Experimental Approaches to Inform Stormwater Modeling During Emergency Response and Recovery

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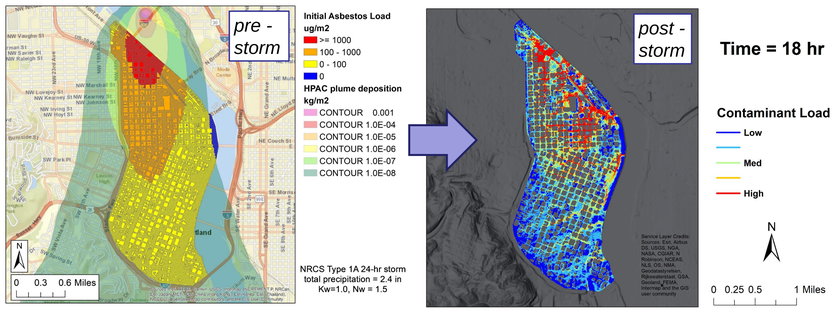
Background: Stormwater Modeling for Homeland Security Needs

- **Goal**: To better understand the impacts of precipitation and water application (for decontamination) on the fate and transport of chemical, biological, and radiological (CBR) agents released in the environment following natural or man-made disasters and to develop tools for tracking CBR agents over time.
- **Contaminant fate and transport challenges**:
  - CBR agents can be hard to detect
  - Urban environments are dynamic (rain, wind, foot/vehicle traffic)
  - Incidents may take years to remediate
  - Mitigation activities may further spread contamination
- **We can use stormwater modeling tools for dynamic contaminant mapping during response and recovery to support**:
  - Site characterization
  - Developing sampling plans
  - Determining waste staging areas
  - Resource allocation

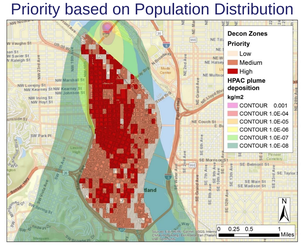
Modeling with EPA's Stormwater Management Model (SWMM)

- **EPA SWMM5** selected after broad survey of potential models
  - Public domain hydrologic & hydraulic model
  - Single event or extended period stormwater quantity and quality
  - Used widely in the USA and globally
- Additional tools used for contamination mapping:
  - **Open Water Analytics SWMM5 API** and **PySWMM** for pollutant values
  - Quasi-2D modeling (PCSWMM used to develop overland flow mesh)
  - Air model plumes (e.g., HPAC) for initial contamination loading

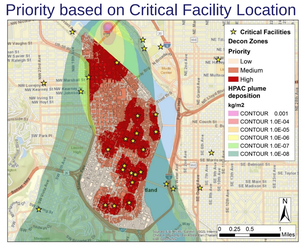


Can combine SWMM modeling results with additional geospatial data (e.g., population distribution, proximity to critical facilities) for decontamination prioritization and planning

Priority based on Population Distribution



Priority based on Critical Facility Location



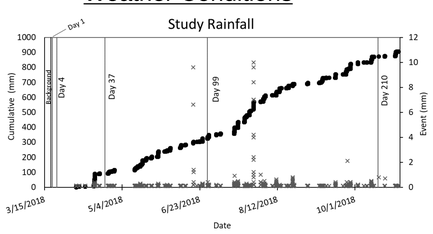
Field Studies to Inform Contamination Modeling Efforts

EPA Urban Watershed Facility, Edison, NJ (March – October 2018)

- How long does a biological agent simulant (*Bacillus atrophaeus* var. *globigii*, for *Bacillus anthracis*) persist on different outdoor surfaces?
- Assess outdoor sample collection method efficacies over time and for different surfaces (concrete, asphalt, vegetation/grass, soil)
- Site inoculated with *Bg* spores at 10^6 CFU/ft^2

Bacillus atrophaeus var. *globigii* (*Bg*) spores

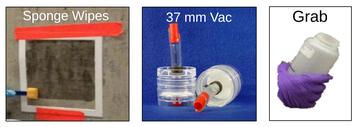
Weather Conditions



Sampling Results

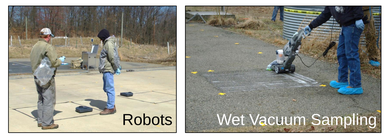
Traditional Biological Sampling Methods:

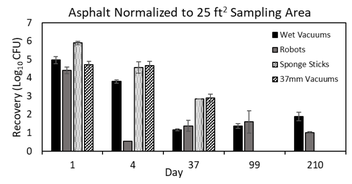
- Sponge wipes
- Grab samples (vegetation and soil)
- 37 mm vacuum cassettes

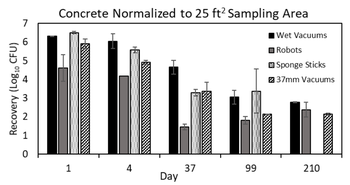


Emerging Methods:

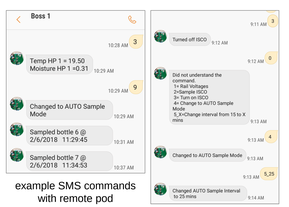
- Wet vacuums
- Robotic floor vacuums







Custom telemetry pods allow for remote control and communication with ISCO autosamplers, soil moisture probes (HydraProbe), and a laser disdrometer (OTT Parsivel²)

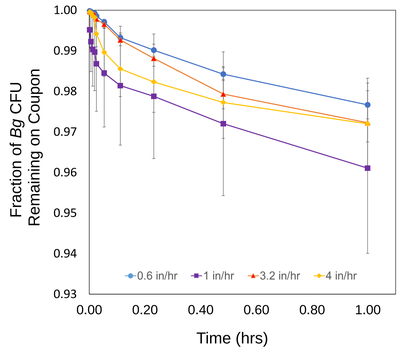


example SMS commands with remote pod

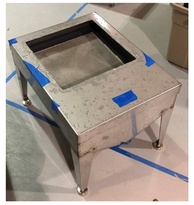
Fate and Transport Laboratory Experiments

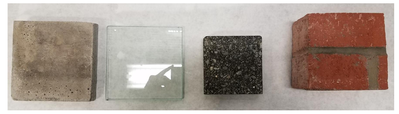
Rainfall Simulator

- Using a 26 ft. tall rainfall simulator to quantify spore washoff with varying rainfall intensity
- Tests conducted with two different *B. anthracis* spore surrogates
- Rainfall pattern tests ongoing



coupon holders

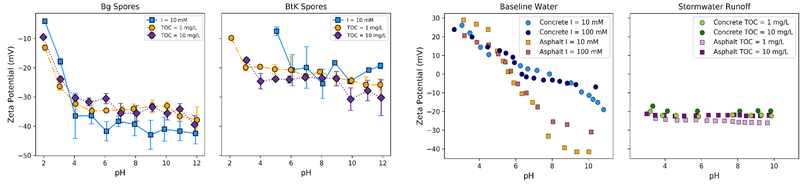




types of materials tested: concrete, glass, asphalt, brick

Zeta Potential and DLVO Modeling

- Lab experiments inform predictions of spore adhesion processes in urban environments (water chemistry dictates interactions)



Future Directions and Additional Information

Upcoming Research

- Additional long-term outdoor studies in different environmental conditions
- Develop and challenge new custom remote sensor and sampler telemetry capabilities at remote sites
- Rainfall simulator tests ongoing
- Quantifying spore detachment in overland flow

Sediment channel for overland flow experiments

For more information:

https://github.com/OpenWaterAnalytics (SWMM5 API and PySWMM)

https://www.epa.gov/homeland-security-research

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