in surface titer would be achieved without active decontamination within one hour simply as the result of environmental decay. The developed methods and data will support future persistence studies on a broad range of biological agents to provide data

and generate agent decay models as function of relative humidity and surface type to inform response and decontamination decisions following contamination of an indoor environment with a biological agent.

Questions, Answers, and Comments

- Q: Very good piece of work. For *Y. pestis,* I wouldn't be that concerned, but for certain organisms, such as *B. pseudomallei,* the agent becomes viable but not culturable, and this would affect decay rate determination. The data may be a little bit off; only culturable bacteria are considered for certain agents. A: We did try to consider that; we also attempted to establish full cytometry conditions, looking at agents that have established potential, but the biggest problem with most of these coupons is that the amount of small particulate you get off the coupons prevents you from accurately determining anything in the cytometer, particularly carpet and laminate; glass is pretty clean. Counting beads will provide an accurate count, but once you put in a surface, the amount of particles coming off prevents accurate determinations. We did think about doing some microscopy studies, but at that point we were near the end of the process and chose not to go forward with that.
- C: These studies are very important for EPA. If you have no detection of viable spores, and you do this study, it is possible that you will end up collecting material from the coupons if you put the same coupons into media and directly culture the bacteria from the coupon.
- A: We tried doing that as well. Those are some of the lessons learned. Growing stuff on a carpet was a bit of a challenge, mostly because the carpet sheds so many fibers and particulate that when we go to do optical density (OD) measurements or visual measurements, it was just a cloud of mess. Secondly, galvanized steel has a large amount of magnesium associated with it, and that leaches off into the media. And when that leaches off into the media, it does two things: First, it causes the media to precipitate out. Secondly, it also creates a bacterial static situation.
- Q: Did you do your persistence test beyond the few minutes to assess whether your D-value was the same? You weren't able to get any recovery of the *pestis*?
- A: The last time point is not shown because when you calculate a decay rate, zeros don't compute the decay rates. When we did our establishment of the decay rate, we went to the last time point that had a detectable colony. We went all the way out to 30 min for these, and by 30 minutes under no conditions were we able to detect any colonies. I can't say what would happen if you have a liquid deposition. Based on older literature, under similar conditions there may be a different decay rate that comes into a risk and remediation situation depending on where you are. If you're right by the source such as someone sneezing, you're probably going to have to do some bleach decon, but if it's across the room, it may change how you can decon.

High-Resolution Spore Coat Architecture, Assembly, and Morphology of Bacillus Spores

9:45 am

Alexander Malkin (presenter) | *Lawrence Livermore National Laboratory*

Abstract

Elucidating the morphology, molecular architecture, and structural dynamics of bacterial systems is essential to understanding mechanisms of pathogenesis, immune response, physicochemical interactions, and environmental resistance. Furthermore, it provides the means for identifying spore formulation attributes and decontamination inputs. I will discuss the application of *in vitro* atomic force microscopy (AFM) for studies of high-resolution coat architecture, assembly and morphology of several *Bacillus* spore species. We have demonstrated that bacterial spore coat structures are phylogenetically (1-3) and growth medium (4,5) determined. We have revealed the high-resolution spore coat architecture, structure, and assembly of B. subtilis spores including previously unrecognized nanometer-scale spore coat structures, and further provided new insight into the function of specific coat proteins (3). We have proposed that strikingly different species-dependent coat structures of bacterial spore species are a consequence of sporulation media-dependent nucleation and crystallization mechanisms that regulate the assembly of the outer spore coat (2). We have discovered and validated, distinctive formulation-specific high-

resolution structural spore coat and dimensional attributes of *B. anthracis* spores (Sterne strain) grown in different formulation condition (5). We further demonstrated that measurement of the dimensional characteristics of *B. anthracis* spores provides formulation classification and sample matching with high sensitivity and specificity (5). I will present data on the development of an AFM-based immunolabeling technique for the proteomic mapping of the *B. anthracis* spore surfaces (6) and on the direct in vitro visualization of the high-resolution structural dynamics of single *Bacillus* spores germinating under native conditions (7). These studies demonstrate that AFM can probe microbial surface architecture, environmental dynamics, and the bacterial life cycle at near-molecular resolution under physiological conditions. Finally, I will discuss how AFM could provide essential structural and physicochemical formulation- and environmental-dependent data on properties of *B. anthracis* spores in relation to risk assessment (i.e. reaerosolization potential, transport properties, etc.), decontamination, and clearance. This work was performed under the auspices of the U.S. DOE by LLNL under contract number DE-AC52-07NA27344. LLNL-ABS-668096

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Questions, Answers, and Comments

- [no questions]

17. Concurrent Sessions 5
Chemical Agent Decontamination

Moderated by Matthew Magnuson | *U.S. EPA*

Site Remediation of a 282,000 cu ft. Penicillin Production Facility Using Chlorine Dioxide Gas

8:30 am

Mark Czarneski (presenter) | *ClorDiSys Solutions, Inc.*
Brett Cole | *BioSafety, Australia*

Abstract

The manufacture of Beta-lactam (penicillin) based pharmaceutical products poses several public health risks to people due to allergies to beta-lactams. This health risk to both workers at Beta-lactam production facilities and the public at large has led to Pharmaceutical industry requiring purpose built facilities for the manufacture of Beta-lactam products separate to their main production facilities or buildings.

A Pharmaceutical company had such a facility where, due to high production costs in Australia, production of Beta-Lactams was moved off-shore. The facility had laid dormant since 2009 and the company wished to re-purpose the building for warehousing and re-use equipment inside the facility for non-Beta-lactam production elsewhere in their plant. This poses several Biosafety concerns as penicillin is difficult to decontaminate due to its inherent high resistance to most disinfectants and sterilants. However, Chlorine dioxide gas has been shown to successfully inactivate major penicillin strains and Chlorine dioxide gas technology was employed to decontamination the 282,000 cu ft facility.

Using similar sampling techniques to those used in previous successful studies, chlorine dioxide gas was used to decontaminate the facility for two strains of Penicillin manufactured there. The two strains were Penicillin-V and Amoxicillin. Successful decontamination was achieved with concentration levels of Chlorine dioxide of 7200 ppm-

hrs (5mg/L for 10 hours) and the chemical indicator coupon analysis penicillin concentration was below 50ppb (EEC, 1990). The facility has been reused for a different application.

Questions, Answers, and Comments

- Q: You said there were 80 injections. How many generators did it take for that?
- A: There were 40 generators.
- Q: How big are they?
- A: They were shown in the slides on the hand trucks.
- Q: How did you bump the ventilation system?
- A: We "bumped" the blowers every 30 minutes for about 5 minutes because it was a recirculation system in the building. We had the building HVAC person there to help. It was used to move the gas through the building.
- Q: Did you only vent to atmosphere afterwards with no scrubbing?
- A: Yes we just vented to the atmosphere. Water treatment and pulp and paper use and emit large quantities of chlorine dioxide, much larger than our activities here. When we measure milligrams, they measure kilograms.
- Q: What were the specifics of the back room that made it difficult to reach the targeted concentration?
- A: That room had a lot of raw wood and concrete which act like a sink for the gas.
- Q: Weren't the floors in the production room also concrete?
- A: Yes, but they were coated.
- Q: You said you the decontamination was verified by coupons. Did the client or buyer require additional sampling?
- A: Yes I believe they did some swabbing, but found no issues. The decontamination was based on chemical indicators that they made.
- Q: Did you consider tenting instead of plastic and taping?
- A: No, we find it easier to seal with plastic and tape, although this building was trickier. Pharmaceutical facilities are usually easy to seal and food facilities are harder because of the volume and all the penetrations.
- Q: Did they have any drains? Wouldn't the gas go right down the drain?
- A: They might have had drains, I can't remember. But there are usually traps on the drains so the gas would only go so far.

Hydrogen Peroxide-Based "Self-Help" and Residue-Free Decontaminants for Chemical Warfare Agents

8:55 am

George W. Wagner (presenter) | *U.S. Army, Edgewood Chemical Biological Center*

Abstract

The versatility of hydrogen peroxide (H_2O_2) for formulating decontaminants for chemical warfare agents (CWA) is exemplified by its ability 1) to be combined with common household chemicals to fashion do-it-yourself, "self-help" decontaminants and 2) to be combined with ammonia (NH_3) and carbon dioxide (CO_2) to render residue-free decontaminants (H_2O_2 decomposes to water and oxygen in the environment). These decontaminants are efficacious for nerve agents such as VX and GD and for blister agent HD. For self-help applications, easy-to-mix decontaminants can be made from 3% topical H_2O_2, ammonia cleaners, baking soda, washing soda, and rubbing alcohol, providing safe, minimally-corrosive, and cost-effective decontamination capability that is readily accessible by the general public. The use of residue-free decontaminants, which can be formulated by professional remediation personnel using higher concentration 30 and 50 % H_2O_2, would benefit the decontamination of large tracts of urban infrastructure, including building interiors, owing to not only its low cost, but also by eliminating the additional burden of having to rinse and/or remove remnants of the decontaminant itself: The residue-free decontaminant would merely evaporate, yielding water, oxygen, NH_3, and CO_2. For the special case of CWA on concrete, H_2O_2 alone decontaminates VX, GD, and HD in a process thought to involve H_2O_2-activation by surface-

bound carbonates/bicarbonates. For surfaces other than concrete, H_2O_2-activation for CWA decontamination is provided by residue-free NH_3 and CO_2. Although H_2O_2/NH3/CO_2 ("HPAC") decontaminants are active for CWA decontamination in solution, testing on actual surfaces of interest is required to assess their true efficacy for surface decontamination.

Questions, Answers, and Comments

- Q: A question about the self-help. Are the results you showed from stirred reactor tests, and if they were, have you done tests where you have the agent on the surface which is a more realistic scenario?
- A: The self-help decon was done with low concentration hydrogen peroxide in a nuclear magnetic resonance (NMR) tube. We didn't do any surface studies. We just wanted to see how quick those reactions were.
- Q: So very likely, when you put it on the surface, where you have a far more static environment, those reaction rates will probably be slower.
- A: Yes, you have to look at your depth of surfaces of interest. We have found with other decontaminations that with the quick solution reactions it is always pretty quick on the surface.
- Q: Early in the conference, an EPA colleague said the most important person is the local health official and he's almost right, it is actually the public—it's the victim. What is the worst-case scenario of the public using your self-help scenario? It sounds great, something I could do, but what's the worst-case scenario in your mind?
- A: We haven't thought through that scenario. All I can say is that actually, the DHS website www.ready.gov recommends that the homeowner can use bleach but it's more corrosive. They note that personal items like eyeglasses, door handles, railings, door handles on car—those would be things that the homeowner would want to decontaminate themselves. If you were in a real chemical event, you would likely need a gas mask so there are a lot of things you need to consider.
- Q: You mentioned surface and that you didn't cover, but could you comment on how long between contamination and start of decontamination and the impact that adds?
- A: I guess if you have absorptive surfaces, the agent tends to penetrate—the longer you wait, the longer it takes to decontaminate because you have to penetrate into the surfaces to get the agent and react with it. The quicker you can initiate decontamination, the better.
- Q: In the NMR experiments, you dosed the coupons. Did you grind them up, dose them, and put them in the NMR tube?
- A: For the concrete, we took a small concrete slab and dosed it, we put the agent right on top of the surface, and then we put that in the NMR tube. It was a couple centimeters by 4 millimeters—very, very slender.
- Q: How long did that soak into the concrete before you put it in the NMR tube and applied the solution?
- A: We just put the agent on the concrete, put it in the NMR tube, and then waited about an hour. It looked like the agent had completely soaked in, so we got a very broad NMR line.
- Q: Did you take that coupon afterwards and evaluate it to see if all the agent really had reacted?
- A: If you look at the amount of products, because NMR is quantitative, you can get a mass balance.
- Q: Are you looking at other agents as well and would you expect the same reaction?
- A: When we developed the decontaminants we basically used VX, GD, and mustard. If you can do VX, GD, mustard, you can do the other agents such as lewisite, sarin, etc.
- Q: Since Defense Threat Reduction Agency (DTRA) funded it, their focus is on the warfighter and I'm guessing they didn't fund it as a process for the general public. Is this being used in military decontamination?
- A: No, this is purely exploratory and we were looking for a decontamination agent that would not leave any residue. This is sort of a curiosity-driven effort to do household decontamination, that is, how can we generate a decontaminant that leaves no residue?
- Q: What was the DTRA project that you were originally working on that this spun out of?
  A: Actually, the vaporous hydrogen peroxide (VHP) work to generate a gaseous decontaminant.

Integrated Decontamination Test and Evaluation System (IDTES) for Evaluation of Hazard Mitigation Technologies

9:20 am

George Wrenn (presenter), Erin Lamb, Bruce Campbell, Scott Mason, Gary Stickel, and Shawn Shumaker | *Battelle Hazardous Materials Research Center*

Abstract

The Integrated Decontamination Test and Evaluation System (IDTES) is a new test capability that is being used in military technology development and acquisition programs to fundamentally improve the realism of evaluating hazard mitigation equipment, decontamination products, and field processes. Previously, researchers faced an unresolvable dilemma. Decontaminants for highly toxic chemicals, including full-strength chemical warfare agents, were typically evaluated in bench scale tests using small material coupons. Full-size decontamination equipment for field processes could not be utilized or effectively simulated in these tests performed in a laboratory setting. Conversely, operational tests in actual field settings could not adequately simulate or effectively predict removal or neutralization of highly toxic contaminants. The IDTES provides a unique capability bridge between laboratory and field, enabling decontamination efficacy tests to be performed with full-strength chemical agents and the actual field equipment and process steps used in hazard mitigation operations.

The IDTES is an 8-foot long enclosed chamber located behind conventional fume hood faces in a room-size toxic chemical facility. Researchers are able to work with small equipment items and material panels up to the size of a tabletop microwave oven. Process equipment fixtures in the IDTES chamber are designed to interface directly with full-scale hazard mitigation systems, enabling the IDTES to provide an enclosed target range for applying decontaminants in sequences that replicate actual decontamination field operations. Field equipment may be operated outdoors adjacent to the laboratory if fuel-powered, or set up inside the laboratory. Spray nozzles from the equipment are mounted on a rotating fixture inside the IDTES test chamber. The fixture is operated using a digital stepping motor to ensure repeatable spray deposition patterns at target distances ranging 1-m to 2-m. The IDTES is also equipped with temperature and humidity controls that provide exposure conditions ranging 15-40°C and 5-85%RH.

Recently, the IDTES has been used to demonstrate the chemical decontamination efficacy of hazard mitigation processes employing multiple decontamination products delivered using a variety of treatment processes, full-scale sprayer systems, and hand-held applicators. Liquid decontaminant delivery systems used in these tests include fuel-powered apparatus (M-26), a portable compressed air foam delivery system (Merlin), and various commercial pumps. Applicator devices include fixed and variable pattern spray nozzles, mixing nozzles, and hand-held devices (wipes or pens). Liquid spray systems were configured to apply detergents, water, decontaminants, and contamination indicator sprays at operationally relevant distances, delivery pressures and deposition volumes. Tests have been performed using a variety of test articles, including small coupon fixtures, segmented panels, and panels partially contaminated with “neat” CWA to evaluate the contamination spreading across surfaces.

Research and development support for implementation of the IDTES was provided by the Joint Program Manager, Protection (JPM_P) and the Defense Threat Reduction Agency (DTRA) Joint Science and Technology Office (JSTO).

Questions, Answers, and Comments

- Q: When you say you are prewashing, are you prewashing with just straight water?
- A: Yes, now we are using only water. This goes back to one of the early EPA tests that suggested that soap actually interfered with decon activity on surfaces. We have been seeing the same thing. The presence of soap residue interfered with decon performance, and you are better off just using water.
- Q: Are you better off just not prewashing at all?

- A: Not necessarily. We're looking at clean surfaces, but in the real world you're going to have dust, dirt, and muck so you need some prewash to remove gross grime and dirt so you can get to the material surface.
- Q: Were you able to tease out the importance of scrubbing on decon? Does it improve efficiency? What type of pressure was used? How do you standardize?
- A: We have one set of tests that indicates that high pressure prewash was just as effective as scrubbing. Scrubbing may or may not help. When you are doing decontamination, and you apply a decontaminant multiple times, then you can or should scrub. If you don't reapply decontaminant after scrubbing, you might simply be spreading your contaminant around. If you reapply decontaminant after you scrub, you get improved efficacy, but it's not better than multiple applications of decon. We are going to be reevaluating this.
- Q: Does the kind of surface make a difference?
- A: Mainly, this applies to porous surfaces. We have noticed with vertical porous/rough surfaces, the decontaminant tends to remain on surface due to surface tension. With hard smooth surfaces, the decontaminant tends to run off, and you might see spotty performance of your decontaminant. You'll get very good decontamination on these surfaces as you would expect, but occasionally in a group of eight samples, you may see one that still has a higher residue. That's simply because the decontaminant spreads on the surface and then pools up and runs off, and there are areas where it didn't have sufficient residence time to finish neutralizing. That's why multiple decon applications are useful.
- Q: You mentioned high pressure washing—did you look just at panels on the sides as we heard yesterday? If you do high pressure on biological, you get a reaerosolization of the contaminant.
- A: We haven't done biological decontamination. With the chemical, we tend to get rid of the contamination because anything that comes off the surface just goes into the collection sites.
- Q: What about the panels to the left or to the right or the walls?
- A: No, we did not really get cross-contamination for chemical substances because you are still spraying these other panels, so you entrain the contamination and continue spraying the whole surface. You are getting chemical contamination in the runoff, but it doesn't have time to get into the materials before it gets sloughed off. We also have other witness panels that we keep in the system. Some go through the entire treatment process, and we do not get any cross contamination to those panels. We also have panels that we keep in the contamination weathering area. On elastomers (typically natural or synthetic rubber), we do see a little agent vapor transfer pickup from the weathering process. The elastomer witness panels that also get decontaminated experience a slight reduction in contamination level. So the decontamination process is working on those panels as well.
- Q: Back to the earlier question on the impact of prewashing—it was in the field manual that you would prewash with soap, water, and brushes and now it's done with the M-26, which I guess is a pressure washer.
- A: Yes, it's the same pressure washer that used to be called the M-17.
- Q: It was in the manual for a long time with brushes. Are you aware of any data that speak to efficacy of these prewashing steps?
- A: Yes, we do have data that do illustrate the whole process: prewash, decon application with or without brushes, and final rinse.
- Q: Is that from your current study.
- A: Yes, which is why I have only parts of it available at this time because some of the data we are still processing.
- Q: When you do your six-hour age period with the contaminant and you are doing vertical orientation, are the panels horizontal?
- A: Yes, we're doing a worst-case agent penetration in the material, so we use horizontal. When we do the decontamination, we're doing them vertical. So again, worst case scenario.
- Q: Are you looking at mass material usage all along your process, including amount of water used, waste generated, etc.?

A: Yes, and you'll see it on the slide that describes the actual field process. In the old field manual, their standard process used about 600 gallons per Humvee that would go through a line. This process—including prewash, decon, and rinse—uses about one quarter of the water used by the old method. So they are cutting the amount of liquid resource by a factor of four using high-pressure delivery systems and advanced decontaminations.

Surface Decontamination of Blister Agents Lewisite, Sulfur Mustard and Agent Yellow

9:45 am

Harry Stone (presenter), David See, Autumn Smiley, Anthony Ellingson, Jessica Schimmoeller, and Lukas Oudejans. |
Battelle Memorial Institute; U.S. Environmental Protection Agency, National Homeland Security Research Center

Abstract

Among its responsibilities related to homeland security, the US EPA has the goal of identifying methods and equipment that can be used for decontamination following a terrorist attack using chemical, radiological, or biological agents. Limited data exist on decontamination approaches that neutralize vesicant properties of Lewisite or chemical agent mixtures containing Lewisite. Research conducted under EPA's Homeland Security Research Program (HSRP) investigated several decontamination solutions on their ability to decontaminate building materials contaminated with Sulfur Mustard (HD), Lewisite (L), and Agent Yellow, a mixture of L and HD.

Bench-scale testing was used to determine the residual amount of these chemical warfare agents remaining on coupons of three building materials (wood, metal and glass) after application of various decontaminants (household bleach, full-strength and dilute; hydrogen peroxide 3% solution; and EasyDECON® DF200). Results of this study indicate that all four decontaminants reduced the amount of L recovered from coupons. Application of dilute bleach showed little or no difference compared to natural attenuation in the amount of HD recovered from coupons. Full-strength bleach was the most effective at reducing HD recoverable from coupons of the four decontaminants. Hydrogen peroxide 3% solution and DF200 did decrease the amount of HD recovered from coupons more than natural attenuation, but substantial HD remained on some materials. Toxic HD by-products were generated by hydrogen peroxide treatment. This presentation will provide details on test methodology, results for the decontamination products tested and the impact of material and reaction time on the effectiveness.

Questions, Answers, and Comments

- Q: What is your hypothesis for the wide variability in the control dissipation rate across the same substance for different panels?
- A: We see variability in wood in particular when you apply chemical decontamination products. For glass we are getting down to very low amounts, and you noticed that there were significant differences when you ran an analysis of variance (ANOVA), but these numbers are so low that these differences appear much greater than they actually are.
- Q: It seemed like it would be more proportional or more related to the material it's on, whether it's wood, glass, or whatever, as opposed to the same material— wood—having different relative efficacies based on what decon agent you are using. You would think it would be all wood or all glass depending on which agent you were using to clean up.
- A: That is true. With wood you get a combination of two factors including whatever goes on in wood with its porosity, and interactions, etc. The second is the decontaminant itself, including how well it gets in, and those kinds of issues. With glass, that's not the case. Here you may be seeing real differences in relative efficacy not associated with the material. However, you are so close to 100% decontamination, these little differences show up as being bigger numbers. For example, with bleach, where we have high levels of efficacy, we see very little difference between what we put on and got off and the test versus control. The other thing I should point out is that these tests were run in different laboratories, at

different times, with different coupon cuts and then we brought all information together, so there could be some interlaboratory variability here as well.

- A: You used a 1 microliter drop. If you have one drop, depending on where the drop falls, especially on wood—on a softer part or a harder part—you may have variability. So if you increase your dosage size by using more drops you might have more representative sampling of how the agent interacts with the material. I was also wondering when you added the Lewisite to the mustard, does the drop stay mixed or does the surface tension/contact with material change the result?
- A: Good question, I don't know, I haven't looked into that.
- C: We have found that the size of the surface area that's contaminated has a huge impact on the efficacy.
- Q: Is 30 minutes long enough contact time? Is that realistic, or a sufficient amount of time?
- A: Generally, we see that it soaks into wood, but occasionally we see that it has remained on the surface, so that is a good point.
- C: Here, we looked to see if there was a significant difference between 30 and 60 minutes and essentially there was not really much of a consistent difference. If observed, it was material-specific.
- Q: Were these all vertical or horizontal?
- A: They were horizontal. These are small, horizontal coupons.

18. General Session 4
Decision Support Tools and Guidance Documents

Auditorium C-111

Moderated by Paul Lemieux and Elise Jakabhazy | *U.S. EPA*

Estimating the Cost and Time for Recovery from WMD or FMD Events under Resource Constraints

10:30 am

Robert Knowlton (presenter), Mark Tucker, Scott Olson, and Kurt Hollowell | *Sandia National Laboratories*

Abstract

National Planning Scenarios were developed to scope the consequences of large-scale events that could have significant negative impacts on human life and/or economic consequences. There are 15 Scenarios ranging from terrorist activities (e.g., biological, chemical and radiological (CBR) releases, cyber attacks) to natural events (e.g., hurricanes, earthquakes, floods). The Prioritization Analysis Tool for All Hazards/Analyzer for Wide Area Restoration Effectiveness (PATH/AWARE) decision support tool was developed to address the consequences of several of these National Planning Scenarios in the areas of Weapons of Mass Destruction (WMD) CBR releases and Foot and Mouth Disease (FMD) outbreaks. For the CBR scenarios, the tool accommodates the following response and recovery processes: characterization sampling, waste handling and disposal, decontamination, and clearance sampling. Several surface decontamination and fumigation technologies can be specified. The tool has the ability to estimate the cost and time for response and recovery. It allows the user to specify available resources (e.g., number of sampling teams, laboratory throughput, decontamination units available, etc.), and to evaluate shortcomings in the resource allocations (e.g., long poles in the tent) that might be used to request additional resources. The CBR module also has the ability to prioritize important infrastructure for the recovery effort. For the FMD scenarios, the tool has several methods for selecting disposal options: a Decision Tree module with a checklist; a Decision Matrix; and a detailed model of the cost/time options for disposal. Options included in the FMD module include: vaccination, depopulation, off-site landfill burial, off-site incineration, rendering, composting, on-site incineration, on-site open burning, on-site burial, facility decontamination, and sampling. The tool estimates the resource needs for disposal options (e.g., area needed for on-site burial, wood needed for on-site incineration, carbon source needed for composting, etc.) in order to assess available capacity. The

PATH/AWARE tool operates in a web-based framework. This tool is unique, and provides an ability to develop explicit plans for many of the National Planning Scenarios.

Questions, Answers, and Comments

- Q: Did you include slaughter and processing facilities with the foot and mouth disease (FMD)?
- A: Yes
- Q: Is the FMD module flexible enough to do avian influenza?
- A: We would need a little tweaking with that, but we're close to it.
- Q: Is it available?
- A: We consider it government "off-the-shelf", but it is not housed on a server where you have access so we would have to work that through DHS.
- C: We need it!
- Q: This conference was all about decontamination and I have yet to see plans for decontamination that is field-ready for wide-area decontamination; so how do you estimate cleanup for wide-area when we don't have cleanup other than demolition, disposal and burying?
- A: In the case of biology or chemistry – where we aren't doing demolition – we are doing decontamination. We handle it by having a rate-based decontamination application. The user can designate a certain percentage of the outdoor area to decontaminate, then it's rate-based. The user puts that in; it's simplistic at this point, but the decontamination technology is for someone else to figure out.

Waste Estimation Support Tool for Developing Decontamination and Waste Management Strategies for Wide-Area Radiological Incidents

10:55 am

Timothy Boe (presenter) and Colin Hayes | *Eastern Research Group*
Paul Lemieux | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
Dan Schultheisz and Tom Peake | *U.S. Environmental Protection Agency, Office of Radiation and Indoor Air*

Abstract

It is important to include waste management considerations during planning and preparedness activities for radiological incidents because waste management can be a driver for time and cost; in addition, waste management and decontamination activities are inextricably linked. Identification of resource limitations and response bottlenecks will be a critical aspect of controlling the overall remediation cost and timeline. The U.S. Environmental Protection Agency's (EPA's) Waste Estimation Support Tool (WEST) is a novel application of the Federal Emergency Management Agency (FEMA) Hazus-MH software coupled with custom software applications and scripts for ESRI's ArcGIS software.

WEST enables users to estimate the characteristics, amount, and residual radioactivity of waste generated from remediation and cleanup activities after a radiological incident, including incidents caused by radiological dispersal devices and improvised nuclear devices, as well as nuclear power plant accidents. WEST was recently updated to include the following enhancements: 1) Improved infrastructure resolution (i.e., decontamination technologies can now be assigned to specific types of buildings); 2) improved reporting capability; 3) significantly reduced user interaction requirements for the GIS procedures; and 4) added the ability to export waste estimates back into ArcGIS or Google Earth so that waste distributions can be mapped. This presentation will describe the recently released update to WEST, including a demonstration of the software.

Questions, Answers, and Comments

- Q: Have you considered collaborating with local, state, or federal emergency operations centers?
- A: We have been making those connections and have had preliminary discussions. For example, we met with the North Carolina Department of Emergency Management last year on this topic, so we are starting to move in the right direction. Great question.
- C: [Paul Lemieux, EPA]: We have an upcoming training with local, state, and federal folks at the Conference of Radiation Control Program Directors (CRPCD) meeting on May 18th in St. Louis. We are expecting to learn quite a bit from this training.
- Q: Did you try to apply your model to Fukushima?
- A: We have started looking at that. One limitation with Hazus is that it is a domestic application in that we cannot look outside the United States; however, one of the capabilities I showed you earlier allows us to garner information remotely when census information is not available. We have done a few scenarios where we have generated waste estimates using remotely sensed information. These estimates are based on occupancy factors specific to each state. When considering countries like Japan (type of infrastructure and amount of square footage), it would be helpful to talk to them directly. We are hoping to start these conversations and make some progress on this capability in the near future.
- C: We worked with you previously to generate a waste estimate for our exercise. We wanted to thank you because this is a good example of a tool that can be used by the planning community. This is something we need as planners to determine amount of debris that might be present following such a scenario. Thank you; this is a great tool – it has helped us immensely.
- Q: Can we call you at 3 a.m. and get revised estimates based on what actually happened?
- C: I am sure if something happened, all hands would be on deck. The EPA emergency operation center would call us for technical support and we would be there. There are people on call at 3 a.m.
- Q: Regarding the plumes in your presentation, which are mathematically smooth and continuous, do you have ways to input actual survey data that are rougher and messier?
- A: A nice feature of this tool is that the waste estimate is partly a function of the plume itself, so we can change that at any time. It essentially serves as a separate input. Initially, we may have a bad guess of where the contaminant actually deposited. As the scenario progresses, by way of improved sampling information, more realistic plumes can be used. This allows the user to refine waste estimates, as the situation progresses.
- C: This is intended to be a first-order estimate. You can make improvements to a certain point. FEMA's Hazus has aggregated infrastructure data at the census-tract level. The accuracy of this estimate declines for dense urban areas. To resolve this issue, we can replace the Hazus infrastructure data with higher resolution data, to better refine waste estimates. This tool is really meant to give an idea of what your first guess is, and how changing your decontamination approach is going to affect your overall waste stream.

Developing Biological Operational Response and Recovery Guidance for Rapid Return to Service of Underground Transportation

11:20 am

Ellen Raber, Dianne Gates-Anderson, and Hank Khan | *Lawrence Livermore National Laboratory*
Robert Fischer (presenter) and Scott Davison | *Sandia National Laboratories*

Abstract

The Department of Homeland Security, in collaboration with EPA, has launched a multi-year effort to develop a comprehensive remediation program for rapid return to service for Underground Transportation Systems. The effort involves the development and testing of actionable strategies and countermeasures in a number of key response and recovery areas such as characterization, decontamination, and clearance. Unique to this project is the integration of these key areas into a rapid return to service strategy designed to quickly restore transit

operations. It is therefore extremely important that the results of the project including overall strategic decisions be translated into an actionable guidance format which is consistent with the existing interagency U.S. White House Office of Science and Technology Policy (OSTP) decision framework. This guidance must be available to the end user so that it can be utilized with little or no formal training in the event of a biological incident. This guidance needs to be flexible in application and meet the needs of the transit agencies, and the responding organizations as well as local stakeholders. A tool which utilizes Adobe AIR® runtime software allows users to be guided through the decision making process providing a real time record of key decisions. Progress on the decision framework and the supporting software tool will be discussed. A conceptual model of the software tool will also be demonstrated as part of an overall discussion on guidance and strategy development.

Questions, Answers, and Comments

- Q: This tool would probably have the data entered in by multiple people; are you going to have this be web-based or standalone on personal computers (PCs) or mobile devices where data can be accessed through a network database?
- A: Yes, one of our goals is to make it platform-independent and totally available, but the main issue was where it will actually be housed. We really need some work on how it will be deployed in the field. Our general goal is to make as available as possible.
- Q: We heard yesterday that bioincident is a real-time research project because we don't have the hard data to help inform what is actually going on, the extent of the sampling, or how to interpret results. What would be the process by which you would have some kind of quality control or peer review on the inputs that are driving decisions in this model, especially if there are multiple people contributing inputs? For Hurricane Sandy, it makes sense because people see water and they know wet and dry, but for bio, given all uncertainties, how can you embed in the procedure a real-time quality control to assure your decisions are going to be based on quality data?
- A: Excellent question. We hope that by having the process outline, there will be a process that each transit agency will have to ready the data for public use; how that happens is what we want to capture. More importantly, we want to capture how the transit agencies shut their system down. Do they have options on how they can control the shutdown of the system? Can the trains be brought back to yards? All of that could have a big impact on how long it would take to restore service. We want to capture that and integrate into our tool as best we can.
- Q: Relating to planning aspects and the New York City work where we were trying to address the subway system, the observation was that the entities or utilities that own airports or subways don't always understand the ICS [Incident Command System]. In the wide area scenario, as Bob presented, the competition for resources is going to be huge, and this response has to integrate with the above-ground response. Otherwise, you actually may clean one part and then actually be in a contaminated part at the same time. Is this going to follow NIMS [National Incident Management System] and help train transit authorities about how to integrate into the decision framework that would occur in these kinds of situations?
- A: I think that to be most useful, we are going to have to integrate it with incident command and NIMS. Transit agencies have lots of knowledge on what it takes to run their system and get it back in operation. We hope to give them enough information so they can effectively interact with incident command. If the priority is to restore trains, we need resources in these areas. If we can determine that the area that we shut down was not impacted, we can start restoring service. The goal is trains running. This is what we need to do. If they do not have the resources to do that, they will have to come from the incident command system. We are hoping to give them tools and data to say this is what we need, this is our plan, and if goal is to restore transit service, then this is what we need.
- C: Thank you for using the right terminology or mostly using it correctly. When I come here, I learn new words. Response and recovery: this actually goes to one of the other questions. There's a difference when it's a *response*; we have authorities under many agencies, and there is leadership and funding associated with it (of course if it is a wide-area thing, people won't have it in their budget, it will have to be approved), but under *recovery* we don't have the same authority or leadership. In fact, cleanup

assessment and mitigation for substances and oil, including weapons of mass desctruction (WMDs), is under the national response framework. In fact, it is not addressed under disaster response framework. Thank you for at least trying to use response and recovery appropriately; recovery is when people are back in their cars and response is when we or someone else is in there cleaning it up.

Challenges in Applying Old Data to New Paradigms in Wide-Area Urban Radiological Response and Recovery

11:45 am

Michael Kaminski (presenter) and Sang Don Lee | *Argonne National Laboratory*
Matthew Magnuson | *U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

Uncontrolled radioactive contamination in a wide urban area presents unique challenges with respect to both response and recovery. These challenges are related to a number of technical factors, many related to the size and nature of such incidents, which are not necessarily associated with other types of radioactive contamination incidents. Paradigms to meet these challenges should consider additional variables such as the involvement of groups and individuals, ranging from first responders to community organizations to the general public. These groups may be implicitly involved from the moment of radiological release to final, potentially protracted, recovery.

Potential targets require an immediate decontamination response or mitigation plan, to limit the social and economic impact of an incident. This presentation discusses the methods and data collected over the past 70 years in the field of external surface decontamination of radionuclide contamination, with emphasis on methods suitable for response to radiological dispersal devices. Similar conclusions also apply to contaminations arising from a nuclear weapon detonation or power plant accident.

To date, experience with urban decontamination of building materials – specifically hard porous external surfaces – is limited to nuclear weapon fallout and nuclear reactor accidents. Effective methods are lacking for performing wide-area decontamination in an urban environment so that the area may be re-occupied without restriction. Also lacking is experience in developing mitigation strategies, that is, methods of decontaminating key areas during the immediate aftermath of an event. This review concludes that the few studies existing on each technique permit only very preliminary estimates of decontamination factors for various building materials and methods. This data shortage limits development of an effective mitigation response plan or decontamination effort.

While mitigation and decontamination of a radioactive dispersion is difficult and there is much research to do, there is some room for optimism. Very importantly, the scientific community has example frameworks for radiological response plans, that can be used as a template for developing improved mitigation and decontamination plans. Many aspects of the decision-making process are included. The information from Fukushima will be invaluable with many additional data points and practical information on deployment, man-hours, and cost. Response plan templates, computer modeling and relevant data could be used to inform preparedness plans and support exercises.

Questions, Answers, and Comments

- [no questions]

19. Poster Session

Building B Atrium
2:25 pm - 4:00 pm

1. Improved Filter Holder and Extraction Protocol for Forensic Vacuum Collections

Jacob Aspinwall and Valorie Ryan | *MRIGlobal*

Abstract

In general, vacuum filtration is a portable and effective method for easily sampling biological particulates from large diverse surfaces including wood, metal, and carpet. Current vacuum collection systems, such as the 3M Trace Evidence Collection System employ a high flow rate vacuum fitted with a collection filter. The replaceable collection filter is hermetically sealed and installed on the end of a detachable vacuum nozzle. The vacuum is also equipped with a HEPA filter to prevent any collected particles from being exhausted through the blower stage during collection. Some of the issues encountered with this system include loss of filter integrity during collection and difficulty recovering targets during sample extraction, both of which can lead to loss of sample. To select a suitable matrix for collection of biological materials, several factors have to be considered including: properties of collected particles, compatibility of the matrix with the collection conditions, characteristics of collection surfaces, and filter/holder design including use and handling procedures. These factors are important because they affect the collection efficiency of the selected matrix. Ultimately, these parameters will affect the ability of the system to collect and retain a representative fraction of the forensic sample under study and make that sample available for analysis.

In consideration of these factors, MRIGlobal has developed a bioforensic collector as an alternative to the 3M Trace Evidence Filter. The MRIGlobal bioforensic collector (BFC) is a vacuum collection device designed for biological targets based on Fibertect decontamination fabric. Fibertect is a commercially available three-layer, nonwoven composite substrate originally developed for absorbing and adsorbing chemical warfare agents (CWAs), toxic industrial chemicals (TICs), and pesticides. It was selected for the BFC based on its resistance to rupture under high vacuum and potential for collection of multiple analyte types (chemical, biological, radiological, and explosive). Its three layers include an activated carbon nonwoven felt inner layer with outside layers that can be varied to provide absorption and adsorption properties as desired. The BFC housing is designed for attachment to any 1 ¼ inch vacuum hose and is compatible with commercial off-the-shelf (COTS) vacuums. Samples are recovered from the BFC using in-situ sample extraction procedures designed to recover biological targets from the collection matrix without removing the filter.

The BFC has been tested for viable target and nucleic acid recovery with performance shown to be equal to or better than commercially available products. Its design allows rapid sampling from large surfaces areas in indoor (building interiors, HVAC filters, etc.) or outdoor (exterior concrete, subway, etc.) settings to determine the focus of decontamination efforts with a threat agent release and to evaluate the effectiveness of the decontamination effort.

2. Evaluation of Oxidant Biocide Formulations for Soil Sanitation

Andrea Beam, Craig Ramsey, Debra Newman, and Paul Freebury | *USDA-APHIS-PPQ*
Steve Newman | *Colorado State University*

Abstract

Due to the phase-out of methyl bromide, alternative methods are needed for nursery soil sanitation. This study was conducted to explore various oxidant biocide formulations for deactivating pathogens in nursery soils. Several biocides were tested in a greenhouse soil column study: ozonated water, liquid chlorine dioxide, chlorine dioxide granules (fumigant), steam treatment (autoclave), and untreated soil (control). We evaluated the effects of soil

type (commercial top soil or potting soil) and the effect of repeated biocide applications (2, 4 or 6 applications) for ozonated water and liquid chlorine dioxide. The two response variables were soil respiration rates and Bacillus *subtilis* spore deactivation for inoculated washers inserted 10 cm into each soil column. The inoculated spore samples were inserted before the liquid biocide treatments, exposed to the biocides for 30 minutes, and then retrieved for viable spore analysis. We hypothesized that a reduction in the native microbial population in both soils, due to the biocide treatment, would reduce soil respiration rates in the treated samples. A single application of chlorine dioxide granules resulted in a soil respiration rate equivalent to the autoclave treatment for the potting soil. For the top soil, the autoclave treatment had a slightly lower soil respiration rate than the chlorine dioxide granules. Chemical reactions created by the autoclave heat and the liquid biocides may have generated carbon dioxide from the organic matter in the soil, which in turn may have confounded the interpretation of soil respiration rates for these treatments. The chlorine dioxide liquid biocide had the lowest viable *B. subtilis* spore count (viable CFU/washer), which resulted in the highest efficacy rating among the three treatments that were tested with the inoculated spore samples. Chlorine dioxide applied as a liquid, or as the granules, had an average log10 reduction of 0.69 and 0.30 for an exposure time of 30 minutes, at 10 cm deep in top soil. This study didn't analyze spore samples that remained in the soils over multiple biocide applications, so the cumulative effect of multiple applications could not be reported for the liquid biocides. We also investigated reactions between the liquid biocides and the soil by measuring changes in oxidation and reduction potential (ORP) before and after the biocide was applied to soil. ORP is the electrochemical strength to acquire electrons from organic matter or living cells, and thus is a measurement of the biocide strength of the solution. For chlorine dioxide, passing through top soil decreased the ORP more dramatically than passing through potting soil. ORP also decreased dramatically for ozonated water after soil application, but this may be attributable to temperature changes rather than a reaction with the soil.

3. Field Test Method Development for Hot Humid Air Decontamination of *Bacillus thuringiensis kurstaki cry*- HD-1

Tony Buhr, Alice Young, Zach Minter, Matt Bohmke, Erica Borgers-Klonkowski, Misty Bensman, Neil Kennihan, Catherine Johnson, Stephen Avila, and Emily Osborn | *Naval Surface Warfare Center-Dahlgren*

Abstract

Aim: To develop test methods and evaluate survival of *Bacillus thuringiensis kurstaki cry*- HD-1 spores after exposure to hot, humid air inside of a C-130 aircraft.

Methods and Results: Spores (9.6e11 spores) of *B. thuringiensis kurstaki cry*- HD-1 were aerosolized over 57 minutes using two foggers inside the cargo hold of a C-130 and then allowed to dry overnight. The mode size of spores was 1.24 µM volume (equivalent to a spherical diameter). Water droplets ranged from 7-30 µM. Assuming all droplets were 30 µM, then an average of 1.6 spores were dispersed per aqueous droplet. Dirty (undefined aircraft debris) complex C-130 surfaces included flat surfaces, bolts, screw heads, wing nuts, and straps tied over insulation were constructed from the following materials: nylon webbing, aircraft performance-coated aluminum, bare aluminum 2024-T3, InsulFab, and non-skid coated aluminum. Complex surfaces were swabbed after spore dispersal and after hot humid air decontamination at 170 °F, 90% RH for seven days. Results are forthcoming.

Conclusions: Test methods to describe hot humid air decontamination in the laboratory were scaled for a large-scale aircraft field test in order to transition a new decontamination technology from S&T to acquisition.

Significance and Impact of the Study: Transition of a new technology from research and development to acquisition at a TRL7 is unprecedented.

4. Test Method Development for Hot Humid Air Decontamination of *Bacillus anthracis*

Alice A. Young, Tony Buhr, Ph.D, Zachary A. Minter, Neil Kennihan, Catherine Johnson, and Harold Barnette | *NSWC Dahlgren*

Abstract

This work is a continuation of the hot humid air decontamination work that was briefed last year.
Aims: To develop test methods and evaluate survival of *Bacillus anthracis ΔSterne* or *B. thuringiensis Al Hakam* spores after exposure to hot, humid air.

Methods and Results: Spores (>7 logs) of both strains were mixed with kaolin or spent sporulation medium plus humic acid, and then dried on five different test materials. Response surface methodology was employed to identify the limits of spore survival at test combinations of temperature (55, 65, 75oC), relative humidity (70, 80, 90%) and time (1, 2, 3 days). Less than one log of spores (<10 spores out of a 10 million spore challenge) survived the harshest test condition (75 °C, 90% RH, 3 days) for all test combinations. Greater than 6.5 logs of spores survived the mildest test condition (55 °C, 70% RH, 1 day). Addition of debris to spores delayed decontamination kinetics compared to neat spores. Spores of both strains inoculated on nylon webbing had greater survival rates than spores on other materials. Inactivation of spores mixed with kaolin was statistically identical for both strains in 73 of 75 test combinations. Inactivation of spores mixed with spent sporulation medium plus humic acid was statistically identical for both strains in 65 of 75 test combinations.

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

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

5. New Developments in the Solid Oxidizer Decontamination Technology – Dahlgren Decon

Timothy Burgin, Bryan Tienes, Vanessa Yates, Wynn Vo, and Kathryn Burns | *Naval Surface Warfare Center Dahlgren Division*

Abstract

Current chemical and biological threat agent decontaminant technology is based on oxidative chemistry in aqueous solutions. A warfighter identified goal for fielding new decontaminants is to reduce the logistical footprint of products. One way to do so is by identifying solid or concentrated components for use in formulations. Naval Surface Warfare Center Dahlgren Division, Code Z21, is the first organization to be successful in meeting this goal, making use of the solid oxidizer PES-Solid. PES-Solid is a peracetyl borate complex that dissolves in water to provide peracetic acid for neutralization of threat agents. It is formulated into a specially designed surfactant system and called Dahlgren Decon.

S&T development of this product has recently focused on establishing the mechanistic understanding of PES-Solid and peracetic acid degradation pathways and also on determination of kinetic constants as a function of pH. An analytical method of peracetic acid determination was optimized for use in this work. PES-Solid solutions are dynamic with multiple different species existing depending on time, temperature, the pH and buffering systems employed. Experiments suggest degradation by first order kinetics and these results will be discussed. Understanding the oxidant concentration over time provides insight into the expected lifetime of the decontaminant (pot-life) and also provides information on the chemical state of the active components in solution and their availability to react with threat agents. Ultimately, knowledge and understanding in this area will allow for optimized PES-Solid formulation development for new chemical and biological decontaminants.

6. DAHLGREN DECONTAMINANT: Continued Development of a Solid Oxidizer Decontaminant

Kathryn G. Burns and R. Chris Hodge | *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). Chemical efficacy, biological efficacy and materials compatibility data will be presented.

7. How Clean is Safe? The Detection of Chemical Warfare Agent at Ultra-Low Concentration After Decontamination

Andrew Chia Chan Wing, Kendrick Chew Khee Siah, Clareene Chan Lai San, Chee Chua Hoe, and Wai Leng Loh | *DSO National Laboratories*

Abstract

From our earlier studies, it was demonstrated that chemical warfare agents (CWAs) can persist in the environment for a long time even after decontamination has been performed. Porous surfaces, for example concrete can trap CWAs where it will be a challenge for decontaminants to take its effect. These trapped CWAs will then offgas to pose a persistent desorption hazard which might not be safe for occupancy. The offgas concentration usually present at a low level that will not be able to trigger a response on a conventional portable chemical agent detector. Furthermore, there should be a methodology to detect chemical agent vapour at an ultra-low, and yet benign concentration to deem an affected area safe for re-entry.

The impetus of this study is to develop a methodology to generate, characterise and detect chemical warfare agents vapour at this ultra-low level. The methodology once developed will aid as a decision making tool to return an incident site to normalcy. DSO National Laboratories has investigated a list of five selected chemical warfare agents at their respective Worker Population Limit (WPL) for declaration of the affected area safe for return to normal activities after a Chemical Agent incident. The Worker Population Limit (WPL) is the average exposure to a contaminant to which workers may be exposed without adverse effect over an 8-hour day for a working lifetime.

Methods

The chemical agent in its WPL concentration is generated using a vapour generation system. The chemical agent is filled in a Teflon permeation tube which is then housed in a glass bottle. The glass bottle is then placed in a heating block to initiate permeation. With a series of dilution, the desired chemical agent at its WPL vapour concentration is generated.

Using air sampling tube packed with adsorbent, Tenax TA, the generated CWAs' WPL vapour is collected, analysed and quantified using Automated Thermal Desorber coupled with Gas Chromatography Mass Spectrometer (ATD-GCMS).

Preliminary results

Sulphur Mustard (HD) and Sarin (GB) vapours have been successfully generated using permeation temperature at 40 °C. These vapours generated have been characterised and quantitated at their sub-WPL levels.

The generated HD vapour was subject to dilution by factors up to 1000 times to 0.3 WPL. The average HD concentration is at 1.15 x 10-4 mg/m^3 with a standard deviation of less than 12%. The generated GB vapour was diluted by factors up to 10,000 times to 0.3 WPL. The average GB concentration is at 9.80 x 10-6 mg/m^3 with a standard deviation of less than 12%.

Conclusion

The capability to generate a steady and sustainable flow of low concentration of agent, provide the means to validate laboratory methods to detect and quantify agents at their sub-WPL levels. The ability to verify and detect chemical agents at an ultra-low and safe concentration, aid in the return of an incident area to normalcy with confidence.

8. Metagenomic Profiling of Air Samples for Surveillance of Contaminated Environments

Tamar Dickerson, Michelle Galusha, Nicole Waybright, Melissa Krause, Danielle Swales, Peggy Lowary, Jeanette Coffin, and Joseph Bogan | *MRIGlobal*

Abstract

Detection of airborne microbial contaminants in indoor and outdoor environments is critical for monitoring the presence and potential spread of bacterial or viral pathogens following a bioterrorist attack or industrial-scale environmental contamination event. By air sampling an environment of interest and characterizing the total genomic content of captured particles by metagenomic next generation sequencing (NGS), it is possible to not only identify the presence or absence of specific pathogenic agents of concern, but also to infer phenotypic features of these organisms. At MRIGlobal, we have been carrying out a year-long study of four airborne microbiomes using a combination of metagenomic NGS and a functional screen for specific phenotypic attributes. Results from this study has shown that deep sequencing of bioaerosols enables ultra-trace detection and identification of pathogenic or otherwise harmful contaminating bacteria and viruses several orders of magnitude below 1% of the total microbial load. Our approach is an NGS platform diagnostic and allows for significant flexibility in sample throughput leading to reduced sampling costs. Furthermore, the sample-to-answer turnaround time is less than 24 hours, thereby providing a highly sensitive means for rapidly and inexpensively characterizing the total microbial content of contaminated environments via aerosol collection.

In conclusion, air sampling and characterization of bioaerosol contaminants through NGS is a powerful method for near real-time surveillance of released bioaerosols. Our approach has a short turnaround time and is a low-cost, highly sensitive method for characterizing hazardous areas otherwise inaccessible as a result of a recent industrial contamination event or bioterrorism attack.

9. Ozone Decontamination Efficiency of Equipment

Melissa Krause, Allison Ferris, Peggy Lowary, and Joe Bogan | *MRIGlobal*
Dan Wilkins | *CDI Marine*

Abstract

Successful defense against biological threat agents not only includes technologies that can detect the agents of concern, but also must incorporate the capability to fully decontaminate items exposed to these agents after detection. In many cases, only modestly sized laboratory or industrial equipment require decontamination. This study was designed to address such a scenario. Ozone has been selected as the decontaminant of choice for the

study, due to the relative safety of its use, the ability for catalytic conversion of the gas as it is vented and lack of demonstrable damage to materials tested in previous studies. MRIGlobal has developed spiked coupons to be used in conjunction with decontamination procedures as a quantitative measure of effectiveness.

We have evaluated seventeen unique material types commonly found in laboratory and industrial environments to determine the recovery efficiency of both ricin toxin and surrogate *Bacillus anthracis Sterne* spores from their surfaces. The recovery efficiency of toxin or spores from surfaces is strongly material dependent. A six log reduction or greater has been proposed by EPA as a requirement for consideration as a sporicidal decontaminant. Recovery from all materials tested has been sufficient to quantitatively demonstrate this level of inactivation. In order to evaluate the efficacy of the coupons as a measure of decontamination efficiency and to determine the optimal conditions for maximum decontamination, a small chamber will be developed in which relative humidity, ozone concentration and time of exposure can be closely regulated. Coupons, spiked with a predetermined concentration of either toxin or spores will be exposed to a variety of conditions and then tested for activity or viability of the spiked agents. Treated coupons will then be compared to unexposed coupons to quantitatively determine the efficiency of the method.

10. Facility Decontamination Strategy and Technology Selection Tool (DeconST)

Donna Edwards, Timothy Sa, Lynn Yang, and Paula Krauter* | *Sandia National Laboratories, Livermore, CA*
Shawn Ryan, Paul Lemieux, and Leroy Mickelsen | *U.S. Environmental Protection Agency, RTP, NC*
William Ginley | *U.S. Army Edgewood Chemical and Biological Center, Edgewood, MD*
*retired

Abstract

A wide-area biological incident may require remediation of tens to hundreds of potentially contaminated buildings, causing dramatic shortages of remediation materials, equipment, and expertise. The situation may provoke decision makers to consider the use of alternate decontamination technologies and strategies in order to support area resilience. The Decontamination Strategy and Technology Selection Tool (DeconST), developed by Sandia National Laboratories (SNL) and U.S. Environmental Protection Agency (USEPA) under the U.S. Department of Homeland Security - Science and Technology Directorate (DHS-S&T) and the U.S. Department of Defense - Defense Threat Reduction Agency (DoD-DTRA) Interagency Biological Restoration Demonstration (IBRD) and Wide-Area Recovery and Resilience Program (WARRP), has been adapted into a web-based tool and tested in a series of technical and operational demonstrations by the DoD-DTRA Transatlantic Collaborative Biological Resiliency Demonstration (TaCBRD) program.

The DeconST supports decision-making for the selection of decontamination options for individual specific buildings contaminated with *Bacillus anthracis* spores and 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 decontamination technologies on the structural and interior materials as well as 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 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.

In addition to operational assessment by EPA OSCs during its development, the DeconST has been tested and evaluated in three technical demonstrations and an operational demonstration by TaCBRD tactical and strategic decision-makers. It has transitioned formally from the DHS S&T directorate to the EPA and was incorporated by the EPA into its BioGuide and by the DTRA's TaCBRD program into its TaCBoaRD integrated suite of response and recovery decision-support tools.

Sandia Review and Approval Number: SAND2015-0852 A

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

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

Mark Tucker, Andres Sanchez, Joshua Hubbard, Matthew Hankins, Matthew Tezak, Scott Davison, Steven Storch, Brandon Servantes, and Andrew Yourick | *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 and other complex spaces. Direct application of liquid formulations to these spaces is difficult so other methods such as gas- or vapor–based technologies are typically used. However, most gas/vapor technologies have significant shortcomings because they are toxic and/or corrosive.

Liquid decontaminants have a greater flexibility for decontamination applications because they can be made with lower toxicity and corrosivity properties. Liquid decontaminants are usually directly applied by spraying or foaming making application to hidden surfaces in complex geometries difficult. An alternative is the use of aerosol-delivered liquid 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 liquid materials is a novel, innovative approach to decontamination of interior spaces. Addition of electrical charges to aerosols can also improve their transport to hidden surfaces.

We have conducted several projects that have significantly advanced the science 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. 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 conducted against bacterial spores using the anthrax simulant *Bacillus globigii*. 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. A currently-funded DTRA project in collaboration with the Boeing Corporation has further advanced this area. The objective for this effort is to provide validation for the electrostatic aerosol transport models for particle size and deposition rate and to determine the feasibility of an electrostatic spray process in delivering non-corrosive decontaminants to complex interior spaces, such as an aircraft. The project utilizes a rotary atomizing induction charged nozzle to disperse small, charged droplets of

liquid decontaminants uniformly through a contaminated space. High decontamination efficacy against both chemical and biological agent simulants has been achieved.

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

12. Composite Sampling for Wide Area Decontamination of Anthrax

Brian France and William Bell | *TDA Research, Inc.*

Abstract

TDA is funded by the Defense Threat Reduction Agency (DTRA) to help develop the capability to decontaminate an airport or seaport in two weeks or less. Time is of the essence to minimize the economic loss from the contamination of critical infrastructure. To determine the extent of contaminant spread (hazard mapping) and demonstrate that a large, complex area, is clear (clearance sampling) will require data on thousands of samples. The rate-limiting step in the recovery process quickly becomes the analysis of these samples, which could require months to complete. Composite sampling has the potential to reduce time and cost by a factor of 20 or more. This validated technique is being developed for use in wide area anthrax decontamination. In this work, we are evaluating and developing methods to apply composite sampling, using already approved and documented sample collection methods and analysis procedures. We will discuss our vision for how composite sampling could be used for wide area anthrax decontamination. We will present our study and test results demonstrating the basic proof of concept and the results of grouping protocols. This approach will benefit warfighters and first responders by allowing them to restore operations in contaminated areas much faster and at lower cost.

13. Electrochemical Generation of Chlorine Dioxide for Efficacy against Anthrax

Brian France and William Bell | *TDA Research, Inc.*

Abstract

TDA is currently funded by the Army Research Office to develop reactive decontaminant solution is needed to neutralize the toxic hazards. There are ever present threats of attack and release of chemical and biological warfare agents, fortunately, the frequencies with which these decontaminants are required are low; this requires that a commercially successful decontaminant must have a long storage lifetime. It must also be easily shipped by normal means (including commercial aircraft) to simplify logistics, safely handled, and environmentally friendly, leaving no hazardous residue after use. However, these requirements conflict with the need for the decontaminant to be highly active when applied. On-site activated decontaminants are ideal because the activated solution is highly reactive and can quickly destroy chemical and biological warfare agents, but prior to activation the decontaminant ingredients can be safely stored for years, shipped, handled and have a very long shelf life. TDA's electrochemical decontamination (EC-Decon or eClO2) technology stores solid salts, which are dissolved at the point of use in water; this solution is electrochemically activated to produce a reactive and effective decontaminant solution. Before any decontaminant with claims of efficacy against a biological organism can be sold in the U.S., it must be registered with the EPA under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The EPA regulates these items to ensure that they are effective, environmentally safe to use and are employed correctly. This solution has already been shown to be effective against anthrax spores using EPA-approved efficacy protocols. We will present data to demonstrate that the electrochemical decon system can safely accomplish the chemical and biological decontamination objectives. Our efforts to register the system with the EPA under FIFRA with claims of efficacy against anthrax will be discussed.

14. Encapsulated CBD Waste for Reduced Cost Transport and Disposal

Brian France and William Bell | *TDA Research, Inc.*

Abstract

During an EPA-funded Small Business Innovation Research (SBIR) Phase I project, TDA developed an encapsulation method to seal in chemical and biological agent contamination on solid wastes that are designated for removal from a decontamination site. This technology will benefit the mitigation effort in three ways. First, it will improve the safety of personnel by protecting them from both vapor/aerosol and contact hazards. Second, it can lower the hazard classification of the waste, which will lower the cost of transporting the contaminated wastes to the disposal site because the contaminants are sealed within the impermeable polymer matrix. Third, the lower hazard classification can dramatically lower the cost of ultimate disposal in a landfill, or by incineration or gasification. During the Phase I effort TDA demonstrated the feasibility of this encapsulation approach and completed tests that showed the benefits and capabilities of the technology.

15. Automated Decontaminant Calculator

Rob Genova, Tammy Stundon, and MSgt Ernie Rude | *Air Force Civil Engineer Center, CXA*
Gina Canfield | *Air Force Civil Engineer Center, CXA*

Abstract

The multi-service approved Automated Decontaminant Calculator for multiservice tactics, techniques and procedures (MTTP) CBRN Passive Defense is a user-friendly tool that allows the warfighter to make a predetermined percentage concentration of chlorine solution without using complicated chemical formulas. This tool can determine the volume of water required for a specific decontaminant amount and vice versa. In addition, the user can choose from the most standard chlorine-based decontaminants: high test hypochlorite (HTH), high test bleach (HTB), calcium hypochlorite (at two concentration variations), and sodium hypochlorite (at three concentration variations). Field-tested on first year warfighters, the tool was developed with their level of chemistry experience in mind. Additionally, the tool includes informational icons that provide a quick reference table with calculated values found in the CBRN Passive Defense MTTP, as well as exercise scenarios. The scenarios include several word problems and answers and guided instruction for each step. Information for free access will be available.

16. Evaluation of a Composite Sampling Method for *Bacillus* Spores on Clean Surfaces

Janine R. Hutchison, Brett G. Amidan, Kevin K. Anderson, and Hanahh R. Lake | *Pacific Northwest National Laboratory*

Abstract

Following the anthrax incident in 2001, research efforts have focused on improving sampling plans, sample collection, extraction, analysis, and response. A bottle neck in the overall process is the laboratory sample extraction and analysis, due to the time it takes to process and analyze the samples. Composite sampling is the process of combining samples to reduce the number of samples collected and downstream sample analysis. This reduction in samples reduces labor cost and sample turnaround time. Composite sampling allows for samples from multiple sites to be combined, with only a single analysis needed. This study evaluated the effects composite sampling on the recovery efficiencies (REs), false negative rates (FNR), and limit of detection (LOD) of Bacillus spores deposited onto nonporous, clean surfaces. Spores were collected following the Centers for Disease Control and Prevention (CDC) surface sampling procedure for *Bacillus anthracis* using a cellulose sponge. A statistical experimental design was generated to test two composite methodologies using a range of low concentrations of *Bacillus atrophaeus* Nakamura spores on four surface materials (stainless steel, vinyl tile, ceramic tile, and painted wallboard). The first composite methodology was the single medium composite and uses a single cellulose sponge to sample four to eight coupons. The second methodology was the combined post-sample composite and uses a single cellulose sponge per sample (4, 8, or 15). The cellulose sponges were then processed sequentially using the

Laboratory Response Network protocol for identification of *B. anthracis* spores from environmental wipes. Statistical tests of the results using analysis of variance (ANOVA) indicate that two of the main effects had significant F tests: coupon material (F-value = 6.1355) and composite method (F-value = 44.7295). RE with the post-sample composite across the concentrations tested (10 to 100 CFU/coupon) was similar for ceramic tile, painted wall board, and stainless steel. RE was lowest for the vinyl tile with the post-sample composite. The recovery efficiency was higher overall for post composite samples compared to the single medium composite samples. Additional statistical analysis is underway to estimate the FNR and LOD using composite sampling. The results of the study suggest that post-sample compositing can be used to reduce sample analysis cost and time during a *B. anthracis* contamination event.

17. Evaluation and Optimization of Sampling and Analysis Protocols for *Bacillus anthracis* for Underground Transport Restoration

Anne Marie Erler, Staci Kane, and Teneile Alfaro | *Lawrence Livermore National Laboratory*

Abstract

To safely and rapidly restore transportation systems following an anthrax attack requires thorough evaluation of current protocols for sample analysis, investigation into possible limitations, and modification of methods for complex samples from railcars, tunnels, and platforms. Railcar undercarriage areas and exposed HVAC filters may represent the highest debris loading, while surfaces from tunnels, platforms, and car interiors impacted by human activity would also cause challenges for analysis. HVAC filters could be targeted for rapid rule-in/rule-out for car decontamination since the filters essentially 'sample' the ambient air including potentially respirable spores; therefore, robust methods for accurate analysis of HVAC filters are critical. Modeling has predicted widespread contamination following even modest spore releases due to railcar movement and resulting airflow patterns, making rapid, high-throughput analysis methods essential to quickly restore transportation facilities. To address these needs, experiments were conducted with exposed HVAC filters from New York City Transit (NYCT) and Bay Area Rapid Transit (BART) railcars, which were vacuum-sampled with 37-mm cartridges following NYCT guidance. *Bacillus anthracis Sterne* spores were then added to sample extracts to assess spore limits of detection (LOD) and potential interferences. Vacuum cartridges containing up to ~1 g debris were analyzed using a recently developed EPA/CDC method, modified slightly for higher debris levels. Replicate cartridges were analyzed using Rapid Viability Polymerase Chain Reaction (RV-PCR) adapted to handle more complex background debris. RV-PCR, co-developed with EPA, was previously shown to significantly shorten the time for confirmed results with a 10-spore level LOD even for samples containing high levels of debris, live non-target spores/cells, or killed target spores. Results from the current study showed that culture analysis did not accurately distinguish added Sterne from Sterne-like indigenous colonies and required PCR analysis of the concentrated 48-h enrichment cultures to obtain some level of positive detection, whereas RV-PCR consistently enabled the 10-spore level LOD after only 9-h incubation (followed by DNA extraction and PCR analysis). Similar results were obtained for culture and RV-PCR analyses of sponge-stick samples containing up to 250 mg BART undercarriage debris or surrogate grime developed by Sandia National Laboratory. When presumptive Sterne colonies from culture plating were analyzed by real-time PCR, typically no Sterne-like colonies could be confirmed and only the 10-fold concentrated 48-h enrichment culture showed some positive PCR results. Conversely, RV-PCR with a 9-h incubation step showed positive results for all replicates at the 10-spore level. RV-PCR also showed consistent detection of Sterne for vacuum samples from exposed HVAC filters quantitatively loaded with ~500 dry Sterne spores. Ongoing efforts are focused on estimating the LOD from culture and RV-PCR analyses using dry spore deposition. In summary, RV-PCR was shown to enable detection of viable *B. anthracis* Sterne spores to the 10-spore level for complex subway samples, providing confirmed results in less than one-third of the time with 100% detection of samples containing *B. anthracis* compared to ~33% detection by the culture method. These results along with the capability for high-throughput analysis would make RV-PCR useful for rapid return to service of underground transport systems.

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

18. Lung Epithelial Cell Model for Exposure Assessment of Stachybotrys Spore grown on PDA vs. Wallboard

Jean Kim and Lauren Harvey | *RTI International*

Abstract

Aerosolized exposure to various biological and nonbiological insults have a significant impact on human health such as asthma, allergy, or infection which can sometimes lead to death. The lungs, one of the first organs to encounter these aerosols, are the sites where disease generally occurs.

In the area of indoor air quality, fungal spore contamination due to water damage has a significant impact on human health. Even after decontamination, the remaining fungi still have the potential to cause disease. An immunological assay in collaboration with EPA was previously developed to understand the biological effects of macrophage exposed to fungal spores grown on different wallboard types. To expand capabilities in understanding the health effects related to fungal spore exposure, lung epithelial cells (Calu-3) under air-liquid interface growth conditions was established mimicking the bronchial environment. A comparison study was performed to assess the biological effects elicited by Stachybotrys spores harvested from potato dextrose agar (PDA) vs. water damaged wallboard.

A confluent monolayer of Calu-3 cells was established and stably maintained under an air-liquid interface growth conditions with high transepithelial electrical resistance (TEER) and tight junction protein (E-cadherin) expression around the perimeter of each cell. There was also expression of the mucin protein (Muc5Ac) indicating the production of mucus. Following exposure to fungal spores grown on PDA versus wallboard, both fungal spore types resulted in the loss of membrane resistance as well as a reduction in Muc5Ac production of the Calu-3 monolayer. However, the lung epithelial cells exposed to fungal spores from wallboard still expressed some amount of E-cadherin while those exposed to spores from PDA showed no expression of E-cadherin. There was also an increase in the levels of lactate dehydrogenase (LDH) released by the Calu-3 cells when exposed to spores from wallboard which indicated a disruption in cell membrane integrity and therefore cytotoxicity. The monolayer exposed to spores from PDA had levels of LDH similar to unexposed control cells, thus indicating no loss of membrane integrity. Interestingly, observation by dark field microscopy showed uptake of a fungal spore by the Calu-3 cell suggesting a signaling mechanism triggered by the spore. Collectively, these data show a more toxic effect elicited by fungal spores grown on water damaged wallboard material compared to standard laboratory media. This model will provide a method for assessing the biological responses generated from microbes resistant to decontamination.

19. Enhanced Isolation of Viable *Bacillus* Spores Using Commercially Available Cell Lysis Solutions

Paul Lemieux and Erin Silvestri | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
Douglas W. Hamilton | *ORISE Research Participant Working with U.S. Environmental Protection Agency, National Homeland Security Research Center*

Abstract

The response to the intentional dissemination of *Bacillus anthracis* spores (anthrax) via the U.S. Postal Service in 2001, and subsequent research activities and planning exercises highlighted the extent to which different materials in a building might be contaminated, and identified the need for sample collection and analytical methods suitable for determining the efficacy of decontamination strategies and to characterize residual wastes. Sample collection methods for surfaces routinely employ swabs, wipes and vacuum socks with culture methods serving as the analytical “gold standard” for determining decontamination efficacy. Recovering spores from complex matrices (e.g., soils, porous building materials, and heterogeneous waste and debris) has been achieved with mixed results by mixing the sample with an aqueous carrier medium to generate a slurry that can be manipulated. Quantification of spores from these slurries using culture methods can be challenging due to the concurrent growth of native organisms in the sample on culture media; therefore, sample processing methods

capable of reducing background flora would enhance the detection limits of analytical procedures and improve the characterization of a sample.

Studies of coat proteins (*B. atrophaeus*) and exosporium proteins (*B. anthracis, B. thuringiensis*) of spore-forming bacteria have identified a possible strategy that may be useful in spore recovery and analysis from complex matrices. The efficient dissociation of spore exosporium proteins is typically realized only after treatment with strong denaturants (e.g., sodium dodecyl sulfate (SDS) buffer + 8 M urea) and harsh physical treatment (e.g., boiling). In contrast, the "gentle" disruption of vegetative bacteria can be routinely achieved with commercially available lysis solutions. Standard protocols for these lysis solutions typically require short incubation times with buffer and are performed under ambient conditions, potentially allowing for high-throughput processing of multiple samples.

Currently, no information is available for the behavior of these commercial reagents with regard to spore inactivation. It is hypothesized that the hardy nature of the spore could be exploited, whereby the spore would remain viable under conditions that reduce the viability of vegetative bacteria. Specifically, chemical, physical and/or enzymatic treatment could be used to reduce, or eliminate, the presence of native vegetative organisms, thereby enhancing spore analytical procedures and improving sample characterization. The data presented herein summarize initial efforts in reducing the growth of vegetative *Escherichia coli* and *Enterococcus faecalis* using commercially available lysis solutions and characterizes the influence of these solutions on *B. atrophaeus* spore germination. Additionally, a comparison is presented between the spread plate technique and the spiral plate technique for the enumeration of spores and bacteria.

20. EPA's Role in Strengthening Community Resilience

Keely Maxwell, Brendan Doyle, and Eli Walton | *U.S. Environmental Protection Agency*

Abstract

Federal policies such as Presidential Policy Directive (PPD)-8, PPD-21, and the National Disaster Recovery Framework provide guidance for federal agencies to incorporate resilience into their disaster preparedness, response, and recovery actions. The U. S. Environmental Protection Agency (EPA) supports community resilience through its work in emergency response, water security, decontamination, waste management, analytical methods, and exposure levels related to disasters. The EPA has developed a number of resiliency tools to prepare for, mitigate, prevent, respond to, and recover from disasters. Many of these tools were developed for application to chemical, biological, radiological and nuclear (CBRN) incidents. They may also be used to support community resilience to the environmental hazards that arise during natural disasters. This paper presents the results of research on community environmental resilience. The research team hosted two community environmental resilience index (CERI) workshops, inventoried EPA resiliency tools, and analyzed resilience indicators. This paper first provides an overview of resilience concepts and policies. Next, it proposes a definition of environmental resilience that can provide the basis for developing a systems approach to analyzing the environmental risks disasters pose to human health, and how disasters might disrupt critical environmental and ecological systems and services. Finally, it discusses the potential application of resiliency tools and indicators to provide a systematic assessment of community environmental resilience before, during, and after a disaster.

21. Initial Testing of Radionuclide Removal Methods to Decontaminate Low Activity Waste Melter Off-gas Condensate Liquid

Daniel J. McCabe, Charles A. Nash, Kathryn M., and Taylor-Pashow | *Savannah River National Laboratory*

Abstract

The Waste Treatment and Immobilization Plant (WTP) under construction at the Hanford site will treat and immobilize the inventory of High-Level Waste stored in underground storage tanks. The decontaminated waste will be mixed with glass forming chemicals and vitrified in the Low Activity Waste (LAW) melter. Vitrification of the waste generates a condensate stream from the off-gas treatment system. The baseline plan for disposition of the stream from the LAW melter is to recycle it to an evaporator and process it into the LAW melter again to increase retention of semivolatile constituents. Some of the semivolatile components in the stream, such as halides and sulfate, also have limited solubility in the glass waste form. These semivolatile species can accumulate to higher concentrations while recycling, impacting the waste glass loading and facility throughput. Radionuclides that partially vaporize and accumulate in the stream include ^{99}Tc, ^{137}Cs, ^{90}Sr, and actinides. The long half-life and environmental mobility of ^{99}Tc makes it a particular challenge when assessing options for separation and disposal. The other radionuclides also present challenges, but have more options for separations. This task is investigating radionuclide removal via precipitation and adsorption to examine potential for diverting this stream to an alternate disposition path. The highly selective sorbents have been developed over many years, typically for much harsher chemical and radiological conditions. Testing has demonstrated that the ^{99}Tc can be removed by reductive precipitation. The ^{137}Cs, ^{90}Sr, and actinides can be removed with commercially available sorbents that were originally developed for treatment of other streams, including high level waste (HLW). Manipulation of the pH is key to ensuring rapid and efficient decontamination of this stream. This work demonstrates that adapting the highly selective technologies developed for treatment of HLW can have significant advantages when treating other waste streams by minimizing secondary waste generation.

22. Evaluation of Decontamination Methods against *Bacillus atrophaeus* on Packaging Materials

Kathryn Meyer and Jenia Tufts | *Oak Ridge Institute of Science Education*
M. Worth Calfee | *National Homeland Security Research Center, Office of Research and Development*

Abstract

Prior to transport of sample containment packages from the exclusion zone, effective decontamination procedures are necessary in order to prevent contamination of assets in the support zone and in support laboratories. Two sample package decontamination approaches (Clorox® Healthcare™ Bleach Germicidal wipes or pH-amended bleach spray) were evaluated for decontamination efficacy on three packaging materials (corrugated fiberboard, polystyrene foam, and polyethylene). Liquid or aerosol preparations of *Bacillus atrophaeus* spores were deposited onto coupons, and simulated two potential real-world modes of contamination. The inoculated surfaces were decontaminated with either pH-adjusted bleach liquid spray or a commercial sporicidal bleach wipe and allowed to dry overnight for 18-24 hours. Following decontamination, surfaces were sampled using a 3M sponge stick sampler to determine the abundance of viable spores remaining on the surface after treatment. To date, results suggest that decontamination efficacy was comparable between the two spore preparations for each of the coupon materials. Also, considering only the aerosol inoculated samples, polystyrene foam was more difficult to decontaminate than corrugated fiberboard or polyethylene. Additional work is ongoing to evaluate the current procedures for collection, packaging, and shipping of biological samples for their potential for cross-contamination. Results of these studies are intended to be used by on-scene coordinators to enhance sample collection, packaging, and decontamination protocols.

23. Bacteriolytic Enzymes Targeting Old Pathogens: Expanding our Biological Arsenal against Old Threats

Ruchir V. Mundra, Krunal K. Mehta, Xia Wu, Elena E. Paskaleva, Marianela C. Lao, Martin A., Jonathan S. Dordick, and Ravi S. Kane | *Rensselaer Polytechnic Institute; U.S. Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory*

Abstract

Bacterial infections are one of the major causes of death worldwide. Not only has there been an increase in the emergence of resistant strains in recent years, but the number of new antibacterials approved has also declined sharply, further highlighting the need to develop novel antibacterials. Our approach makes use of bacteriolytic enzymes that target non-redundant defense features within the bacterial cell wall minimizing the emergence of resistance. A particularly relevant target of high economic, medical and biodefense importance is the spore-former *Bacillus anthracis*, the causative agent of anthrax.

We have developed an approach to identify novel bacteriolytic enzymes by using the amino acid sequence of a consensus binding domain as a probe to analyze in silico bacterial or bacteriophage genomes. We used this approach to identify a new lysin, AmiBA2446 from the genome of *B. anthracis* Str. Ames, and characterized the mechanism of action of this enzyme on isolated cell wall peptidoglycan using liquid chromatography/mass spectrometry (LC/MS). We evaluated the antimicrobial efficacy of the enzyme against rapidly dividing cells as well as germinating spores. We tested the activity of AmiBA2446 against various *Bacillus* species and also found that the enzyme was exceptionally stable in aqueous solution, making it well suited for incorporation in active nanocomposites for the environmental decontamination of bacterial pathogens. Another high-profile target is the clinically-relevant pathogen methicillin-resistant *Staphylococcus aureus* (MRSA), which is one of the primary causes of hospital-acquired infections. Taking inspiration from nature, we used the cell-wall lytic enzyme lysostaphin (Lst) to make nanocomposite coatings with antimicrobial activity against *S. aureus.*

While bacteriolytic enzymes are highly effective against vegetative cells and germinating spores, they are unable to deactivate intact spores. The presence of protective layers – the spore cortex, spore coat, and exosporium – inhibit the access of bacteriolytic enzymes to its target site in germ cell wall. To facilitate the applicability of these enzymes for the decontamination of spores, we developed a unique “outside in” enzymatic decontamination strategy. Specifically, we use mild proteases to degrade the outermost spore coat layer, followed by treatment with spore cortex degrading enzymes; this treatment facilitates access of bacteriolytic enzymes to the germ cell wall leading to spore killing. We have thus developed a mild and environmentally benign biocatalytic approach for spore decontamination.

24. Micro-vapor Chambers and Design of Experiments Approach for Investigating Vaporous Decontaminants

Lawrence Procell, Jay Davies, and Matt Shue | *U.S. Army, Edgewood Chemical Biological Center*
Janlyn Eikenberg | *Leidos*

Abstract

Vaporous decontamination chemistries are ideally suited to homeland response scenarios. They may provide decontamination for all exposed surfaces, do not create runoff or transfer contamination, and can greatly reduce manpower requirements. Furthermore, they may reduce hazards associated with applying solution-based decontaminants. However, efficient investigation of these chemistries is greatly hampered when using standard vapor test chambers as typically only one condition can be assessed per test session per test chamber due to the long exposures required and the time associated with bring the concentration to equilibrium in a large chamber. A highly efficient approach for investigating the vaporous decontamination of chemical agent contaminated surfaces was recently explored using a combination of micro-vapor chambers and a design of experiments (DOE) approach. Small Petri dishes acting as micro vapor chambers were employed to permit examination of multiple reaction chemistries, concentrations and conditions using hydrogen peroxide and acidic vapors. The use of

multiple micro-chamber tests per test session provided much greater throughput and efficiency than that provided by standard vapor exposure chambers. The statistical DOE approach coupled with the micro-vapor chambers was used to identify the most influential decontamination process factors associated with using hydrogen peroxide, formic acid and acetic acid vapors as decontaminants. These process factors included decontaminant vapor concentrations, humidity, temperature, exposure time, and contaminant droplet volume. The approach allowed a large number of reactions to be assessed per test session and permitted the generation of high vapor concentrations (~10,000 ppm calculated) and multiple vapor chemistries to be evaluated with a great reduction of test sessions along with multiple controls. Analysis of the DOE results allowed estimated optimal efficacy settings to be modeled and predicted, using all main, 2-way interactions and 2nd order effects in the model. Optimal vapor conditions obtained from the DOE results were compared and confirmed by experiments conducted using similar conditions in a larger traditional vapor chamber.

25. The Effect of Malathion on the Activity, Performance, and Microbial Ecology of Activated Sludge

Erik Rauglas, Seth Martin, Jr., and Willie F. Harper | *Air Force Institute of Technology, Department of Systems Engineering and Management*
Matthew Magnuson and Stuart Willison | *US Environmental Protection Agency, National Homeland Security Research Center, Water Infrastructure Protection Division*
Rebecca Phillips | *Oak Ridge Institute for Science and Education Research Participation Program*

Abstract

Detoxification and decontamination protocols may cause the release of chemical warfare agents (CWAs) into the wastewater streams that eventually flow into municipal wastewater treatment plants. These facilities are designed to serve as an important barrier against the spread of chemical pollutants into the aquatic environment but it is not clear how the activated sludge process will be impacted by the presence of CWAs. The goal of the current study was to evaluate the effect of malathion on the activity, performance, and ecology of activated sludge bioreactors. Malathion is one of many organophosphates (OPs) and is sometimes considered a simulant for VX, which is an OP CWA. This study employed respirometry, short term batch tests, and long term exposure experiments to investigate the effects of different concentrations of malathion on bioreactor performance and microbial community diversity. Respirometry results showed that the maximum respiration rates were approximately 47 ug O_2/min when the sludge was not exposed to malathion (i.e. controls). However, when malathion was added over a range of concentrations between 0.1 ppb and 5 ppm, the maximum respiration rates varied between 41 and 55 ug O_2/min. The shape of the oxygen consumption curves were identical in each case, beginning with a rapid, increasing respiration rate during the first 1.5 - 2 hours, followed by a gradual, nonlinear decline in the respiration rates until the experimental time reached ~ 4 hours when the respiration rates were generally between 6 -12 ug O_2/min. The relationship between the concentration of malathion and the maximum respiration rates were successfully captured using a dual use model that accounts for malathion as both a driver and inhibitor of inhibition. Short term batch tests showed that both chemical oxygen demand (COD) and ammonia-N removal were not negatively impacted by the presence of 0.1 – 3 ppm malathion. Short-term exposure to malathion is unlikely to interrupt microbial respiration, COD removal, or nitrification in the range of concentrations tested in this study. Long term continuous exposure (i.e., 30 days) inhibited both COD and N removal when the initial malathion concentration was 3 mg/L but no detectible malathion was present in the effluent. Long term exposure to 0.1 and 3 mg/L of malathion was associated with shifts in the abundance of species that are common to activated sludge.

26. The Effect of Duty Cycle on the Transformation of Organic Chemicals during Advanced Oxidation with Pulsed Ultraviolet Light Emitting Diodes

Robert Scott, Patrick Mudimbi, Brandon Stewart, Willie F. Harper, Jr., and Michael E. Miller | *Air Force Institute of Technology, Department of Systems Engineering and Management*
Matthew Magnuson and Stuart Willison | *U.S. Environmental Protection Agency, National Homeland Security Research Center, Water Infrastructure Protection Division*
Rebecca Phillips | *Oak Ridge Institute for Science and Education Research Participation Program*

Abstract

Military and civilian facilities may become contaminated as a result of an intentional or unintentional hazardous chemical release. Remediation may require large volumes of wash-down water, which will result in wastewater that may require pretreatment before entering a publicly-owned wastewater treatment plant. This study applied Ultraviolet Light-Emitting Diodes (UV LEDs) in an Advanced Oxidation Process (AOP) for the degradation of three test chemicals: Methylene Blue, tartrazine and Brilliant Blue FCF. AOP experiments were carried out with custom electronics and a stainless steel reactor containing seven LEDs, each with an output wavelength of 240 nm. UV light was applied using an energy-saving strategy called pulsed UV (PUV), a drive technique that forces light to turn on and off rapidly when operated according to a duty cycle (i.e. time on/total time in service). This operational strategy has the potential to extend the lifetime of the LEDs while also exploiting their size and durability. The results demonstrate an increased adsorption of the cationic Methylene Blue onto the quartz window of the LED as compared to the two anionic chemicals. Nonlinear, first-order degradation of each chemical was observed in 300-minute experiments. The final relative concentration of Brilliant Blue FCF was similar to Methylene Blue (0.2 at 100% duty cycle), however, the relative concentration of these two chemicals was lower than that of tartrazine (0.8 at 100% duty cycle) for a given duty cycle. The duty cycle was positively correlated with the first order rate constants (k) for all three chemicals but, interestingly, normalized first order rate constants (k/duty cycle) for each chemical increased when the duty cycle was 10% or less. These results demonstrate the potential of UV LED applications for liquid streams requiring pretreatment.

27. Developing Decontamination Methods to Address Indoor Pesticide Contamination from Improper Bed Bug Treatments

Emily Snyder, Lukas Oudejans, and Paul Lemieux | *U.S. Environmental Protection Agency, National Homeland Security Research Center*
Dennis Tabor | *U.S. Environmental Protection Agency, National Risk Management Research Laboratory*
James Starr and Daniel M. Stout II | *U.S. Environmental Protection Agency, National Exposure Research Laboratory*
Amy Mysz | *U.S. Environmental Protection Agency, Region 5, Land and Chemicals Division, Pesticides Section*
Barbara Wyrzykowska-Ceradini and Joshua Nardin | *ARCADIS G&M*

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 and the application of approved pesticide products that are applied improperly or at concentrations that far exceed the labeled rates. It is generally expected that the ongoing bed bug epidemic will result in a growing number of pesticide misuse incidents. EPA Regional Offices are often called on to assist local communities in remediating homes and businesses following indoor misapplications.

Currently, there are no cleaning procedures with known efficacies to reduce pesticide levels in contaminated structures. Occupants of contaminated homes may be exposed to high concentrations of pesticides and be forced to evacuate. If occupants attempt to decontaminate their home by themselves they may create toxic by-products or be exposed to decontamination agents with their own inherent risks.

This research aims to provide responding agencies with information to reduce occupant exposures. Findings will guide remediation needs and illustrate the potential effectiveness of cleaning agents. The poster will describe the effort to accomplish these objectives for neat malathion, carbaryl, fipronil, deltamethrin, and permethrin on select surfaces. Specifically, results for surface decontamination and dissipation studies will be presented for a model surface in a simulated indoor environment, with and without light. Results for surface decontamination of malathion and carbaryl technical formulations on surfaces will also be outlined and will be compared to the results from the neat pesticides.

28. Interaction of Cs-137 Fallout Surrogate on Urban Building Material Surfaces

Mark Sutton, Norris (Kip) Harward, | *Lawrence Livermore National Laboratory*
William Bernt | *Particle Characterization Laboratories, Inc*
Sang Don Lee | *US EPA National Homeland Security Research Center*

Abstract

Radionuclide contamination in Japan following the events at the Fukushima Daiichi facility have highlighted the need for a better understanding of the interaction of cesium (Cs-137) with porous outdoor materials. Environmental Protection Agency's Homeland Security Research Program is currently collaborating with Lawrence Livermore National Laboratory to evaluate the fate of Cs-137 on representative urban surfaces.

A wide body of data exists on Cs-137 migration in soil and plants following the events at Chernobyl, but data is limited on Cs behavior on porous anthropogenic materials, particularly those used for construction. Solid Cs-137 may undergo deliquescence or dissolution in atmospheric or standing water and be available for adsorption on (and migration into) porous materials. Adsorption of Cs-137 on granite, brick, limestone and concrete has been evaluated at 25 °C and compared to previously published data. Individual (conditional) distribution coefficients were determined for a range of solid: Cs ratios and compared to the surface potential and particle morphology. Urban construction materials (even when milled and sieved) are typically heterogeneous materials, often consisting of minerals such as quartz, hematite, calcite, dolomite, pyrite, clay, feldspar, hornblende, biotite and clays such as illite. A two-step adsorption mechanism was elucidated for Cs-137 interaction with granite, while single-step adsorption kinetics were determined for brick and limestone. Sorption magnitude and kinetics involving concrete were not consistent due to the formation of an amorphous layer. The results show that Cs-137 binds to the investigated surfaces in the order brick > granite > limestone, with limestone showing the slowest sorption kinetics. The relatively low porosity of granite was responsible for a higher retardation factor for Cs-137.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-667477.

29. Should I Coat My Building? Protecting Buildings from CBR Contamination

Catherine Toque and Matthew Simpson | *Defence Science and Technology Laboratory, UK*

Abstract

Specialist impermeable protective coatings are increasingly used to prevent contamination permeating porous surfaces in the industrial workplace. In the nuclear industry, these coatings facilitate both routine and end-of life decontamination and disposal. They either act as permanent barriers that stop contamination ingress, and so reduce the need for decontamination of the matrix, or they are peelable and thus also directly assist surface decontamination. These benefits are widely recognised.

However, there is reluctance to adopt similar measures to protect buildings in the wider public space where, for example, the effects of atmospheric pollutants (e.g. crusts, grime) are mitigated by regular cleaning and maintenance of external surfaces. The reluctance arises from concerns that: (1) there may be a long term impact

on the aesthetics or physical integrity of a building with such a coating, and (2) coatings may not have appropriate longevity or performance. This leaves porous external building surfaces potentially vulnerable to releases of chemical, radiological, or biological contaminants.

This project looked at the possibility of using commercial and novel coating technologies as protection against building contamination. Technologies incorporate functionalised silicon and flurocarbon chemistries, as well as nanotechnology. Marketing claims include vapour breathability together with hydro- or omni-phobicity, and hydrophilicity with self-cleaning or easy-clean properties, which potentially could have direct benefits to the protection and decontamination of external building surfaces.

Information from open sources was used to compare the marketing and technological claims against building requirements, as provided by building owners and other stakeholders, to identify if they were compatible. Technologies were assessed according to their ability to repel chemical, radiological or biological contaminants from technical data that was provided or inferred from the claims.

It was concluded that no technology could be identified as a universal treatment for all buildings, and that a bespoke approach was needed. Omniphobic coatings would be desirable to protect against the range of potential challenges, and novel formulations that combined a number of technologies (i.e., fluro-alkyl-silanes-with nanoparticulates) were potential future solutions, but required to be tested in relevant environments. Biomimetic formulations (such as those that mimic the Lotus leaf effect) were too technologically immature for deployment in the outside environment.

30. Destruction of Syrian Chemical Agents and the Field Deployable Hydrolysis System (FDHS)

Brian O'Donnell and Amy Dean | *U.S. Army, Edgewood Chemical Biological Center, Chemical Biological Applications & Risk Reduction Unit and Joint Program Executive Office for Chemical Biological Defense*

Abstract

This briefing will cover several topics associated with the destruction of the Syrian Chemical Agent and pre-cursor materials stockpile to include:

- Technology Selection, field deployable hydrolysis system (FDHS) Design, Fabrication, and System Attributes;
- Operation of the FDHS on the Cape Ray; and
- Successful Decontamination, Monitoring, and Sampling which led to the Return of the Cape Ray to Service.

The technology selection discussion of the presentation will cover the initial problem set, the timeline and limitations for destruction, the methodology for evaluating technologies, and the formulation of a complete solution set. The presentation will cover the changing destruction paradigm that occurred over 2013 and how the FDHS modular design was adapted to suit the operational environment and end state. The construction of the FDHS on the Cape Ray will be discussed to include the Cape Ray's attributes for performing the mission, and how the Cape Ray had to be retrofitted to allow for the operation of the FDHS and the number of personnel needed for the operation on the Cape Ray. The briefing will cover the overall destruction operation on the Cape Ray to include DF and HD operational experiences.

This briefing will also discuss the application of decades of decontamination and closure methods from the former production facilities, stockpile destruction facilities, and non-stockpile equipment to the Cape Ray FDHS. Through the application of a comprehensive program for contamination mapping, deconstruction and demobilization, decontamination, analytical sampling and unventilated monitoring the Cape Ray was returned to the Maritime Administration for unrestricted future use.

31. The Critical Reagents Program

Kristin Jones | *Patricio Enterprises supporting Joint Program Executive Office for Chem-Bio Defense, Medical Countermeasure Systems, Critical Reagents Program, Frederick, MD*
Bruce Goodwin, Mark Ballman, Eric Thompson, Bryan Necciai, Dr. Michael A. Smith | *Joint Program Executive Office for Chem-Bio Defense, Medical Countermeasure Systems, Critical Reagents Program, Frederick, MD*
Dr. Shanmuga Sozhamannan, Leigh Anne Alexander | *The Tauri Group, LLC supporting Joint Program Executive Office for Chem-Bio Defense, Medical Countermeasure Systems, Critical Reagents Program, Frederick, MD*

Abstract

CRP Overview

The Critical Reagents Program (CRP) serves as the principal resource of high quality, validated, and standardized biological reference materials, reagents, and assays that meet the technology-development and sustainment needs of the Department of Defense (DoD) and its partners. In 2007, the CRP instituted program-wide quality initiatives to integrate and execute formal quality management systems into all aspects of its program operations. The CRP Product Support Office is ISO: 9001-2008 certified; CRP production activities and associated reference standards qualification are registered under ISO Guide 34 and relevant ISO 17025, where appropriate. As such, the CRP provides the highest quality biological detection solutions to the DoD, international allies, and homeland defenders including the Department of Homeland Security (DHS) BioWatch Program.

CRP Support of Interagency Partners

The CRP supplies antigens (inactivated organisms), genomic material, antibodies, PCR detection assays, electrochemiluminescence (ECL) immunoassays, and lateral flow immunoassays (LFIs). The program also provides technical support to various programs within the US Government and the DoD Chemical and Biological Defense Program.

Recent Developments

In 2012, CRP launched their TARMAC initiative. TARMAC stands for the Targeted Acquisition of Reference Materials Augmenting Capabilities, and works to ensure that emerging threats and capability gaps are effectively addressed by ensuring new pathogen collections are relevant to the current mission space. Strains acquired through TARMAC are used to evaluate and improve the performance of existing assays and expand the products that are offered to CRP customers.

As a complement to TARMAC, the CRP created a pathogen data resource called CRPµTIC (the CRP (microbial) Threat Information Center). This data resource contains strain metadata, and phenotypic and genotypic characterization data on the strains contained in the Unified Culture Collection (UCC). The UCC serves as the foundation for a wide variety of CRP products, so these data greatly enhance the information available to a wide variety of CRP stakeholders. All strain acquisitions through the TARMAC initiative are also accessioned into the UCC and characterized for inclusion in CRPµTIC.

In FY15, the CRP is introducing online ordering for its customers. The system, dubbed OSCAR (Ordering System for CRP Assays and Reagents), integrates customer ordering with the entire fulfillment process — it's truly an end-to-end solution that allows customers to place orders online and have 24-hour visibility into their order status and history. The CRP office, government support laboratories, and contracted storage and distribution partners will all be using the system, so orders will always be updated in real time.

Appendix A
Agenda

DAY 1: TUESDAY, MAY 5, 2015
Auditorium, C-111

7:30 AM	**Registration**
8:00 AM	**Logistics** Lukas Oudejans, Conference Chair | *U.S. Environmental Protection Agency* **Welcome and Historical Perspective** Shawn Ryan | *U.S. Environmental Protection Agency* **Objectives of the Conference** Gregory Sayles | *U.S. Environmental Protection Agency*
General Session 1 - Connecting Response and Research Activities Auditorium, C-111. Presentations and Q&A moderated by Shawn Ryan and Leroy Mickelsen | *U.S. EPA*	
8:30 AM	**Science and Environmental Response Decision Making: Examples of Research Supporting Field Operations** Erica Canzler, Invited Speaker | *U.S. Environmental Protection Agency*
9:00 AM	**Emergency Response Research, Development, Education & Training: A Researcher-Responder Perspective** Joseph Barbera, Invited Speaker | *George Washington University*
9:30 AM	**Lessons Learned from Three Recent EPA Ricin Responses** Mike Nalipinski | *U.S. Environmental Protection Agency*
9:55 AM	**EPA Region 6's Two Recent Bio Responses** John Martin | *U.S. Environmental Protection Agency*
10:20 AM	**BREAK**
General Session 1 (cont.) - CBR Response Activities and Recovery Handbooks Auditorium, C-111. Presentations and Q&A moderated by Marshall Gray and Chris Gallo | *U.S. EPA*	
10:45 AM	**Destruction of Syrian Chemical Agents and the Field Deployable Hydrolysis System (FDHS)** Brian O'Donnell | *U.S. Army*
11:10 AM	**Indoor Contamination from the Fukushima Nuclear Power Plant Incident** Atsushi Tanaka | *NIEHS Japan*
11:35 AM	**Returning to Normality. The UK Recovery Handbook for Biological Incidents (UKRHBI)** Thomas Pottage | *Public Health England*
12:00 PM	**LUNCH**
General Session 1 (cont.) - Field Demonstration and (International) Program Review Auditorium, C-111. Presentations and Q&A moderated by Sarah Taft and Mario Ierardi | *U.S. EPA*	
1:00 PM	**Methyl Bromide Fumigation: *Bacillus anthracis* Inactivation, Emissions Containment, and Conservation of Sensitive Materials** Rudolf Scheffrahn | *University of Florida*
1:25 PM	**Hazard Mitigation Science and Technology Program for the DoD Chemical and Biological Defense Program (CBDP)** Charles Bass | *Defense Threat Reduction Agency*
1:50 PM	**UK Government Decontamination Service – Framework Assurance** Suzanne Young | *Department for Environment, Food and Rural Affairs*

2:15 PM	**Canadian Safety and Security Program Project for Infrastructure Mitigation for Rapid Response after a Radiological Incident** Matthew Magnuson | *U.S. Environmental Protection Agency*		
2:40 PM	**BREAK**		
Concurrent Sessions 1			
	Biological Agent Decontamination **Auditorium, C-111** **Moderated by Sanjiv Shah and Benjamin Franco | *U.S. EPA***		**Radiological Agent Response and Recovery** **Classroom, C-113** **Moderated by Jeff Szabo | *U.S. EPA***
3:00 PM	Development of Microemulsion Decontaminant Against Chemical and Biological Agents Lee Hwi Ang | *DSO National Laboratories*	3:00 PM	Providing First Responders with Scientifically Based Tools, Easy-to-Understand Protocols, and Actionable Guidance for Radiological Response and Recovery Benjamin Stevenson | *Department of Homeland Security*
3:25 PM	Novel Bio-decon Approach – DeconGel Vipin Rastogi | *U.S. Army, Edgewood Chemical Biological Center*	3:25 PM	Radiological Contaminant Stabilization Technologies Mark Sutton | *Lawrence Livermore National Laboratory*
3:50 PM	New Advanced Oxidant Generation Method for Large Area Biological Decontamination Brian France | *TDA Research, Inc.*	3:50 PM	Toward Best Practices for Gross Decontamination Methods in a Radiological Response Michael Kaminski | *Argonne National Laboratory*
4:15 PM	Decontamination of Large Spaces – Scopes and Limitations Marek Kuzma | *Institute of Microbiology of AS Czech Republic*	4:15 PM	Full-Scale Demonstrations of a "Toolbox of Options" for Radiological Incident Mitigation Technology Ryan James | *Battelle*
4:40 PM	Methyl Bromide Decontamination of Indoor and Outdoor Materials Contaminated with *Bacillus anthracis* Spores Morgan Wendling | *Battelle*	4:40 PM	Early-Phase Waste Staging for Wide-Area Radiological Incidents Paul Lemieux | *U.S. Environmental Protection Agency*
5:05 PM	**DAY 1 ADJOURNS**		

DAY 2: WEDNESDAY, MAY 6, 2015
Auditorium, C-111

General Session 2 – Data Models, Research Overviews and Remediation Plans
Auditorium, C-111. Presentations and Q&A moderated by Lukas Oudejans and Mike Nalipinski | *U.S. EPA*

8:15 AM	**Systems Analysis of the Data and Models Used for Federal Emergency Management** Ellie Graeden | *Gryphon Scientific*
8:40 AM	**An Overview of EPA Homeland Security Research Program's Biological Decontamination Research** Joseph Wood | *U.S. Environmental Protection Agency*
9:05 AM	**New York City (NYC) Department of Health and Mental Hygiene (DOHMH) Environmental Remediation Plan for Biological Incidents** Kobria Karim | *New York City Department of Health and Mental Hygiene* Shannon Serre | *U.S. Environmental Protection Agency*
9:30 AM	**Water Sector Decontamination** Marissa Lynch | *U.S. Environmental Protection Agency*
9:55 AM	**BREAK**

Concurrent Sessions 2

Biological Agent Detection Auditorium, C-111 Moderated by Worth Calfee and Shannon Serre | *U.S. EPA*		Water Infrastructure Decontamination Classroom, C-113 Moderated by Marissa Lynch | *U.S. EPA*	
10:15 AM	Independent Testing of Hand Portable Biodetection Equipment Rachel Bartholomew | *Pacific Northwest National Laboratory*	10:15 AM	Decontamination and Restoration of Critical Water and Wastewater Infrastructure Matthew Magnuson | *U.S. Environmental Protection Agency*
10:40 AM	Rapid Viability PCR Method for Detection of *Bacillus anthracis* Spores: Overview and Historical Perspective Sanjiv Shah | *U.S. Environmental Protection Agency*	10:40 AM	The Water Security Test Bed – A Pilot Scale Test Bed for Water Infrastructure Decontamination Stephen Reese | *Idaho National Laboratory*
11:05 AM	Development of a Rapid Viability PCR Method for Detection of *Yersinia pestis* in Water Samples Staci Kane | *Lawrence Livermore National Laboratory*	11:05 AM	Radiological Contaminant Persistence and Decontamination in Drinking Water Pipes Ryan James | *Battelle*
11:30 AM	Sample Preparation Considerations for Detection of Biological Threat Agents in Complex Environmental Matrices Richard Winegar | *MRIGlobal*	11:30 AM	Adherence of Contaminants to Drinking Water Storage Tank Sediments Jeff Szabo | *U.S. Environmental Protection Agency*
11:55 AM	**LUNCH**		

Concurrent Sessions 3

	Biological Agent Sampling Auditorium, C-111 Moderated by Tonya Nichols and Lawrence Kaelin | *U.S. EPA*		Water and Waste Water Treatment Classroom, C-113 Moderated by Hiba Ernst | *U.S. EPA*
12:45 PM	Efficient Sampling Strategies to Minimize Number of Samples Needed for Clearance Brett G. Amidan | *Pacific Northwest National Laboratory*	12:45 PM	Management and Treatment of Copious Amounts of CBR Contaminated Water and Wastewater Matthew Magnuson | *U.S. Environmental Protection Agency*
1:10 PM	Composite Sampling of a *Bacillus anthracis* Surrogate with Cellulose Sponge Surface Samplers from a Nonporous Surface Jenia A. M. Tufts | *ORISE Research Participant with U.S. EPA*	1:10 PM	Survivability and Disinfection of *Bacillus anthracis* Vegetative Cells in Drinking Water Lisa S. Smith | *U.S. Army, Edgewood Chemical Biological Center*
1:35 PM	Potential Use of Robotic Vacuum Cleaners to Sample Biological Contamination Thomas Pottage | *Public Health England*	1:35 PM	Deployable Treatment of Decontamination Effluents Jonathon Brame | *U.S. Army Corps of Engineers*
2:00 PM	Sample Analysis Laboratory Capabilities to Support Large Scale Environmental Responses Joseph Bogan Jr. | *MRIGlobal*	2:00 PM	Advanced Oxidative Process Treatment of Heavily Contaminated Water for Drain Disposal and POTW Acceptance Rebecca Phillips | *ORISE Research Participant with U.S. EPA*

Poster Session
Building B Atrium

2:25 – 4:00 PM

Poster Session of the Decontamination R&D Conference

Join us in the Building B Atrium to view posters and interact with poster presenters.

1	Improved Filter Holder and Extraction Protocol for Forensic Vacuum Collections
2	Evaluation of Oxidant Biocide Formulations for Soil Sanitation
3	Field Test Method Development for Hot Humid Air Decontamination of *Bacillus thuringiensis kurstaki cry*- HD1
4	Test Method Development for Hot Humid Air Decontamination of *Bacillus anthracis*
5	New Developments in the Solid Oxidizer Decontamination Technology – Dahlgren Decon
6	DAHLGREN DECONTAMINANT: Continued Development of a Solid Oxidizer Decontaminant
7	How Clean is Safe? The Detection of Chemical Warfare Agent at Ultra-Low Concentration After Decontamination
8	Metagenomic Profiling of Air Samples for Surveillance of Contaminated Environments

9	Ozone Decontamination Efficiency of Equipment
10	Facility Decontamination Strategy and Technology Selection Tool (DeconST)
11	Aerosol Delivery of Liquid Decontaminants: A Novel Approach for Decontamination of Complex Interior Spaces
12	Composite Sampling for Wide Area Decontamination of Anthrax
13	Electrochemical Generation of Chlorine Dioxide for Efficacy against Anthrax
14	Encapsulated CBD Waste for Reduced Cost Transport and Disposal
15	Automated Decontaminant Calculator
16	Evaluation of a Composite Sampling Method for Bacillus Spores on Clean Surfaces
17	Evaluation and Optimization of Sampling and Analysis Protocols for *Bacillus anthracis* for Underground Transport Restoration
18	Lung Epithelial Cell Model for Exposure Assessment of Stachybotrys Spore grown on PDA vs Wallboard
19	Enhanced Isolation of Viable *Bacillus* Spores Using Commercially Available Cell Lysis Solutions
20	EPA's Role in Strengthening Community Resilience
21	Initial Testing of Radionuclide Removal Methods to Decontaminate Low Activity Waste Melter Off-gas Condensate Liquid
22	Evaluation of Decontamination Methods against *Bacillus atrophaeus* on Packaging Materials
23	Bacteriolytic Enzymes Targeting Old Pathogens: Expanding our Biological Arsenal against Old Threats
24	Micro-vapor Chambers and Design of Experiments Approach for Investigating Vaporous Decontaminants
25	The Effect of Malathion on the Activity, Performance, and Microbial Ecology of Activated Sludge
26	The Effect of Duty Cycle on the Transformation of Organic Chemicals during Advanced Oxidation with Pulsed Ultraviolet Light Emitting Diodes
27	Developing Decontamination Methods to Address Indoor Pesticide Contamination from Improper Bed Bug Treatments
28	Interaction of Cs-137 Fallout Surrogate on Urban Building Material Surfaces
29	Should I Coat My Building? Protecting Buildings from CBR Contamination
30	Field Deployable Hydrolysis System and the Destruction of the Syrian Chemical Agent Stockpile

Concurrent Sessions 4			
Biological Agent Decontamination Equipment **Auditorium, C-111** **Moderated by Matthew Magnuson and Lawrence Kaelin | *U.S. EPA***		**Waste Treatment and Disposal** **Classroom, C-113** **Moderated by Jeff Szabo | *U.S. EPA***	
4:00 PM	Portable Decontamination System for FAD and CBR Response Bob Henderson | *Integrated Solutions for Systems Inc.*	4:00 PM	Field Demonstration of the "Aboveground Burial Enhanced with Phytoremediation" (ABEP) System as a Tool for Managing Animal Carcasses Following an Agroterrorism Attack or Disease Outbreak Gary Flory | *Virginia Department of Environmental Quality*
4:25 PM	Equipment Decontamination with Disinfectants and Mobile Pressure Washer with Water Containment Mat Craig Ramsey | *U.S. Department of Agriculture*	4:25 PM	Capture of Cesium from Combustion of Contaminated Biomass Using Sorbent Injection Paul Lemieux | *U.S. Environmental Protection Agency*
4:50 PM	Spray Equipment Selection for Wide Area Application of Decontaminants Richard Derksen | *U.S. Department of Agriculture*		
5:15 PM	**DAY 2 ADJOURNS**		

DAY 3: THURSDAY, MAY 7, 2015
Auditorium, C-111

General Session 3 - Biological Agent Reaerosolization
Auditorium, C-111. Presentations and Q&A moderated by Lukas Oudejans | *U.S. EPA*

8:00 AM	Understanding Reaerosolization and Exposure: What happened to "SPORE"? Marshall Gray | *U.S. Environmental Protection Agency*
8:25 AM	**BREAK**

Concurrent Sessions 5

Biological Agent Aerosols and Morphology of Spores Auditorium, C-111 Moderated by Joseph Wood and Michael Boykin | *U.S. EPA*		Chemical Agent Decontamination Classroom, C-113 Classroom, Moderated by Matthew Magnuson | *U.S. EPA*	
8:30 AM	Comparison of Reaerosolization of Anthrax and Surrogates from Common Outdoor Surfaces Alfred Eisner | *Alion Life and Environmental Sciences*	8:30 AM	Site Remediation of a 282,000 cu ft. Penicillin Production Facility Using Chlorine Dioxide Gas Mark Czarneski | *ClorDiSys Solutions, Inc.*
8:55 AM	Evaporation and Transport of Bodily Fluid Aerosol Droplets Howard Walls | *RTI International*	8:55 AM	Hydrogen Peroxide-Based "Self-Help" and Residue-Free Decontaminants for Chemical Warfare Agents George W. Wagner | *U.S. Army, Edgewood Chemical Biological Center*
9:20 AM	Development and Evaluation of Methods to Extract Aerosol Deposited Bacteria from Indoor Surfaces to Determine Bacterial Environmental Decay Ian M. Gut | *National Biodefense Analysis and Countermeasures Center*	9:20 AM	Integrated Decontamination Test and Evaluation System (IDTES) for Evaluation of Hazard Mitigation Technologies George Wrenn | *Battelle Hazardous Materials Research Center*
9:45 AM	High-Resolution Spore Coat Architecture, Assembly, and Morphology of *Bacillus* Spores A.J. Malkin | *Lawrence Livermore National Laboratory*	9:45 AM	Surface Decontamination of Blister Agents Lewisite, Sulfur Mustard and Agent Yellow Harry Stone | *Battelle Memorial Institute*
10:10 AM	**BREAK**		

General Session 4 - Decision Support Tools and Guidance Documents
Auditorium, C-111. Presentations and Q&A moderated by Paul Lemieux and Elise Jakabhazy | *U.S. EPA*

10:30 AM	Estimating the Cost and Time for Recovery from WMD or FMD Events Under Resource Constraints Robert Knowlton | *Sandia National Laboratories*
10:55 AM	Waste Estimation Support Tool for Developing Decontamination and Waste Management Strategies for Wide-Area Radiological Incidents Timothy Boe | *Eastern Research Group*

11:20 AM	Developing Biological Operational Response and Recovery Guidance for Rapid Return to Service of Underground Transportation Robert Fischer | *Lawrence Livermore National Laboratory*
11:45 AM	Challenges in Applying Old Data to New Paradigms in Wide-Area Urban Radiological Response and Recovery Michael Kaminski | *Argonne National Laboratory*
12:10 PM	Closing Remarks *NHSRC*
12:30 PM	**CONFERENCE ADJOURNS**

Appendix B
Participants

Bruce Akers
NCDA&CS EP Division

Erica Akers
NCSU

Andrea Allen
Department of Homeland Security

Brett Amidan
Pacific Northwest National Laboratory

Lee Hwi Ang
DSO National Laboratories, Singapore

Pervez Azmi
Environment Canada

Don Bansleben
Department of Homeland Security

Joseph Barbera
George Washington University

Rachel Bartholomew
Pacific Northwest National Laboratory

Charles Bass
Defense Threat Reduction Agency

William Batt
CTTSO/TSWG

Wayne Baxter
REAC/TS

Pamela Bayles
Jacobs

Andrea Beam
USDA-APHIS-PPQ

William Bell
TDA Research, Inc.

Kent Berg
Decontamination Professionals International, LLC

Doris Betancourt
U.S. Environmental Protection Agency

Madeline Bette
Sabre Technical Services

Mohammad Nazeem Bin Mustafah Kamal
National Environment Agency

Nathan Birnbaum
USDA APHIS

Timothy Boe
Eastern Research Group

Joseph Bogan
MRIGlobal

Michael Boykin
U.S. Environmental Protection Agency

Jonathon Brame
U.S. Army Corps of Engineers

David Brown
ANL

Tony Buhr
Naval Surface Warfare Center - Dahlgren Division

Kathryn Burns
Naval Surface Warfare Center - Dahlgren Division

Joan Bursey
U.S. Environmental Protection Agency

Anne Busher
CSS-Dynamac

Kirkley Cain
EPA-ORD-OPARM-RPPBPD

Worth Calfee
U.S. Environmental Protection Agency

Deborah Campbell
MIT Lincoln Laboratory

Erica Canzler
U.S. Environmental Protection Agency

Michael Carpenter
Idaho National Laboratory

Michelle Cawley
ICF International

Andrew Chia
DSO National Laboratories, Singapore

Margaret Chong
U.S. Environmental Protection Agency

Brian Combs
NC Public Health

Tod Companion
Department of Homeland Security Science & Technology/Interagency Office

Teresa Cremer
BioSAFE ENGINEERING

Francisco Cruz
U.S. Environmental Protection Agency

Mark Czarneski
ClorDiSys Solutions, Inc.

Joseph Dalmasso
Yakibou, Inc

Brent Daniel
Pacific Northwest National Lab

Scott Davison
Sandia National Laboratories

Timothy Dean
U.S. Environmental Protection Agency

Herb Dempsey
Xeruca Partners

Rich Derksen
USDA

Christina Devorshak
USDA APHIS PPQ

Diane Dixon
U.S. Environmental Protection Agency

Mark Durno
U.S. Environmental Protection Agency

Alfred Eisner
ALION/EPA

Gerald Epstein
Department of Homeland Security

Hiba Ernst
U.S. Environmental Protection Agency

Benjamin Ervin
MIT Lincoln Laboratory

Robert Fischer
LLNL

Richard Fitzpatrick
Avarint

Brian France
TDA Research

Benjamin Franco
U.S. Environmental Protection Agency

Christopher Gallo
U.S. Environmental Protection Agency

Kerry Garcia
USDA, APHIS

George Gardenier
U.S. Environmental Protection Agency, ORISE

Dianne Gates-Anderson
Lawrence Livermore National Laboratory

Erik Gaull
Applied Research Associates, Inc.

Rob Genova
United States Air Force Civil Engineer Center Emergency Management Division

Ellie Graeden
Gryphon Scientific

Marshall Gray
USPHS detail to USEPA ORD NHSRC

Kim Green
USDA

Steve Greenbaum
BAI, Inc.

Jayson Griffin
U.S. Environmental Protection Agency

Ian Gut
NBACC/BNBI

Wendell Hall
Missouri Department of Natural Resources

Wendy Hall
Department of Homeland Security

Douglas Hamilton
ORISE Research Participant

James Hanley
RTI International

Jasper (Joe) Hardesty
Sandia National Labs

Elsbeth Hearn
U.S. Environmental Protection Agency

Bob Henderson
IS4S

Michael Hennessey
APHIS-PPQ

Jonathan Herrmann
Creating Community Resilience, LLC

Dudley Hewlett
Uk Government Decontamination Service

Chris Hodge
NSWC Dahlgren

Kent Hofacre
Battelle

Janine Hutchison
Pacific Northwest National Laboratory

Mario Ierardi
U.S. Environmental Protection Agency

Elise Jakabhazy
U.S. Environmental Protection Agency

Ryan James
Battelle

Colin Johnson
U.S. Environmental Protection Agency

Kristin Jones
Critical Reagents Program

A. Neil Jones
Southeast Techinventures

Lawrence Kaelin
U.S. Environmental Protection Agency

Michael Kaminski
Argonne National Laboratory

Staci Kane
Lawrence Livermore National Laboratory

Amit Kapoor
First Line Technology

Jean Kim
RTI International

Brian Kleinman
U.S. Environmental Protection Agency

John Klostermyer
Steris Corp

Robert Knowlton
Sandia National Laboratories, U.S.

Dean Komm
USDA

Wenxing Kuang
Environment Canada

Marek Kuzma
Institute of Microbiology

Shawn Lafferty
U.S. Environmental Protection Agency

Ricky Langley
NCDHHS

Diane Lasher
U.S. Environmental Protection Agency

Wei Har Lau
National Environment Agency

Sok-Kiang Lau
DSO National Laboratories, Singapore

Earl Layton
METIS Scientific

Sang Don Lee
U.S. Environmental Protection Agency

Paul Lemieux
U.S. Environmental Protection Agency

Xiao Fang Lim
National Environment Agency

David Lipton
NC DHHS DPH

Bryan Luukinen
ICF International

Marissa Lynch
U.S. Environmental Protection Agency

Matthew Magnuson
US EPA/NHSRC

Alexander Malkin
Lawrence Livermore National Laboratory

Saverio Mancieri
LLNL

Blair Martin
Self

John Martin
U.S. Environmental Protection Agency

Keely Maxwell
U.S. Environmental Protection Agency

Daniel McCabe
Savannah River National Laboratory

Katrina McConkey
Booz Allen Hamilton

Don McLaughlin
U.S. Environmental Protection Agency

Tanya Medley
U.S. Environmental Protection Agency

Kathryn Meyer
ORAU

James Michael
U.S. Environmental Protection Agency

Leroy Mickelsen
U.S. Environmental Protection Agency

Ben Midyette
NC Public Health

Wendy Mills
U.S. Army Research Office - Contractor

Ong Ming Kwei, Alvin
Singapore National Environment Agency

Jason Musante
U.S. Environmental Protection Agency

Dwayne Myal
DHS/FEMA

Michael Myers
Sabre Companies, LLC

Michael Nalipinski
U.S. Environmental Protection Agency

Tonya Nichols
U.S. Environmental Protection Agency

Kathleen Nickel
HSRP

Brian ODonnell
Edgewood Chemical And Biological Center

Jeremy OKelly
Federal Bureau of Investigation

Lukas Oudejans
U.S. Environmental Protection Agency

Erdal Ozkan
Ohio State University

Lucas Pantaleon
Ogena Solutions

Cayce Parrish
U.S. Environmental Protection Agency

Renato Perez
University of Florida

Rebecca Phillips
U.S. Environmental Protection Agency, ORISE

Thomas Pottage
Public Health England

Lawrence Procell
U.S. Army ECBC

Ellen Raber
Lawrence Livermore National Laboratory

Christa Radford
NC DHHS

Craig Ramsey
USDA-APHIS

Vipin Rastogi
US Army, ECBC

David Rees
U.S. EPA - Region 10

Stephen Reese
Idaho National Laboratory

Karen Riggs
Battelle

Obhie Robinson
FEMA Region 4

Shawn Ryan
U.S. Environmental Protection Agency

Gregory Sayles
U.S. Environmental Protection Agency

Rudolf Scheffrahn
University of Florida

Gary Schmidt
PRI Bio

Caitlin Schreider
NBACC

Megan Schuette
U.S. EPA - Region 7

Shannon Serre
U.S. Environmental Protection Agency

Sanjiv Shah
EPA-NHSRC

Grace Silva
UNC Lineberger Cancer Center

Courtney Skuce
ICF International

Lisa Smith
Edgewood Chemical Biological Center

Emily Snyder
U.S. Environmental Protection Agency

James Starr
U.S. Environmental Protection Agency

William Steuteville
U.S. EPA, Region 3

Benjamin Stevenson
DHS S&T

Harry Stone
Battelle

Daniel Stout
U.S. Environmental Protection Agency

Kevin Strohmeier
KY Department for Environmental Protection Agency

Tammy Stundon
United States Air Force Civil Engineer Center, Emergency Management Division

Mark Sutton
Lawrence Livermore National Laboratory

Jeffrey Szabo
U.S. Environmental Protection Agency

Sarah Taft
EPA/ORD/NHSRC

Atsushi Tanaka
National Institute for Environmental Studies, Japan

Laura Thomas
ICF International

Bryan Tienes
NSWCDD

Catherine Toque
Defence Science and Technology Laboratory

Mark Tucker
Sandia National Laboratories

Jenia Tufts
ORISE Research Participant

Alexander Venzin
Pacific Northwest National Laboratory

Mandeep Virdi
MIT Lincoln Laboratory

Konstantin Volchek
Environment Canada

Karen Wade Cavanagh
Sabre Companies

George Wagner
U.S. Army Edgewood Chemical Biological Center

Howard Walls
RTI International

Morgan Wendling
Battelle

Art Werner
Amec Foster Wheeler Environment & Infrastructure

Russell Wiener
U.S. Environmental Protection Agency

Steven Wilkinson
ChemCentre

Richard Winegar
MRIGlobal

Stephen Wolfe
U.S. Environmental Protection Agency

Joseph Wood
U.S. Environmental Protection Agency

George Wrenn
Battelle Memorial Institute

Suzanne Young
Department for Environment, Food and Rural Affairs

Alice Young
Naval Surface Warfare Center - Dahlgren Division

Appendix C
Presentation Slides

See separate documents entitled:

Appendix C 2015 EPA Decon Conference Presentation Slides Vol I.pdf
(presentation slides)

Appendix C 2015 EPA Decon Conference Presentation Slides Vol II.pdf
(poster presentations)

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