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General Session 1 – Cross-Cutting Initiatives for Response and Recovery



U.S. EPA Efforts to Support Regions and Local Initiatives

Richard Yamada

U.S. Environmental Protection Agency

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How Science Makes Us Safer and More Resilient: Lessons From the Homeland

Juliette Kayyem

Harvard University

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How Homeland Security Research Augments State and Local Resiliency

Juan Reyes

Fairfax County, Virginia, Department of Public Works & Environmental Services

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Management and Disposal of Waste: A State Cooperative Perspective

Gary Flory

Virginia Department of Environmental Quality

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Wide Area Atmospheric Deposition of Asbestos Site-Specific Scenario (River Street Warehouse Asbestos Fire Emergency Response)

Randy Nattis

U.S. Environmental Protection Agency

This presentation is designed to provide participants with a thorough understanding of the procedures and activities the U.S. EPA used in conducting a Unified Command response to a fire that destroyed a 120-year-old, 78,000-square-foot warehouse and distributed Asbestos Containing Material (ACM) over a 3-mile by 1-mile area throughout downtown Portland, Ore. In coordination with the Oregon Department of Environmental Quality (ODEQ), the U.S. EPA deployed up to nine teams over 17 geographical divisions, which included public streets and parks, as well as commercial and apartment buildings, roof tops, and balconies. Additionally, the Unified Command also managed the warehouse burn pile while it continued to smolder and threaten additional ACM releases. This four-week response included working with multiple stakeholders, managing access issues, and supporting the city of Portland through an environmental crisis during the Rose Festival, which was located in the middle of the affected area and drew more than 500,000 attendees. The talk will cover technology used to track the assessment and remediation teams in real-time to maximize resources and minimize the disruption to normal city activities. An additional conversation will take place in regards to information collection, management and dissemination throughout the Unified Command to improve situational awareness, operations, risk assessment and decision making. This scenario could be easily modified for responding to a wide area / urban deposition of a Radiological or Biological assessment and remediation response scenario.

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U.S. EPA Research Supporting Homeland Security

Greg Sayles

U.S. Environmental Protection Agency

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Decontamination Efforts at Defense Threat Reduction Agency

Charles. A. Bass

Defense Threat Reduction Agency

The Defense Threat Reduction Agency (DTRA) RD has many efforts ongoing in decontamination and mitigation and remediation of chemical and biological threats. This presentation will include an overview of several projects ongoing at DTRA. One project has successfully utilized hot, humid air to decontaminate both large and small items to successfully demonstrate remediation of biological threats with no damage to sensitive equipment. This process is being further evaluated for chemical decontamination of small items including personal effects. DTRA is also conducting research into zirconium hydroxide (Zr(OH)4) to detoxify chemical agents. This includes development of a sprayable slurry to support immediate and operational decontamination of military vehicles and contaminated sites effectively and expeditiously. DTRA is also continuing work in the chemical agent disclosure sprays to support targeted decontamination, reducing decontamination time and conserving resources. Currently this technology is continuing development to demonstrate low-light performance and disclosure of opioid contamination.

DTRA has developed a new military standard test procedure to measure absorption and support development of low-absorption coatings to improve Chemical Agent Resistant Coatings (CARC) resistance to chemical agents. DTRA is also funding an effort to develop a temporary over coat for CARC to control agent absorption while preserving the optical performance of the underlying CARC. DTRA is also looking at wide area decontamination of chemical and biological agents. DTRA’s research also includes germination of anthrax to increase bacteria’s susceptibility to decontamination. This could allow for less harsh, lower volume, environmentally benign decontaminants and development of high-throughput, low-volume spray applications systems which decontaminate anthrax spores over large complex areas.

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Laboratory to Field: Characterizing Decontamination Effectiveness Through Exposure Assessments

Brent A. Mantooth

U.S. Army Edgewood Chemical Biological Center

The overarching goal of decontamination technologies is to provide hazard mitigation and prevent negative health effects in personnel that must interact with contaminated assets (e.g., vehicles, buildings). To determine if personnel will experience negative health effects, one must determine the dose of contaminant personnel would receive while interfacing with the decontaminated assets. Limits on field testing against real chemical agent on full-scale assets inhibits directly obtaining this data. Consequently, testing must rely on materials-level, lab-scale tests to determine doses of contaminant that personnel may receive while interacting with full-scale decontaminated equipment. Typically lab-scale testing has focused on characterizing efficacy in terms of how much agent remains on a material after a decontamination process by extraction techniques. However, these data do not enable direct calculation of exposure dose to unprotected personnel.

To determine if a decontamination process will prevent negative health effects requires an exposure assessment which requires data in the form of vapor emission source terms. These source term data are used to calculate potential exposure doses using modeling and simulation (M&S) tools. This talk will demonstrate how to compute potential exposure doses from laboratory measured vapor source terms to determine if materials have been sufficiently decontaminated to make them safe for acute exposures (i.e., short time duration). From this work we show that the capability to predict source terms requires an understanding of the underlying mass transport processes occurring during both the contamination and decontamination processes.

Further, the efficacy of a decontaminant depends on its ability to access and remove contaminant absorbed in the bulk of materials. The ability to bridge the gap from laboratory to field for assessing decontamination effectiveness depends on the ability to convert laboratory-measured source terms to field-scale personnel dose using computational-based exposure assessments.

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Omics in Space (OIS): Biological Detection in Remote Place

Kasthuri Venkateswaran

National Aeronautics and Space Administration (NASA)

The Omics in Space (OIS) project, a biological detection system development for remote place, is charted to develop instrumentations for extracting nucleic acids (NA) and sequencing methodologies for insitu detection and measurement of biomolecules related to physiological and immunological effects related to spaceflight (e.g., aging, crew health, elevated antimicrobial resistance, and virulence). Onboard the International Space Station (ISS), we will generate data related to microbiome (targeted for bacteria, fungi, and viruses) to address the microbial composition, metagenome (crew and environments) for functional characteristics, miRNA for immunological function, as well as epigenetic data to elucidate radiation-induced damage, cellular disruption, and aging of astronauts.

Since Sanger's founding discovery of dideoxynucleotide sequencing, researchers have successfully developed automated DNA sequencing instruments to rapidly sequence biological materials. Generating large data sets remained difficult throughout the 1990s, but next generation sequencing (NGS) platforms emerged in 2005 to solve this issue and lower cost barriers. The interplay and optimization of chemistry, engineering, software, and molecular biology with NGS development enables the examination of previously unresolvable biological questions. The ability to generate genome-scale datasets is transforming the nature of biological inquiries and investigations.

The next generation sequencing using the MinION platform and PCR instruments (SmartCyler and RAZOR) were adopted by the National Aeronautics and Space Administration (NASA) in 2016 and were successful in sequencing libraries that had been prepared on Earth and shipped to the ISS.  
Limitation in this study was that samples had to be prepared on Earth before sequencing could be performed on the ISS, as there are no technologies in place to process samples, extract biomolecules, and prepare libraries for NGS sequencing in space or remote areas. The OIS team recognizes these limitations and is developing an automated Sample Processing Instrumentation for NA extraction that is streamlined, requires minimal labor time, reducing the amount of contamination between samples, and producing consistent results.

The state-of-the-art molecular methods targeting to differentiate viable microorganisms developed by NASA will allow researchers to not only describe the changes in microbial communities in remote areas, but also distinguish whether these biological signatures are of potential pathogens. Focused and targeted molecular approaches are likely to reveal a subset of medically important microbes posing particular threats to human health. The OIS project will deliver knowledge that can be used to develop countermeasures to mitigate the relevant risks for non-NASA programs. The OIS database generated will contain metadata that enables to evaluate microorganisms that potentially increase virulence.

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Concurrent Session 1 – Regional, State, and Local Initiatives



Fentanyl Toxicity, Exposure, and Risk

John Lipscomb

U.S. Environmental Protection Agency

The same properties that make chemicals valuable for industrial manufacturing processes can make them hazardous to humans, and the same properties that make some drugs valuable as therapeutic agents makes them toxic when they are abused. Applying peer reviewed risk assessment approaches to relevant toxicity information for chemicals can identify human doses or exposure concentrations expected to produce certain levels of risk; these doses and exposures can then be translated into environmental concentrations by applying information quantifying human-environment contact. This approach is used to develop regulatory enforceable exposure limits and non-enforceable exposure guideline values. Fentanyl is a uniquely potent therapeutic agent, and intentional and inadvertent human exposures have proven lethal. This opioid targets receptors in the brain to cause respiration to decrease, then cease, causing death. It is readily absorbed through oral and inhalation exposures, however, the penetration of powdered fentanyl across dry and intact skin seems unlikely. Nonetheless, all three routes of exposure are important regarding human exposures. Toxicity data from oral dosing studies are more frequently available because of the certainty and ease of oral dosing, and because of the uncertainty of absorption when conducting dermal exposures and the expense associated with inhalation exposures. But for humans, inhalation and dermal routes of exposure are also important. There is no default approach for a route to route extrapolation of toxicity, so chemical-specific pharmacokinetic approaches based on chemical-specific data are necessary. Regardless of the route of exposure, once absorbed into the bloodstream, fentanyl distributes to the brain, causing toxicity. This presentation will review pertinent human and animal toxicology results for fentanyl and pharmacokinetic models that predict fentanyl blood and brain concentrations. The use of data like these to establish exposure guideline values (e.g., Regional Screening Levels) will be shown and the value of such guideline values in establishing clean-up goals will be explored.

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Fentanyl Decontamination Studies: Dahlgren Decontamination

Evan Durnal

MRIGlobal

MRIGlobal performed multiple trials on the ability of Dahlgren Decontamination (Decon) to effectively degrade and therefore decontaminate Fentanyl HCl and Carfentanil HCl powders on a glass surface, fentanyls in solution, as well as characterizing the effluent for both known and unknown degradants. Our operational definition of efficacy is the chemical destruction via molecular disassembly of the target threat. Efficacy is not simply the physical separation or displacement of the threat chemical. Both decontamination time and ratio of decontaminant to threat were evaluated on a limited scale.

Dahlgren Decon offers promise in the decontamination of bulk and solubilized Fentanyl HCl and Carfentanil HCl in relatively short reaction times. Dahlgren results are statistically reproducible (n=5 for each condition) and remove over 99.9% of the target material within 5 minutes. The LD50 of Fentanyl HCl is unknown; Fentanyl Citrate (similar salt) has been reported as low as 0.03mg/kg in Monkeys. The Fentanyl HCl results are roughly 280X lower than the mass required (2.04mg) to kill 50% of exposed 150lb (68kg) humans; Carfentanil HCl results are roughly 130X lower than the mass required (0.02mg). Extrapolated, current data suggests that an appropriate (at least 5:1) volume of Dahlgren Decon could potentially neutralize (to the LD50 level) around 200mg of fentanyl and 2.5mg of Carfentanil. The resultant area and/or containers should still be carefully handled, as active ingredient may still be present but at significantly less hazardous levels, and without generating hazardous waste or by-products. This is not final field guidance on use, but rather an important data point in the path toward a final answer to the opioid decontamination problem.

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Trust and Stigma: Analyzing Community Considerations in Emergency Response

Keely Maxwell

U.S. Environmental Protection Agency

Trust in government is fundamental to local acceptance of clean-up. Yet the U.S. EPA and other agencies working to clean up contaminated sites may encounter local resistance to removal and remediation strategies, concerns about stigma, and conflict over cleanup levels. Agency interactions with the public and other stakeholders have real consequences for protecting human health and the environment when disaster strikes; for example, debris disposal after Hurricane Maria was stymied in part by islanders’ rejection of air curtain incineration. During emergency response, residents may not heed recommendations for evacuation, prophylactic medicine, or cleanup self-help. Additionally, the U.S. EPA staff often encounter public distrust of government agencies that affects the cleanup timeline. Social science research provides a systematic understanding of why these challenges arise and how to address them effectively. For example, it sheds light on what aspects of trust are most relevant to decontamination decisions, how trust is lost, and how to rebuild it.

Decontamination research has produced important scientific and technical information on sampling, analysis, cleanup strategies, and waste disposal for chemical, biological, and radiological materials. To date, however, there has not been a comprehensive analysis of the social science of decontamination. This research project fills a knowledge gap by conducting an interdisciplinary, systematic literature review of the social science of environmental cleanups for emergency response, removal, and remediation. The review provides scientific confirmation that labor practices, public trust, social identity, worker physical and mental health, and property values affect and are affected by cleanups. It also identifies areas where more research is needed. First, further analysis is needed of cleanup situations that have had limited coverage in existing social science studies, such as decontamination following bioterrorist threats or infectious disease outbreaks. Second, new research should field-test public engagement strategies for building trust and reducing stigma. Third, the principal methodology for measuring local benefits of cleanup has been economic analysis of property values. Additional schema for capturing community outcomes are needed.

Overall, this literature review makes three main contributions: 1) It provides a better understanding of the community complexities that the U.S. EPA encounters in emergency response and removal; 2) It identifies research gaps in decontamination social science; and 3) It supports development of social-science based tools to add to the U.S. EPA’s toolkit.

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Management and Disposal of Vehicles Following a Wide Area Incident

Colin Hayes

Eastern Research Group, Inc.

Following a wide area incident, it is assumed that a large number of vehicles will be left unattended within the impacted area. The resource demand required to gather, transport, store, treat, recycle, or dispose of these vehicles may overwhelm local, state, and federal recovery efforts. Incidents involving chemical, biological, radiological, or nuclear (CBRN) contaminants further complicate recovery efforts, and management and disposal activities are expected to be impacted by given the contaminant and the state of the vehicles at the time of and following contaminant release (e.g., on/off, windows open/closed).Because of this, research efforts to reduce the cost and time associated with assessing, collecting, and recycling or disposing of contaminated vehicles resulting from a wide area incident are necessary. This presentation will summarize research findings resulting from a comprehensive literature review and stakeholder workshop. Specifically, findings addressing the following topics and important data gaps requiring further research will be presented:

• Identification and estimation of the amount and type of vehicles present in a geographical area

• Collection and transportation of large numbers of impacted vehicles

• Vehicle contamination characterization

• Vehicle decontamination/reuse or recycling/disposal considerations

• Mass decontamination or disposal of large numbers of vehicles

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Municipal and Commercial Equipment Assets and Their Use in a Radiological Response and Recovery Event

Michael D. Kaminski

Argonne National Laboratory

A timely response and recovery effort requires equipment assets that are immediately available and practical guidance for their effective use. Common municipal and commercial equipment could support specific goals associated with radiological response and remediation in the time-frame before a federally-coordinated effort. In order to facilitate the development of ideas and methods for the use of such equipment, we proposed specific missions or scenarios organized under five “Support Goals”. These missions should not be considered exhaustive, but are intended to address specific scenarios that might be considered probable and to promote out-of-the-box thinking of potential uses of equipment. The common initial state for all scenarios is that contamination has spread over a wide area of the city. First responders have completed their response protocols to provide a preliminary spatial assessment of the radioactive levels. Life-saving operations have been completed.

The five Support Goals are:

1. Survey and monitoring
2. Mitigation of received dose to first responders
3. Decontamination (gross and final)
4. Waste management
5. Containment of wastewater

All scenarios under the Support Goals ask the same question – What types of municipal and commercial equipment can be used to complete the scenario activity and do we have sufficient data to recommend their use and predicted efficacy? To develop a list of answers to the scenarios posed, we solicited responses from various subject matter experts across the country and the United Kingdom. We reviewed citywide all-hazards response documents and radiologically-specific response documents; distributed a survey to local and regional emergency management and response personnel from around U.S.; and held workshops, teleconferences, and meetings to brainstorm and discuss potential options and identify gaps in our approach.

This information was collected in the form of a list of tools. This list contains a description of the equipment and its potential use, the primary advantages and limitations, and opportunities for gathering additional data on its efficacy. We will report on the technologies ranked according to their potential impact in addressing the major needs under each of the Support Goals. We will also discuss additional recommendations made by subject matter experts as we work toward providing a guidance document on the best practices and efficacy of methods. We intend that such a document will facilitate the development of detailed local recovery plans across the country and for U.S. allies.

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Concurrent Session 1 – Water Infrastructure Protection and Decontamination



Research for the Kinks, Loops, and Twists in the Water Cycle During Recovery From Contamination Incidents

Matthew Magnuson

U.S. Environmental Protection Agency

Unintentional (industrial spills, natural disasters, transportation accidents, etc.) and intentional (terrorist, cyber, criminal, etc.) contamination incidents can result in a vast array of interrelated response and recovery activities. For example, wide area decontamination may result in the use of large volumes of water, which must then be managed as contaminated wastewater. At the same time, sufficient water must be available to supply daily customer needs as well as recovery operations, possibly necessitating onsite treatment and reuse of wash water for continued recovery operations.

The term “water cycle” summarizes many processes that influence water in the environment. During recovery from contamination, many interrelated issues cause the normally predictable water cycle to be out of expected sequence as recovery contains “kinks, loops, and twists” that end-users have to effectively navigate.

This presentation will explore the U.S. EPA’s Homeland Security Research Program (HSRP) activities in providing the science to support responses to a variety of potential water contamination incidents. It will address a variety of potential contaminants, including crude oil, *Bacillus globigii* (anthrax surrogates), radionuclides, fluorinated fire retardants, organophosphate compounds (pesticides and nerve agents), and other contaminants of emerging interest.

HSRP research topics include 1) underlying science of contaminant fate and transport such as permeation of organic contaminants into plastic pipes; 2) experiments from bench- through full-scale for distribution system and premise plumbing decontamination, including by chemical treatment and flushing; 3) application of innovative, mobile, on-demand technologies for treatment and management of large volumes of wastewaters; and 4) the effects of chemical and biological contaminants on activated sludge and receiving waters, to demonstrate the effects that contamination incidents may have on wastewater treatment facilities and how to mitigate those effects.

This research supports water/wastewater utilities that may be impacted by chemical, biological, and radiological contamination incidents, aiding them with determination of the extent of contamination, potential response strategies, and the effectiveness of potential decontamination responses.

Further, this research assesses potential concerns related to the disposal of treated and untreated decontamination waste streams and other contaminated effluents. In this manner, water utilities can navigate the “new”  
geometry of the water cycle to integrate all inter-related response technical aspects, and, more importantly, position themselves for response to the next incident.

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Improving Water Sector Preparedness Through Laboratory Full-Scale Exercises

George Gardenier

U.S. Environmental Protection Agency

Drinking water and wastewater systems face a number of challenges when confronting a contamination incident. Whether the contamination happened because of a natural disaster or due to an accidental or intentional release, several key decisions need to be made. These include how best to access the analytical laboratory support that will be necessary to respond to the incident and return the water system to service. The decisions made and actions taken during the response, remediation and recovery processes will depend on the circumstances of each incident. Therefore, responders and water utility personnel can benefit from tools that help utilities practice and update their response plans and decontamination strategies.

During a water contamination incident, laboratories and utilities will need to reach out to the appropriate analytical partners to help confirm the identity of the contaminant, characterize the extent of contamination, and verify that cleanup efforts have been successful. The Water Laboratory Alliance (WLA) provides a nationwide network of analytical laboratories that are available to provide water and wastewater utilities with the analytical capabilities and capacity to assist with the response to a contamination incident. Practicing the coordination between the utility and laboratory communities in advance of an incident is important for ensuring an efficient and appropriate response during an emergency. The Water Laboratory Alliance program in the U.S. EPA’s Water Security Division has developed tools and resources to aid the water sector in preparing for and responding to chemical, biological or radiochemical contamination incidents. One such resource is the Analytical Preparedness Full-Scale Exercise (AP-FSE) Toolkit. This toolkit provides water utilities with the necessary information to plan and conduct a laboratory full-scale exercise. The toolkit outlines a step-by step process for how to design, initiate and implement an exercise involving coordination between the water utility and laboratory sectors. The toolkit includes a chemical and a biological scenario, as well as relevant templates and forms for developing the necessary exercise documentation and training, and for collecting evaluations and feedback to assist the implementation of an exercise improvement program. The toolkit has been piloted with five utilities and is scheduled to be released in early 2018.

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Decontamination Research at U.S. EPA’s Water Security Test Bed

Jeff Szabo

U.S. Environmental Protection Agency

The U.S. EPA Water Security Test Bed (WSTB) supports full-scale drinking water distribution system research on a variety of drinking water topics including biofilms, water quality, sensors, and homeland security related contaminants. Located at Idaho National Laboratory, the primary component of the WSTB is 450 feet of 8-inch diameter used cement-mortar lined iron drinking water pipe excavated from the ground and reassembled above ground. Since 2014, the WSTB has been used to perform experiments on decontamination of *Bacillus* spores from water infrastructure with chlorine dioxide, decontamination of Bakken oil from water infrastructure via flushing, and treatment of biologically contaminated wash water. This presentation will provide an update on the following previously unreported decontamination research experiments conducted in recent years:

* A model home plumbing and appliance system was built in a building adjacent to the 450 feet pipe. The plumbing is attached to the 450 feet pipe via a 1-inch diameter service connection. The plumbing and appliance system was contaminated with *Bacillus* spores and Bakken oil (in separate experiments), and decontamination with flushing (Bakken oil) and chlorination followed by flushing (*Bacillus* spores) was performed. Like in the 450 feet pipe, flushing reduced the levels of oil components (measured as benzene, toluene, ethylbenzene, xylenes, and total petroleum hydrocarbon) to undetectable levels. Flushing and chlorination reduced the number of *Bacillus* spores in the plumbing and appliance system by 6 to 7 log. However, spores were still detected in the water phase, which suggest that more aggressive decontamination techniques may be needed.
* Previous experiments showed that chlorine dioxide was ineffective at decontamination of *Bacillus* spores from the 450 feet pipe. Therefore, a more aggressive form of decontamination called pigging, or physical scouring of the pipe interior, was attempted. Pigging with a slurry of ice (ice pigging) was ineffective, but pigging with a chain cutter (a spinning chain that scours the inner pipe surface) followed by chlorination reduced the number of spores attached to the pipe interior by 4 log. Spores were still detected on the pipe surface after pigging and chlorination. Future experiments, including pipe relining, will be discussed that could address the issue of residual spores on the pipe interior surface after aggressive decontamination techniques have been implemented.

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Water Based Spore Fate and Transport: From Lab to Field Scale

Anne Mikelonis

U.S. Environmental Protection Agency

In the event that a biological agent release results in the contamination of a wide area, understanding how the agent spreads during precipitation and washing is important to efficiently and effectively sample and decontaminate surfaces. This presentation will highlight work performed at the US Environmental Agency’s National Homeland Security Research Center (NHSRC) in RTP, NC and the Urban Watershed Research Facility in Edison, NJ. At RTP the work included the determination of washoff coefficients for *Bacillus thuringiensis kurstaki* (Btk) and *Bacillus globigii* (Bg), simulants for *Bacillus anthracis*, from concrete and asphalt using a rainfall simulator.

These coefficients are in the process of being field verified using real rain events and collection of runoff water from a non-trafficked parking lot at the U.S. EPA’s Edison facility. In addition, a number of washing tests have been performed in RTP as well as in the field using a power washer and garden hose for removal of the spores. This presentation will compare rain vs manual washing for removal and transport. It will also discuss the technology that was developed in order to conduct this research including the construction of two rainfall simulators, coupon holders for washoff, automated runoff samplers and telemetry for field sensors compliant with the U.S. EPA server regulations. The results of resulting information is available for use in anthrax specific parameterization of stormwater models and operational cleaning procedures for washing roadways.

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Use of Small Scale Physical Models for Conducting Transport and Decontamination Experiments

Sujoy Roy

Tetra Tech, Inc.

There is a long engineering history of using small-scale models for performing controlled experiments in numerous domains. In recent decades, however, much environmental fate and transport research has been conducted with mathematical models. Although mathematical models are versatile, there is a still a need to explore and confirm behavior at the laboratory scale, especially for substances with properties for which limited field data exist. In the specific area of decontamination research, small-scale models are beneficial because performing field-scale studies, even with substances that are analogs to potential contaminants of concern, is a challenge.

Here we describe the processes associated with the development of a small-scale printed model for decontamination studies. In this work we have focused on a particular urban area, and developed prototype three-dimensional “prints.” We describe the specific software and instrument requirements for developing these physical models, and discuss the additional factors that must be considered for an effective scale model.

These include the surface coatings and textures that must be considered and an effective scaling of hydraulic properties, such as raindrop size and sheet flow velocities. The physical model being developed is complemented by an InfoWorks ICM model (part of the SWMM family of stormwater transport models) of the subject area. The outcome of this work is one or more physical models that may form the backbone of a variety of fate/transport and decontamination experiments in future work.

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General Session 2 – Chemical, Biological, and Radiological Research Efforts



Cooperative Efforts Within Homeland Security

Shawn Ryan

U.S. Environmental Protection Agency

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Disaster and Chemical, Biological, Radiological, and Nuclear (CBRN) Preparedness and Response: U.S. Coast Guard and U.S. EPA Working Together

Dana Tulis

United States Coast Guard

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Cooperative Biological Engagement Program

Lance Brooks

Department of Defense

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Non-Governmental Organization (NGO) Perspectives From International Ebola/Health Emergency Response

Amanda BenDor

PATH

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Concurrent Session 2 - Biological Agent Decontamination



Underground Transport Restoration Following a Biological Incident

Shannon Serre

U.S. Environmental Protection Agency

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Combining Spore Germination and Hot Air Treatment to Reduce the Costs and Time, and Lower the Temperature for Hot Air Decontamination

Tony Buhr

Naval Surface Warfare Center – Dahlgren Division

Aims: To add a spore germination step prior to hot air decontamination in order to reduce decontamination temperature and time requirements from the current Joint Biological Agent Decontamination System, which is ≥75°C, ≥72 h, 70-90% RH, down to ≤60°C for ≤24 h.

Methods and Results: Extensive testing resulted in an optimized germinant formulation with L-Alanine, inosine and calcium dipicolinate. A single germinant application followed by heat treatment could inactivate >2 log10 (>99%) of spores. However, a repeat germinant application was needed to achieve the objective of ≥6 log10 spore inactivation out of a 7 log10 challenge: a repeat cycle with a 2 h germinant application, followed by 60°C, 90% RH treatment for 1 h, followed by a 16 h germinant application, followed by another 60°C, 90% RH treatment for 1 h showed approximately 6 log10 spore inactivation. Additional tests have shown that temperature optimization may further improve germination efficiency.

Conclusions: Including the temperature and relative humidity ramp-up/ramp-down times, this testing achieves the objective of ≤60°C for ≤24 h within the space constraints of a small environmental chamber.

Significance and Impact of the Study: The 60°C goal is targeted because many materials are tested and qualified at 60°C (140°F). The reduction in time and temperature (and possibly the elimination of RH) may result in improved materials compatibility, and broader applications and user acceptance compared to hot, humid air decontamination alone, which is currently specific only to C-130 aircraft.

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U.S. Air Force Aircraft Decontamination Demonstrations

William Greer

Air Force Research Lab

Aircraft decontamination presents a serious challenge for the Department of Defense (DoD). Several DoD organizations have identified aircraft decontamination as a critical need due to the nature of their missions (humanitarian aid, high-threat environments, etc.) and the limited numbers of specialized aircraft available to support such specific missions. Despite these needs, the only decontamination methods approved for use on US Air Force aircraft are weathering and Hot Soapy Water, which have very limited efficacy on exterior surfaces and cannot be used for interior decontamination.

For over a decade, the US Air Force has studied, matured, and demonstrated emerging technologies for chemical/biological (CB) decontamination that are safe for use on sensitive aircraft systems. While focused on key Air Force assets, like the C-130 and F-35, decontamination systems that are suitable for full-scale decontamination of these sophisticated air vehicles should also be suitable for other vehicles and/or equipment for all DoD Services and beyond. This research culminated in two full-scale decontamination demonstrations that will be presented: the Joint Biological Agent Decontamination System (JBADS) Joint Capability Technology Demonstration (JCTD) and the CB Live Fire Test & Evaluation (LFT&E) for the F-35 Joint Strike Fighter.

The JBADS JCTD demonstrated a 7-log reduction of a biological warfare simulant in 4 days on a recently decommissioned C-130H using BioThermal Decontamination (BTD). BTD uses hot-humid air to effectively neutralize biological threats without adversely affecting aircraft systems. The aircraft was treated in an insulated, conformal enclosure that supported simultaneous interior and exterior decontamination. JBADS is now a formal acquisition program with conservative estimates of potential fielding in 2020.

The first LFT&E for CB decontamination was completed for the F-35 program in March 2017. The LFT&E consisted of six decontamination trials -- three chemical simulant trials and three biological simulant trials -- and two different F-35 variants (CTOL and STOVL). In each trial, the aircraft was sealed in an insulated enclosure with a CB-resistant liner that was specifically designed for the LFT&E. Within the enclosure, successful decontamination was accomplished using Hot Air Decontamination (HAD, hot-dry air) in 7-12 days, depending on the trial (chemical versus biological) and the starting challenge.

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Using Low-Concentration Hydrogen Peroxide to Decontaminate a Home From *Bacillus anthracis*

Leroy Mickelsen

U.S. Environmental Protection Agency

The U.S. EPA Consequence Management Advisory Division of the Office of Emergency Management and the U.S. EPA’s National Homeland Security Research Center (NHSRC) are providing information to the response community on decontamination technologies for restoring sites contaminated with biological, chemical, or radiological agents. For biological remediation technologies, this project focused on evaluating “low-tech” solutions for decontaminating building materials contaminated with *Bacillus anthracis* (Ba) spores.

We evaluated the sporicidal efficacy of low-concentration hydrogen peroxide (LCHP) vapor in a typical residential home. The LCHP vapor was generated from a 3% hydrogen peroxide (HP) aqueous solution placed in commercial off–the-shelf humidifiers. The potential application of this method would be for homes and small businesses near a contaminated area but not in the exclusion zone. These structures may be sparsely contaminated with Ba.

Decontamination resources would be occupied leaving homes and small businesses near the contaminated area without access to remediation options.

Tests were conducted using spores of *Bacillus atrophaeus* var. *globigii* (Bg) and *Geobacillus stearothermophilus* (Gs), both non-pathogenic surrogates for Ba. Coupons and biological indicator (BI) containing Bg and Gs spores, respectively, were placed in a typical single-family home which was subsequently fumigated with LCHP.

The technique consisted of (1) inoculating coupons of carpet and galvanized metal, (2) fumigating the home, coupons (inoculated with Bg) and BIs (inoculated with Gs), and (3) evaluating the viable spores recovered after decontamination and comparing the results to positive controls.

Results show that LCHP vapor disseminated by humidifiers can be an effective sporicidal surface decontamination technique to help reduce potential indoor exposure to Ba. In some configurations, test coupons exhibited a six-log reduction in recovered spores. This method makes Ba self-decontamination accessible to the public; however, details on how to best deliver this technology to the public during an emergency are currently being framed.

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Concurrent Session 2 – Chemical Agent Research



Chemical Hot Air Decontamination of Sulfur Mustard Contaminated Personal Effects

Kevin Morrissey

U.S. Army Edgewood Chemical Biological Center

Chemical Hot Air Decontamination (CHAD) has been shown to be effective at removing/detoxifying absorbed chemical warfare agents from materials, such as coating systems, after an extended aging period. The Defense Threat Reduction Agency (DTRA) has recently funded an effort to evaluate humidified CHAD as a process to decontaminate sulfur mustard (HD) from the personal effects of fallen warfighters. Thorough decontamination of personal items is essential before an item can be returned to the warfighter’s family members as a keepsake. Items evaluated in this study include coins, military patches, nylon webbing, ID cards, and pocket knives. Traditionally, surfaces that readily absorb chemical warfare agents (such as fabrics, etc.) present a significant decontamination challenge. Complex features, such as grooves and multi-material interfaces also present significant challenges for decontamination.

The Decontamination Sciences Branch (DSB) of Edgewood Chemical Biological Center (ECBC) performed a series of experiments to evaluate the benefit of using humidified CHAD to improve the decontamination procedure for personal effects from chemical causalities after an extended aging period. Prior to humidified CHAD treatment, all samples were subjected to a bleach pre-treatment procedure. Contaminated samples were then placed into small item vapor chambers (SIV) at CHAD conditions (170°F, ~20% RH, and 2 air changes per hour). Samples were removed at specified time points to develop decontamination profiles for HD on each material. Humidified CHAD treatment provided a significant reduction of remaining HD compared to the bleach pre-treatment only control for the test substrates.

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U.S. Department of Defense Model Development for Chemical Warfare Agent (CWA) Post-Decontamination Off-Gassing Hazard Estimation

Timothy J. Bauer

Naval Surface Warfare Center – Dahlgren Division

The Department of Defense defines requirements for chemical warfare agent (CWA) decontamination efficacy in terms of human effects toxicity. Following contamination of a piece of military equipment or a surface on a vehicle, aircraft, or ship, the decontamination process is expected to reduce hazards to unprotected personnel from inhalation of off-gassing vapor below operationally relevant levels. Decontamination testing is done at the laboratory and chamber scales to measure the vapor flux from test coupons or panels subjected to a contamination, weathering, decontamination, and drying cycle. Cost and schedule determine the number of tests than can be conducted, and test infrastructure limitations determine the range of environmental and contamination conditions that can be tested. Further, vapor flux cannot be directly interpreted in terms of human inhalation exposure. A series of modeling products are being developed from theory and test data to: estimate vapor off-gassing profiles from decontaminated military systems, determine the atmospheric transport and dispersion (ATD) in the near-field region, and interpret vapor exposure in terms of human effects based on defined proximity and duration. This presentation provides details on the models being developed and the end-to-end evaluation process from threat to human response. The Decontamination System Performance Model (SPM) combines theory with test data to simulate post-decontamination off-gassing for a given CWA-decontaminant-environment combination. The Near-Field Downwind Hazard Model (NFDHM) combines off-gassing profiles generated by the Decontamination SPM to represent a military system and performs the ATD computations to estimate human exposure at specified locations. The Health Effects Test Guide (HETG) provides guidance on defining the threat and operational conditions and ties results from the NFDHM to human effects. HETG process results can be compared to defined threshold values to determine if decontamination efficacy requirements will be met.

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Engineering the Organophosphorus Acid Anhydrolase Enzyme for Increased Activity on Chemical Nerve Agents

Steve Harvey

U.S. Army Edgewood Chemical Biological Center

Catalytic enzymes offer the potential for rapid decontamination of nerve agents under conditions of neutral pH and ambient temperatures. The wild-type Organophosphorus Acid Anhydrolase (OPAA; EC 3.1.8.2) enzyme has relatively high levels of activity against G-type nerve agents and slight levels of activity against V-agents. Several generations of OPAA mutants created primarily at the Y212, V342, and I215 sites have resulted in enzymes with large increases in catalytic efficiency on five different G-agents (kcat/Km ~108 M−1 min−1; the highest levels yet reported for these substrates) and lesser improvements in activity on four different V-agents (kcat/Km ~104 M−1 min−1). One mutant was also produced with broadened stereospecificity on Russian VX such that both enantiomers of Russian VX are catalyzed at similar rates. In combination with stability data, results suggest the potential for a broad range catalytic decontaminant using the OPAA enzyme.

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Decontamination Options for Sensitive Equipment-Related Materials Contaminated with Persistent Chemical Warfare Agents

David See

Battelle

Sensitive equipment may become contaminated following a release of a chemical warfare agent (CWA) in critical infrastructure (e.g., a transportation hub), and would require decontamination. Due to the high costs and long lead times associated with procurement of sensitive equipment, the decontamination approach has the additional requirement that the process should not degrade the equipment materials or deter functionality of the equipment so that it can be retained for future use. Many traditional and efficacious decontaminants are known to be corrosive and would impact the functionality of (electronic) equipment. This investigation is focused on identification of technologies that are simultaneously both efficacious in decontamination of CWAs and compatible with sensitive equipment-related materials.

Literature searches were initially conducted to gather information related to decontaminants that are either demonstrated or anticipated to be simultaneously efficacious and material-compatible. Forty-five decontamination technologies were identified from the data collected.

Technologies were ranked based on their demonstrated or anticipated CWA decontamination efficacy and compatibility with common sensitive equipment-related materials. Based on the ranking results, three technologies were selected for bench-scale decontamination efficacy testing: Dahlgren Decon by First Line Technology, EasyDECON DF200 by Intelagard®, and the Handheld Electrochemical Decon Apparatus (HDA) by TDA Research, Inc.

Bench-scale laboratory testing included the determination of the efficacy of the technologies to decontaminate three common sensitive equipment-related materials contaminated with CWAs VX and HD: ABS molded plastic, acrylic, and aluminum. Coupons of each material type were contaminated with a single 2 microliter droplet of either VX or HD. 60 minutes following contamination, 100 microliters of one of the candidate decontaminants was applied onto the contaminated area of the coupon and allowed to react with the CWA on the coupon surface for 60 minutes. Following the decontaminant reaction period, the coupon was first wiped to recover residual CWA and then subsequently extracted in solvent. The total CWA mass remaining following decontamination was based on recovery from the wipe sample and extraction of the coupon, and was used to calculate percent efficacy for the candidate decontaminant.

Concurrently, compatibility of the three test decontaminants with the three sensitive equipment-related materials were assessed qualitatively. Visual observations of the interactions between the decontaminants and materials were made, and any obvious changes (any corrosion, deterioration, damage, or any effect otherwise) in the appearance of the coupons (e.g., changes to the color, reflectivity, or apparent roughness of the coupon surfaces) documented. Results of this study will be discussed in terms of efficacy of each decontamination approach and path forward to provide recommendations to end users on clean-up options for sensitive equipment.

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Concurrent Session 3 − Biological Agent Sampling & Analysis Methods



U.S. EPA Sampling and Analysis Science Tools

Sarah Taft

U.S. Environmental Protection Agency

Following a chemical, biological, or radiological incident, the U.S. EPA will oversee site characterization and remediation of contaminated water systems and indoor and outdoor areas. Contamination characterization may be required during the cleanup operations to assess progress, to characterize waste streams, and to inform clearance decisions. The U.S EPA’s National Homeland Security Research Center (NHSRC) develops standardized sample collection and analysis methods and strategies for characterization of contamination to support emergency response field personnel and laboratories. The overall research objective is to provide the science needed to establish sampling strategies for indoor and outdoor areas and water systems that provide the maximum amount of information regarding the extent of contamination while minimizing the sampling and laboratory resources required. ESAM is a website developed by NHSRC to support the entire environmental characterization process from collection of samples all the way to their analysis (https://www.epa.gov/homeland-security-research/sam). This website includes searchable methods queries and downloadable documents. During a large environmental response, ESAM provides responders and laboratories the single best available sample collection and analysis method. When this method is used, those making decisions based on the data, can feel confident about the integrity of the data and can more easily interpret what it means and communicate it to the general public. NHSRC ensures that ESAM includes methods for the highest priority contaminants and are updated with the most recent methods. To support ESAM, NHSRC develops novel sample collection techniques and analysis methods, and evaluates existing sample collection and analysis methods for traditional environmental matrices including air, water, soil, surfaces, wastes, and wastewater. Collectively, the ESAM’s sampling and analysis tools will help local, state, and federal emergency response field personnel and the supporting laboratories more efficiently respond to incidents enabling smooth transitions of samples and data from the field to the laboratory to the decision makers.

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Sample Analysis of Native Filters for Characterization and Extent Mapping of Biological Incidents

Scott Nelson

Battelle

Following an outdoor biological threat agent (BTA) incident, U.S. EPA has a role and responsibility to support protection of human health and the environment, which, in part, will include environmental sampling to determine the extent and magnitude of contamination. The U.S. EPA, in partnership with Battelle, is investigating the feasibility and limitations of using laboratory testing of native air filters (NAFs) – i.e., filtration media that are in use for other applications such as ambient air quality monitoring or in building or vehicle filtration systems – to rapidly estimate the geographic scope of contamination following detection of a BTA dissemination. However, NAFs used for this purpose may have previously collected ambient particulate matter that can adversely affect analytical methods used to detect and quantify the target analyte. This study seeks to understand the compatibility of NAFs with current U.S. EPA analytical procedures for detection of *Bacillus anthracis*.

The findings and results generated from this research will better inform the U.S. EPA and local government decision-makers on environmental sampling strategies to characterize the extent of contamination following outdoor dissemination of a BTA and potentially reduce the cost and recovery time.

NAFs from air quality monitoring sites in four geographic regions, two filter types (PM2.5 and PM10), and various ambient particulate matter loadings (including unused), were obtained. Additionally, new-, mid-, and end-of -duty cycle filters from a building HVAC system, subway car HVAC system, subway platform ventilation system, and bus air intake filter were obtained.

*Bacillus anthracis Sterne* (BaS) spores were spiked onto ~4 cm2 swatches of filters (or a quarter of 47-mm diameter filters) with a target of 30, 300, and 3,000 total spores. Following the U.S. EPA research procedures for spore recovery from filters, the recovered spore suspensions, with associated ambient particulate matter that also was recovered with the spores, were analyzed using U.S. EPA-established methods for culture enumeration method using TSA II (TSA with 5% Sheep Blood) and a duplex rapid-viability (DRV)-PCR method.

Limited samples were also cultured and enumerated using a Brilliance *Bacillus cereus* chromogenic agar. Preliminary results and findings will be presented that demonstrate a measurable impact of the ambient particulate matter on the ability to quantify and identify the BaS. Other findings associated with the implementation and execution of the method will also be presented.

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Rapid, Quantitative Biological Indicator System with *Bacillus thuringiensis* Al Hakam Spores

Yoojeong Kim

Triton Systems, Inc.

Biological agents pose high threats, because they are invisible and odorless and a relatively small amount can infect a large population when released in a densely populated area. For the same reasons, assuring safety after cleaning decontaminated sites can be challenging. Currently available technologies require considerable labor, and results typically cannot be obtained before 24 – 48 hours up to 7 days. Therefore, a system that can detect the effectiveness at a shorter period in a less labor-intensive manner can lessen the burdens of decontamination. Desired traits for such a system are: 1) suitable simulants for *Bacillus anthracis* spores, 2) various materials for spore strips, 3) simple and rapid, 4) quantitative, and 5) portable. Our rapid and quantitative biological indicator (BI) system with *B. thuringiensis* Al Hakam spores assesses the viability of the spores quantitatively within 12 hours. It is comprised of a self-contained biological indicator and an incubator/detector system. The main components of the biological indicator are a glass ampoule with an assay mixture and a strip inoculated with *Bt* Al Hakam spores. After an exposure to a decontamination treatment, the ampoule is broken so that the assay mixture will come in contact with the spore strip. Then, the vial is incubated at 37°C in the incubator/detector unit, and fluorescence is monitored to provide a quantitative number of viable spores. The assay evaluates the ability of the spores to germinate and carry out protein synthesis as a measure of the viability of the spores. It is based on the activity of an enzyme that is synthesized during spore germination and vegetative growth.

When the spores germinate, the substrate is taken up by the spores and is hydrolyzed by the enzyme into a highly fluorescent compound. The enzyme activity and, thus, fluorescence generation are further enhanced by promoting outgrowth and vegetative growth of the spores. A single spore can be detected within 10 – 12 hours, whereas 107 spores can be observed in < 3 hours.

Triton’s rapid, quantitative BI system is capable of estimating the spore population within ±1 log and allows a reduction in the time to verify 7-log destruction by 12 – 36 hours, when compared to most of current BIs. It also enables quantification of the outcome to accelerate the development of new protocols for military and commercial health care applications. It has no or a very low possibility of contamination during manipulation for culture, because it is self-contained. The procedures for culture and detection are simple, and the incubation/detection system is portable. It provides not only decontamination assurance in the field, but also the capability to model the decontamination kinetics for emergency responses or developing new decontamination systems for biological agents.

A part of this work was funded by the Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD) through the CBD SBIR Phase II under U.S. Army Research Office Contract No. W911NF-16-C-0074. The content of the information does not necessarily reflect the position or the policy of the Government, and no official endorsement should be inferred.

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Strategies for a Bioaerosol Air Sampling Network Following a Wide Area Attack

Jonathan Thornburg

RTI International

Following the wide area release of a biological agent, like *Bacillus anthracis*, one source of uncertainty confronting decision makers is the degree to which reaerosolized organisms present a public health hazard.

Bioaerosol sampling methods deployed as individual samplers or as an integrated network may provide federal agencies, like the U.S. EPA, another option for responding to a wide area biological incident. This study assessed whether a bioaerosol sampling network could cost-effectively detect spores reaerosolized from urban surfaces.

We performed the air sampling network assessment in two phases. Both phases incorporated publicly available information on bioaerosol sampler performance, spore emission rates, meteorology, and estimated cost. The first phase used Excel models to assess the types of bioaerosol samplers that should be considered for the more detailed assessment. In the second phase, we developed a system performance model (SPM) in MATLAB to optimize the bioaerosol sampling network design for detection probability and minimize cost. We evaluated four different bioaerosol network strategies deployed in two cities, Denver, CO and New York City, NY.

Phase 1 results determined that current commercially-available point and stand-off, real-time bioaerosol sensors do not have the sensitivity to detect resuspended spores. Calculated bioaerosol concentrations, even near the point of resuspension, were always less than 1000 agent-containing particles per liter. Therefore, we developed four bioaerosol network strategies based on 1) low flow filter samplers, 2) high flow filter samplers, 3) native samples like building ventilation filters, and 4) a combination of the three.

Preliminary Phase 2 results using the SPM found that a ratio of 1:4 high flow to low flow samplers, 80 total, detected bioaerosol concentrations of less than 10 colony forming units per cubic meter for up to 30 days following an attack. A significantly higher density network comprised solely high flow or low flow samplers provided equivalent detection capability but also doubled the period of detection. These results were based on a limited range of spore resuspension rates, human activity levels, and meteorological conditions.

Further work will expand the range of data inputs and include strategy 3. The outcome will be an optimized network design for each city to provide the highest probability of bioaerosol detection for the maximum time period balanced against the cost of the network.

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Concurrent Session 3 – Radiological Agent Research



Estimating Post-Radiological Contamination Scenario Local to Regional Scale Cesium-137 Ambient Impacts from Wildfire

Kirk Baker

U.S. Environmental Protection Agency

Radiological release events can potentially contaminate wide areas with radiological materials and decontamination efforts are typically focused on populated areas leaving radionuclides in forested areas for long periods of time. Large wildfires in contaminated forested areas have the potential to reintroduce these radionuclides into the atmosphere and cause exposure risk to first responders and downwind communities. The most notable radionuclide contaminant released from radiological incidents is Cesium-137 due to high yields and long half-life of 30.2 years. From Chernobyl and Fukushima incidents, high levels of Cesium-137 have been measured in vegetation and litter and wildfires have been identified as a mechanism by which this contaminant can be redistributed in the environment.

A Eulerian 3D photochemical transport model was used to estimate potential ambient impacts of Cesium-137 re-emission due to wildfire following hypothetical radiological release scenarios in Denver, CO and Los Angeles, CA. Cesium-137 emissions were based on laboratory measurements that were adjusted to reflect post-incident levels using data collected in a forest near Fukushima. The Community Multiscale Air Quality (CMAQ) model version 5.2 was applied to an area covering northern Colorado and southern California using 4 km sized grid cells and the vertical atmosphere from the surface up to approximately 15 km with emissions from all known anthropogenic (e.g., vehicles, power plants, etc.), biogenic (vegetation), and geogenic (wildlandfire) sources. Emissions from a large hypothetical wildfire were introduced into the wildland-urban interface (WUI) impacted by a previous hypothetical radiological release event and PM cesium impacts resulting from the hypothetical wildfire were estimated for a variety of meteorological conditions to capture the full potential extent of downwind population exposure. PM cesium distribution values were obtained from the recent U.S. EPA’s laboratory simulation study that examined the partitioning of cesium-133 (a non-radioactive isotope of cesium) between airborne particulate matter and residual non-entrained ash when pine needles and peat were doped with cesium. This type of information is intended to provide context for understanding what level of exposure mitigation may be necessary for communities downwind of wildfires in areas of recent radiological contamination.

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Interactions, Dynamics, and Migration of Caesium from Building Materials

Thomas Hofmann

ZHAW Zurich University of Applied Sciences, Switzerland

Background

There are several historical examples of nuclear accidents which have had major national or global effects. Correspondingly, there is much information concerning environmental contamination and human health effects, but very little on how to effectively decontaminate exposed building surfaces.

In more recent times, the main risk of exposure to radioisotopes has shifted from nuclear accidents to the intentional release of nuclear products by terrorist groups. Indeed, a number of organisations are known to have attempted to acquire radioactive materials such as uranium, cobalt, caesium and strontium for use in "dirty bombs" - devices which use conventional explosives to disseminate radioactive materials over a potentially large area.

The major implication of this development is that urban areas may become heavily contaminated with radioactive materials. Therefore, the lack of knowledge on how radioisotopes interact with building materials and a corresponding dearth of information on how to effectively decontaminate buildings is a priority research area.

The purpose of this study is to evaluate the interaction of a common element (caesium) associated with a dirty bomb in order to understand the absorption kinetics and thus determine the window of opportunity for effective decontamination.

Moreover, the project will then identify the optimal technical approach for performing building decontamination and compare current decontamination products and methods on market.

Examples of migration

Due to the structure, porosity and the different crystal structure of the four natural materials (concrete, roof tiles and sandstone) a wide range of concentrations were found. Additional the way of contamination, the not "lab-scale" handling of the heavy materials as well the long-term storage and transportations had some influences as well.

Chemically the materials are totally different: concrete has by itself and by its supplement aggregates a rather good affinity to the big Cs-ions, Roof tiles show no such behaviour, just capillary effects.

Regarding decontamination with common products at different times its seen, that the products which were used for decontamination at privet sides (Belfor lattices) and the Nato grade products from Christanini (BX24, BX40, SX34) were in most cases as good working as tab water (M10) and remove about 50% of the contamination. Planning accessibility to detergent the result that with normal water in most cases the same results as with industrial tested detergent can be achieved is a factor which improves the resilience to an acceptable level because water, even in a catastrophic situation will be more available then special treatments with an enormous prices and similar performance.

In this issue, the procurement offices have to be informed and trained to ask for reliable test methods with real Caesium.

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Large Area Mitigation Using a Water-Based Formulation for Rapid Response After a Radiological Incident

Jaleh Semmler

Canadian Nuclear Laboratories

Environment and Climate Change Canada developed a rapidly deployable, water-based formulation for use in early-phase mitigation after a major radiological or nuclear incident in an urban area. The operational readiness of this technology was established in a decontamination/mitigation technology demonstration trial in June 2015, organized by the U.S. Department of Homeland Security (DHS) and U.S. EPA. Pilot tests were subsequently carried out at Canadian Nuclear Laboratories to mitigate five infrastructure materials including concrete, patio stone, limestone, brick and asphalt contaminated with Co-60, Sr-85, Cs-137 and Am-241.

Of the common building materials studied (six inch by six inch coupons), asphalt was the easiest material to mitigate because of its hydrophobic properties. Concrete and limestone were less effectively mitigated as their porous hydrophilic surfaces allowed penetration of radionuclides into water-filled pores in the substrate facilitating adsorption or ion exchange and making the radionuclides difficult to remove. Brick was the most difficult material to mitigate because the major component of brick is clay which retains most mono- and divalent ions. The removal of Co-60, Sr-85 and Cs-137 from the surfaces of concrete, limestone and brick increased when the pH of the radionuclide solutions used to contaminate the coupons was moderately acidic to neutral compared to when they were highly acidic.

Fresh concrete patio stone and aged asphalt (two foot by two foot coupons), selected as common urban materials of roads and parking lots, were contaminated with either Co-60 or Cs-137 solutions and then mitigated using a common house-hold carpet vacuum cleaner which mimics a street and/or parking lot sweeper. Tests were carried out to compare the effectiveness of mitigation using deionized water (simulating rain fall) and the water-based formulation. This work presents results of the pilot tests and the dependence of the process effectiveness on the properties of the contamination and mitigation solutions and of the substrate.

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Real-time, Low-Cost, High Efficiency In-Situ Radiological Threat Agents Detection Using Tensioned Metastable Fluid Detectors

Rusi Taleyarkhan

Purdue University

Highly challenging to detect (yet, most health-environmentally consequential) radiological threat agents pertaining to weapons of mass destruction are neutron-alpha radiation emitters: Pu/U and fission fragments. Alpha-neutron radiation is x20+ more lethal than gamma-beta radiation and in fact, the dose-conversion factor for 239Pu-235U-222Rn-210Po (neutron-alpha-fission) isotopes can be ~10^6 mRem/micCi whereas, only ~ 10^3 mRem/micCi for gamma-beta emitters, 131I or 137Cs.

Unfortunately, present day detectors are costly ($50K to $500K+), cumbersome-heavy, and can require long times for off-site forensics testing. Additionally, a different nuclear detector technology is needed for identifying isotopes that emit neutrons vs alpha separated from gamma/beta. Such systems readily get saturated in 1R/h+ gamma-beta fields.

Field-worthy real-time detection/forensics of trace (dispersed) levels of neutron-alpha radiation emitting radiological threat agents could be game-changing.

Purdue University, along with Sagamore Adams Laboratories, LLC have developed a novel nuclear radiation sensor technology – referred to as tensioned metastable fluid detector (TMFD) sensors. TMFDs offer low-cost, robust, lightweight 100% gamma-beta blind capability (even in 1,000 R/h background) for high efficiency (80%-95%+) spectroscopic detection of range of alpha-neutron emitting radiological agents in air-soil, in near-real time and~1 keV resolution.

Briefly, tensioned (yes, sub-zero pressure) fluids are in state of metastability; their intermolecular bonds weakened such that, select stimuli types can “poke” nm holes to create transient bubbles that can rapidly (within mics) grow to states that are visible-audible to humans. Amazingly, hard to detect sub-atomic neutral particles like neutrons or ions (tell-tale signatures from U/Pu nuclear fission) can be now detected with unparalleled intrinsic efficiency [1-2]. Unlike complex/expensive conventional sensors for radiation detection which rely on electronics, PMTs, scintillators, etc., TMFDs offer an intuitive alternative.

The presentation of TMFD sensing technology will highlight the key enabling features, and, if feasible, PU/SAL team will also be able to offer live demonstrations (together with video footage for identifying high-consequence, trace level radiological threat agents. With active attendee participation.

At the 2016 IEEE SENSORS international competition, our demonstration and paper were awarded 1st Prize [3].

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Concurrent Session 4 – Biological Agent Research



Preserving Viability of BioWarfare Vegetative Cells in Environmental Samples

Vipin Rastogi

U.S. Army Edgewood Chemical Biological Center

Following an intentional or accidental bio release, environmental sampling is crucial to determine the zones of contamination, threat assessment before the remedial action, and to confirm the effectiveness of remedial treatment. Retention of viability of bacterial cells in environmental samples collected to result in a colony-forming unit is central to such assessment analyses. Despite recent advancement in nucleic acid sequencing technologies, a realistic threat assessment and positive identification of BW agents in environmental samples must be made through the ability of cells to form a colony-forming units after culturing. Loss of viability during the period between collection and analysis renders such studies difficult. An exhaustive investigation was completed to determine the viability of Gram-negative *Yersinia pestis* (avirulent A1122) cells under permissive and non-permissive conditions. Solutions have been identified to preserve the viability of pathogens contained within clinical samples, but many of them have not been examined for their ability to preserve biological warfare (BW) agents in environmental samples. The purpose of this study was to systematically examine preservation materials that allow retention of viability of *Y. pestis* vegetative cells in samples stored under non-permissive temperatures, i.e. 37 ᵒC. The results show effectiveness of four solutions out of 17 tested preservatives, which are capable of retaining viability of avirulent derivative of *Y. pestis*, when stored under non-refrigerated regimes. The same four solutions were demonstrated to preserve the viability of *Y. pestis* sampled off two surfaces, concrete and steel, for a period of up to 14 days at ambient conditions of 25 or 37 ᵒC. Furthermore, the genomic DNA was found to be of high-quality, when three targets were amplified in non-viable samples.

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Colony Forming Unit Versus Enrichment-Polymerase Chain Reaction Assay for Sensitive Detection of *Bacillus atrophaeus* subsp. *globigii* Spores

Dale Griffin

U.S. Geological Survey

A published colony forming unit (CFU) assay was compared to an enrichment-polymerase chain reaction (PCR) assay for the detection of *Bacillus* sp. spores in soil samples. The purpose of the study was to evaluate alternative assays that may yield increases in spore detection sensitivity.

Spikes of spores, ranging from ~5 to ~1350 spores per 9 grams of loam, sand and clay soils, respectively, were screened with the two assays. The CFU assay consistently detected spores at spike ranges of 225, 225 and 45 in loam, sand and clay soils respectively. Volume adjusted percent recoveries of spores from these same soil types averaged 56%, 63% and 146%, respectively.

The enrichment-PCR assay consistently detected spores at all spike concentrations. Clay soil CFU percent recoveries were greater than 100% of the spike, indicating a potential influence of clay in spore germination. To access the influence of clays on spore germination pure sand and clay and sand:clay soil mixtures (%) of 80:20, 60:40, 40:60, 20:80 were spiked with concentrations of spores as previously described. The CFU assay detected an average 11 CFU/9 grams of soil for 100% sand through a stepped increase to 14 CFU/9 grams of soil for 100% clay. Collectively, these results show the enrichment-PCR assay is a more sensitive method for detecting spores in soil samples and that clay may contribute to spore germination. The enrichment-PCR assay achieved consistent sensitive detection of spores in three different soil types and could provide data compatibility when screening diverse soil sample sets and regional sample types.

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Viral Persistence in Landfill Leachate

Megan Howard

Battelle

Little is known about the fate and persistence of viruses in landfills. The limited capacity of incinerators and hazardous waste sites in the United States, coupled with the difficulty of sampling and analyzing waste matrices may result in the placement of incompletely decontaminated infectious waste in municipal solid waste (MSW) landfills following the response to a release of a viral biothreat. The fate of any virus introduced in a MSW landfill is of concern, as it may pose a threat to human and/or environmental health if the live virus persists and migrates into a higher risk area, such as the leachate collection system. In addition, the knowledge of virus persistence in the landfill environment will assist the landfill industry in developing waste acceptance criteria for bio-waste disposal. We evaluated the fate and persistence of multiple viruses in landfill leachate to determine viral persistence at moderate and elevated temperatures. We evaluated a human pandemic virus (Zika virus), and two surrogate viral threat agents (Phi6 and MS2 phage). Landfill leachate samples from three MSW landfills were spiked with each virus and incubated at 12°C and 37°C. Samples of each spiked leachate were tested in triplicate for viral titer over time. Viruses persisted in leachate for days to months, with persistence varying primarily by temperature. Survival increased when incubated at 12°C, and decay was more rapid at 37°C. Leachate effects on viruses also varied between landfills. The data suggest that different viral types are affected by leachate in unique ways, and that leachate composition plays a significant role in viral persistence. For instance, Zika virus (enveloped human virus) persisted for 4-5 days while MS2 (non-enveloped bacterial phage) persisted for up to 48 days in leachate at 12°C. Additionally, the variation in viral persistence emphasizes that surrogate choice for testing is critical in obtaining actionable data to inform decision making involving biothreat agents. The study results suggest that viruses may persist in landfill leachate for days to months in mild conditions present in the majority of the landfills in the US. Therefore, if solid waste is carrying a live virus and is disposed of in a landfill, perhaps after an intentional attack, an understanding of the viral persistence in leachate would allow landfill operations to be better adapted in minimizing potential exposures to waste management workers and the public.

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Development of a Rapid Viability Polymerase Chain Reaction (PCR) Method for Detection of *Francisella tularensis* in Water Samples

Staci Kane and Sanjiv Shah

U.S. Environmental Protection Agency

*Francisella tularensis*, which causes tularemia, is a Category A select agent due to its capacity to be weaponized, low infective dose (1-10 cells), and high morbidity/mortality. These characteristics, along with its persistence in water and occurrence of drinking water outbreaks, have necessitated sensitive and specific methods for *F. tularensis* detection. To meet this need, a *F. tularensis*-specific Rapid Viability Polymerase Chain Reaction (RV-PCR) method for water samples was developed through a U.S. EPA and Lawrence Livermore National Laboratory (LLNL) collaborative effort, extending previous work for *Bacillus anthracis* and *Yersinia pestis* detection from surface and environmental samples. The RV-PCR method uses the difference in PCR cycle threshold (CT) before and after growth in liquid medium for detection, with ∆ **CT** ≥ 6 indicative of viable cell presence. In this effort, we have shown that the RV-PCR method could provide more rapid detection of viable *F. tularensis* cells compared to the current plate culture-based method, which requires 72 – 96 hr incubation for the slow-growing bacterium. A 6X-concentrated growth medium was used, which upon addition of a water sample was diluted to 1X concentration. Using this approach, reproducible *F. tularensis* growth was observed at low inoculum levels (< 10 cells per mL) in 48-well deep well plates for high throughput sample incubation and analysis. Testing with soluble (Fe2+, humic acid) and insoluble chemical interferences (mineral oxides in reference dust), and live, non-target microbes (e.g. *Bacillus spp*. spores in reference dust) was conducted to address potential challenges. Results showed RV-PCR method sensitivity of ~12 CFU/3-mL sample in the presence of 30 g Fe2+ and 150 g humic acid per sample using a 30-hr incubation period, with ∆ **CT** values of ~16 - 18. For samples containing reference dust (with 104 – 105 indigenous microbes), it appeared that growth and PCR inhibition may have prevented consistent detection with 30-hr incubation suggesting a need for a longer incubation. The RV-PCR method is expected to be compatible with ultrafiltration and secondary filtration based concentration of large volume water samples, although this would need to be evaluated. Overall, the results demonstrated that the RV-PCR method could provide more rapid and high throughput analysis for *F. tularensis* contamination compared to the plate culture-based approach, thus affording a useful tool for restoration following a tularemia incident.

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Concurrent Session 4 – Radiological Agent Research



Evaluation of Low-Tech Remediation Methods Following Wide Area Radiological/Nuclear Incidents

Ryan James

Battelle

The U.S. EPA’s National Homeland Security Research Center (NHSRC) and Battelle have recently completed experiments that have determined the effectiveness of a variety of common outdoor cleaning methods (wet wipes, brooms, vacuum, mopping, water spraying, etc.) in the removal of radiologically-tagged simulated fallout material (RTSFM) from multiple outdoor surfaces (roofing, wall material, fence/decking, concrete, ceramic tiles, etc.) staged in a pilot-scale experiment. These are outdoor surfaces that would be immediately important for decontamination of residences during recovery efforts in the event of a radiological incident. The RTSFM was generated using Arizona road dust in two distinct particle size ranges: less than 10 micrometers (µm) and greater than 250 µm. Then, each particle size range was tagged with a unique radionuclide. The smaller particles were tagged with rubidium-86 and the larger particles were tagged with cesium-137.

The RTSFM was applied to the outdoor surfaces using a dry deposition of as well as an aqueous application referred to as aqueous simulated fallout material (ASFM). Following deposition of the RTSFM and ASFM, gamma radiation from the contaminated surfaces was measured. The various outdoor cleaning methods were then used to decontaminate each surface. Lastly, the gamma radiation emitted from the “decontaminated” outdoor surfaces was measured and a decontamination factor (i.e., efficiency of radionuclide removal) was calculated. Results will be presented that include the quantitative (i.e., percent removal) and qualitative performance of the cleaning methods on each outdoor surface including an estimate of contaminated waste generated. In general, the ASFM contamination was more difficult to remove, resulting in lower percent removal than the RTSFM contamination. Particle size was not indicated as a strong indicator of effective removal, while porous materials resulted in lower percent removals than non-porous materials. Percent removals ranged from 0% to 100% depending on the combination of surface and cleaning methods.

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Irreversible Wash-Aid, Treatment, and Emergency Reuse System (IWATERS): Ad-Hoc Systems for On-Site Treatment of Chemical, Biological, Radiological, and Nuclear Contaminants from Wash Waters

Michael Kaminski

Argonne National Laboratory

Removal of Chemical, Biological, Radiological, and Nuclear (CBRN) contaminants from process decontamination waters to enable their unrestricted disposal or on-site reuse is a necessary goal for many contamination scenarios. Given the difficulty in stockpiling resources for low probability but high impact events, over the past years, we have been developing on-site decontamination systems that incorporate on-site water treatment and can be implemented ad hoc using existing equipment stores. Meeting this goal is highly challenging because decontamination technology must be technically compatible with the on-site water treatment approach for potentially billions of gallons of contaminated water.

The Integrated Wash-Aid, Treatment, and Emergency Reuse System (IWATERS) is designed, developed, and demonstrated for multi-scale decontamination/recovery operations in the urban environment, which will be water-scarce during such recovery. This presentation will highlight the application of IWATERS for radiological contaminants and illustrate how the underlying technology is also applicable to chemical and biological contaminations, and nuclear fallout. Furthermore, contaminant transport models are being developed to enable rapid, site-specific implementation.

Solutions containing radioactive fission products were prepared, and used in batch experiments with mixtures of natural sorbents and sand to determine solid-liquid distribution coefficients, Kd, used in subsequent modeling. A filter bed was modeled using GoldSim CT and verified using experimental breakthrough curve results. Many natural sorbents were evaluated for their adsorption efficacies of radionuclide and chemical agents from wash waters.

The modeling simulations agreed well with the experimental breakthrough curves for radionuclides. For example, both experimental and modelling results indicated that to process up to 250 gallons of IWATERS wash solution formulated for decontamination of radioactive cesium, the filtration bed can be constructed inside a 55-gallon drum. Results for smaller and much larger (millions of gallons) volumes of contaminated wash waters will be also presented.

Moreover, IWATERS was demonstrated in two separate full-scale events, with water containment systems appropriate for building and vehicle wash down activities. Wash waters were applied to a building façade and a command vehicle, and the “contaminated” waters were clarified for reuse in further decontamination activities using commonly available equipment and supplies. During the two full-scale IWATERS demonstrations, process waters passed through filtration/settling beds containing suspended clay solids and were clarified for reuse via a Separmatic™ filter system. A similar filter system completed the U.S. EPA’s Environmental Technology Verification program for treatment of particulates (such as microbiological agents) and could also include nuclear fallout. An investigation of chemical treatment via this system is currently underway.

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Superior Process for the Treatment of Difficult Chemical, Biological, and Radiological Liquids

Adriano Marin

WOW Kemical, Italy

WOW Technology and its subsidiaries WOW Nuclear Srl and WOW Kemical Srl has developed a superior process to treat many types of liquids including radioactive and hazardous wastes. This evaporation technology produces two products, a high-volume, clean liquid free of Chemical, Biological, and Radiological (CBR) constituents which can be released to the environment without further treatment, and a low-volume concentrated liquid or slurry containing the CBR constituents which can be further treated as needed for disposal. The process offers the following attractive features,

* high volume reduction of the CBR liquid,
* operates in batch or semi-continuous modes,
* produces no secondary waste,
* is modular and easily scaled to the volume of liquid requiring treatment,
* the processing equipment is readily decontaminated (i.e., absence of recalcitrant deposits on internal surfaces) allowing relocation and reuse in other applications,
* offers a Decontamination Factor ( DF ) that is an order of magnitudes better than existing evaporation methods, and
* low capital and operating costs.

This presentation will discuss details of the treatment technology including applications in the nuclear and chemical industries.

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High Pressure Decontamination of Building Materials: Understanding Removal Mechanisms and Waste Production During Urban Radiological Recovery

William Jolin

Argonne National Laboratory

The release of radiological material from a nuclear incident (meltdown, radiological dispersal device, or improvised nuclear device) has the potential to cause extensive radiological contamination requiring rapid decontamination. A promising method for rapid remediation is the use of pressure washers to decontaminate building and street surfaces. Pressure washers utilize both physical removal through surface ablation and chemical removal through desorption of bonded radionuclides. To understand the extent that each removal mechanism is present, overall removals, depth profiles, and waste water were analyzed from the pressure washing of various surfaces contaminated with cesium, strontium, and europium. Removals were dependent on surface type and nuclide as over 80% of the radionuclides were removed from concrete, 50-80% from asphalt, and only 20-25% from brick. Generally, the closer the radionuclide was to the surface of the material the higher the removal, as europium was removed most readily followed by cesium and strontium, though some exceptions were evident. Comparing these removals and depth profiles of radionuclides in non-decontaminated coupons revealed that cesium and europium are mostly removed through surface ablation. Strontium, on the other hand, is chemically removed, especially from brick and asphalt surfaces. Correspondingly, cesium and europium were attached to the particulates that were likely removed with the pressurized water. Strontium was primarily dissolved in the waste water, supporting the observation that the radionuclide is chemically removed from each surface. Finally, the faster the surfaces were brought through the high pressure spray the lower the removals, arising from decreases in both the physical and chemical mechanisms. Pressure washers were concluded to be a promising decontamination method during radiological event relief. However, the surface and radionuclide identity must be considered when developing proper procedures.

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Concurrent Session 5 – Biological Agent Decontamination



Real-Time Thermal Distribution During Virucidal Heat Treatment of a Commercial Poultry Barn Under Field Conditions

Julian Rosenberg

The Sabre Companies LLC

Commercial poultry production facilities affected by highly pathogenic avian influenza (HPAI) or other biological contaminants pose potential risks to public health. While heat inactivation of HPAI is a well-established method of barn disinfection, publicly available data describing the efficacy of this process at field scales are limited. Under a joint research program with the U.S. EPA, a large-scale field test examined heat treatment of a commercial layer barn in Iowa. The field trial sought to close knowledge gaps associated with heat disinfection efficacy across the diverse material matrices and thermal gradients present in poultry barns. Under the guidelines set forth by USDA, the heat disinfection process requires seven days of treatment with at least three consecutive days above 100° F at all monitoring points within the facility (USDA APHIS, FY2016 HPAI Response). Prior to heat treatment, thorough cleaning of the barn is also required. In this field trial, the 50 × 600 feet, two-level, caged layer barn required 24 single-pass indirect heaters (each 800,000 BTU/hour) and 18,000 gallons of diesel to treat the roughly one million cubic foot volume. Over the one week treatment cycle, air temperature and relatively humidity (RH) were monitored in real-time using HOBO® data loggers (Onset Computer Corp.). A total of 20 real-time monitoring points were stratified between the cage and ground levels of the facility. In order to further quantify the overall consistency of heat treatment at points likely to show the greatest thermal imbalance (e.g., doorways, windows, eaves, and ventilation openings), an additional 40 locations were selected for temperature and RH monitoring. The resulting graphical heat maps provide valuable temporal insight into the distinct temperature profiles, thermal barriers, and potential opportunities for process improvement. Analysis of this data also identified maximum thermal conditions and concomitant effects on RH throughout the process. Critical length scales of thermal distribution and notable time points throughout the process were defined. Throughout the treatment cycle, surface temperatures of designated reference materials were measured manually at six-hour intervals using an infrared thermometer. While the air temperature in the barn was maintained above 100° F for the seven-day heat treatment, surface monitoring identified certain discrepancies between air and material temperatures. As a whole, this work offers a detailed view of the full scale barn heat treatment under field conditions. The efficacy of the process with respect to viral elimination, operational feasibility, material effects, cost considerations, and biosecurity implications will be discussed.

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Update on Techniques to Decontaminate Soil Contaminated with *Bacillus anthracis* Spores

Joseph Wood

U.S. Environmental Protection Agency

Spores of *Bacillus anthracis* are highly resistant to environmental conditions and may remain viable for decades in soil. Several studies have been conducted in recent years to evaluate techniques to inactivate spores of *Bacillus anthracis* in different types of soil. Soil materials contaminated with *B. anthracis* spores are difficult to decontaminate for several reasons, including the soil’s porosity and sometimes high organic material content.

This presentation will provide an overview of the research conducted to date, and will also focus on a more recent soil decontamination study.

The purpose of the present investigation was to determine the efficacy of three chemical decontaminants: chlorine dioxide gas (CD), sodium persulfate activated with aqueous hydrogen peroxide (SP/HP), and methyl bromide (MeBr).

Three types of soil materials were included in the test matrix: a topsoil, a sandy soil, and a clay-based soil. Several efficacy tests were conducted using spores of the *Bacillus anthracis* Ames strain, with efficacy quantified in terms of log10 reduction. Tests were conducted with varying operational parameters such as relative humidity, contact time, and concentration to assess the effect of these parameters on decontamination efficacy. Efficacy was also assessed as a function of soil depth; spores were placed on top of the soil and at increments down to a 5-inch depth.

From the seven experiments conducted with CD gas, it was able to achieve complete kill of anthrax spores down 5 inches in both the sand and clay materials, but was ineffective at decontaminating topsoil at depths greater than 1 inch.

With the use of SP/HP, it was similarly effective in clay at depths to 5 inches, but effective to only 1 inch on topsoil and sandy soil. The SP/HP was also highly reactive with the topsoil, and produced vigorous foaming upon application.

MeBr was less effective than anticipated based on previous lab tests. None of the four tests conducted demonstrated effective decontamination at any depth, although there were a few cases in which the spores on top of the soil column were completely inactivated. Additional research is suggested to investigate this discrepancy. Interestingly, decontamination efficacy was generally similar across all depths for a particular soil and test condition, suggesting that penetration of the MeBr gas through the soil matrices was not a limiting factor.

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Electrostatic Sprayer Efficacy for Personnel Personal Protective Equipment (PPE) Decontamination

John Archer

U.S. Environmental Protection Agency

Following a bioterrorism event, the impacted area would be characterized and work zones established based on the extent of indoor/outdoor contamination.

The personnel decontamination (decon) line, established in the Contamination Reduction Zone (CRZ), is essential for ensuring potentially biohazardous materials on worker personal protective equipment (PPE) do not migrate outside of this zone. During personnel decontamination, conventional backpack sprayers are often used to distribute liquid decontaminant over PPE surfaces, and this process generally produces significant volumes of aqueous liquid waste and may lead to migration of biological agents. A previous U.S. EPA study showed that electrostatic spray technology is more efficient for decontamination and reduces waste by delivering a more uniform distribution of liquid droplets over uneven surfaces than conventional sprayer systems. A follow-on U.S. EPA National Homeland Security Research Center (NHSRC) study was conducted to compare the performance of an electrostatic sprayer to a conventional backpack sprayer for PPE decontamination. Efficacy of each sprayer was evaluated in removing and inactivating *Bacillus atrophaeus var. globigii* (Bg) spores from common types of PPE materials.

A decontamination test chamber was used to evaluate both sprayers using 14- X 14-inch vertical coupons that were prepared from each PPE material (nitrile, butyl, latex, Tyvek®, Tychem®, neoprene and ChemTape®) and inoculated with 1 × 107 Bg spores. Test coupons were sprayed with the conventional backpack or electrostatic sprayer until visibly wet, using 10% diluted bleach.

Following a 5-minute contact time, coupons were removed from the test chamber and wipe sampled. Liquid runoff samples were also collected, immediately neutralized, and analyzed. Sprayer decontamination efficacy was determined by comparing the average number of colony forming units (CFUs) observed for inoculum controls to the average number of CFUs observed for decontaminated test coupons.

Surface efficacy results for both sprayer types indicated a log reduction (LR) ≥ 7.0 for all materials, suggesting that both sprayer types provide a high level of decontamination efficacy (p-value = 0.49). Results from liquid runoff samples, however, showed that a significant number of viable spores (≥ 6 Log CFU) were observed in the runoff from the conventional backpack sprayer. Conversely, few to no viable spores were observed in the electrostatic sprayer liquid runoff samples for all material types. This suggests that spores are removed or washed off from material coupons with the conventional backpack sprayer which may lead to cross contamination.

Additionally, the electrostatic sprayer generated on average 75 times less liquid runoff, which leads to waste minimization and decreased disposal costs. These findings suggest the electrostatic sprayer may be useful for biological decontamination of PPE in a personnel decon line. Further studies are warranted to evaluate efficacy of the electrostatic sprayer for decontaminating full PPE ensembles, assessing reaerosolization and migration from PPE, and evaluating larger, field-deployable decon systems to achieve more efficient spray coverage.

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First Responder Use of Electrostatic Sprayers for Decontamination

Gary Sharp

Oakland County, MI Hazmat Team

Electrostatic sprayers deliver an electrical charge to a decontamination solution to create small, evenly sized droplets which provide an electrostatic adhesion and electrostatic wrapping effect while spraying. The result is a more uniform coverage of the decontamination solution on the target, including difficult to reach or “shadowed” areas. Electrostatic spraying technology has evolved from large, transportable systems to now include small, hand-held, cordless sprayers. The result is electrostatic spraying units that are suitable for field use. Electrostatic sprayers use considerably less decontamination solution, resulting in reduced decontamination logistics.

Electrostatic decontamination tactics are now in use by a wide range of first responder organizations including law enforcement, emergency medical services, hazmat response teams, urban search and rescue task forces, and clandestine lab enforcement teams. This presentation will provide an overview of how electrostatic sprayers work, their use and limitations in decontamination, and tactics developed by first responders. We will discuss a variety of applications first responders are deploying electrostatic sprayers for, including disinfection of ambulances after transport of highly infectious patients, decontamination of synthetic opioids, and disinfection of law enforcement facilities. The presentation will share the results of field testing conducted by first responders and several incident case studies where electrostatic decontamination tactics were actively employed by first responder agencies and federal law enforcement.

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Organization of Economic Cooperation and Development (OECD) Quantitative Method for Assessing the Effectiveness of Antimicrobial Products on Hard Surfaces: Technical Attributes and Applications

Stephen Tomasino

U.S. Environmental Protection Agency

To address the regulatory challenges associated with an ever-changing marketplace, novel product claims, and the emergence of new clinical pathogens, the U.S. EPA is interested in the development, validation, and use of new methodologies for assessing the effectiveness of antimicrobial products.

As part of this effort, the U.S. EPA and other Organization of Economic Cooperation and Development (OECD) member countries are jointly evaluating a quantitative method for the purpose of international method harmonization.

The method under consideration (OECD Quantitative Method) is derived from an existing standard method, ASTM E2197, the Standard Quantitative Disk Carrier Test Method. The method can accommodate testing of bacteria, mycobacteria, viruses, and fungi. In the method, 1 cm diameter brushed stainless steel disks (carriers) are inoculated with 10 µL of a suspension of the test microbe and a three-part soil load. After drying, each carrier is placed in a vial and the inoculum is exposed to 50 µL of the antimicrobial agent.

Control carriers receive 50 µL of phosphate buffered saline. Following the contact time, a neutralizer solution is added to the vial, contents vortexed, serially diluted, and the viable microbial population is enumerated using membrane filtration and direct plating. The difference between the mean log density for control and treated carriers is used to calculate a mean log reduction (LR) value. The LR value is used as the measure of product effectiveness, where higher LR values are indicative of greater microbial kill. An overview of the technical aspects of the method, the international harmonization initiative, and current regulatory applications will be provided.

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Concurrent Session 5 – Chemical Agent Research



Best Practices to Minimize Laboratory Resources for Waste Characterization During a Wide Area Release of Chemical Warfare Agent

Stuart Willison

U.S. Environmental Protection Agency

A wide area release of chemical warfare agent may result in the contamination of several square miles of urban area. The response and recovery activities from a wide area incident could generate several million tons of solid and aqueous waste. All waste generated during management of the wide area incident must be appropriately characterized. However, laboratory demand during a wide area incident will likely be greater than the available capacity due to the need for sampling and analysis during site characterization, assessment of decontamination efficacy, waste characterization, and clinical or medical testing. As a result, laboratory analysis could become a chokepoint and limit overall progress in incident management.

To minimize the collective load on laboratory analysis attributable to waste characterization, best practices were identified to assist potential users of laboratory services while still meeting the data needs of regulators and receivers of the waste. A “Best Practices to Minimize Laboratory Resources for Waste Characterization During a Wide Area Release of Chemical Warfare Agents”, document has been developed. It describes the overall waste characterization process and identifies best practices. The U.S. EPA incident responders participated in a review of the best practices document with a traditional table-top and computer simulation of waste characterization process decisions. The computer simulation was a customized application of the Realistic, Adaptive, Interactive Learning System (RAILS) designed to provide players with the opportunity to perform waste characterization in a realistic, three-dimensional environment. The Best Practices document, combined with the RAILS computer simulation, provides a thorough and user-interactive way of ensuring that appropriate waste characterization will be performed. A summary of the document and a demonstration of the computer simulation will be provided during this presentation.

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Evaluation of Surface Applied Decontamination Methodologies for Partially Permeated Persistent Chemicals in Permeable Layers and Underlying Porous Subsurfaces

Barbara Wyrzykowska-Ceradini

Jacobs Technology, Inc.

Clean up activities following a release of a toxic, persistent, chemical is likely to involve the in situ neutralization of the chemical via hydrolysis, oxidation or nucleophile substitution. Most in situ decontamination technologies are aqueous and can yield high efficacy if the release impacted only nonporous materials. Water-based decontamination strategies generally have limited success if the contaminant migrates into a permeable surface or further into an underlying porous sublayer. Following surface decontamination, chemical compounds previously permeated into the surface layer or sublayer, can migrate back to the surface, reintroducing a potential hazard. Little is known about the partitioning of toxic industrial compounds (TICs) – including chemical warfare agents (CWAs) – into permeable building materials, and even less is known about the efficiency of standard decontamination techniques to remediate materials containing permeated compounds.

This work determined the permeation of two CWA surrogates – malathion and 2- chloroethyl phenyl sulfide (2-CEPS) – into and through free standing paint (FSP) and free-standing sealant (FSS) layers placed on top of a porous solid phase extraction disk (SPE). In general, it is practically impossible to separate paint or coating layer(s) from a porous material such as drywall board, wood, or concrete without the use of strong physical or chemical removal/separation methods. As a result, procedures to generate representative and uniform free-standing paint and sealant layers, independent from a support layer were developed. Surface wipe sampling and layer-specific chemical extractions permitted temporal and material-specific mass fraction estimates. Coupons with a nonpermeable sublayer were used to determine chemical partitioning for the selected paint and sealant surface layers. Following permeation, two surface decontamination techniques using off-the-shelf bleach with and without reapplication were evaluated on FSP and FSS systems spiked with malathion or 2-CEPS. Outcomes from these studies will be discussed in terms of efficacy of each decontamination approach and path forward to provide recommendations to end users on how to remediate these challenging types of materials.

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The Use of Airborne Spectral Photographic Environmental Collection Technology (ASPECT) Remote Sensed Chemical and Situational Data to Support Region VI Arkema Response Activities

Mark Thomas

U.S. Environmental Protection Agency

The impact of hurricanes on the Gulf coast chemical industry has been documented for a number of storms. Hurricane Harvey was no exception and while not a strong category storm, it did generate record amounts of precipitation and flooding in and round Houston proper. The Arkema facility, a producer of industrial peroxides, was in an area forecasted to be impacted by flooding and prepared for a loss of power by moving product from on-site cold storage to refrigerated trailers. Prolonged flooding prevented plant personnel from servicing the trailers and one by one each trailer lost power and refrigeration. On 30 August 2017 the Region VI emergency operations center requested that the U.S. EPA Airborne Spectral Photometric Environmental Collection Technology (ASPECT) respond to a reported peroxide fire at the flooded Arkema facility. ASPECT was a logical choice for this situation since the system was able to monitor the site in a remote fashion and relay situational information rapidly to the Region. ASPECT used a set of sensors to monitor the thermal state of the fire and the surrounding storage trailers using a broad-band mid-wave camera, monitor for the presence of chemical vapors in and downwind of the facility using a passive airborne Fourier Transform Infrared spectrometer, and photo-document the situational environment uses a set of high resolution digital cameras. A feature unique to the ASPECT program was the use of a multivariate pattern recognition method to rapidly identify chemical signatures. Detections and other situational information were then extracted from the aircraft using a satellite system, examined for quality and then forwarded to the Region. The objectives of this presentation will include how the pattern recognition method was adapted to peroxide emissions and how this information was used by the Region to manage the response.

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Vapor Hydrogen Peroxide Decontamination of Biological and Chemical Warfare Agent (CWA) Contaminated Materials: Field Tests

Marek Kuzma

Institute of Microbiology, Czech Republic

Vapor hydrogen peroxide (VHP) is well established for biological decontamination in pharmaceutical industry to reach sterility in clean rooms.

The high oxidation potential of hydrogen peroxide make it suited for decomposition of chemicals. VHP can be easily applied in large spaces because it can easily fill the decontaminated area, although sufficient distribution should be ensured. Subsequent aeration of the space is also undemanding because hydrogen peroxide readily decomposes to harmless water and oxygen.

Hence, the deployment of large quantities of VHP does not represent an environmental risk. It seems that VPH can serve as a universal decontamination agent for the elimination of both biological and chemical contamination.

Institute of Microbiology in cooperation with Military Research Institute underwent a field-test of VHP in the outdoor testing facility, which is designed for tests with highly toxic substances. The decontaminated area was a hall with dimensions: 12 m (39.4 foot) long, 5.7 m (18.7 foot) width, 3 m (9.8 foot) high, approximate total volume: 205.2 m3 (7 246.5 cuft).

Spores of *Geobacillus stearothermophilus* were used as a surrogate of biological contamination and as a standard of chemical warfare agent was used sarin. Biological test coupons were both of commercial origin (STERIS®, MesaLabs®) and home-made. The home-made coupons are composed of five spots, each with one million spores of *Geobacillus stearothermophilus* placed on parafilm. Moreover, we tested also decontamination of metal plates covered by standard military painting used in the Czech army and plasterboard as an example of porous material. VHP tests for sarin decontamination was arranged in two different ways. Samples contaminated by sarin were prepared by adsorption of sarin from gas phase or by dropping neat sarin on a carrier.

A simple autonomous generator of VHP, which does not require any external source of energy, was used. This system allows also combination of VHP with various chemical additives, which activity was also tested. It was correlated localization of test coupons and the extent of decontamination. Furthermore, it was evaluated consumption of material and labor costs to establish the economic feasibility of the process.

Our test with autonomous VHP generator approved that the VHP decontamination can be very simple in terms of design and successful for both biological and chemical warfare agent (CWA) decontamination when the procedure is carefully set up. We reached sterility of 98 to 100% test spots. Degree of degradation of sarin on painted steel and plasterboard was up to 95 %. Additives to VHP can also affect the rate and degree of decontamination.

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PRISM: An Evidence-Based Guidance on Mass Casualty Disrobing and Decontamination Following a Chemical Incident

Efrain E. Garcia

Department of Health and Human Services

Recent research performed at the University of Hertfordshire (UH) and sponsored by the Biomedical Advanced Research and Development Authority (BARDA), part of U.S. Department of Health and Human Services (HHS), has led to an optimization of a protocol for mass casualty decontamination following a chemical incident. The revised, evidence-based process has been incorporated into HHS’ Primary Response Incident Scene Management (PRISM) guidance, which addresses strategic, tactical, and operational aspects of preparedness and response to mass casualty incidents involving the deliberate or accidental release of hazardous materials, including chemical warfare agents. PRISM provides an evidence-based protocol for disrobing and decontamination that has been shown to be faster and more effective than current processes. One notable finding of the research is that carefully removing clothes and wiping skin with a paper towel or absorbent cloth can remove more than 99% of chemical contamination. In addition, recent data from in vitro and human volunteer studies show that hair offers a protective effect from chemical exposure. The findings also suggest the need to avoid the common practice of using high¬ pressure water from fire engines to shower clothed patients, as showering in contaminated clothing washes chemicals through to the skin, actually increasing skin exposure. Based on the PRISM recommendations, community planners can build scientifically sound actions into emergency response plans. These considerations include providing places for people to disrobe privately, paper towels, disposal of the contaminated towels, and working with community partners to provide clean clothing after these initial decontamination steps. To aid first responders with critical decisions regarding decontamination following a potential chemical incident, UH and BARDA have developed a mathematical model, based on the PRISM guidance, to assess the utility of disrobing and decontamination on a case-by-case basis.

BARDA is collaborating with UH and The National Library of Medicine to incorporate this model into existing platforms like the Chemical Hazards Medical Management (CHEMM) to develop an online decontamination decision-aid tool with the goal of providing authoritative and customized guidance to help first responders appropriately respond to a chemical incident. The PRISM guidance is part of BARDA’s advanced research and development portfolio of medical countermeasures and medical products to diagnose, prevent, treat, and protect the US population against CBRN threats.

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Concurrent Session 6 – Technology & Software Supporting Disaster Response



Mapping the Great Indoors: Spatial Context Through Indoor Maps

Jorge Chen

University of California, Santa Barbara

Indoor space represents an important environment for research related to chemical, biological, and nuclear (CBR) incidents, since CBR material are often stored indoors and most people spend roughly 85% of their daily lives within the confines of buildings. The accidents at the Japanese Fukushima Dai-ichi nuclear power plant in 2011 and Soviet Chernobyl nuclear power plant in 1986 provide two extreme examples of radiological incidents with a significant indoor component. However, any type of man-made or natural disaster can create indoor CBR challenges, such as acts of terrorism or major floods that can spread hazardous materials throughout the interior of buildings.

Not surprisingly, maps play a vital role in this inward-looking research, both as tools of communication and of analysis. For most buildings, indoor maps have traditionally existed in the domain of architects and engineers and have often been generated as afterthoughts in the facility life cycle. Most of these “maps” exist as two-dimensional technical drawings that can confound most non-engineers, and they come in many different versions (e.g., as-designed, as-built, as-is, etc.), each with accompanying spatial and temporal errors and uncertainties.

Recent advancements in building modeling and close-range remote sensing have made it possible to rapidly generate significantly improved indoor maps while presenting them in more human-readable forms in both two- and three-dimensions. These include models from the building information modeling (BIM) process that are gradually replacing 2D technical drawings, 3D building models for urban modeling applications (e.g., CityGML), and a fast growing body of affordable close-range remote sensing instruments.

This presentation will examine three topics related to the state-of-the-art in indoor mapping: recent developments in modeling standards, indoor remote sensing, and automated modeling techniques; the need for a cartographic indoor mapping practice separate from BIM and urban modeling; and potential uses of 3D indoor maps that extend beyond conventional applications in areas such as spatial analysis, autonomous indoor navigation, and augmented reality for emergencies. The goal of this presentation will be to inform the audience of developments in indoor mapping that can inspire new ideas and approaches to dealing with CBR incidents in indoor environments.

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Application of Fukushima Derived Radiological Cleanup Metrics for Assessing Decontamination Feasibility in the United States

Paul Lemieux

U.S. Environmental Protection Agency

In order for emergency planners and federal responders to holistically assess waste and debris management issues resulting from a radiological response and recovery effort, it is critical to understand not only the quantity, characteristics, and levels of contamination, but also the impact on the quantity and rate of waste generation resulting from selecting various response and cleanup approaches. As observed from Chernobyl and Fukushima incidents, wide area radiological incidents have the potential to generate an enormous amount of waste with varying characteristics and residual radioactivity. It could take years or decades before waste related issues are resolved, likely invoking a series of policy, social, financial, and ethical issues along the way. Forgoing uncontrollable factors such as emission source, radioisotope, contamination level, and impacted surface area, the cleanup level and overall decontamination strategy (e.g., technology, application method, and removal efficacy) largely determine the amount and characteristics of waste generated.

Historically, national level exercises have minimally evaluated the impact of waste on the response and recovery process. When waste was considered, dated (e.g., Chernobyl era) or laboratory-based decontamination performance data have been referenced. Following the Fukushima Daiichi nuclear disaster, more operationally feasible and up-to-date decontamination technology performance metrics are available. These metrics can be applied to assess their practicality in terms of waste generation, time- and cost-benefit, and overall feasibility.

This presentation will feature a live demonstration of the U.S. EPA’s Waste Estimation Support Tool (WEST) and the application of Fukushima Daiichi nuclear disaster derived decontamination metrics to a hypothetical radiological scenario in the United States. The resulting discussion will highlight the differences between pre- and post-Fukushima era waste estimates with an emphasis on waste volume and characteristics, potential cultural/policy differences that might impact

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All-Hazards Waste Management Planning Tool

Anna Tschursin

U.S. Environmental Protection Agency

Many manmade and natural incidents have the potential to produce significant amounts of waste. The U.S. EPA believes that communities should have a pre-incident waste management plan (WMP) that addresses everything from natural disasters and foreign animal disease outbreaks to chemical spills and nuclear incidents to terrorist attacks involving conventional, chemical, radiological, or biological means. These homeland security incidents can create more waste than a community typically manages on a regular basis, as well as waste streams a community does not normally handle. Past experience has shown that communities with comprehensive and well-coordinated pre-incident WMPs recover more quickly and at less cost from these incidents, making these communities more resilient.

Unfortunately, planning for waste management during large-scale homeland security incidents has been identified as a major capability gap in overall Homeland Security Response and Recovery Preparedness.

To assist emergency managers, planners, and responders in the public and private sectors in creating or updating a comprehensive plan for managing waste generated by manmade and natural incidents, the U.S. EPA Office of Resource Conservation and Recovery (ORCR) Materials Recovery and Waste Management Division, in collaboration with U.S. EPA Office of Homeland Security, and the U.S. EPA National Homeland Security Research Center (NHSRC), has developed an interactive on-line waste management planning tool “quickstart” to aid state, local, tribal, and territorial planners in developing a preliminary waste management plan.

ORCR is hoping to expand this quickstart into a more robust tool to provide step-by-step guidance on creating a comprehensive pre-incident WMP. This tool would provide a framework to help managers, planners, and responders initiate plan development. It would provide variable degrees of assistance from providing a simple outline of plan contents, to creating customizable language, to providing scenario-specific default waste quantity values to use in developing a plan. The tool would not only provide an adaptable format for drafting the plan itself but, in addition, is envisioned to provide users with the ability to view plans developed and shared by other users and access resources such as fact sheets, databases, and other online tools such as I-WASTE.

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All-Hazards Tool for Estimating the Resource Demand Associated with Transporting Large Volumes of Waste

Molly Rodgers

Eastern Research Group, Inc.

Large‐scale disasters have the potential to generate a significant amount of waste and debris. For example, Hurricane Katrina and the Joplin, Missouri tornado resulted in 100 million and 1.5 million cubic yards of waste, respectfully. Man‐made chemical, biological, radiological or nuclear (CBRN) incidents either by way of terrorism, war, or accidents have the potential to generate as much or more potentially contaminated waste and debris.

Management and transportation of large volumes of debris and waste, including all components of the waste stream (e.g., vehicles, soil, vegetation, aqueous waste, etc.), will be a challenging process, which can impact overall response and recovery timeline. This presentation will provide an overview of an all-hazards logistics planning tool the U.S. EPA is developing. This tool will support identifying and prioritizing potential staging and storage locations to manage materials and waste, as well as generating estimates of the cost, time, and logistical requirements (i.e., resource demand) associated with transporting large volumes of waste from a disaster-stricken area to waste management sites. The tool is being developed to build upon and expand existing tools and integrate Geographic Information System (GIS)-based visual analyses to inform planning and response efforts.

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RemediAtion DAta Repository (RADAR): A Multi-Hazard Research Tool for Searching, Applying, & Sharing Scientific Information

Timothy Boe

U.S. Environmental Protection Agency

Numerous decision support tools and technical/operational data have been developed under the U.S. EPA’s Homeland Security Research Program (HSRP). Collectively, the research data and tools support decision makers in a wide range of emergency response and recovery activities. In many cases, tools developed under HSRP (and elsewhere within the federal government) tend to rely on static data that are individually distributed with each tool and are therefore susceptible to becoming out of sync with source data updates and can be costly to maintain and update. Additionally, technical/operational data generated through various research initiatives are often shared through static reports that require an arduous amount of time to review or reference.

To confront this issue, HSRP is developing the Remediation Data Repository (RADAR), a searchable database for accessing multi-hazard research and operational data conducted by the U.S. EPA and other federal and international partners. The tool acts as a central repository (i.e., database) that stores up-to-date data derived from HSRP literature reviews, studies, and tools.

RADAR will allow the U.S. EPA’s homeland security specific research or operational guidance to be shared among partners and a broad array of users by way of an online platform – an offering that currently does not exist. RADAR is being designed to provide users access to data both through a user-friendly searchable interface and via an application programming interface (API) to facilitate consumption of data through web services by other HSRP tools. This capability will greatly reduce the cost of updating models and tools and ensure end-users are referencing the most up-to-date information, all the while significantly reducing development and maintenance costs.

The proposed presentation will provide an overview of RADAR, future applications and enhancements, and will conclude with an operational demonstration.

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Concurrent Session 6 – Water Infrastructure Protection and Decontamination



Water Distribution System Tools to Support Decontamination Efforts

Terra Haxton

U.S. Environmental Protection Agency

The U.S. EPA has the responsibility to work with the water sector to reduce vulnerabilities, minimize consequences, identify and disrupt threats, and hasten response and recovery efforts related to critical water infrastructure. To address these needs, the U.S. EPA and their partners have been investigating, developing, and evaluating methods to improve the security and resilience of drinking water distribution systems.

The research areas being explored include consequence assessment, online water quality sensor placement, contamination detection and source identification, identification of grab sample locations, and evaluation of response, remediation, and strategies for contamination incidents as well as natural disasters, such as earthquakes or power outages. The approaches utilized to address these research areas include modeling, simulation, systems analysis, optimization, and data analysis. Over the past decade, the U.S. EPA has developed modeling and simulation software tools (e.g., TEVA-SPOT, EPANET-MSX, WST, EPANET-RTX, WNTR) to help the water industry be prepared for and respond to hazards of all types. The tools could help a water utility to rapidly detect water quality changes, evaluate different response actions, and assess decontamination best practices following a natural disaster, industrial spill, or other environmental emergency. These tools, such as the Water Security Toolkit (WST), could support decontamination efforts by identifying the optimal sampling locations to define the extent of contamination and evaluating consequence management strategies, such as which areas are best to contain the contamination or which hydrants should be flushed to remove the contaminated water. By applying these tools, water utility managers and operators can more effectively prepare for and respond to emergency situations. This presentation will provide an overview of the U.S. EPA’s water distribution system security and resilience modeling tools that support decontamination efforts.

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Removal of Perfluorinated Compounds from Post-Emergency Wastewater by Advanced Oxidation Process and Granular Activated Carbon Adsorption

Sean Dyson

Air Force Institute of Technology

This research presents a novel approach to chemical decontamination of per- and polyfluoroalkyl substances (PFAS) from aqueous film-forming foam (AFFF) impacted wastewater with high (~100 mg/L) total organic carbon (TOC) concentrations. A treatment-train process was investigated involving an initial ultraviolet (UV)/hydrogen peroxide (H2O2) advanced oxidation process (AOP) followed by a secondary filtration treatment using Calgon Filtrasorb® 600 (F600) granular activated carbon (GAC). UV/H2O2 AOP experiments were conducted to determine whether TOC concentrations could be reduced during the pre-treatment step before filtering the water with F600-GAC. Results showed using UV/H2O2 AOP reduced TOC in solution by > 98% (to < 2 mg/L down from initial 99.1 mg/L). Reducing TOC concentrations was achieved by using a 250 mg/L H2O2 concentration and operating the UV/H2O2 AOP system for 8-hours.

Rapid small-scale column tests (RSSCT) were used to determine whether pre-treatment with AOP affects GAC adsorption capacity for PFAS, specifically perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). The UV/H2O2 AOP pre-treatment process increased GAC capacity through 10% breakthrough (BV10) for PFOS by 1800% (increasing the adsorbent’s solid phase concentration from 3 mg-PFOS/g-GAC without pre-treatment up to > 52 mg-PFOS/g-GAC with pre-treatment). The treatment-train process also improved GAC capacity through BV10 for PFOA by 1100% (1.1 mg-PFOA/g-GAC up from 0.1 mg-PFOA/g-GAC) when operating the UV/H2O2 AOP for 8-hours versus two-hours.

This research also indicated GAC capacity increases for shorter chain PFAS such as PFBA, PFBS, PFHxA, PFHxS, and PFHpA. These shorter chain PFAS – which are not excluded from newer AFFF formulas – may be of greater importance moving forward as more research and data is collected on PFAS released from AFFF. In summary, it is expected that using the proposed treatment-train to remove TOC from natural waters (TOC ~1-4 mg/L) will also increase GAC capacity. This may prove useful for treatment facilities tackling the larger problem of legacy PFAS contamination across other known sites dealing with low (µg/L or ng/L) PFAS contamination concentrations.

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Radiological Contaminant Persistence and Decontamination in Drinking Water Pipes

Ryan James

Battelle

The objective of this work was to evaluate the absorption, persistence, and possible decontamination approaches of radioactive cesium-137 on concrete-lined, copper, and polyvinyl chloride (PVC) pipe using the U.S. 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 four components: 1) Surface contamination with cesium-137 and activity measurements on the three pipe materials; 2) Persistence evaluations (PE) of cesium-137 on the pipe coupon surface after contact with clean tap water; A chemical cleaning agent evaluation (CCAE) with 3) 1 molar (M) ammonium chloride (NH4Cl) and 4)1 M potassium chloride (KCl) solutions. Shear was applied to the contaminated concrete-lined, copper, 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 CCAEs. Prior to contamination of pipe coupons, a biofilm was grown on all of the coupons.

The results of the PE showed that exposure to clean drinking water reduced the contamination level by about 75% for the copper pipe materials and >90% for the PVC and concrete pipe materials. When NH4Cl was used to decontaminate, there appeared to be more variability in the results on the copper coupons compared to the PE results, possibly due to a precipitate that formed. The precipitate is a form of enhanced corrosion for the copper piping material and could cause physical damage to a water system. The NH4Cl CCA was effective at removing the Cs-137 from the PVC and concrete piping materials to about 9% and 15% P remaining after decontamination, respectively. The KCl CCAE results show cesium-137 adhered to the copper coupons remained persistent at about 50% P after five days of KCl exposure, although there was no damage to the coupons from a precipitate. The PVC contamination was reduced to the detection limit of both instruments after 2 days of KCl exposure. The concrete coupon contamination levels decreased to about 10% P after 2 days of exposure to KCl, then remained at Day 2 levels for the remainder of the experiment.

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Development and Testing of the Decontamination Effluent Treatment System (DETS)

Victor Medina

U.S. Army Corps of Engineers

The Army maintains extensive decontamination capabilities to mitigate chemical, biological, radiological, and nuclear (CBRN) attacks. 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 a major handling, logistical, and political burden.

An effective on-site effluent treatment approach would allow for 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.

To explore the efficacy of treatment of decontamination wash water, a pilot scale treatment system called the Decontamination Effluent Treatment System (DETS) was designed and constructed. This system was designed to address decontamination from a series of battalion sized events, which was calculated to require a flow rate of 10 gallons per minute. The system uses a series of physico-chemical treatment processes, including sand filtration, granular activated carbon, and reverse osmosis, to remove a wide range of constituents to allow for effective removal of highly toxic CBRN agents. The system is designed to be rugged, easy to operate and is relatively inexpensive. A field evaluation was conducted to test the system in a simulated decontamination event. Testing indicated that the system met target performance goals. The treated water is suitable for reuse and reuse allows for a factor of 6 increase in water availability for decontamination, and this can be further increased by treatment of the concentrate.

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Predicting Effectiveness of Removal of Organic Contaminants From Polyethylene Pipes by Flushing

Levi Haupert

U.S. Environmental Protection Agency

Polyethylene tubing has been used in indoor plumbing for decades, typically for drainage or for subfloor heating applications. More recently, cross-linked polyethylene (PEX) tubing has gained market share for domestic potable water systems. Polyethylene, however, is permeable to a range of organic contaminants such as pesticides and petroleum products. Once permeated, polyethylene pipes have been observed to leach contaminants into drinking water. Considerable attention has been paid to leaching of organics from polyethylene tubing contaminated with solvents during the manufacturing process. However, less attention has been paid to the question of how to remediate polyethylene pipes that have been contaminated at the point of use.

For instance, guidance for responding to incidents like the 4-methylcyclohexyl)methanol spill in Charleston, West Virginia in 2014 typically advises residents to flush their water for 10 to 30 minutes.

However, the kinetics of decontaminating permeated polyethylene pipes by flushing remain largely unexplored in the scientific literature.

We employ numerical solutions to the diffusion equation, validated by experimental data from a custom-built single compartment diffusion apparatus, to predict the flushing times required to decontaminate permeated polyethylene pipes for several real world scenarios. Based on results of our work, an overnight exposure to 300 mg/L toluene solution is expected to be sufficient to allow contamination to penetrate into the bulk of a typical 3/8” polyethylene domestic water pipe. The resulting contaminated pipe is expected to significantly re-contaminate fresh water even after 48 hours of treatment by continuous flushing. For longer contamination contact times, or for higher contaminant concentrations, weeks of continuous flushing may be required to achieve adequate contaminant removal. Thus, depending on the diffusion and solubility properties of the contaminant, a 10 to 30-minute flushing procedure may not be sufficient to remediate polyethylene drinking water pipes that have been heavily permeated. The findings of this study are expected to assist water utilities in selecting optimal strategies in responding to contamination incidents.

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Poster Session



Novel Fast Analysis Method for Processing Low-Concentration

**1**

Ahmed Abdel-Hady

Jacobs Technology, Inc.

Environmental sampling is a critical component of the post decontamination procedures following a bioterrorism event. This work was performed to produce a less labor-intensive method for processing cellulose sponge-wipes used for sampling areas potentially contaminated with low concentration (i.e., post-decontamination) *Bacillus anthracis*. A novel fast analysis processing method was compared to the processing protocol validated by the US. Centers for Disease Control and Prevention (CDC) for their Laboratory Response Network (LRN). Glazed tile coupons (144 in2) were inoculated with *Bacillus thuringiensis var. kurstaki* (Btk) with 50, 500, and 5000 spores and then sampled with cellulose sponges (P/N SSL10NB; 3M, St. Paul, MN, USA). Sampling was limited to a 10- by 10-in area and performed in the same manner as the CDC sampling method. Samples were then processed using either the novel “Fast Analysis” method or utilizing the “CDC protocol”. Three different analysts repeated the tests at each concentration utilizing each method. Mean recoveries, labor time, and potentially hazardous waste produced were compared for the two methods. The mean percent recoveries and standard errors for the samples processed using the “CDC protocol” were 39.9 +6.7, 43 +7.6, and 36.8 +10.1 % for the 50, 500, and 5000 spore inocula respectively, compared to 54.2 + 12.9, 64.2 +21.7, and 45.2 +8.6 % for the “Fast Analysis” method. At each concentration tested the “Fast Analysis” method produced a statistically significant higher percent recovery. Furthermore, analysts processed samples utilizing the “Fast Analysis” method in less than half the time and generated half as much potentially hazardous waste compared to the “CDC protocol”.

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Incorporating RV-PCR Measurements into Characterization Sampling Strategies

**2**

Brett Amidan

*Pacific Northwest National Laboratory*

When a site is potentially contaminated with a biothreat agent, characterization of the contamination at the site is quickly needed.

Understanding where and how much of the biothreat agent is present, helps in determining the most effective remediation approach. After remediation, rapid results of the effectiveness of the decontamination measures are also needed before reopening the site to the public. Commonly used methods, like culturing, are low throughput and are labor, space, cost, and time intensive.

Rapid-Viability (RV-PCR) was developed to help reduce the time needed to process samples, allowing for a quicker response time and more effectively detect and quantify the presence of *Bacillus* spores.

The BOTE (Bio-Response Operational Testing and Evaluation) project, as discussed in the journal article “Operational Evaluation of the Rapid Viability PCR Method for Post-Decontamination Clearance Sampling” by Kane et al. (J Bioterr Biodef 2013), tested the effectiveness of RV-PCR as compared to culturing samples. The contamination and sampling was performed in a real world environment. Samples were taken post-decontamination.

Overall, the RV-PCR provided rapid results that were 98% consistent (156/159 samples) when compared to culture results. This indicates that RV-PCR results correlate to culture positive results, however, it might not be quite as effective.

This poster will discuss the benefits of using RV-PCR measurements in contaminant sampling plans. Its focus will be on how the use of RV-PCR impacts sampling strategies, not how to implement the RV-PCR methodology.

It will also discuss how increasing assumed false negative rates can help account for the decreased sensitivity in RV-PCR measurements, when compared to culturing. Also, a use case study will be presented using VSP (Visual Sample Plan). The purpose of this use case study will be to demonstrate how to develop a statistically defendable sampling plan, incorporating RV-PCR measurements.

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Laboratory Research on the Efficacy of the TDA, Inc. Photochemical Mold Remediation (PMR) Technology

**3**

Doris Betancourt

U.S. Environmental Protection Agency

The goal of the U.S. EPA and TDA, Inc. (TDA) Cooperative Research and Development Agreement (CRADA # 901-16) is to evaluate the efficacy of TDA, Inc. - “Photochemical Mold Remediation” (TDA-PMR) technology for the remediation of building materials contaminated with molds. The TDA-PMR technology consists of an on-site photochemical generation of active chlorine dioxide (ClO2) species to deactivate biological organisms in biofilms. Previous U.S. EPA research of ClO2 technologies for fumigation of viable mold contaminated building materials showed the potential of these technologies for remediation of extremely water-damaged buildings.

Through this U.S. EPA-TDA CRADA, TDA plans to develop a specific formulation (F) of the photochemical system that is designed for use against fungi and fungal spores. The U.S. EPA laboratory evaluations consisted of testing the efficacy of the PMR technology on building materials that support mold growth.

Four mold species frequently isolated from water-damaged buildings were used: *Alternaria alternata*, *Aspergillus versicolor*, *Chaetomium globosum*, and *Stachybotrys chartarum*. These contaminants were individually inoculated onto the surface of six building materials: gypsum wallboard (W), latex-painted gypsum wallboard (L), bare-structural pine wood (PW), concrete (CN), ceiling tile (C) and glass (G). The inoculated building materials were fumigated with the TDA-PMR formulations F1; F2; F3 and F4. Each formulation was tested individually. The reduction in viable spores was determined by subtracting the average log values of colony forming units (CFU) recovered from the treated coupons from the CFU recovered from the positive controls. The target reduction, determined by the U.S. EPA for previous remediation studies was a 4 log reduction (99.99% inactivation efficiency). F1 and F2 were used for the optimization of the testing conditions (results not shown). Formulations F3 and F4 were the most effective for fumigation of mold-contaminated building materials using an exposure time of 4 hours under a Repti-Sun light @ 9,000 – 10,000 lux. F3 and F4 fumigations showed a ≥ 4-log reduction in CFU for *A.versicolor*, and *S.chartarum* on W, CN and PW. Likewise, a ≥ 4-log reduction in CFU for *A. alternata* was observed on W. A < 4-log reduction in CFU for *A versicolor*, *S.chartarum*, *A.alternata* and *C.globosum* was observed on L and C. Likewise a < 4-log reduction in CFU for *C.globosum* was observed on CN.

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Analysis of Sulfur Mustard (HD) by Thermal Desorption Tube Collection and Analysis by Gas Chromatography/ Time‐of‐Flight Mass Spectrometry

**4**

Julia Capri

*CSS, Inc.*

Objective: The purpose of this study was to develop a method for the deposition of Sulfur Mustard (HD), in atmospheric samples, onto thermal desorption tubes and the subsequent analysis using Gas Chromatography / Mass Spectrometry – Time-of-Flight (GCMS-TOF).

Significance: This method allows for the analysis and detection of HD in atmospheric samples at a level of detection 0.000010mg/m-3.

Experimental Procedures and equipment used: GCMS-TOF interfaced with a Markes thermal desorption unit. Air samples were collected onto Tenax® tubes. The GC run time was 7 minutes with ~3 injections per hour.

A six–point calibration was performed by spiking 1uL aliquots of liquid HD standards onto thermal desorption tubes ((Markes #C2-CAXX-5138 (PAH)) (Tubes) via a Markes CSLR (calibration solution loading rig) at a flow (N2) of 400mL/min-1 for 2 minutes. The tubes were analyzed by GCMS-TOF/TDU.

Samples were prepared by spiking HD at various concentrations onto Tubes with a flow of (N2) at 400mL/min-1 for 2 minutes (via CSLR). The Tubes were then transferred to a manifold where the the flow was set at 100ml/min-1 for 100 minutes (10L of N2 pushed across tube). An NOX Teflon/HD pre - filter (CAMSCO 13mm CHROMOSORB P 30/60) was placed in-line prior to the N2 entering the manifold. After 10L of N2 was pushed through the Tubes, the Tubes were immediately capped and placed on the Markes autosampler for analysis by GCMS-TOF. Tubes at six different concentrations were analyzed, in duplicate, each day, for four consecutive business days. This equates to 12 tubes analyzed per day or 48 tubes analyzed over the four day period. This procedure was performed by two different chemists on two different gas chromatography columns for a total of 192 samples analyzed.

Results Obtained: HD recoveries for the 192 samples analyzed were, in general, ≥ 75% of true values.

Conclusions: Data from calibration curve and samples analyzed by the developed method validate the method as a viable quantitative procedure for the analysis of HD in atmospheric samples.

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Redistribution and Effectiveness of Spore Removal from Urban Surfaces

**5**

Jason Colon

*Science Systems and Applications, Inc*.

Following a wide area bioterrorism or contamination event, involving *Bacillus anthracis* (Ba), numerous factors can influence the fate and transport of spores from urban surfaces. Redistribution of spores following a precipitation event, or during a wash-down procedure are possible occurrences that could be expected following a release of spores. However, the redistribution and effectiveness of spore removal from urban surfaces under natural precipitation events, or following remediation events using wash-down procedures, are not well known. The purpose of this work was to characterize the magnitude and temporal characteristics of spore removal from urban surfaces, specifically, concrete, asphalt, and brick. A rain simulator (30-ft height) was designed and constructed to mimic critical parameters of actual rain fall including rain intensity, droplet size, kinetic energy, and droplet terminal velocity. A stainless-steel chamber (40 in. × 38 in. × 36 in., L × W × H) was used for wash-down testing to simulate an actual wash-down remediation approach. The chamber has an acrylic hinged door on the front.

Both the door and the top contain multiple ports through which the interior of the chamber can be sprayed. The wash-down event was simulated using a conventional garden hose–type bore nozzle (40 psi), and pressure washer (rated at 1600 psi). The side spray was applied at a 90° angle with the material surface. Spray parameters such as flow rate, application duration, additives, and spray pattern (wash-down from above on vertical surfaces versus perpendicular spray-down for vertical surfaces) were evaluated.

Test coupons were inoculated with *Bacillus atrophaeus var. globigii* (Bg) or *Bacillus thuringiensis subsp. kurstaki* (Btk), both non-pathogenic surrogates for Ba, and then subjected to various intensities and durations of simulated rain, or wash-down events. In addition to determining surface removal effectiveness (by determining the abundance of spores remaining on the surface after a rain or wash-down event), spore fate and transport into runoff liquid, and aerosolization were determined. Comparisons of hose/pressure washing removal to rain removal will be presented in this poster.

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Polyhexamethylene-Guanidine Hydrochloride: A Low Dose, Safe and Effective Water-Soluble Facility and Equipment Friendly Antimicrobial Compound

**6**

Herb Dempsey

*Pure Global Solutions LLC*

The dynamics of infection spreading throughout a population necessitates new safe disinfectants as resistance develops and effectiveness attenuates. The biocidal properties guanidine compounds have long been recognized and Polyhexamethylene biguanide hydrochloride (PHMB) is well established and widely accepted as biodegradable, noncorrosive and nontoxic disinfectant when used as directed. Another guanidine compound, Polyhexamethylene-Guanidine Hydrochloride (PHMGH) has been demonstrated to have biocidal properties comparable to or more effective than PHMB. PHMGH studies have shown that PHMG in water solution has fungicidal as well as bactericidal activity against both Gram-positive and Gram-negative bacteria including effectively destroying Methicillin-resistant *Staphylococcus aureus* (MRSA), *Escherichia coli*, spore forming bacteria such as *Clostridium difficile* at biocide concentrations well below what is required for other disinfectants.

Our work at Pure Global Solutions, LLC (PGS) and Arizona State University (ASU) is demonstrating the biocidal efficacy of PHMGH in a variety of applications covering diverse scenarios including controlling toxic algal blooms in surface water, algae and bacteria in ornamental fountains, mold and mildew on a variety of surfaces, zebra mussel larvae on submerged boat surfaces in fresh water, and extending the work of others by incorporation of our proprietary formulation of PHMGH into a full range of sanitizer, disinfectant, healthcare, personal hygiene and other products.

PHMGH as a biocide is effective at concentrations as low as 0.002%, in water, with sufficient contact time. Concentrations of 0.05% to 0.1%, in water, shortened required contact time to seconds as would be required for wiping down surfaces and as hand sanitizers. Without additives, PHMGH solutions in water are mild and safe for all surfaces that can be dampened with water.

And, the low toxicity of PHMGH based products could substantially reduce the cost of personal protective equipment (PPE) required safety equipment in daily use and/or emergency situations. When stored at room temperature and out of direct sunlight PHMGH has a shelf life of five years or more. These properties make PHMGH potentially quite useful for routine or emergency disinfection of large spaces, both interior and exterior, included but not limited to hospitals, animal husbandry facilities, food processing facilities; quarantined areas (personnel and equipment); food animal transport trailers and boats; surface water contaminated by storm runoff or intentional releases.

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Fate and Transport of Radionuclides in Freshwater Rivers

**7**

Jessica Duffy

*U.S. Environmental Protection Agency*

As part of the Regional Research Partnership Program (R2P2), sediment was collected from an ongoing U.S. EPA removal site, Safety Light Corporation Site, to be used at the National Homeland Security Research Center (NHSRC) laboratory in Research Triangle Park, NC. The sediment was brought to the lab to conduct experiments to determine the potential impacts to a water treatment facility in the event that sediment surrounding the intake was radiologically contaminated. This poster will address the logistics of collecting, processing, screening and analyzing the sediment.

The project team encountered many challenges when attempting to bring potentially radiologically contaminated sediment into the research laboratory. Coordination with different regional offices, divisions, and the U.S. EPA special teams for both laboratory analysis and equipment procurement was necessary and will be highlighted in the poster. Additionally, many steps were taken to ensure the laboratory remained in compliance with the NRC licensing requirements for the time which the sediment was stored at the lab.

The team also had to take care to be sure radiation levels were within the guidelines set for radiation health and safety at both the removal site and the lab. A combination of field screening tools and laboratory analysis were used to ensure the sediment was in compliance for use and storage at the lab, and the sampling team limited their exposure.

Projects like this one conducted as part of the R2P2 are integral to creating partnerships and networks within the agency while furthering our internal research capabilities. The intent of this poster is to assist others that wish to conduct similar work in the future, and encourage people to look outside of their programs to use other agency resources to conduct their work.

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Decontamination Strategy and Technology Selection Tool for Decontamination of Facilities Contaminated with Biological or Chemical Agents

**8**

Donna Edwards

*Sandia National Laboratories*

Successful decontamination of a complex facility may be achieved through one or more of several potential decontamination methods, based upon the environmental conditions, application requirements, and site-specific inputs.

Remediation with each potential technology may involve different levels of cleaning and removal (and possibly off-site treatment) of potentially contaminated items or materials (source reduction), and additional management of items and materials (waste removal), all with associated costs and benefits.

The Decontamination Strategy and Technology Selection Tool (DeconST) provides a framework for considering decontamination options and facilitating the development of facility-specific remediation approaches following attack or contamination with *Bacillus anthracis* (B.a.) or a chemical agent such as the blister agent sulfur mustard (HD) or the nerve agent VX. The comparison includes for each decontamination technology the required operational conditions, source reduction, materials compatibility, waste management, and costs to the facility. The DeconST uses published experiment-based data on the decontamination technologies and has the flexibility to incorporate updates to those data as well as new decontamination strategies and technologies and new facility structural and nonstructural materials and contents.

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 Commander (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, cost implications, and waste estimates. The DeconST 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.

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Decontamination of Select Agents on Smart Cards in a High Containment Laboratory

**9**

Lindsay Gabbert

*U.S. Department of Homeland Security*

Validated procedures for decontamination of laboratory surfaces and equipment are essential to biosafety and biorisk programs at high containment laboratories (HCLs). Each HCL contains a unique combination of surfaces, procedures and biological agents that require decontamination methods tailored to specific facility practices. The Plum Island Animal Disease Center (PIADC) is an HCL operating multiple biosafety level (BSL)-3, ABSL-3 and BSL-3 Ag spaces. The PIADC facility requires the use of federally issued smart cards, called Personal Identity Verification (PIV) cards, to access IT networks within the HCL. Because PIV cards require transit through the PIADC HCL, a validated procedure for disinfecting PIV card surfaces prior to removal from the HCL is critical to ensure biosafety and biosecurity. Two high risk select agents used in the PIADC HCL are Foot-and-Mouth-Disease Virus (FMDV) and Swine Vesicular Disease Virus (SVDV). We evaluated disinfection of PIV cards intentionally spotted with FMDV and SVDV using a modified quantitative carrier test and the liquid chemical disinfectant Virkon® S. Our experimental design modeled a “worst case scenario” of PIV card contamination and disinfection by combining high concentrations of virus dried with an organic soil load and¬¬ use of aged Virkon® S prepared in hard water. Results showed that FMDV and SVDV dried on PIV card surfaces were completely inactivated after immersion for 30 and 60 seconds, respectively, in a 5-day-old solution of 1% Virkon® S.

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Advancing Chemical, Biological, Radiological, and Nuclear (CBRN) Decontamination Through European Research and Development

**10**

William Guglielmo

*ITL Solutions*

US foreign partners, specifically in our NATO allies, have extensive experience in research and development and operationally combating Chemical, Biological and Radiological (CBR) Threats. Integrating foreign technology, research and development and expertise which have already undergone significant testing and operational use can rapidly and significantly enhance US capability in defeating Chemical, Biological, Radiological, and Nuclear (CBRN) threats in the United States. Advances in rugged, high mobility decontamination systems, sensitive equipment decontamination, decontamination chemicals and large volume decontamination systems through our NATO allies commercial research and development programs can quickly enhance and upgrade current systems capabilities. With full spectrum Chemical, Biological and Radiological decontamination equipment currently in use in Europe, from decontamination chemicals and high performance equipment, the ability to provide an improved and more reliable response to CBR threats is readily available. In place Research and Development programs which are conducted jointly between University and Commercial partners and tested in laboratories worldwide are continually moving forward to enhance existing capabilities and systems.

Specific proven enhancements include:

* Military grade multi-fuel hot water generation systems to provide hot water, steam and electrical power generation in a single unit can enhance response capability and reliability.
* Sensitive equipment decontamination using spray on encapsulation technology can quickly restore sensate electronics to service after exposure to CBR threats.
* Tested and proven Chemical Biological (CB) neutralization chemicals can improve responses to CB threats as well as mitigate effects of runoff and containment by neutralizing threats on site. Long shelf life and no mixing requirements enable quick and easy response to Chemical and Biological Threats with low environmental impact.
* Activated H2O2 based decontamination systems is undergoing testing to improve the capability to combat Chemical and Biological threats in large volume areas, such as airports and subways, both for airborne agents and agents on surfaces.

Furthermore, specific case studies will be presented regarding how these technologies have been used operationally.

* Aircraft decontamination after transporting Ebola infected patient.
* Neutralization of Mustard agent shells in Baltic Sea.

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The Impact, Fate, and Viability of *Bacillus globigii* Spores and MS2 Bacteriophage Injected into Activated Sludge

**11**

Willie Harper

*Air Force Institute of Technology*

Introduction of biocontaminants into the water cycle may pose a threat to public safety. Biocontaminated wastewater could result from accidental or intentional contamination incidents, including wash down water in the aftermath of an attack, as well as hospital waste. The impacts, fate, and viability of these biocontaminants within and after biological treatment processes are key concerns for addressing disposal of biocontaminated wastewaters. This work used two biocontaminants, *B. globigii*, a surrogate for *B. anthracis*, and MS2 bacteriophage, a common surrogate for noroviruses. *B. globigii* spores and MS2 bacteriophage did not cause statistically significant differences in the maximum rate of oxygen (O2) uptake, and they did not discernably alter the shape of the respirometric profiles over a wide range of initial concentrations. Chemical oxygen demand (COD) and nitrogen removal were not negatively impacted by *B. globigii* spores or MS2. However, when *B. globigii* spores were added without washing off the ethanol, the relative cumulative O2 uptake was significantly higher in two of four experiments at a spore concentration of 2 x 10^5 CFU/mL. Overall, these results showed that *B. globigii* spores and MS2 bacteriophage do not interfere with microbial respiration; however, ethanol caused initial inhibition. This result could be significant if biocontaminants are introduced into a treatment plant with an organic co-solvent. Typically, biocontaminants were present both in the bulk and in the solid phase. Plating and microscopic analysis of effluent samples indicated that both MS2 and *B. globigii* spores remained viable after exposure to activated sludge in batch experiments. When *B. globigii* spores were injected into the pilot plant system at 3.7×10^5 cfu/ml, samples collected over 7 weeks all showed the presence of germinated *B. globigii* cells regardless of collection location (i.e., primary effluent, activated sludge at different locations, and secondary effluent). The germination percentage (i.e., the number of germinated spores relative to the total number of spores in a given sample) was between 1 – 25% across all samples and generally increased with time, suggesting the formation of new, biochemically active daughter cells.

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Defense Threat Reduction Agency Technical Reachback

**12**

Terence Hill

*Defense Threat Reduction Agency*

Defense Threat Reduction Agency (DTRA) Reachback provides 24/7, 365 Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) subject matter expertise, advice, and decision support capability for planning, operations, and post event analysis to: Combatant Commands (CCMDs), Office of the Secretary of Defense (OSD), Joint Staff (JS), Intelligence Community (IC) command elements, and other U.S. Government Agencies, State/Local/Tribal Governments and first responders. With over 40 subject matter experts, deep scientific analysis of technical questions regarding CBRNE hazards is provided through hazard modeling and CBRNE decision support during Real-world CBRNE events, exercises, and planning for special event support. Software tools to provide this analysis include, but are not limited to; Hazard Prediction and Assessment Capability (HPAC) for atmospheric plume modeling. This software incorporates high-resolution numerical weather forecasts to predict the transport and dispersion of CBRN hazards through the outdoor environment and the health effects to the population in the geographic area of the hazard.

For modeling of hazards within indoor building environments the Multi-zone airflow and Contaminant transport analysis software (CONTAM). For modeling the transmission of infectious diseases DTRA Reachback relies on the Comprehensive National Incident Management System (CNIMS). The CNIMS platform was developed by researchers at Virginia Tech, and uses high-performance computing and agent-based modeling to simulate the spread of infectious disease throughout communities and can be used to assess the impact of public health interventions. In addition, modeling capabilities for waterborne & natural disasters are available through (ICWater/Specialized Hazard Assessment Response Capability, SHARC/and HAZUS). DTRA Reachback is consistently engaged in research and development to improve modeling and simulation capabilities necessary for hazard response to CBRNE events. DTRA Reachback modeling products have been utilized in support of real-world events, IMAACs, Arkema Chemical Plant post Hurricane Harvey, Deep water Horizon oil spill, the 2014 Ebola outbreak, Fukushima Daiichi operational support, and planning for major events including Super Bowls, Inaugurations, and Olympic Games.

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Development of Custom Growth Media for Rapid Detection of Chlorine Stressed *Escherichia coli*

**13**

Janine Hutchison

*Pacific Northwest National Laboratory*

Detection of bacterial targets of interest, specifically total coliforms and *Escherichia coli* in water samples, typically requires 18-24 hours to complete. Detection within 8 hours is highly desirable to detect, assess, and prevent health effects from adverse exposures. Since standard methods require detection of concentrations as low as a single organism (coliform and/or *E. coli*) in 100 mL, an enrichment or bacterial growth step is necessary. For treated water, bacteria are typically chlorine-stressed and must be resuscitated, which adds additional steps and time to the overall method.

Resuscitation is often performed using growth media that are not selective for the target organisms, followed by growth in selective media. While selective media limits the growth of non-target organisms, it also slows the growth of target organisms and is not an ideal growth media for stressed organisms. This study focused on the development and evaluation of custom rapid enrichment media for the detection of 1-10 unstressed and chlorine-stressed total coliform and/or *E. coli* cells in 100 mL water samples. A comparison of the performance, specifically fold change in growth via viable plate counts, of the custom rapid enrichment media was compared to commercially available baseline growth media, including Colilert-18. Numerous additives were tested, and it was determined that at least four additives enhanced the growth of both chlorine-stressed and non-stressed *E. coli* cells in 100 mL samples by one log compared to samples without additives after 8 hours. Final cell counts varied, but were on the order of ~1E7 CFU/100 mL when starting from one to ten chlorine-stressed cells after 8 hours in the developed media. Temperature was also found to be an important variable for improved growth rates. Further refinement and media development in combination with novel concentration methods are expected to improve cell yields in the future. Additionally, complex samples such as non-chlorinated secondary sewage effluents need to be tested.

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Developing Surrogate Far-Field Nuclear Fallout and its Rapid Decontamination from Aircraft Surface

**14**

William Jolin

*Argonne National Laboratory*

Naval aircraft and vehicles deployed in response to the Tsunami of 2011 and subsequent nuclear meltdown at the Fukushima Daachi nuclear power station were exposed to and contaminated with radioactive materials released to the atmosphere. In response, the Navy and Argonne National Lab are currently testing various decontamination methods to clean aircraft surfaces exposed to far-field nuclear fallout. Far-field fallout, which can travel hundreds of miles, includes dissolved radionuclides and fine particulate matter. To simulate contamination with such materials, dissolved Cs-137 and radiolabeled particles were deposited on coupons (1” x 1” sections) of tire, acrylic, and painted metal surfaces. These coupons were subjected to six different decontamination methods including four strippable products, a soap solution, and tap water. Removals of dissolved Cs-137 were generally high, as over 90% of the deposited radionuclide was removed after three decontaminations.

To simulate exposure to radioactive particles, silicate particles were developed as surrogate fine particulate matter. A method was developed to radiolabel silica particles by first depositing Eu-152 or Am-241 on the particle surface as sesquioxides, then coating the particle with sodium silicate. Scanning electron microscopy confirmed particle size was not altered while leaching studies into numerous solutions and decontamination agents confirmed that minimal amounts of the radiolabel dissolved in solution. Three different methods to apply the particles were then evaluated.

Pressing the coupons into a dish containing the particles resulted in particle clumping on the surface, while applying the particles within water also resulted in a heterogeneous surface coverage. Suspending the particles in ethanol and then applying them to the surface supplied a homogenous surface coverage that provided acute and precise removal percentages.

Finally, particle-surface interactions seemingly play an important role in radiological decontamination as removals of particles were lower than those of soluble Cs-137 for aqueous decontamination methods. These decreased removals indicate that more complex removal methods such as the strippable decontamination agents are required to remove particulate far-field fallout from aircraft and similar vehicle surfaces. These results can be extrapolated to civilian applications where contaminated vehicles may require decontamination.

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Demonstration of Municipal and Commercial Equipment for Response/Recovery Operations

**15**

Michael Kaminski

*Argonne National Laboratory*

This demonstration builds onto a companion Oral/Poster submission to the U.S. EPA Decontamination Conference entitled “Municipal and Commercial Equipment Assets and their Use in a Radiological Response and Recovery Event.”

Based on the collected information from our study entitled “Municipal and Commercial Equipment Assets and their Use in a Radiological Response and Recovery Event,” we propose to design visual aids and live demonstrations during the Conference. We were able to rank municipal and commercial equipment technologies from subject matter expert opinion that may be more important to accomplishing scenarios under the Five Support Goals discussed in this study. To help visualize how such technology options might be used, we propose presenting a video stream on a rolling marques that shows how some technologies might function. Plus, we consolidated a number of technologies into a live demonstration. Below, we describe the video stream, and live demonstration.

Rolling Marques – Assembly of Demonstration Videos

Goal: Collect a variety of videos from on-line sources and through partnerships with existing vendors to demonstrate the use of municipal and commercial equipment. For instance, these videos can be shown as part of a continuous rolling marques during the U.S. EPA Decontamination Conference in the hall outside the entrance to the meeting rooms or at the poster sessions.

Potential technologies to be included are:

* Smart phones radiation detector apps and issues with QA/QC (on-line sources).
* Chip sealer distributor for reducing loose contamination on paved areas (on-line sources).
* Best practices in cleaning surfaces from hospitals and power plants (on-line sources plus contacts at local hospital and nuclear power stations).
* Soil stabilizer polymer spray systems (on-line sources).
* Automatic window and building washer units (on-line sources).
* Integrated Wash-Aid, Treatment, and Emergency Reuse System (IWATERS) inside transport container and demonstrating washing of emergency management (EM) vehicle and municipal equipment (with Separmatic and local EM and Municipal offices).
* Radiation detector-mounted drones (with Nuvia via on-line sources)
* Wash systems for freight (vehicle and train) and shipping containers.

Expected running time of rolling marque: 3-5 minutes.

Resources required: Video screen with possible audio, possible computer if video screen cannot run on USB memory stick.

Live Demonstration for the U.S. EPA Decontamination Conference

Goal: Several equipment options and techniques ranked highly in our surveys and can be demonstrated live as a single storyline. Two demonstration storyline options are proposed. One would be selected.

Mock setting (see adjacent Figure): Radiation survey station location for vehicles along egress route from a restricted contamination zone. Contains gamma-ray monitoring station, vehicle wash station adjacent to the survey station, and mobile IWATERS-Separmatic water recycle trailer.

Storyline 1: Municipal or contract vehicles are passing through one of several monitoring stations set up at the boundary of an exclusion or limited access zone that has been characterized by higher radiation and contamination levels. The monitoring station would scan vehicles. Contaminated vehicles are routed to a decontamination station before leaving the restricted zone.

Storyline 2: Personal vehicles are passing through one of several monitoring stations set up within the inhabitable but contaminated zone. The monitoring station would scan vehicles. Contaminated vehicles are routed to a decontamination station before release to the owner.

Demonstration details: Set up mock monitoring station on roadway, parking lot, or similar. We will use portable NaI detectors as surrogate for a portal monitor. Drive several vehicles up to monitoring station for interrogation. Allow first one or two “clean” vehicles to pass in turn.

(30 second interrogation). Third vehicle would contain a sealed source or natural radioactive source material (e.g., bags of potassium chloride) that can be picked up by the monitors. Divert vehicle to decontamination line and run IWATERS. A second monitoring station (we will not set up) would provide final verification of cleanliness and allow vehicle to pass.

Expected running time: 10-15 minutes.

Equipment/Techniques to be demonstrated (see adjacent Figure):

1. Paved surface to accommodate one or two vehicles to act out the storyline, the monitoring station, the wash tent, the IWATERS trailer and tow vehicle, video screens to show views of the gamma scan and the vehicle travel history.
2. Use of NaI monitors to scan vehicles.
3. Use of drain covers to protect sewer inlets (if available).
4. Design of ad hoc wash bay (secure tenting, spray system that uses lessons learned and best practices).
5. Equipment for water collection (tarps, swimming pool noodles or similar to create a shallow tub with tarps, sump pump).
6. IWATERS using trailer-mounted barrel filter and water clarifier for wash water reuse (trailer attached to F150 vehicle). We propose a blackbox trailer (empty trailer with a barrel to hold water) and the real trailer system parked in the viewing area so viewers have direct hands-on access to the trailer unit operations.
7. Removal of vehicle air filter for in situ or ex situ interrogation [gamma-beta survey instruments (specifications needed), tools to remove filter housing)].
8. Vehicle route history information (e.g., from google maps or from in-vehicle monitor) to revisit potential hotspots for decontamination.
9. Use of street sweeper with on-board radiation detectors (mock call-in; may or may not demo actual sweeper activity) to eliminate hotspots on identified route or travel for contaminated vehicle.
10. Public/private messaging to municipal worker to notify of the reasons to wash vehicle and risks being mitigated and to maintain public confidence.

Messaging to private vehicle owner to control fear and anxiety by notifying of the need to wash vehicle to reduce risk and to maintain public confidence.

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Evaluation of Spray-Based, Low-Tech Decontamination Methods under Operationally Challenging Environments: Cold Temperatures

**16**

Madhura Karnik

*Jacobs Technology, Inc.*

Eight non-freezing bleach-based (NFB) formulations, developed by Environment and Climate Change Canada (ECCC), were evaluated under a large range of temperatures (-25° C to 25° C), for decontamination efficacy against spores of *Bacillus anthracis* surrogate *Bacillus atrophaeus var. globigii* (Bg), on two common building material surfaces: concrete and glass. These solutions contained de-icing agents that depressed the freezing point of the solutions below the target test temperatures so that the solutions could be spray-applied. Surfaces of small coupons prepared from concrete and glass were inoculated (contaminated) with 107 Bg spores, then sprayed for a prescribed exposure time with formulations under various temperatures.

Results for each NFB formulation were compared, when temperatures permitted, to a baseline pH amended bleach (pAB) solution. The spray operation was set up for a 5 second spray duration, with one repeat application (2 total spray applications). The total solution contact time was 20 minutes (10 minutes after first spray and 10 minutes after the second spray). The spray duration was increased to 1 hour to determine its effect, if any, on the decontamination efficacy of the tested solutions.

In terms of surface decontamination, the NFB formulations achieved lower sporicidal efficacy (LR < 4.2) than the reference pAB solution (LR > 6.5).

Under the specific test conditions, none provided the 6 LR required to be deemed an effective decontamination agent for *Bacillus* spores. Surface decontamination efficacies for the NFB formulations were observed to have decreasing trends as temperatures decreased from 25° C to -25° C.

Increasing the contact time from 20 minutes to 60 minutes did not have a remarkable effect on the decontamination efficacy of pAB, but one test NFB formulation did show increased efficacies of 1 LR and 0.6 LR for glass and concrete coupons respectively. Furthermore, the overall results showed that the spraying operation dislodged many spores that were recovered and quantified during analysis of the neutralized rinsate samples. Such decontaminant quenching action may be comparable to that of a neutralizing soil matrix in an actual field situation.

Despite the NFB solutions demonstrating lower surface and total decontamination efficacies compared to pAB, these solutions are currently the only non-freezing decontaminants evaluated against *Bacillus* spores. At conditions below 0⁰ C, these solutions may provide utility to remediation efforts. More broadly, these solutions provide an important baseline to further develop and characterize new decontamination options under environmentally challenging conditions such as freezing temperatures.

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Lessons Learned from Biological Decontamination in Resource Restricted Regions in the Defense Threat Reduction Agency Cooperative Threat Reduction’s Cooperative Biological Engagement Program (CBEP)

**17**

Paul Kendall

*Jacobs (C2HM)*

The Defense Threat Reduction Agency (DTRA) engages with a number of countries (including in Africa, the Middle East and Eastern Europe) in the expansion of regional disease surveillance capacity, improving biosafety and biosecurity, and implementing disease surveillance programs. CH2M (now Jacobs), a contractor for DTRA, has been involved with the field decontamination of contaminated biological laboratories, facilities, and equipment during building renovations, upgrades and training processes. Common contaminants include biological agents such as bacteria and viral contaminants. Materials decontaminated include porous and non-porous materials, such as wood, plastics, masonry and stainless steel. Decontamination technologies used include vaporized hydrogen peroxide, paraformaldehyde, and aqueous chlorine solutions, and a wheel wash system. This paper reviews some of the lessons learned in conducting these decontamination processes and provides insight into applicability of these technologies in a resource-restricted environment. These include challenges with limited equipment availability, unknown contamination levels, and availability of trained local personnel.

This experience can aid developers of decontamination technologies in developing protocols that are as easy to use and flexible as possible.

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Development of Solar, Telemetry, and Control Systems for Remote Instrumentation Used in Field Support of Spore Fate and Transport Projects

**18**

Alexander Korff

*Science Systems and Applications, Inc.*

A series of instruments were retrofitted with custom solar, telemetry and remote control systems to support field-based projects focused on spore fate and transport in urban environments. This work was performed to better characterize fate and transport of spores in a wide area release following currently utilized washdown procedures or subsequent rainfall events. Of special interest is the transport and removal of spores during a natural rainfall event. A weather station, surface overflow sensor, and pair of autosamplers were used in combination to characterize rainfall events. Soil infiltration was investigated using soil probes (HydraProbes), installed at three levels to track moisture, conductivity and temperature. ISCO 6700 Autosamplers were equipped with solar modules, weather proofed enclosures, and water level sensors to detect runoff accumulation. Surface water sampling was triggered by SMS (text) message, or by time interval and water level triggers in autosampler mode. The system was also designed to communicate key parameters like voltage, bottle number, and water level to any user following a SMS prompt. The telemetry system was also designed to communicate and store data on a FedRAMP complaint server. This allows the system to operate autonomously while data are transmitted back to the U.S. EPA team who can respond without continuous travel to the field site. A RQ-30a – water velocity and depth sensor – was fitted with the same solar power and telemetry system, and used to measure the velocity and depth of runoff during rainfall events.

Similar to the ISCO system, this instrument transmits real-time data back to the U.S. EPA without any need site visits. The data can be viewed in real-time or downloaded from the U.S. EPA-ERT VIPER Server to be analyzed further. A Parsivel2 (laser-optical disdrometer) weather sensor was also deployed to characterize rainfall events (droplet size, velocity, count, and kinetic energy). The Parsivel can also be configured to communicate via SMS with the ISCO autosamplers to automatically change mode under specific rainfall events.

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Use of Novel Extremophilic Enzymes for the Removal of Biofilms Relevant to Space Flight

**19**

Kyle Landry

*Liberty Biosecurity*

Biofilms are microbial communities that can form complex 3-dimensional structures of cells and extracellular matrix (ECM) which attach to surfaces. They clog flow within life support systems, cause biofouling of hardware, and are often responsible for chronic infections, making biofilms significantly impactful for the National Aeronautics and Space Administration (NASA) and numerous Earth-bound industries. This is particularly concerning on the International Space Station (ISS), where critical systems such as water pipes, air ducts and life support can be difficult, dangerous and time-consuming to disinfect. Due in large part to the physical and chemical barrier provided by the ECM, biofilms are several orders of magnitude more resistant to antimicrobials and disinfectants than their unattached (planktonic) counterparts. There also appears to be a selective advantage for microbes to form biofilms in microgravity environments, exacerbating the problem of keeping crew healthy, and space hardware functional. However, the shift from vulnerable planktonic cells to virtually indestructible biofilms is reversible. Liberty Biosecurity's novel extremophile enzyme cocktail (NEEC) hydrolyzes biofilm ECM and releases cells from the community. The current formulation is able to remove over 90% of a multi-species Listeria biofilm within 1 hour at 55 oC using a static biofilm PVC microtiter plate assay. The percent removal is constant on glass and stainless-steel surfaces. Under similar testing conditions, NEEC is effective against other clinically and industrially relevant species; for example, it is able to remove 58%, 48% and 72% of biofilms produced by *E. faecalis*, *K. pneumoniae* and *P. aeruginosa*, respectively. This cocktail is also able to break down multi-genera biofilms. A 4 hr treatment at 55 oC was able to remove 73% of a *S. aureus*, *L. monocytogenes*, and *P. aeruginosa* biofilm and 50% of a *S. pyogenes*, *L. monocytogenes*, and *P. aeruginos*a biofilm. NEEC has demonstrated activity over a broad range of conditions, including temperature (32 - 72oC) and pH (7-10.5), and its activity range has by no means been exhausted. With preliminary data indicating an LD50 of >5,000 mg/Kg and >2,000 mg/Kg for acute oral and dermal studies, respectively, NEEC offers a safe, non-corrosive, biodegradable, robust alternative to canonical disinfectants and antimicrobials.

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Cesium Emissions from Laboratory Fires

**20**

Sang Don Lee

*U.S. Environmental Protection Agency*

If a radiological incident such as a nuclear power plant accident, a radiological dispersal device, or detonation of an improvised nuclear device occurs, significant areas may be contaminated. Initial cleanup priorities would likely focus on populated areas, leaving the forested areas to pass several seasons where the overhead canopy materials would fall to the forest floor. In the event of a wildfire in a radionuclide-contaminated forest, some radionuclides would be emitted in the air while the rest would remain in the ash. This presentation reports on a laboratory simulation study that examines the partitioning of cesium-133 (a non-radioactive isotope of cesium) between airborne particulate matter and residual non-entrained ash when pine needles and peat are doped with cesium. Only 1-2.5 percent of the doped cesium in pine needles was emitted as particulate matter, and most of the cesium was concentrated in the particulate fraction greater than 10 µm in aerodynamic diameter. For peat fires, virtually all of the cesium remained in the ash.

The results from this study will be used for modeling efforts to assess potential exposure risks to firefighters and the surrounding public.

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Chemical Warfare Agent Sensors and Decontaminant for Sensitive Site Exploitation

**21**

Anna Leech

*FLIR Detection, Inc.*

Sensitive site exploitation (SSE) is a challenging mission requiring a wide array of sensitive presumptive detection tools and decontamination capability. FLIR has developed a set of highly sensitive and selective sensors ideal for detecting Chemical Warfare Agents (CWAs) by class. The Agentase C1 Chemical Agent Detection (CAD) Kit contains colorimetric point sensors capable of specifically detecting trace levels of nerve, blister, or blood CWAs presenting in solid, liquid, or gaseous states. A sampling device is also included with the kit for survey teams to collect bulk or complex matrix samples for laboratory analysis or use with multiple CAD sensors. The CAD sensors are non-destructive to agents, and the polymeric sponges can be extracted for further analysis. These sensors offer dependable, interference-resistant tools to enhance SSE reconnaissance efficiency by accurately detecting CWAs and smoking gun precursors while providing a sample for identification analysis.

Once the survey mission is complete, operators must be decontaminated or otherwise cleared to doff protective equipment. FLIR has developed the Agentase Threat Decontamination, a broad-spectrum enzymatic decontaminant that can rapidly hydrolyze CWAs. FLIR has demonstrated a reduced need for chemical agent-specific formulations; it is possible to achieve hydrolysis of G- & V- nerve agents and detoxify sulfur mustard with the decontaminant. The Agentase Threat Decontamination operates at neutral pH without oxidizers thereby offering a benign decontaminant that does not compromise protective gear or sensitive equipment. The decontaminant is inherently environmentally friendly and shows outstanding materials compatibility with sensitive equipment relevant materials. Using an improved surfactant package, the Agentase Threat Decontamination achieves greater than 99.999% decontamination of CWA simulants. The dry powder formulation is shelf-stable and can be rapidly reconstituted in water and applied to protective or sensitive equipment.

After the decontamination step, the CAD sensors can again be used to verify the efficacy of decontamination. This is especially useful where agent removal can be challenging. Once decontamination is verified, protective equipment can be removed, and sensitive equipment can be recirculated back into the field with minimal concern for inadvertent cross-contamination.

FLIR has combined the CAD-Kit and the Agentase Threat Decontamination to provide a quick and inexpensive method for detection and decontamination of CWAs, and to assure the efficacy of decontamination. This approach can be adapted to a scalable sensitive equipment and protective equipment decontamination kit for post-SSE missions.

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Determining the Health Protective Capability of Analytical Detection Methods for Short Duration Exposures

**22**

John Lipscomb

*U.S. Environmental Protection Agency*

Emergency response decisions require integrating exposure and risk information. Optimal guideline values for acute or short-term exposures are based on dose-response data for the relevant duration and address multiple levels of severity. The U.S. EPA’s National Homeland Security Research Center (NHSRC) has tools to characterize exposures and risk during temporary reutilization of previously contaminated infrastructure: The Provisional Advisory Levels (PALs) and Selected Analytical Methods for Environmental Remediation and Recovery (SAM). Oral and inhalation PALs cover three tiers of severity (minimal, reversible; more severe, irreversible or escape-impairing; and lethal) for multiple durations of exposure pertinent to emergency responses. PAL values (inhalation concentrations, oral doses) decrease with time and increase with effect severity. SAM recommends optimal analytical methods for a matrix-analyte pair and describes performance. Using SAM, the sufficiency of analytical capability for acrylonitrile (ACN), a widely used industrial chemical, relative to the PALs values was evaluated. Oral PALs (as drinking water equivalents for children) ranged as low as 0.064 mg/L. SAM identified U.S. EPA Method 524.2 (run time ~ 30 minutes) as the optimal method for drinking water (GC/MS). This method provides a detection limit of 0.00022 mg/L and a limit of quantitation of 0.0009 mg/L, sufficient to detect ACN concentrations associated with even minimal, reversible effects. Inhalation PALs ranged as low as 0.030 mg/m3. From SAM, OSHA Method PV2004 for acrylamide (HPLC/UV) may be applicable, with a possible detection limit of 0.001 mg/m3. Confidence will be increased when this method can be verified for ACN and a limit of quantitation established. For some acute exposures, the logistical constraints for sample collection, transport and analysis serve to emphasize the value of enhanced field detection capabilities. This process has also been applied to other priority chemicals. This abstract may not represent the views and policies of the U.S. EPA/NHSRC.

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Diversifying Aircraft Decontamination Technologies to Address Mold and Biofilms

**23**

Dan Lorch

*METSS Corporation*

For over a decade, the US Air Force has studied, matured, and demonstrated emerging technologies for biological decontamination that are safe for use on sensitive aircraft systems. These technologies may soon become fielded capabilities, and the logistics of supporting a technology for a low-likelihood, high-consequence event have become quite apparent. In response, the Air Force Research Laboratory (AFRL) is identifying other uses for aircraft decontamination technologies to provide additional benefit to the aircraft community, while enhancing the readiness of the system to address a biological threat. Routine use ensures that the systems are regularly maintained and modernized as needed; allows operators develop expertise beyond theoretical training; and provides the maximum benefit from the financial investment. Through collaboration with AFRL’s Materials Directorate and the aircraft sustainment community, researchers have identified opportunities related to mold in aircraft interiors and biofilms in bulk fuel storage tanks that could be remediated with technologies developed for biological warfare agents.

On occasion, large-frame aircraft like the C-130 and C-5 become contaminated with black mold, particularly in warm, humid climates. Treatment with Hot Air Decontamination (HAD) has been shown effective in neutralizing mold in complex aircraft interiors in a fraction of the time required to neutralize hardy biological warfare agents for which the system was designed. HAD treatment is safe for the aircraft and requires far less manual labor than conventional mold remediation and does not require disinfectants that are not approved for aircraft use, like bleach. The pervasiveness of the thermal-treatment ensures neutralization beyond the reach of conventional methods without dismantling the aircraft.

HAD is also being evaluated for use in biodiesel storage tanks that become contaminated with thick biofilms. Although the biofilms can be removed by manual cleaning, interior surfaces of the tank harbor microorganisms after cleaning that seed the next batch of fuel, causing rapid regrowth and increasing the regularity of labor-intensive cleaning. Research is now underway to determine if HAD can be used to further reduce the microbial population during cleaning and extend the time between cleanings, without leaving any residuals that could contaminate the fuel.

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Fogging of Chlorine-Based Sporicidal Liquids for the Inactivation of *Bacillus anthracis* Surrogate Spores in an Office Environment

**24**

Stella McDonald

*Jacobs Technology, Inc.*

Spray application of sporicidal liquids directly to surfaces contaminated with bacterial spores can be effective yet labor intensive, hazardous, and potentially generate large volumes of decontaminant waste solution. The use of fogging technology to disseminate sporicidal solutions has the potential to be a less arduous, more economical, and effective alternative for surfaces and volumetric decontamination. This investigation evaluated the sporicidal efficacy of an off-the-shelf fogger using chlorine-based sporicidal liquids for decontaminating an office environment.

Twenty-six pilot-scale tests were conducted to assess the decontamination efficacy of chlorine-based decontaminants for inactivating *Bacillus atrophaeus* (*B. anthracis* surrogate) spores inoculated on different test materials. Test materials included carpet, ceiling tile, concrete, glass, laminate, painted wallboard (PWB), galvanized metal, and wood. Spore levels of 107 colony forming units were loaded onto the material coupons, with replicates placed in three locations in a mock office: under the desk, on the desk, and above the ceiling. The decontamination solutions investigated included pH-adjusted bleach, diluted bleach, sodium dichloro-s-triazinetrione (dichlor), and aqueous chlorine dioxide. The test parameters evaluated were active ingredient concentration, volume of solution fogged, dwell time, coupon location, and chamber air exchange. Efficacy was assessed in terms of log reduction (LR), based on the difference in spores recovered from positive controls and test coupons.

All the materials were effectively decontaminated (≥ 6 LR) in at least one test condition, except for the carpet and ceiling tile. The nonporous materials were easier to decontaminate (higher efficacy), while materials that were porous and/or comprised of organic chemical constituents proved more difficult to effectively decontaminate. In the majority of the tests, galvanized metal, glass, laminate, and PWB were effectively decontaminated.

Fogging of the chlorinated decontaminants was moderately effective for concrete and wood, with only one test achieving an average ≥ 6 LR on concrete, but several tests in which ≥ 5 LR was achieved. The wood material was effectively decontaminated in three test conditions.

Maximizing the fogged solution quantity and the active ingredient concentration improved efficacy and produced similar results for all sporicides. More specifically, the average decontamination efficacy for all materials in the tests at these optimized operating conditions was generally above 5 LR, and was independent of the sporicide fogged. With regard to the effect of location, coupons positioned on the desk showed significant yet minor improvement (~ 0.5 LR) in spore inactivation compared to their counterparts located in the areas under the desk and above the ceiling.

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Evaluating the Leaching Behavior of Coal Ash Deposits in Mine Land Reclamation: A Column Study

**25**

Mina Mohebbi

*Middle Tennessee State University*

Reclamation of mine sites using coal ash has been shown to potentially alleviate the negative effects of mining activities such as neutralizing the acid mine drainage. However, during coal combustion process, trace elements are concentrated onto fly ash particles, and the long-term leaching of harmful elements from coal ash to subsurface aquifers is an environmental concern. This research study focuses on evaluating and enhancing the beneficial uses of fly ash (as the predominant coal combustion byproduct) in mine site reclamation through evaluating the leaching behavior of fly ash deposits to water resources in short and long term. Leaching behavior of fly ash deposits was evaluated through (i) defining the host phases for environmentally important elements and (ii) developing a reactive transport model to predict the long-term leaching behavior. Determining the host phases was achieved through a framework including micro-characterizing the coal ash, and flow-through column leaching tests. It was found that amorphous aluminosilicate is the main host phase for silicon (Si), aluminum (Al), iron (Fe), and magnesium (Mg). Alkalis, such as sodium (Na), potassium (K), and trace elements including arsenic (As) and selenium (Se) are also distributed in the bulk Al-Si glass in low concentrations. The Initially high concentrations of calcium (Ca) and sulfur (S) in the leachate were mainly due to the dissolution of gypsum.

Surface associated salts (e.g., sulfate and borate salts) dissolve Na, K, S, and boron (B) ions at early stages of leaching. Iron was found both as ferromagnetic particles containing magnetite and hematite, and also included in the amorphous phase in lower amounts. The host phases were then considered as input data for a quantitative reactive transport 1D model using CrunchFlow code. The calibrated model was used to predict the concentration of major elements (Ca, S, Si, Al, Fe, Na, K, Mg), and trace elements (As, (molybdenum (Mo), Se, B) along 10 years of leaching. The leachate composition at early ages of leaching might exceed the environmental limits for S, B, Mo, and Al. However, in long-term the overall composition meets the leaching limits except for aluminum content.

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Detection of *Bacillus anthracis* Spores from Non-Porous Surfaces using ‘Bioluminescent’ Reporter Bacteriophage

**26**

Cathy Nguyen

*Guild BioSciences*

*Bacillus anthracis* is a pathogenic spore-former and etiological agent of anthrax. Spores are naturally found in the environment where they can persist and remain infectious for more than 200 years. A contaminated area has potential to cause extensive disruption as it is uninhabitable until successful remediation. To ensure public health and preparedness for such an event, an efficient and rapid environmental detection system for spores is essential. To address this need, we previously generated a ‘light-tagged’ *B. anthracis*-specific reporter phage (Wβ::luxAB) which can rapidly and sensitively detect pure cultures of germinating spores by conferring a bioluminescent response.

The efficacy of Wβ::luxAB to detect *B. anthracis* ΔSterne spores from 3 non-porous contaminated surfaces was assessed. 2x2 inch coupons of stainless steel, glass and polycarbonate were used to represent the various surfaces.

Coupons were inoculated with spores (10^1 to 10^4 CFU/coupon) suspended in 95% ethanol (EtOH), then left overnight for EtOH to evaporate, leaving ‘dried’ spores on the coupon surfaces. To sample, macrofoam swabs moistened with phosphate-buffered saline with 0.02% Tween 80 (PBST) were used to methodically wipe the coupon surface to ‘collect’ spores, which had an estimated processing time of 1 min per coupon. Extraction efficiency was assessed by plating samples and controls for CFU onto brain heart infusion (BHI) agar plates. Swabs were submerged in media containing reporter phage (10^9 PFU/mL), vortexed vigorously for 2 min, incubated at 35C with continuous shaking (250rpm) to allow for germination and phage infection, and then analyzed for bioluminescence after 4-8h. To emulate ‘real life’ environmental samples, swabs were also deliberately ‘dirtied’ by moistening in PBST harboring either Arizona test dust (10mg/mL), *Bacillus thuringiensis* spores (10^4 CFU/mL), *Staphylococcus epidermidis* (10^4 CFU/mL) or all three contaminants combined before sampling.

Swab sampling extraction efficiency was similar from all 3 surfaces, consistently yielding 50-70% recovery of spores from coupons. *B. anthracis* was detectable from ‘clean’ coupons deliberately inoculated with spores, yielding a limit of detection of 10^1 CFU/coupon within 6 h or 8 h for polycarbonate, stainless steel and glass surfaces, respectively. Wβ::luxAB was able to detect 10^1 CFU within 8h from ‘dirty’ stainless steel, glass and polycarbonate coupons. As the methodology is simple with minimal hands-on time, the technology displays potential for rapid detection of viable spores from various non-porous surfaces under fieldable or laboratory conditions.

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Composite Sampling of Persistent Chemicals: Wet-Vacuum Sampling of Chemical Agents on Building Material Surfaces

**27**

Lukas Oudejans

*U.S. Environmental Protection Agency*

In the event of a chemical incident, samples must be collected, preserved, and analyzed to assess the size of the contaminated area, and degree of contamination, and following decontamination, determine whether surface cleanup goals have been accomplished. Surface sampling is typically conducted using wipes that can sample only a relatively small hard surface area (often less than one square foot). Statistical sampling approaches often require the generation of a large number of samples to achieve reasonable confidence.

Limited laboratory capacity and costly analysis – especially for chemical warfare agents – makes traditional sampling activities difficult to implement as part of the remediation and clearance process. Aside from revising sampling strategies, sampling larger areas via composite sampling, such as by wet-vacuum sampling, may be an alternative approach that can present many advantages such as a reduced sampling time during a response; fewer number of samples to process; and coverage of large sampling areas that would improve detection of a wide-spread contamination at or below detection limit of the traditional sampling methods. Sampling cost and efforts can be further reduced by avoiding a wipe extraction step when sampling directly into a solvent that can be analyzed (e.g., by gas chromatography/mass spectrometry [GC/MS]), without further sample processing.

A commercially-available, handheld wet-vacuum system was evaluated for surface sampling of a large nonporous surface that had been spiked with various chemicals (phenol, triethyl phosphate, methylphosphonic acid, 2-chloroethyl ethyl sulfide), all with different degrees of water solubility.

Research was conducted to optimize the sampling efficiency when using water, water with surfactants, or a relatively mild organic solvent (isopropyl alcohol) as media for the wet-vacuum sampling. These tests included sampling from nonporous, yet permeable, semi-porous, and porous building materials.

Further optimization, as performed for selected chemicals, consisted of inclusion of a pre-wetting step of the wet-vacuum system and a post-sampling rinse. Optimized sampling method efficiency results are reported and are compared to existing wipe-based sampling methods and/or modifications thereof. Outcomes of this research will benefit responders as it will allow them to consider composite sampling approaches for the sampling of chemical agents.

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Surface Decontamination Options for Indoor Materials Contaminated with Fentanyl

**28**

Lukas Oudejans

*U.S. Environmental Protection Agency*

The recent increase in unintentional fentanyl-related overdose fatalities in multiple states across the U.S. is driving research efforts to identify decontamination technologies that are effective in neutralizing fentanyl contamination in premises. Current remediation efforts rely on physical removal approaches including dry vacuuming followed by “soap and water” cleaning. The current understanding of fentanyl degradation chemistry and associated rates is limited to highly favorable conditions where fentanyl is dissolved in an organic solvent and allowed to interact with a liquid decontaminant. The investigation described here is focused on identification of decontamination technologies that are effective for direct neutralization of fentanyl on a material or surface.

Bench-scale laboratory testing included determination of efficacy of select decontamination technologies to decontaminate fentanyl-HCl salt from the surface of five commonly-encountered indoor materials: borosilicate glass, stainless steel, acrylic, laminate, and painted drywall. Decontaminants evaluated include bleach (5% hypochlorite), pH-amended bleach (pH 6.5 to 7.0, 0.5% hypochlorite), Dahlgren Decontamination by First Line Technology, OxiClean™ Versatile Stain Remover, EasyDECON DF200 by Intelagard®, and trichloroisocyanurate (from MAXBlue™ chlorinating tablets [pool shock]).

Coupons of each indoor material type were contaminated with a target 1 milligram of solid fentanyl- HCl salt. 60 minutes following contamination, candidate decontaminants were applied to coupons via moderately low-flow spray (similar to that delivered from a commercially-available backpack sprayer system) at a target application volume of 600 microliters per 10 cm2 coupon (60 microliters per cm2). The method included the decontaminant reacting with the fentanyl-HCl on the surface of the coupons for 60 minutes.

Following the decontaminant reaction period, the coupons were extracted in a solvent and extracts were analyzed by liquid chromatography/mass spectrometry to quantify the mass of residual fentanyl (HCl and freebase) and calculate efficacy. The two best performing decontaminants were carried forward into additional testing to determine the residual surface hazard remaining on two material types following decontamination. Outcomes from these studies will be discussed in terms of efficacy of each decontamination approach and other lessons learned. These outcomes have a high relevancy to the end users on how to remediate a fentanyl contaminated site.

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Preliminary Exposure and Risk Assessment of a Hazardous Urban Release Using the Quick Urban and Industrial Complex (QUIC) Dispersion Model

**29**

Michael Pirhalla

*U.S. Environmental Protection Agency*

Toxic chemical, biological, radiological, or nuclear (CBRN) releases pose significant environmental and human exposure risks, especially in urban areas with high population densities. Oftentimes, toxic industrial chemicals (TICs) are transported via train or semi-truck near or through cities for the use in various industrial and consumer products. While TICs are generally regarded as important commodities, the transport is not without inherent risks. An accidental or intentional spill could become deadly within a matter of minutes, requiring emergency responders to be prepared for possible scenarios. The complex nature of a cityscape brings substantial challenges when determining pollutant dispersal within an urban canopy. This is still a poorly understood area of research. However, atmospheric dispersion modeling is a potential tool that could be employed for efficient and precise emergency preparation and response to minimize civilian exposure. The objective of this project is to use a building-aware dispersion model called QUIC (Quick Urban and Industrial Complex) in an urban, hypothetical case-study scenario to analyze the local meteorological effects associated with an intentional or accidental toxic gas release. The case study will involve a release on a roadway in downtown Los Angeles, California and focus on the fact that the city has a climatologically varying diurnal wind pattern due to a sea-breeze circulation. This is the same concept that modulates photochemical smog production and transport throughout the Los Angeles Basin.

The goal is to use the model output of breathing-level concentration plumes for a preliminary exposure and risk assessment that quantifies potential dose (PD) and/or lifetime average daily dose (LADD) using U.S. Census tract demographic data. While the scenario is mock, it demonstrates that a situation like this could occur in real life, and the results could be of interest to local stakeholders and emergency responders who want to prepare for an event of this magnitude.

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Investigation of Gaseous Disinfections Systems for Use Within High Containment Laboratories

**30**

Lesley Hetherington

*UK’s Department for Environment, Food, and Rural Affairs (DEFRA)*

Formaldehyde is routinely used for fumigation within microbiological high containment laboratories, but changes in both its classification as a carcinogen and the European Biocides Products Directive (Annex 1) means there is now a search in Europe for effective replacements. The laboratory sector poses some unique challenges for gaseous disinfection systems, such as the use of high titre agents suspended in organic media. PHE has commissioned an internal project to assess two hydrogen peroxide systems against a panel of representative agents such as bacterial endospores (*Geobacillus stearothermophilus*), mycobacteria (*Mycobacterium fortuitum*), Gram-positive catalase producers (MRSA) and against a range of RG3 agents worked on by PHE, both within our diagnostic and research facilities. The efficacy studies carried out with RG1 and 2 agents were time course studies within safety cabinets and laboratories. All studies with RG3 agents were end-point studies carried out in a Class 3 safety cabinet. Similar studies using formaldehyde have also been carried out in parallel with the same agents.

The first high-pressure (HP) system tested was capable of achieving 6-log reduction of *G. stearothermophilus* spores in 30 min in a Class 3 safety cabinet study, but was less effective for the other RG2 agents. With an enhanced 90 minute exposure period only a 1-log reduction could be achieved with MRSA, 3-log reduction against MS2 bacteriophage, and 6-log reduction against *Mycobacteria fortuitum* and *Clostridium difficile* spores. Six log reductions against all these agents were obtained using formaldehyde. The preliminary results of the RG3 study demonstrates that inactivation of *Bacillus anthracis* spores, *Brucella abortus*, *Burkholderia pseudomallei* and *Yersinia pestis* can be achieved at the concentrations they have been grown at (ranging from 108-105 CFU per coupon). Results for *M. tuberculosis* are awaited and will be presented along with formaldehyde results and preliminary data from the second HP system. The study also demonstrates the bacterial spores might not be the most appropriate indicator organism for gaseous decontamination.

During these studies some materials were adversely affected by exposure to HP and these results will also be presented.

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Decontamination Efficacy of Disinfectants Delivered as Foam, Liquid, or Gel on Vertical Surfaces

**31**

Vipin Rastogi

*U.S. Army Edgewood Chemical Biological Center*

For fixed site surface decontamination and cleanup, two distinct options among liquid disinfectants include pH-adjusted bleach (pAB) and per-acetic/peroxide formulation Spor-Klenz (Steris Corp., Mentor, OH).

Efficacy of these two sterilants in lab-scale studies has been well-documented. In a recent study completed by a multi-agency group led by the U.S. EPA, pAB was found to be effective, however, some collateral damage was evident (EPA/600/S-15/001). In different studies throughout recent years, disinfectants have been applied as liquids, foams, or gels. While no information is currently available on comparative effectiveness of foam or gel over liquids, it is often hypothesized that foam- or gel-based decontaminants will be more effective because of prolonged wetted contact times. Scientific data supporting this assumption is lacking. The objective of current effort was to compare three delivery methods, i.e. liquids, foam and gel, of two decontaminants, Spor-Klenz and pAB (representing two distinct chemistries) on vertical surfaces. Ultimately, only foam was compared with liquid. Ambient conditions were varied to include: 50 ºF/70% RH and 90 ºF/25% RH, with fan ON or OFF to simulate wind velocity. With just application of disinfectant, runoff was collected to assess mechanical dislodgment vs. sporicidal efficacy, and panels were wiped-sampled following the 30 minute contact time to estimate the amount of viable spores remaining.

As for control panels, water was applied instead of disinfectant for each method of application. Additional panels were simply wiped down to determine the inoculation density for each test run. Procedural blanks and air filter controls were also included throughout the experimental study to monitor possible sources of contamination.

Unfortunately, the gel application was discontinued mid-way through the work because of issues related to its application after re-formulation. A modified gel (lacking 10% aqueous component, for reconstitution with 10% decontaminant volume) was unable to be procured from the vendor.

Detailed results of this study will be presented to show that vertically-oriented surfaces are difficult to decontaminate with just one application of a sporicidal chemical, regardless of decontaminant formulation (liquid or foam). Direct observation tests showed that foam application maintained surface wetness longer than liquid. However, no significant difference in efficacy in terms of log reduction with the use of foam was observed relative to liquid application.

(Funding from U.S. EPA’s National Homeland Security Research Center (NHSRC), RTP, NC, is greatly acknowledged.)

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Stormwater Models: Effective Tools for Tracking Contamination During Response and Recovery

**32**

Katherine Ratliff

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The U.S. EPA’s National Homeland Security Research Center (NHSRC) conducts research to develop science and technology that enhances communities’ abilities to respond to and recover from both intentional and unintentional catastrophes. Understanding the fate and transport processes of chemical, biological, and radiological (CBR) agents in urban environments is necessary for effective emergency response and site remediation, yet determining the magnitude and extent of both surface and subsurface contamination can be difficult in dynamic urban systems. These challenges are amplified following precipitation events or the application of liquids on roads or other surfaces (which may further spread contamination) during the decontamination process. Preexisting stormwater models, which are traditionally used to map and trace stormwater runoff volumes and velocities, as well as estimate suspended sediment and pollutant loads, can be adapted to map the spread of CBR agents. The U.S. EPA’s Stormwater Management Model (SWMM) has been widely used to model stormwater networks both throughout the country and across the globe. By using the SWMM methodology for modeling pollutant transport, as well as a newly-developed functionality in PySWMM, a Python interfacing wrapper for the SWMM application programming interface (API), we can model and map how contamination on urban surfaces and in the stormwater system will evolve throughout the remediation process. This not only better informs emergency responders as to the location and evolution of contamination hot zones, but it also better informs decision-makers in the allocation of resources for response and remediation. At the NHSRC, we are using a number of case studies to streamline and refine the process of using preexisting stormwater models to track CBR agent extent and magnitude following a manmade or natural disaster. Steps may involve integrating FEMA-model-generated air plume information, exporting and adapting stormwater models developed in different proprietary software packages to ensure their compatibility with the SWMM API and PySWMM, and using GIS software to map contaminated surfaces and pipes.

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The Synthetic Opioid Fentanyl is Degraded by Temperature and Ultraviolet Irradiation in the Environment

**33**

Raven Reitstetter

*U.S. Army Dugway Proving Ground*

The ever increasing use of pharmaceuticals to improve quality and length of life results in an increasing release into the environment through waste water treatment facilities, improper disposal of unused drugs and illicit drug manufacture and use. In this way pharmaceutical compounds end up in sewage sludge, water and soil. The stability and breakdown processes of synthetic opioids in the environment are not completely understood. Here, we show that synthetic opioids, exposed at the surface, are broken down by irradiation and temperature. Pharmaceuticals entering the environment are usually sequestered into soil, sewage sludge or water. A fraction of these compounds is also exposed at surfaces. We applied the synthetic opioid fentanyl on filter paper and mixed with soil as a model for synthetic opioids released to the environment. Preliminary results show that ultraviolet irradiation at a wavelength and radiant flux similar to sun exposure degraded fentanyl over a period of four days. In a similar fashion temperature broke down fentanyl, although to a lesser extent. Thus, surface-exposed synthetic opioids are degraded by sun exposure and temperature. These results may also indicate that synthetic opioids segregated into at least the upper soil layer may be degraded by temperature alone.

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Evaluation of Commercially-Available Equipment for the Decontamination of *Bacillus anthracis* Spores in an Urban Subway System

**34**

William Richter

*Battelle*

The underground transport restoration (UTR) project was an inter-agency effort aimed to improve the capability for transit systems to rapidly and safely recover from a wide area biological contamination incident by refining existing methods, tools, and protocols for characterization, clean-up, and clearance of contamination in physical structures (i.e., tunnels, stations) and rolling stock (i.e., subway trains). The U.S. EPA, in partnership with Battelle, investigated the potential use of commercially-available or fielded equipment for the use in dispensing liquid chemicals at a large scale to decontaminate subway surfaces following a biological contamination incident.

Initially, a survey of equipment was conducted resulting in identification of three pieces of priority spray equipment [MM Sprayers, Air-O-Fan® (AOF), and Dust Boss®]. This equipment was selected based on input provided by a working group comprised of U.S. EPA, Battelle, and stakeholders representing transit authorities from across the United States. This equipment was subjected to 100 hours of operation with pH-amended bleach (pAB) using smaller proxy equipment designed in consultation with the vendors of the equipment to test for material compatibility. Based on this durability assessment, two pieces of equipment (AOF and Dust Boss sprayers) were further down-selected to participate in a field-scale demonstration at a subway platform/tunnel at Fort A.P. Hill (Bowling Green, VA). For purpose of demonstration, both were placed atop a flatbed railcar and used to spray water while the railcar was pulled through the subway platform/tunnel at a speed of 1.2 miles per hours (mph). Video and leaf wetness data (5 locations) were collected during this demonstration. The leaf wetness sensor measures the percentage of the capacitive grid that is covered by moisture. Based on the leaf wetness data, review of video, and observer input, a single piece of equipment was selected (AOF sprayer) to perform field scale efficacy tests using *Bacillus atrophaeus* (B.g.) spores as a surrogate for *B. anthracis* the causative organism of anthrax.

These efficacy tests were conducted within an ambient breeze tunnel (ABT) testing facility with internal dimensions representative of many existing subway tunnels. Decontamination efficacy of operationally sprayed pAB against surrogate B.g. was evaluated at target delivery speeds of 1.2 and 2.4 mph on vertical and horizontal coupon orientations, and contact times ranging from 30 minutes (min) to 12 hours (overnight) for a total of 4 tests. Ceramic tile resulted ≥ 6 log reduction (LR) at each condition tested (Tests 1-3).

Unpainted concrete resulted in LRs ranging from 1.62 to 2.34 and 1.32 to 3.02 at locations 1 (column) and 2 (floor), respectively. Repeated applications (2 and 3) with 30 min contact times between applications resulted in increased LR for concrete ranging from 3.51 to 4.70 for 2 and 3 applications, respectively. Collectively, the data from this project may help guide decontamination equipment selection during remediation following a contamination incident involving an underground transportation system.

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Radiological Decontamination in the Urban Environment Utilizing an Irreversible Wash-Aid Recovery System

**35**

Keith Saunders

*U.S. Air Force*

The radioactive fallout from the Fukushima Daiichi nuclear reactors accident and the ongoing threat of nuclear or radioactive terrorism have forced the need for urban radiological decontamination into the forefront. Many of the established decontamination techniques are not ideally suited for the urban milieu. One of the keys to maximize the effectiveness of long-term remediation and recovery in the urban environment is immediate mitigation within a few days of the incident and before a rain event.

The Integrated Wash-Aid, Treatment, and Emergency Reuse System (IWATERS) provides a potentially safe and effective method for early responders and remediation teams to perform decontamination operations in urban areas. The system is set up with water barriers to catch wash water coming off of the building, pumps are then used to move the water through a series of absorbent beds, ion exchange filter, and finally into a holding bladder for eventual reuse. The goal of this research was to characterize: filter bed sizes for the decontamination of a modeled city block, exposure rates pre and post decontamination, and equivalent dose to early responders.

The research found that the expected cesium activity from an entire city block can be contained safely in a filter bed of approximately one cubic meter. Shielding of the filter bed brings exposure rates down to a negligible level and enables the filter beds to be deployed in multiple configurations. The highest estimated exposure rate at the working locations of 0.66 milliroentgen per hour is kept below the Nuclear Regulatory Commission public exposure rate limit of 2 milliroentgen per hour. In addition, the worst-case expected equivalent dose of 46 millirem for a person who was exposed at the middle of the street for the entire decontamination process is below the 5,000 millirem guideline of the Environmental Protection Agency protective action guide for emergency responders and the 5,000 millirem per year limit for occupational radiation workers set by the Nuclear Regulatory Commission.

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Evaluation of Removal and Inactivation of Bacterial Spores on Outdoor Surfaces

**36**

Brian Sechrest

*Jacobs Technology, Inc.*

In a wide area release of *Bacillus anthracis* spores, street sweepers may offer a relatively quick method of removing and/or inactivating spores from contaminated roadways, parking lots, etc. In the present study, a commercially available walk-behind floor scrubber (used to represent a small-scale street sweeper) was evaluated in several tests, to determine its ability to remove or inactivate bacterial spores from concrete and asphalt surfaces. Initial tests were conducted with the floor scrubber using either water or a water/surfactant mix, to evaluate removal efficiency of spores.

Additional tests were then conducted with decontaminant solutions of either pH-amended bleach (PAB) or sodium dichloro-s-triazinetrione (dichlor) to assess inactivation. The tests on concrete were conducted in a shed, and the tests on asphalt were conducted in a parking lot with a tent enclosure.

In each test, spores of *Bacillus atrophaeus var. globigii* (Bg; a *Bacillus anthracis* surrogate) were inoculated onto a 3-foot by 3-foot area using a metered dose inhaler method, to produce a “hot spot” on a larger test grid. (A positive control area was also inoculated.) The floor sweeper was then operated over the test area. Several samples (positive and negative controls, as well as test samples) throughout each experiment were collected from the test surfaces, the scrubber liquid collection tank, and air. Surface samples of the test area were collected using multiple wet vacuums. Between each test, the test surface was reset via spraying of a PAB solution.

In the tests on concrete using water or soapy water, removal efficiency of the spores from the test surface ranged from 99% to over 99.9%. However, even with these relatively high removals, the sweeper also spread the contaminant to adjacent areas of the hot spot. (Although tests also confirmed that surface sampling caused some spread of the contaminant as well.) When using PAB or dichlor on concrete, decontamination efficacy was greater than 6.9 log reduction, with no spores detected over the entire test area.

The tests on asphalt are ongoing as of the writing of this abstract, but preliminary results show that the removal efficiency with water or soapy water was less than 90%. Final results will be presented at the conference.

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U.S. EPA Consequence Management Advisory Division’s Bioanalytical Laboratory: Capabilities and Collaborations

**37**

Sarah Staggs

*CSS, Inc.*

The CMAD Bioanalytical Laboratory, located at the U.S. EPA National Enforcement Investigations Center (NEIC) in Lakewood, Colorado, is a certified Biosafety Level 2 Enhanced (BSL-2E) facility. Unknown, diagnostic, and/or environmental samples can be accepted in this laboratory for the analysis of biological select agents or toxins (BSATs). The laboratory is self-contained with isolated air supply, exhaust, and liquid waste biotank systems. The laboratory is equipped to provide molecular detection of pathogens as well as traditional microbiological culture methods. Analytical equipment includes two real-time quantitative PCR (qPCR) machines used for detection of pathogen-specific gene expression and an electrochemiluminescence (ECL) instrument which uses immunoassay technology to detect specific biological toxins/proteins. The laboratory also possesses a large capacity microbiological incubator capable of holding 300 bacterial media plates for high throughput analysis.

The CMAD Bioanalytical Laboratory provided support to two U.S. EPA/US. Department of Homeland Security (DHS) collaborations. For the Underground Transportation Restoration-Operational Technology Demonstration (UTR-OTD), the Bioanalytical Laboratory analyzed over 300 samples of surface material and gravel ballast wash for the presence of a B*. anthracis* surrogate organism. The laboratory also provided support for the NYC Subway Tracer Particle and Gas Releases for the Underground Transport Restoration (UTR) Project. The laboratory assisted in improving detection methods and optimizing the qPCR analytical protocol prior to particle deployment in the NYC subway system, and following deployment, processed air filters, swabs, gauze wipes, and cloth wipes by DNA extraction and qPCR analysis, resulting in over 250 total samples analyzed for the entire project.

Currently, the laboratory is working on implementing two additional analytical capabilities. Due to the increase in ricin toxin incidents, the laboratory is in the process of developing methods to detect ricin toxin in environmental samples using ECL technology. Additionally, the laboratory is presently collaborating with the U.S. EPA National Homeland Security Research Center (NHSRC) and Office of Water to verify the B. anthracis Rapid Viability-PCR method.

With the unique facility design and the multiple analytical capabilities, the CMAD Bioanalytical Laboratory can support the U.S. EPA’s mission to protect human health during an emergency response as well as provide a high level of support during studies which seek to improve pathogen method detection.

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Wet Vacuum-Based Biological Agent All Surface Sampler

**38**

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A release of hazardous biological material in an urban area would require decontamination of a wide range of surfaces to protect the public. The potential surface sampling approaches for characterization and post decontamination are using various methods depending on the surface types. The currently available surface sampling methods include wet wipes (for smooth nonporous surfaces), dry vacuuming (for rough and porous surfaces), and wet swabs (for small and/or hard to sample areas such as keyboards). These methods can sample only small surface areas (1-4 ft2) and can be labor intensive and expensive to deploy. This study assessed a commercially available (or built with off-the-shelf materials) wet-vacuum cleaning device as a spore surface sampling method for both porous and non-porous surfaces.

This method uses a liquid sampling agent that can be analyzed directly without the extraction step required for surface sampling, which may reduce the sample analysis turnaround time and cost.

Bench-scale experiments were conducted using a custom-built wet vacuum to assess the parameters affecting sampling efficacy. The tested parameters were liquid sampling agent, elapsed time between liquid application and suction, and liquid amount used to perform the needed wetting process. Three material types [porous material with large pores (carpet), porous material with small pores (concrete), and non-porous material (laminated wood)], inoculated with a target test organism concentration of 2 x 106 colony forming units (CFU)/ft2 were evaluated. Four commercially available wet-vacuum cleaners were selected based on user reviews regarding ease of use, separate clean and recovery (dirty) tanks, suction power, portability, and cost. The vacuum cleaner sampling comparative recovery (CR) for each material were determined by comparison of the recoveries of the four vacuum cleaners to that of currently-available sampling methods such as vacuum sock (carpet) and 37 mm cassette (concrete), and wipe (laminated wood). The test results showed CR values on the same order of magnitude compared to the currently-available sampling methods. This presentation will discuss the test results and potential benefits of using wet vacuums for surface sampling.

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Public access to chemistry and toxicity data for 760,000 substances via the U.S. EPA CompTox Chemistry Dashboard

**39**

Antony J. Williams

*U.S. Environmental Protection Agency*

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Evaluation of Pre- and Post-Sample Compositing for Low Concentration *Bacillus* Spores from a Simulated Post-Decontamination Sampling of Indoor Surfaces

**40**

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Post-decontamination sampling is a potential step to confirm the effectiveness of decontamination efforts following a biological contamination incident. With the currently available standard sampling methods, which typically utilize small discrete area sampling and analysis protocols, post-decontamination sampling of large areas can be lengthy and present a high financial burden to responsible agencies. Furthermore, the wipe-based surface sampling methodologies typically focus on sampling of smooth and non-porous surfaces, and do not address porous environmental substrates.

This work evaluated the effectiveness of composite sample collection and composite sample analysis methods using the sponge stick method for quantitative determination of low surface concentrations (50 to 5000 CFU ft-2) of *Bacillus thuringiensis var. kurstaki* (Btk) spores (surrogate for *Bacillus anthracis*) from representative porous and semi-porous indoor surfaces (painted drywall and glazed ceramic tile, respectively). In addition, a comparative analysis of the operational time and cost, as well as the environmental burden (amount of waste generated) were performed for various sampling and analysis approaches.

The results indicated that the current methodology recommended for sampling non-porous smooth surfaces – which utilizes a single implement (sponge stick) for a multi-pass sampling of one discrete location (Centers for Disease Control and Prevention [CDC], 2012) – offers the highest average recovery of target organism for all [semi-porous and porous] surface type and concentration combinations tested in this study. Two multi-location (4 x 1 ft2) composite sample collection methods were deployed using a single implement, and both methods showed decreases in target organism recoveries when compared to a single-location sampling (1 x 1 ft2), with multi-pass methods generally outperforming a single-pass approach. Contaminant transfers and diminishing collection efficiencies during sampling of consecutive areas within a four-point composite were observed for both single-pass and multi-pass techniques. Further assessment of composite sample analysis approaches (with up to four implements [sponge sticks] extracted together) showed no statistically significant difference in target organism recovery between analytical subsets. These results suggest that post-sample compositing of multiple implements from a standard discrete location sampling of semi-porous and porous indoor surfaces offers a balance between the analytical method performance for hazard characterization and the time and cost of analysis.

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