Abstracts

Contents

[ Day 1 2](#_Toc24373553)

[Plenary Session 2](#_Toc24373554)

[Concurrent Session 1 – Regional, State, & Local Initiatives 4](#_Toc24373555)

[Concurrent Session 1 – Biological Agent Decontamination 5](#_Toc24373556)

[Concurrent Session 2 – Cross-Cutting Innovation 7](#_Toc24373557)

[Concurrent Session 2 – Public Engagement 9](#_Toc24373558)

[ Day 2 12](#_Toc24373559)

[Concurrent Session 3 – Fentanyl Detection & Cleanup 12](#_Toc24373560)

[Concurrent Session 3 – Water Infrastructure Protection & Decontamination 13](#_Toc24373561)

[Concurrent Session 4 – Biological Agent Sampling & Analysis Methods 15](#_Toc24373562)

[Concurrent Session 4 – Technology & Software Supporting Disaster Response 17](#_Toc24373563)

[Concurrent Session 5 – Beyond Water Infrastructure 19](#_Toc24373564)

[Concurrent Session 5 – Biological Agent Decontamination 22](#_Toc24373565)

[ Day 3 25](#_Toc24373566)

[Concurrent Session 6 – Chemical Agent Research 25](#_Toc24373567)

[Concurrent Session 6 – Waste Management 27](#_Toc24373568)

[Concurrent Session 7 – Radiological Agent Research 30](#_Toc24373569)

[Concurrent Session 7 – Biological Agent Decontamination 32](#_Toc24373570)

[Poster Session 36](#_Toc24373571)

[General Poster Session 36](#_Toc24373572)

[Student Poster Competition 52](#_Toc24373573)

#  Day 1

Plenary Session

Welcome

Timothy Boe, Conference Chair | U.S. Environmental Protection Agency

Mr. Timothy Boe will greet attendees, point to recent updates in decontamination research and development, and provide important considerations. He will also provide relevant safety information and reminders.

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Introduction

Ted Stanich, Acting Associate Administrator | U.S. Environmental Protection Agency, Office of Homeland Security

Mr. Ted Stanich will begin the conference by presenting opening remarks.

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U.S. Biodefense Enterprise and National Biodefense Strategy

Robert Kadlec, Assistant Secretary of Health and Human Services | U.S. Department of Health and Human Services

Dr. Robert Kadlec will contextualize the conference by providing his perspective on past and present homeland security issues.

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National Biodefense Strategy Calls for a Robust Decontamination Capability

Tonya Nichols | U.S. Environmental Protection Agency

The National Biodefense Strategy (NBS) sets the course for the U.S. Government to combat serious 21st century biothreats both domestically and internationally. It calls for a whole-of-government approach to biodefense; and is the first to recognize infectious disease outbreaks as critical threats alongside biological threats from terrorists, other nations, or lone actors. The National Security Presidential Memorandum (NSPM) -14 directs implementation of the NBS by establishing U.S. policy to coordinate Federal Government programs, actions and budgets. To that end, the U.S. will be better positioned to anticipate, prevent, prepare for, respond to, and recover from biological disasters. Until now, government agencies have had disparate programs and actions that were not centrally coordinated. Also, the NBS calls for the U.S. Government to strengthen national biodefense partnerships from both industry, non-government organizations, and international partners.

The NBS supports five different goal areas, three of which address bio-related decontamination efforts, including Goals (3) Ensure biodefense enterprise preparedness to reduce the impacts of bioincidents; (4) Rapid response to limit the impacts of bio incidents; and (5) Facilitate recovery to restore the community, the economy, and the environment after a bio-incident and multiple departments and agencies. Specifically, Goal 3 calls for research to understand the persistence and potential for secondary transmission of biological contaminants in a variety of environments and the ability of various disinfection technologies to inactivate or remove biological contaminants. Also, Goal 3 pushes for the development of technologies for all phases of environmental cleanup (characterization, decontamination, waste management, and clearance) for the natural, inhabited, and engineered environments, including critical infrastructure, contaminated with known and emerging biological threats. These technologies should be readily available and scalable for natural, accidental, or deliberate releases of biological agents.

The intent of the presentation and discussion is to provide awareness of the NBS to the research and response community dedicated to environmental cleanup. The presentation will provide a survey of U.S. Government efforts related to enhancing preparedness and response related to decontamination following a biological incident.

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Coastal Operational Resiliency (AnCOR) Project

Dana Tulis | U.S. Coast Guard

Ms. Dana Tulis will give an overview of a collaborative project between the U.S. Coast Guard, Department of Homeland Security, and EPA that focuses focusing on post-biological incident consequence management of urban and maritime structures, assets, and surfaces. The project covers activities such as sampling, decontamination, and waste management.

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The Skripal Incident – Addressing the Decontamination Challenge

Norman Govan | U.K. Defence Science and Technology Laboratory

Dr. Norman Govan will discuss the work undertaken by the U.K. Military Task Force and Defence Science and Technology Laboratory to address decontamination challenges in the wake of the Novichok nerve agent incidents in Salisbury and Amesbury.

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Waste Management following the Novichok Incidents in the U.K.

Sara Casey | U.K. Department for Environment, Food, and Rural Affairs

On 4th March 2018, Sergei and Yulia Skripal were found seriously ill on a bench in Salisbury, England having been exposed to military-grade nerve agent Novichok. On 30th June 2018, two further civilians were taken unwell in a private property in the nearby town of Amesbury and later confirmed as having been exposed to the same substance.

These incidents triggered a massive clean-up effort. The Department for the Environment, Food, and Rural Affairs (Defra) plays a leading role in the United Kingdom’s government preparedness for major incidents involving chemical, biological, radiological, nuclear, and hazardous materials. This presentation focuses on some of the waste management challenges faced by Defra during the remediation of sites contaminated by Novichok. Defra’s roles and responsibilities will be covered along with the approach used for the containment, transportation, and disposal of the waste produced from these incidents.

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The California Camp Fire: EPA’s Response Efforts

Martin McComb | U.S. Environmental Protection Agency

Mr. Martin McComb will present EPA’s perspective on the Camp Fire response effort. He will discuss EPA’s implementation of a large-scale response and lessons learned in the process as well as the continuing processes of recovery and public outreach.

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Concurrent Session 1 – Regional, State, & Local Initiatives

Animal Carcass Disposal Following Hurricane Florence

John Howard, Joseph Hudyncia | North Carolina Department of Agriculture & Consumer Services

Many farmers in the lower coastal plain of North Carolina were directly impacted by rain and floodwaters from Hurricane Florence. One of the many challenges North Carolina Department of Agriculture & Consumer Services (NCDA&CS) faced was how to help these farmers dispose of poultry carcasses and saturated manure in a manner that would protect public health and the environment and would quickly get the farms back into operation. NCDA&CS needed to accomplish this monumental task while simultaneously completing other critical response activities in support of the agricultural sector.

In the immediate aftermath of Florence, NCDA&CS chose to contract out the main elements of the response and recovery effort for flooded poultry houses. By doing so, their staff was able to manage other aspects of the entire agricultural recovery effort and focus efforts on the oversight of the contractors to ensure a rapid and efficient response. NCDA&CS developed and executed contracts for the three main components of recovery operations: subject matter expertise for composting, equipment operations for moving materials and compost windrow construction, and carbon materials sourcing and delivery. The Florence response framework was built on a series of interrelated steps requiring highly coordinated interaction among NCDA&CS, specialized contractors, and farms.

As demonstrated during the Hurricane Florence response, composting has the potential to be a valuable waste management tool during natural disasters. Composting can help solve the immediate needs of protecting public and the environment, provide the basis for a rapid agricultural recovery, and create a safe product for beneficial reuse in agricultural systems. The NCDA&CS response plan for Hurricane Florence, which incorporated lessons learned from disease and disaster events across the United States, is a successful model of the effort needed to execute composting on a large scale in the agricultural sector for disaster response.

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Case Study: A Fentanyl Incident, Notification, Response, and Remediation. A Local Jurisdiction’s Perspective

Jason Doerflein | Marion County Public Health Department

This presentation examines a local health department’s role in a fentanyl incident that involved an overdose within a fentanyl lab operation. The presentation is presented in chronological order from the notification phase to the incident response phase and including the remediation phase. Specifically discussed are applicable local regulations, decontamination concerns, remediation concerns and criteria for a release of interest.

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How S&T is Supporting the DHS Counterdrug Mission and Combating Opioid Smuggling

Rosanna Anderson | U.S. Department of Homeland Security

Through Executive Order 13784, the President established the Commission on Combating Drug Addiction and the Opioid Crisis to counter the surge of drug abuse, addiction, and overdose plaguing the Nation. This public health crisis was responsible for more than 45,000 deaths in 2017, causing significant pain and financial harm to families and communities across America. As part of the comprehensive government effort to address the opioid crisis, the Department of Homeland Security (DHS) Science and Technology Directorate (S&T) established the Opioid/Fentanyl Detection Program to deliver improved drug detection capabilities to support DHS counterdrug missions. The physical nature of synthetic opioids presents immense challenges to detection, particularly in the context of the complexities of facilitating legitimate trade, including speed and high volume of commerce. In this effort, S&T collaborating with U.S. Customs and Border Protection (CBP), United States Coast Guard (USCG), other Federal agencies, and first responders to identify and develop capabilities, ranging from detection standards and advanced rapid detection technologies to analytics, to better detect opioids, like fentanyl, and increase capacity to disrupt the supply of drugs being smuggled into the United States. This talk will provide an overview of results and progress to date, including the Standard Specification for Field Detection Equipment and Assays Used for Fentanyl and Fentanyl-Related Compounds (ASTM WK66045), characterization of chemical signatures/profiles, and technology developments.

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Teaming of Federal and Private Sector Capabilities on Highly Hazardous Chemical and Biological Agent Remediation Projects

Amy Dean | U.S. Army, Chemical Biological Center

A joint presentation will be presented by Veolia and the U.S. Army Chemical Biological Applications and Risk Reduction (CBARR) business unit. The presentation will focus on the teaming of federal and private sector capabilities on highly hazardous chemical and biological agent remediation projects involving CDC Select Agents and similar materials. The presentation will address immediate site-hazard assessment, decontamination/remediation activities, sampling, monitoring, waste management, transportation and waste disposal. The joint team will provide lessons learned from past projects such as the Syrian Chemical Weapons Destruction Project, Panama chemical agent destruction operations, mail screening facilities and other on-going destruction and recovery operations. The team will summarize key “lessons learned” to aid responders in contingency plan development for remediation and recovery related to domestic chemical and biological incidents. The need for coordination of federal and private sector capabilities in order for the nation to be prepared for recovery from a large scale domestic chemical or biological event will be stressed. This real-world experience offers valuable insight into

* sampling strategies (air and surface),
* decontamination efficacy,
* waste characterization, transportation, and disposal,
* and clearance levels for facility re-occupancy

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Concurrent Session 1 – Biological Agent Decontamination

Evaluation of Three Devitalization Methods for Plant Origin Materials as Quarantine Treatment at U.S. Ports of Entry

Hong Chen | U.S. Department of Agriculture

Plant origin materials with quarantine concerns are seized, held or otherwise intercepted by CBP or APHIS at ports of entry and Plant Inspection Stations. In the past two years, more than 13,000 species and subspecies of plant pests including viruses, bacteria, fungi, nematodes and insects were detected on these materials. Other groups of plant pests such as mites, mollusks and weeds may also be found with these materials. Although such quarantined materials by definition are not regulated garbage, they have historically been treated using the regulated garbage approaches such as grinding and discharge into an approved sewage system, dry or steam heat sterilization at 212°F (100°C) for 30 minutes followed by burial in a landfill, or 6’ deep burial with double plastic bags within 24 hours, mainly depending on the available devices and facilities on site.

A preliminary literature review on the three destruction and disposal treatments against the regulated plant pests is summarized here. With high confidence of efficacy, each of the three devitalization methods has been used to treat some species in every groups of plant pests associating with the plant origin materials. However, the predicable efficacy of a treatment method for a whole group of plant pests may not be sure because high distress tolerances to the treatment lethal factors exist in certain species of a particular group of plant pests. Given the uncontrolled or untested parameters such as temperature and time in the three methods and certain forms of life stages such as bacterial endospore and fungal sclerotium and teliospore, the efficacy of some methods is difficult to predict. With minimal literature of direct relevance to efficacy of these methods against the regulated plant pests, more research will be needed on some regulated plant pests with known high distress tolerances in order to confirm and ensure the treatment effects.

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Decontaminating Materials Contaminated with an Enveloped RNA Virus Surrogate for Influenza, Ebola, and Smallpox, and *Francisella* Vegetative Cells Using Hot Humid Air

Tony Buhr | Naval Surface Warfare Center Dahlgren Division

Aims: To develop test methods and evaluate survival of the enveloped RNA bacteriophage Ф6 or *Francisella* *philomiragia* vegetative cells on contaminated materials after exposure to hot, humid air.

Methods and Results: Dirty preparations of the enveloped RNA bacteriophage Ф6 (containing host cell debris) or *F. philomiragia* vegetative cells (mixed with humic acid) were dried on wiring insulation, aircraft performance coating, polypropylene, or nylon at > 8 log10 per test coupon. Inoculated materials were exposed to numerous test combinations of temperature, relative humidity and time. Virus inactivation was similar on different materials. Vegetative cell inactivation was most difficult on nylon. High temperatures, high relative humidity and longer times strongly correlated with inactivation of both organisms.

Conclusions: Hot, humid air effectively decontaminates materials contaminated with enveloped RNA virus or *Francisella* vegetative cells at ≤60°C and ≤12 h in the presence of high humidity. Inactivation was minimal at 60°C under dry conditions.

Significance and Impact of the Study: Response surface models were developed which may be used to select decontamination parameters for contamination scenarios including aircraft. The temperature and time parameters are significantly lower than for *Bacillus* spores. This greatly increases the applicability of hot, humid air decontamination.

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Development of a Dry Decontamination Method for Mass Casualty Events – The NIOSH DryCon System

Barbara Alexander | National Institute for Occupational Safety and Health

This presentation describes the development of a prototype dry decontamination system (DryCon) for use in the event of a mass casualty incident involving an aerosol contaminant. Wet decontamination is currently used almost exclusively in such cases, although it may be infeasible in cold weather, and there may be cultural sensitivity and/or modesty compliance issues with the requirement to disrobe. During disrobing, aerosol contamination could also re-suspend, leading to increased inhalation of contaminants.

NIOSH’s prototype DryCon system uses air jets for dry decontamination, avoiding some of these drawbacks. The system is portable and can run on building-supplied or generator power. Multiple people can be decontaminated rapidly, one after the other, using this system.

DryCon has been tested in a controlled environment, using a manikin, a fluorescent powder as a simulated contaminant, and three types of fabric squares, using a decontamination time of 60 seconds. At the higher airflow tested, 90% of full blower speed, or approximately 540 cfm, mean decontamination efficiencies of 56.8%, 70.3% and 80.7% were measured for firefighter turnout fabric, cotton denim, and polyester double knit fabric, respectively. The addition of static neutralization via a linear ionizer increased the decontamination efficiencies for firefighter turnout fabric and cotton denim to 68.0% and 76.2%. Removal of this easily re-aerosolized contamination helps to protect personnel from further inhalation exposures.

The results demonstrate the promise of this technique for use as an alternative to wet decontamination, as a first step before disrobing for wet decontamination in a more secure indoor environment, or for use in an industrial setting for post-work-shift decontamination. Further research will be necessary to prove the effectiveness of this technique in real-world applications.

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Laboratory Decontamination Using Low-Concentration Hydrogen Peroxide

Leroy Mickelsen | U.S. Environmental Protection Agency

Remediation and recovery efforts after a release of *Bacillus anthracis* (*B. anthracis*) spores may be difficult and costly. In addition, sophisticated decontamination technologies may be focused on critical resources, potentially leaving small businesses, homeowners, and laboratories without immediate remediation options. To address this gap, this study evaluated the efficacy of relatively low levels of hydrogen peroxide vapor (HPV) delivered from an off-the-shelf house humidifier for the inactivation of *Bacillus* spores within two laboratory settings.

A previous study reported successful HPV decontamination within a household setting when *Bacillus atrophaeus* var*. globigii (Bg)* (surrogate for *B. anthracis*) was inoculated on carpet and galvanized metal coupons. This update will present results from the low-level HPV decontamination in a typical laboratory setting, and inside a wind tunnel, where both the laboratory and the closed-loop wind tunnel had previously been experimentally contaminated with surrogates of *B. anthracis* such as *Bg* and *Bacillus thuringiensis* subsp. *kurstaki* (*Btk*). To perform the tests, a section of a laboratory was isolated using plastic and decontaminated to evaluate the effectiveness of this method; and, the wind tunnel was closed during decontamination and air flow was static.

Decontamination efficacy results will be presented for both the traditional laboratory setting and the wind tunnel. These results, together with those from the household decontamination study, can be used to develop and recommend effective commercial off-the-shelf remediation strategies.

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Concurrent Session 2 – Cross-Cutting Innovation

Will 2D Nanomaterials be the New Security Threat in the Next Decade?

Rouzbeh Tehrani | Temple University

2D nanomaterials have been extensively explored in the past decade. This new class of materials is possibly the most promising alternative materials in developing the next generation of technologies from electronics to biomedical and environmental devices. Mass production of graphene family has already started, and pervasive synthesis of other 2D materials are expected to follow the same pattern. Therefore, the eventual release of nanosheets to the environment and unintended human exposure is very likely. Environmental toxicity and biological interactions of a few families of 2D nanomaterials have been studied. However, there is an important knowledge gap in understanding their impacts on human health and vulnerable ecosystems. The vast diversity of 2D nanomaterials with unique chemical and physical properties has made it more challenging to deliver consistent toxicological and environmental conclusions.

Previously, our group has shown the impact of vertically aligned and randomly oriented MnO2 and MoS2 nanosheets on *Escherichia coli* and *Bacillus subtilis* cultures. We speculate that the sharp edges of nanosheets attribute to the loss of bacterial membrane integrity. Gram-positive bacterial cells have shown more susceptibility compared to those expressed by Gram-negatives. Our current work is focusing on studying the effects of a new class of Van del Waals heterostructures on bacterial communities and their biological functions. This work attempts to provide insight into the environmental fate of 2D nanomaterials.

Many of the newly developed 2D nanomaterials are still under research and development. Currently, the majority of newly developed materials are expected to be unstable or to aggregate under atmospheric pressure or ambient environment. Nevertheless, developments of engineered nanocomposites and vertically aligned 2D nanosheets designed explicitly for biomedical or antibacterial purposes could take a wrong turn and become a severe environmental or security concern soon.

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Recent Advances in Autonomous Radiation Survey and Sample Collection for SRNL

Mitch Pryor | University of Texas at Austin

Recent advances in mobile robotics by the University of Texas at Austin's Nuclear & Applied Robotics Group support routine survey and inspection of hazardous environments at Savannah River National Laboratories (SRNL). These advances are extensible to routine survey and detection of chemical, biological, and radiological threats. In collaboration with SRNL, we have developed a robotic inspection system for a long (approx. 1 km), wide (approx. 15 feet) underground tunnel with uneven, muddy terrain, 50 kph acidic winds, 12+ inches of standing water, and sufficient radioactivity to prevent human entry. The survey requires the remote collection of visual data, LIDAR data, air sampling, radiation activity counts, isotopic characterization, and soil/water sample collection without risking cross contamination. The survey system must continuously operate via autonomously and via user commands for multiple hours in order survey the large space. These requirements have significant overlap with a variety of other survey missions in the environmental domain including high-density LIDAR mapping that identify environmental changes between successive mappings, autonomous navigation, software architecture that simplifies the integration and data archiving from selected sensors, and a dexterous sample collection system designed to collect and isolate multiple samples in harsh, uncertain environments. The system is built around a commercially available mobile platform and manipulator rated for outdoor use. The mapping and navigation capabilities are well-suited for uncontrolled operating environments that change over time and are large enough that stitching multiple point clouds together is necessary to form a complete map. Operator situational awareness is assured using a variety of vision sensors including fish-eye cameras to generate a complete panospheric view without a pan-tilt system. This enables multiple people to use the system and simultaneously observe the environment from independent perspectives. The sample collection system is implemented as a tool changer mechanism on a compliant manipulator. The compliant manipulator allows for tools and sample collection devices to be interchanged without any power source (electrical or pneumatic). A drum style tool magazine stores unused tools and sample collection vessels shielding them from the environment and each other. These software, sensor, and mechanical choices enable the developed mobile manipulator to work in outdoor and harsh environments relevant to the EPA. The proposed presentation will include a review of the SRNL environment, system requirements, its design, and demonstration of the developed functional prototype.

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NASA's Sterilization Working Group for Backwards Planetary Protection for Mars Sample Return Planning

Alvin Smith | California Institute of Technology, Jet Propulsion Laboratory

Returning samples from Mars for scientific analysis on Earth would be a complex effort that NASA and the European Space Agency (ESA) are studying in detail. It would require intricate planning and novel engineering to meet stringent planetary protection requirements. Planetary protection is the practice of avoiding the harmful contamination of solar system bodies so that they can be studied as they exist, in their natural state, and of preventing harm to Earth’s environment from returning spacecraft or samples. One of the key factors in understanding any potential biology on Mars means that missions must avoid contamination that could prevent the confirmation of any possible native life, a critical facet of forward planetary protection. For backward planetary protection in the context of sample return, the challenge lies in preventing contamination from a putative extraterrestrial biological life form that may exist. For “restricted” sample return missions NASA policy requires the containment of any unsterilized material from the body that is returned to Earth. Additionally, samples must remain contained unless treated by an effective sterilizing procedure or shown to be safe. To date there are been several solutions investigated by NASA engineers that can effectively contain the collected samples and sterilize uncontained assumed terrestrial analogs of putative Martian biology. To generate a technically acceptable “sterilization” process across a wide array of scientific and other stakeholders, NASA convened a group of sterilization subject matter experts (SMEs) from industry, academia, and government to assess methods for sterilization and to identify future work needed to verify these methods against biological challenges and feasibility for their implementation on robotic spacecraft in deep space. Preliminary group recommendations pointed to several industry standards for sterilization to include heat, chemical, UV radiation, and low heat plasma; however, due to uncertainty of potential Martian biology, novel definitions and testing are needed to ensure concurrence on effective “sterilization” in the context of a possible Martian threat to Earth’s biosphere. Technical trades for each sterilization modality were also discussed when considering the engineering challenges and limitations for spaceflight. Future work includes further discussion on technical trades of sterilization modalities, identifying and testing Earth analog biological challenge organisms and molecules against chosen modalities, and executing collaborative agreements between NASA and external working group partners to help close data gaps, and establishing sterilization standards for potential Mars Sample Return.

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Biological Indicator and Test Program for Sterility Assurance for Mars Sample Return Planning

J. Nick Benardini | National Aeronautics and Space Administration

NASA’s next Mars rover launching in summer 2020 will collect and cache promising samples of Mars rock and regolith on the Red Planet’s surface. In parallel, the agency is studying a Mars Sample Return Campaign architecture that includes several conceptual missions that could bring those samples back to Earth someday. A fetch rover, Mars ascent vehicle, capture orbiter, Earth-entry vehicle, and sample containment facility are the notional components that would be critical to the success of such a Mars Sample Return Campaign. To prepare for sample return, NASA must adhere to International Policies for planetary protection by ensuring a low probability of release of unsterilized Martian particles into Earth’s biosphere. To explore the feasibility of this requirement, based on current sterilization modalities in use, NASA has assembled a sterilization working group comprised of federal, international, industry, and academic subject matter experts. Based on available data gained from previous Mars missions, one key design assumption the working group has agreed upon for the probabilistic risk assessment is that potential Mars-based biology must adhere to Earth-based physics which bounds the physical and biochemical properties of Mars-based life. A series of sterilization/inactivation steps including passive environmental conditions (e.g. solar radiation, UV, deep space vacuum) and active spacecraft systems (e.g. chemical, heat, UV) are being considered to microbially reduce any possible initial Mars-based life starting at the launch into Mars orbit through Earth containment. To validate these active and passive processes, biological indicators (BIs) are being explored for ground-based testing to establish D- and z-values for both single and the additive impact of simultaneous modalities. NASA is taking a widely proven approach to gain expert input for selecting BIs, by surveying the scientific community for the widest spectrum of extreme environmental isolates to include bacterial, spore forming, fungal, archaeal, plasmids, and prions. Preliminary polling identified ~75 candidates, and 13 candidates were down-selected to begin initial testing. Draft test procedures will include relevant portions of the international standard experimental design defined in ISO 11138 “Sterilization of health care products - Biological indicators” and will be performed on spacecraft materials. Future work includes finalizing the candidate list of BIs, standardizing testing procedures, and establishing the candidates D and z-values as input into a probabilistic risk assessment which would inform the spacecraft design and operational scenarios.

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Concurrent Session 2 – Public Engagement

Measuring Success Beyond Cleanup Levels in Environmental Decontamination

Keely Maxwell, Brittany Kiessling | U.S. Environmental Protection Agency

The standard way of measuring the success of environmental remediation, removal, and decontamination work depends on achieving cleanup levels. Thinking about success beyond this is important for assessing societal benefits and articulating the value of cleanup work. However, it can be fraught with uncertainty due to the complexity of contamination situations. There are complications with unknown risks from emerging contaminants or combinations of contaminants and differences between how stakeholders conceptualize “clean” or “safe.” These differences go beyond discrepancies in exposure limits set by technical studies; they also include differences in acceptance of risk, public health priorities, and societal values. In other words, one person’s success story may be another person’s failure. But despite these challenges, measuring success is an important part of a project’s life-cycle because it provides an opportunity to analyze outcomes, share lessons learned, and establish best practices. It holds people accountable to the quality of their work and contributes to transparency throughout EPA’s programs.

Untangling the multi-faceted concept of remediation success and how different stakeholders define measure it, has been one focus of an ongoing research project conducted by social scientists in EPA’s Office Research and Development. The research team has been investigating how social processes impact environmental decontamination actions, and in turn, how cleanups affect everyday life within communities.

Building upon research presented at last year’s conference, we will share the findings from the latest phase of our project. The team conducted 25 interviews with EPA experts, such as OSCs, CICs, RPMs, and Brownfields managers. We asked a series of questions about working in the field, the types of obstacles they face, how they engage with stakeholders, and how they evaluate success. These insights developed our understanding of the role of trust building and communication in overall decontamination success. Ultimately, our interview findings revealed that decontamination professionals have many ways in which they measure the success of their projects, but there is a lack of formalized criteria. Many explained that they do not have a system to record success stories and lessons learned. Other key elements of success that participants identified, such as success in building relationships, are difficult to quantify.

This presentation summarizes the findings of our interviews, with specific attention to ways of defining and measuring success in environmental cleanups. We suggest opportunities for improving measures of success so that EPA staff can preserve lessons learned and share their achievements with each other.

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Mass Casualty Decontamination Research: What Next?

Kate McCarthy-Barnett | U.S. Department of Homeland Security

In response to the increase of Chemical, Biological, Radiological and Nuclear threats, implementation of attacks and HazMAT incidents, this presentation will focus on how responders must evolve decontamination capabilities to meet these threats for the whole community.

Currently, there is no federal evidence-based decontamination procedures for at-risk individuals including those with disabilities, seniors, chronic health conditions, service animals, durable medical equipment and those with language barriers. Recent research has found that the throughput of these populations was 10 times slower and the delays associated with decontamination processing will consequently have a negative impact for all casualties in terms of clinical and operational effectiveness.

The U.S. is currently implementing a response to CBRN and Hazmat incidents using a triple combination approach of dry, ladder pipe system and technical decontamination (Primary Response Incident Scene Management--PRISM). An international large-scale, multi-agency response exercise to evaluate the effectiveness of the PRISM (“Operation DOWNPOUR”) demonstrated for the first time that current disrobe and decontamination procedures lack technical evidence and are based on perceived best practices, relying on an assumption that the needs of all casualties can be met using ambulant protocols for those who are able to walk and maneuver through without assistance or accommodations.

In order to effectively respond to a CBRN or HazMat incident, communities must be resilient to such catastrophes which requires scientific data to support planning and response. Reducing the delay between initial exposure to a contaminant and subsequent emergency response actions is considered one of the most important factors for optimizing the number of lives saved. The longer duration of treatment observed for at-risk casualties will either have a detrimental effect on the operational effectiveness of established incident response procedures or will result at- risk casualties receiving treatment secondary to other casualties.

There is a clear and urgent requirement to perform research to generate evidence-based federal decontamination guidance for at-risk casualties. Recognizing and understanding the threat and the risk that it poses is critical to determining the appropriate response. This interactive session will provide participants the forum to review and discuss new decontamination research aimed at removing the inequalities and fully integrate an evidence-based response for the safe and effective disrobe and decontamination for the whole community during a CBRN or Hazmat incident.

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Management and Disposal of Vehicles Following a Wide Area Incident

Colin Hayes | Eastern Research Group, Inc.

Large-scale natural disasters have the potential to generate a significant amount of waste. Man-made chemical, biological, radiological, and nuclear (CBRN) incidents, either by way of terrorism, war, or accident, also have the potential of generating as much or more waste. Furthermore, following a wide-area incident, it can be assumed that a large number of vehicles will be damaged, contaminated to various degrees, and/or left unattended or abandoned within the impacted area. The resource demand required to manage (gather, transport, store, treat/decontaminate, recycle, or dispose of) these contaminated vehicles may overwhelm local, state, and federal recovery efforts. Therefore, EPA is undertaking researching efforts to reduce the cost and time associated with assessing, collecting, and recycling or disposing of contaminated vehicles as a result of a wide-area incident.

Under a two-pronged approach, EPA first conducted a literature review followed by a stakeholder workshop to synthesize existing knowledge and research related to managing vehicles impacted by a natural disaster and a wide-area CBRN incident. Results of the initial literature review and insights gained through the stakeholder workshop confirm that while there are many valuable lessons learned from natural disaster responses and work by other federal agencies to address decontamination of valuable vehicle assets, many questions remain unanswered. In addition, other important stakeholders were identified. EPA undertook additional research including the organization of several focused meetings with various stakeholders that represented all stages of the post-manufacturing vehicle life cycle to better identify and understand key issues to advance preparedness efforts for handling large volumes of vehicles resulting from a wide-area event. This presentation will highlight the key findings from this recent effort.

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EPA’s Office of Research & Development Engagement Efforts with State, Local, and Tribal Government

Viktoriya Plotkin | U.S. Environmental Protection Agency

ORD has been working for the past seven years to strengthen its direct relationship with states. Starting with its partnership with the Environmental Council of States (ECOS) and the Environmental Research Institute of the States (ERIS), ORD has worked with its stakeholders to determine environmental research priorities, engage early on in product development, and disseminate research information and tools. These collaborations with end-users of ORD research have been further enhanced through partnerships with several public health associations, such as the National Environmental Health Association (NEHA), the National Association of City and County Health Officials (NACCHO), and the Association of State and Territorial Health Officials (ASTHO). Recognizing that ORD’s efforts can also support organizations outside of ECOS and public health associations, in March 2018, ORD announced the creation of a Framework to strengthen its relationship with states and tribes by building engagements with Natural Resources Agencies, State Scientists, Tribes, and Emergency Management.

Recent natural disasters, such as Hurricanes Harvey, Maria, and Irma, as well as man-made disasters, like the Deepwater Horizon oil spill, highlight the importance of state and local emergency responders, who are first on the scene when disaster strikes. To assist in these efforts, EPA’s Office of Research and Development (ORD) conducts research and acquires expertise to improve water utilities’ ability to prepare for and respond to incidents and to advance the Nation’s capabilities to respond to wide-area contamination incidents. To ensure that the research products being developed are relevant and timely for state and local responders, as well as our federal partners, ORD has embarked on a systematic approach to engaging these end-users and building relationships.

ORD’s collaboration effort in Emergency Management has employed a three-pronged approach for reaching first-responders at the state and local level, such as engaging with national level state associations that represent emergency responders. This approach has further broadened appeal to organizations and state officials that may not have otherwise known or heard of the capability and expertise that ORD can provide during emergency events. ORD plans to further pursue awareness activities for first-responders as well as find ways to work in collaborative fashion to understand state and local needs during an event that would make our research tools more impactful.

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 Day 2

Concurrent Session 3 – Fentanyl Detection & Cleanup

Scenario Specific Opiate Detector Selection

Evan Durnal | MRIGlobal

MRIGlobal created a baseline market survey of portable detection equipment capable of identifying fentanyl, other opiates, and related compounds. Specific performance, operational, and physical criteria were developed to narrow the focus of the survey to those products best suited for field detection scenarios. The technical approach for compiling product information was to review the open literature (including market surveys compiled by other groups), conduct internet searches, and contact vendors, users, and subject matter experts in the area of field-portable chemical detection products. The scores presented therein are applicable to the described scenarios only. The market survey provides product information for 128 chemical detectors covering 15 technologies. To qualify for inclusion, products must be COTS/GOTS, have a maximum weight of 70lbs, operate without power or on battery only, and identify the target materials. Products were assigned an overall score based on four categories, 3-5 criteria within each category, weight (importance) of each of 14 criteria, and associated scoring level (1-4) within each criterion. For example, baseline rankings will preferentially select a product with more consumables and durability over size, whereas field users may desire the most portable product available, regardless of durability and consumables. USG users have access to the full data set and the ability to create customized rankings and filtered reports via a secure portal. The portal contains active user customizable ranking whereas the criteria weighting can be independently modified to best represent the user needs and therefore resulting in operationally specific product rankings. In addition, USG users can generate custom reports on all PBA products based on specific search or filter criteria of over 40 unique field.

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Evaluation of Environmental Fentanyl Contamination and Sampling Effects for Remediating Affected Areas

Stuart Willison | U.S. Environmental Protection Agency

Illicit fentanyl activities cause unique contamination incidents and risk to law enforcement, first responders, remediation personnel, and the public. Fentanyl is fast-acting, but the life-threatening effects are reversible if detected early and treated. Characterization of contaminated areas requires media-specific sampling and analysis procedures to ensure accurate chemical identification and quantitation. The information provided by sampling and analysis efforts will guide health-based decisions made before, during, and after remediation. It enables decisions that protect workers and civilians, including those that may reoccupy previously contaminated areas and decisions that include decontamination and remediation to reduce exposures to acceptable levels of risk. Sampling and analysis procedures should be developed not only for water contamination (because decontamination efforts typically involve the use of aqueous-based solutions and these compounds are water soluble and identified in water sources), but also for fentanyl contamination within residences (e.g., indoor surfaces, such as bathrooms and living areas). Surface recovery results and the effects of wipe sampling variables on recovery results will be discussed for several indoor matrix types.

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Decontaminant Reactivity Screen with Select Fentanyls

Amanda Schenning | U.S. Army Combat Capabilities Development Command

The fentanyl class of synthetic opioids has recently generated an immense interest outside the medical field due to an increasing number of drug overdoses and chemical attacks worldwide. Like traditional chemical weapons agents (CWAs), pharmaceutical based agents (PBAs) can be used to cause great harm, incapacitation and death to both the warfighter and the general public. In addition, the illicit drug trade has reinforced the threat by making many PBAs, such as opioids, readily available to those who either knowingly or unknowingly seek them. With a lethality on the same level as the nerve agent VX, opioids and opioid contaminated surfaces present a significant potential hazard to personnel who come in contact with them. In light of the current opioid epidemic and the increasing potential for a military or civilian response to a clandestine drug operation, the need to effectively decontaminate assets following an operational scenario involving PBAs has recently come under the umbrella of credible threat scenarios.

Our initial assessments into the decontamination of select opioids demonstrated that dissolution challenges and limited chemical reactivity were the main obstacles to formulating an effective decontaminant for the neutralization of opioids. Decontamination efforts are further complicated by the numerous available forms of opioid analogs including the free base, hydrochloride, citrate and oxalate salts. There is a paucity of data to make informed decisions regarding the effects of PBA form (freebase vs. salt), decontamination treatment of materials, and contact transfer potential, to guide efforts by warfighters and first responders.

In FY18 we conducted a limited scoping study that examined liquid phase reactivity and material decontaminant performance of three decontaminants against carfentanil citrate and carfentanil freebase. An effort is currently underway to evaluate liquid phase reactivity with an expanded number of decontaminants against the oxalate salt forms of fentanyl, remifentanil and carfentanil. The intent of this presentation is to provide data on time-resolved reactivity, capacity, and potential by-product formation to aid warfighters and first responders in making informed decisions regarding decontaminant choice and processes.

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Surface Decontamination Options for a Fentanyl Contaminated Building Interior

Lukas Oudejans | U.S. Environmental Protection Agency

Illicit fentanyl activities can cause unique contamination incidents and risk to law enforcement, first responders, remediation contractors, and the public. This presentation will provide an overview of EPA’s role in a fentanyl response and will contain the results from research that was initiated to fill select gaps identified during the development of EPA’s Fact Sheet for OSCs: Fentanyl and Fentanyl Analogs (Fentanyl Fact Sheet).

Decontamination operations will benefit from in situ neutralization options for fentanyl, its analogs, and derivatives on materials. Current remediation knowledge is largely limited to the fundamental, aqueous-phase chemistries of several oxidizers such as hydrogen peroxide, peracetic acid, and hypochlorite (bleach). EPA has collected data describing the efficacy of several, applied decontamination options. These data describe results from decontamination tests using nonporous surface materials contaminated with solid fentanyl salt. They included spray application of multiple decontamination solutions that are identified in the Fentanyl Fact Sheet, as well as more recently identified decontaminants of interest. The impact of material type, as well as that of benign additives that may be found in illicit fentanyl formulations, on the decontamination efficacy will be discussed.

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Concurrent Session 3 – Water Infrastructure Protection & Decontamination

(Un)expected Water Contamination Research

Matthew Magnuson, Jeffrey Szabo | U.S. Environmental Protection Agency

Water contamination associated with unintentional (industrial spills, natural disasters, transportation accidents, etc.) and intentional (terrorist, cyber, criminal, etc.) incidents can result in a vast array of interrelated response and recovery activities. Confounding these activities are, in addition to anticipated scenarios, the unexpected ways water systems can become contaminated. For instance, who would have thought forest fires could result in drinking water system contamination?

This presentation will discuss multiple EPA research projects that support water/wastewater utility response to and recovery from chemical, biological, and radiological contamination incidents. These research projects also help utilities determine 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 integrate all inter-related response technical aspects, and, more importantly, position themselves for response to the next incident.

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Microbial Inactivation by Peracetic Acid in Sewage and Feces to Optimize Disinfection of Highly Infectious Waste Waters

Collin Knox Coleman | University of North Carolina at Chapel Hill

Introduction: Waters impacted by improperly treated or untreated human excreta, such as high risk human wastes and wastewaters discharged from hospitals, waters in close proximity to open defecation sites, or urban areas with combined sewerage can contain high levels of pathogens. Poor quality wastewaters, such as those contaminated by human feces, can contain high levels of suspended solids and organic loads that prevent on-site decontamination by traditional treatment technologies, such as chlorine dosing, by rapidly reducing disinfectant concentrations before target microbial reductions are achieved.

Objectives: Evaluate and quantify inactivation of *E. coli*, *S. typhimurium*, *R. terrigena*, *Clostridium sporogenes* spores, MS2 and ΦX174 coliphages, and *Cryptosporidium parvum* oocysts by Peracetic Acid (PAA) in hospital sewage and feces.

Methods: Evaluation of microbial reductions in pasteurized hospital sewage and a fecal matrix consisting of 33% feces in hospital sewage was performed in batch lab-scale experiments seeded with microorganisms. Seeded test waters were dosed with PAA concentrations ranging from 4 mg/L to 4000 mg/L and neutralized at time points up to 30 minutes. Influent and effluent *E. coli*, *S. typhimurium*, and *R. terrigena* were enumerated by spread plate method on Bio-Rad Rapid’*E. coli* 2 agar. *C. sporogenes* spores were assayed by spread plate method on reinforced clostridial medium and anaerobically incubated in jars. MS2 and ΦX174 coliphage were enumerated by DAL plaque assay method, EPA method 1602, with *E. coli* Famp and CN13 hosts, respectively. *C. parvum* infectivity was assayed for infectious focus-formation in HCT-8 mammalian cell cultures and enumerated by immunofluorescent microscopy.

Results: An Initial PAA dose of 4000 mg/L gave greater than 4 log10 (99.99%) inactivation by 10 minutes in the hospital sewage and the fecal matrix for *E. coli*, *S. typhimurium*, *R. terrigena*, *C sporogenes* spores, and ΦX174 coliphage; for MS2 coliphage and *C. parvum* greater than 2 log10 (99%) inactivation was achieved by 10 minutes. PAA concentration x contact time (CT) values of 2960 and 16,939 min\*mg/L were reached at 10 minutes of exposure for 400 mg/L and 2000 mg/L initial PAA doses, respectively in hospital sewage. A CT value of 17,083 and 34,167 min\*mg/L was reached at 10 minutes for 2000 mg/L and 4000 mg/L initial PAA dose respectively in the fecal matrix. This research demonstrates that rapid and effective disinfection of highly infectious hospital waste is achieved by mixing 1% PAA (15% stock PAA concentration) by volume directly into the toilet or other container.

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The PFAS Effluent Treatment System (DETS): Design, Construction and Testing

Jacob Lalley | U.S. Army Engineer Research and Development Center

This study compliments the previous one in that it focused on the treatment of a simulant from Mass Personnel Decontamination (MPD). MPD wash water has less suspended solids than vehicle wash water and does not have bleach. However, it can have higher amounts of surfactant. The test on MPD simulant was requested by the National Guard Bureau. Treatment of both cesium 133 (used as a surrogate for radioactive cesium 137) and Malathion (as a surrogate for organophosphate chemical warfare agent) equaled or exceeded 99.95%. The conclusion was that the system proved to be highly effective at treating wash water from MPD, which would allow discharge or even potential reuse for more decontamination.

DETS testing also included a road test and integration into a National Guard CERFP exercise in Louisiana. And the DETS was tested on the treatment of PFOS, a component of PFAS.

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Disinfection of *Legionella pneumophila* within Drinking Water Biofilms Using Various Treatment Technologies

Jeffrey Szabo | U.S. Environmental Protection Agency

Regrowth and survival of opportunistic pathogens, such as *Legionella pneumophila*, in building water systems are promoted by low disinfectant residual, high surface-to-volume ratio, amenable growth temperatures, water stagnation, and microbial colonization of drinking water (DW) biofilms (BFs). Most of the DW biomass is located within BFs, which provides protection from environmental stresses, access to higher levels of nutrients, and opportunities for symbiotic interactions with other microbes. Disinfectant efficacy information is historically based on the inactivation of pathogens in their planktonic (PL), free-floating forms. However, due to the ecological importance of BFs for pathogen survival, the aim of this study is to determine the effectiveness of free chlorine (FC), monochloramine (MA), and copper/silver ions in the inactivation of BF-associated *L. pneumophila* developed on copper (Cu) and polyvinylchloride (PVC) surfaces. Ct (disinfectant concentration x time) inactivation values for 2-, 3-, and 4-log10 reduction of PL and BF *Lp* were determined. *L. pneumophila* 16S rRNA gene transcript levels were also measured to determine the effect of disinfectant type on bacterial transcription. Results from this study indicate that BF association, disinfectant type, and substratum play an important role in the survival of *Legionella pneumophila*. Overall, this, and other related research, will provide a better understanding of *Legionella* ecological stability and survival and aid policy makers in the management of exposure risks to water-based pathogens within building water systems.

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Concurrent Session 4 – Biological Agent Sampling & Analysis Methods

Feasibility of a Bioaerosol Sampling Network to Measure Resuspended Spores

Johnathan Thornburg | RTI International

This research assessed in silico the feasibility of a bioaerosol sampling network to monitor *Bacillus anthracis* spore concentrations during the remediation phase following a large-scale biological incident. We modeled the performance and cost of four air sampling strategies over a 36 km2 area of New York City and Denver, CO to detect the resuspension (e.g., reaerosolization) of spores from contaminated urban surfaces in cities with different topography and meteorology. A system performance model assessed the ability of multiple network designs for each air sampling strategy consisting of a combination of low-flow, high-flow filter samplers, and/or building outdoor air make-up ventilation filters to maximize spore detection at the minimal cost. The modeled performance of the same 121 high-flow monitor network deployed in both cities and the network optimization modeling found that city specific designs may be required because urban infrastructure, human activity, topography, and meteorology differences influence resuspended spore dispersion and airborne concentrations. However, the optimal network design when balanced by bioaerosol detection versus network cost was similar in both cities. A mix of 7 high-flow samplers deployed around the perimeter of the release area and 17 low-flow samplers and 17 building air intake filters positioned in a regular pattern further from the release point. The estimated cost of this design was between $1,200 to $2,400 per positive filter sample, or a total of $813,000 for 30 days of sampling. This work did not consider potentially important operational aspects of the network deployment, such as the labor and time required to erect the network, access to trained personnel and the samplers, and access to the selected monitoring locations. A knowledge gap identified was a quantitative understanding of how the resuspension fraction changes over time from surface loading depletion and changes in spore adhesion. Additional future work will determine how bioaerosol sampling fits into the overall wide area decontamination and recovery strategy.

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Comparison of Sampling Methods for an Extended Duration Outdoor Biological Study

Anne Mikelonis | U.S. Environmental Protection Agency

Following a bioterrorist attack, materials contaminated with a biological agent pose significant health threats and may require remediation. To assess biological persistence, a six-month outdoor sampling study was conducted using *Bacillus globigii* (*Bg*) to compare the spore recovery of traditional versus emerging sampling methods over time. *Bg* is a surrogate for the Center for Disease Control (CDC) select agent *Bacillus anthracis*, the causative agent for anthrax. Traditional sampling methods included sponge wipes, grab samples, and vacuum sampling with 37 mm cassettes. Emerging sampling methods included commercially available wet vacuums and automated robotic floor vacuums. An asphalt and a concrete parking lot (each area approximately 800 ft2) were gridded and inoculated with 106 CFU/ft2 as well as adjacent areas of soil, grass, and leaves. Samples were collected in triplicate at 1, 4, 37, 99, and 210 days after inoculation. For all sampling methods, higher spore recoveries were observed for concrete vs. asphalt samples. Only the emerging methods (wet vacuums and robots) recovered spores at 99 and 210 days for asphalt whereas all methods recovered spores at 99 days. Wet vacuums, robots, and 37 mm vacuums recovered spores at 210 days for concrete samples. Spores were recovered from the grass, leaves, and soil grab samples up until the 37-day point, but only soil samples had recoverable spores at the 99-day sample collection. Methods for collecting and processing the samples as well as a statistical analysis of the results will be discussed in this presentation.

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Development of an Improved Concrete Testing Coupon for Recovery of Viruses in Quantitative Carrier and Decontamination Efficacy Tests

Lindsay Gabbert | Plum Island Animal Disease Center

Concrete is a common building material routinely encountered in environments where biological contamination events may occur, thus, validation of decontamination procedures for concrete surfaces is desirable. Efficacy tests designed to assess biological decontamination require recovery of infectious agent from untreated surfaces prior to evaluation of disinfectants. Unfortunately, recovery of viable virus from porous concrete has been a reported challenge. We investigated the use of induced rapid carbonation as a tool to lower the pH of homemade concrete testing coupons to compare viral recovery from high and low-pH porous concrete surfaces. Newly carbonated concrete coupons were used in quantitative carrier tests to determine the virucidal efficacy of a liquid chemical disinfectant against two livestock pathogens, Foot-and-mouth disease virus (FMDV) and African swine fever virus (ASFV). Neither FMDV nor ASFV were recovered from untreated concrete coupons unless the pH of the concrete was lowered to approximately pH 9. Viral recovery from carbonated concrete was similar to recovery values from non-porous stainless steel coupons. FMDV titers were reduced by 4-log10 after a 5-minute exposure to 1% Virkon® S on both concrete and stainless steel. Inactivation of ASFV required a 10-minute contact time with 1% Virkon® S on stainless steel, and a 10-minute contact time with 2% Virkon® S on concrete. This study outlines a reproducible method for generation of low pH concrete testing coupons that may be used in quantitative carrier tests to model efficacy of chemical and physical decontamination practices under controlled conditions, and further demonstrates recovery and disinfection of FMDV and ASFV from this challenging surface matrix.

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Evaluation of Analytical Methods for the Detection of *Bacillus anthracis* Spores: Compatibility with Real-World Samples Collected from Outdoor and Subway Surfaces

Scott Nelson | Battelle

The EPA is responsible for the remediation of land and public infrastructure following a biological contamination incident such as an act of bioterrorism involving the release of *Bacillus anthracis* (*B. anthracis*), the bacterium that causes anthrax, in an urban area. The EPA, in partnership with New York City and Battelle, investigated the impact of real-world interferents collected from mid-town Manhattan (Times Square and Grand Central Station areas) using Sponge-Sticks and vacuum filter cassettes (VFCs). Surface samples collected in the field were sent to the analytical laboratory, spiked with *B. anthracis* Sterne spores, then recovered and analyzed using Rapid Viability (RV) PCR and microbiological culture analytical methods developed by the EPA. From Sponge-Sticks, RV-PCR analytical method correctly detected the presence of viable *B. anthracis* in > 97% of spiked samples. By comparison, microbiological culture using Tryptic Soy Agar II (TSA with 5% Sheep Blood) correctly detected the presence of viable *B. anthracis* in 77% of spiked Sponge-Sticks, meaning the presence of real-world material collected during surface sampling can hinder identification of viable spores using the culture method. Neither the RV-PCR nor culture analytical methods performed as well with surface samples collected using the VFC method. Only 47% and 54% of spiked samples correctly identified as containing viable *B. anthracis* spores for RV-PCR and culture (all spike levels pooled), respectively. The relatively low positive identification success was attributed to poor physical recovery of *B. anthracis* Sterne spores from the VFC. The results from this study show that RV-PCR can be used to positively identify viable *B. anthracis* in presence of complex, dirty sample matrices from Sponge-Stick surface samples. The background flora and grime collected on the Sponge-Sticks can hinder detection and/or suppress the sensitivity of the *B. anthracis* signal, but samples with as few as 15 *B. anthracis* spores applied to the sponge could routinely be positively identified.

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Concurrent Session 4 – Technology & Software Supporting Disaster Response

A Virtual Reality Platform for Training Personnel on Biological Surface Sampling Techniques

Ellen Shumaker | RTI International

The significance of disaster response training and exercise activities on emergency personnel are well documented throughout the literature. However, these exercises, especially full-scale disaster exercises, are expensive, time consuming, difficult to organize, and are limited in scope. One technology solution capable of addressing this dilemma is virtual reality (VR). VR is a simulated, immersive environment that the user can explore and interact with through the use of a head-mounted display. Studies have found that sensory-motor tasks learned in VR could be transferred to real-life environments, and in some cases, VR-trained personnel performed better than personnel who trained in the field. VR also provides the ability to track users’ movements and actions, including body position and head direction, which provides a wealth of information about where users are focusing their attention, what they observe from their own specific vantage points, and their reactions to the environment.

This presentation will highlight the recent development of a VR platform for training personnel on biological surface sampling techniques. The platform uses photogrammetry, which is a technology that captures multiple high-resolution images and combines them with software to create a realistic 3D environment with minimal level of effort compared to traditional modeling techniques. Users of the platform can walk through various rooms, delineate areas of interest throughout the environment as potential sample locations, and select the tool with which to collect the sample. A hand-tracking framework built for the Oculus Rift S Touch Controller tracks the user’s hand to assess sampling patterns, percentage of area sampled, and swapping between sampling tools. It allows for precision tracking of hand movements inside VR environments. A user’s total time to collect a sample is also recorded.

The training platform seeks to address the burden associated with planning and conducting full-scale disaster exercises by creating an immersive experience that allows the user to explore and interact with their environment through the use of VR. Furthermore, by integrating hand-tracking capabilities, a sampling collecting training module has been developed for training personnel on biological surface sampling techniques.

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An Introduction to the U.S.-EPA CompTox Chemicals Dashboard – Web-Based Access to Data
for ≈900,000 Chemicals

Antony Williams | U.S. Environmental Protection Agency

The CompTox Chemicals Dashboard (available at https://comptox.epa.gov/dashboard) is the latest in a suite of dashboards that have been delivered to the community by EPA’s National Center for Computational Toxicology. The dashboard delivers access to data for >875,000 chemicals and includes experimental and predicted physicochemical properties, hazard and exposure data, access to Toxcast/Tox21 bioactivity screening data and provides a link farm to dozens of other online resources. The dashboard delivers access to data with a variety of powerful search capabilities including searching by chemical identifier (e.g. CAS Number or Name), by commercial product type, or by mass or formula. Searches can be performed one chemical at a time or in batches of thousands. Whether you are a chemist, an analytical scientist or a toxicologist the dashboard is of value as it seamlessly integrates data from dozens of databases into a web-based user experience. Other integrated modules include real-time physicochemical and toxicity endpoint prediction and an integrated search to PubMed and almost 30 million publication abstracts. The data and functionality available via the dashboard can be of value in terms of decontamination by providing access to data to assist in detection (specifically via mass spectrometric detection), accessing literature and potential decontamination approaches associated with specific chemicals, and access to toxicity values for chemicals such as Military Exposure Guidelines. This presentation will provide an overview of the CompTox Chemicals Dashboard and how it has developed into an integrated data hub for environmental data.

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An Open Source Quick Response System for Tracking Personnel and Resources

Jonathan Pettit | U.S. Environmental Protection Agency

A key element of EPA oversight during emergency responses is the tracking of personnel as they check in and out of the Incident Command Centers at the beginning and end of their daily shift. This has typically been done using paper sign-in sheets and requires significant manual effort to key personnel’s names and arrival/departure times into a computer so that timekeepers can properly track labor hours and location. This is a critical aspect of Agency response activities, both so that the worker can be properly paid and so that the Agency can be reimbursed by FEMA for recoupable labor hours resulting from response activities, as well as for health and safety purposes (i.e., confirming the status of personnel). Recent hurricane seasons have necessitated the EPA to stand up multiple Incident Command Centers, making this paper-based process extremely complicated and time-consuming to implement.

As part of the Homeland Security Research Program’s (HSRP’s) ongoing collaborative efforts with the Department of Homeland Security (DHS) and other parts of EPA’s Homeland Security Enterprise, a field test, the Underground Transportation Restoration (UTR) Operational Technology Demonstration (OTD), was performed in 2016 to assess techniques to rapidly decontaminate and return a subway back to normal operation following a biological agent (e.g., anthrax) release. Part of the OTD included assessing the total cost of different aspects of the response, so that multiple considerations, including sampling, decontamination, and waste management, could all be related back to time and material costs. To do this, it was necessary to track the movements of test personnel at each step of the process as they donned their personal protective equipment (PPE), entered into the contaminated zone, performed their tasks (e.g., sampling), exited from the contaminated zone, underwent personnel decontamination, and finally doffed their PPE. HSRP developed a system using commercial off-the-shelf components that consisted of webcams and open source software that uses quick response (QR) codes attached to personnel’s PPE as a means for recognizing, recording, and sharing timestamped information. HSRP was able to use that information to perform a detailed cost analysis of the entire remediation process. From this prototype, an EPA-supported application was developed to serve as a cost-effective, customizable, and easily deployable solution capable of tracking people and assets in the field during emergency responses.

This presentation will provide a background on the tool, its methodology and capabilities, and highlight recent accomplishments.

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A GIS Application for Developing Biological Sampling Designs and Estimating Resources Necessary for Implementation

Colin Hayes | Eastern Research Group, Inc.

A large-scale release of a biological or radiological (BR) agent can result in contamination of a wide area and would require significant time and resources for recovery. Many unknowns are associated with characterization and clearance sampling during response to a wide-area (including indoor, outdoor, and underground areas) BR incident. The BR agent and its characteristics, the release mechanism, amount of contaminant released, and a plethora of environmental and meteorological factors are separate, yet interconnected processes that greatly influence the extent and level of contamination. Similarly, decisions related to the sampling strategy (i.e., sampling media, sampling area, spacing, etc.) will affect the cost, time, amount of waste generated, and personnel (i.e., resource demand) required to characterize and clear the contaminated area. A systems approach can be used to understand how these elements influence one another and contribute to effectively solving the problem. However, to what degree sampling and cleanup, more specifically, variations in these strategies interact and contribute to overall resource demand, following a wide area BR incident, is still largely unknown.

To better understand the impacts sampling designs can have on resource demand, especially when considering large-scale sampling campaigns, EPA’s Homeland Security Research Program (HSRP) developed the Trade-Off Tool for Sampling (TOTS). TOTS is a GIS-based tool for developing sampling designs within ESRI’s ArcMap and estimating the associated resource demand. TOTS consists of a point-and-click interface for importing externally-developed sampling plans or for developing plans by plotting sample locations using aerial imagery or computer aided design (CAD) drawings as a reference. From the developed sampling plans, the tool estimates the total time and cost necessary for implementation, which includes sampling kit preparation, sampling campaign, and lab analysis. The resulting sampling plan can be used to consider trade-offs in one’s sampling design (i.e., cost-benefit analysis), alternate sampling approaches (i.e., traditional vs innovative sampling methods), and sampling coverage. Furthermore, the sampling design can be directly imported into ESRI’s Collector and Survey123 applications for use in acquiring sampling data in the field. This presentation will provide an overview of TOTS, a case study featuring its use in the Bio-Response Operational Testing and Evaluation (BOTE) project, and future enhancements.

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Concurrent Session 5 – Beyond Water Infrastructure

Using Stormwater Models to Inform Recovery Efforts Following a Wide-Area Contamination Incident

Katherine Ratliff | U.S. Environmental Protection Agency

Following a terrorist attack or natural disaster, chemical, biological, or radiological (CBR) contamination can be spread broadly throughout the environment. This is particularly problematic in cities, where densely populated areas and complex infrastructure pose unique challenges during emergency response and remediation efforts. Since many of these CBR agents are environmentally persistent and wide area remediation efforts can take months or even years, understanding the fate and transport of these contaminants is necessary for developing effective and efficient decontamination strategies. For example, rainfall may mobilize and further spread contamination into areas and/or infrastructure that was not initially contaminated. To address these concerns, the United States Environmental Protection Agency (US EPA) has been developing methods for using the EPA’s Stormwater Management Model (SWMM) to model the spread of CBR agents over time. EPA SWMM is a public domain hydrologic and hydraulic model that has been used extensively in the U.S. and throughout the world to simulate single event or extended duration stormwater runoff quantity and quality. We have developed additional capabilities for tracking contamination through expanding the SWMM application programming interface (API) and its python wrapper, PySWMM. Modeling the contaminant transport that occurs as a result of precipitation or decontamination activities allows new maps of pollutant loading to be generated over time, which are useful for informing other aspects of remediation efforts, such as developing sampling and waste management plans. This presentation will demonstrate these capabilities through a case study using the air deposition plume generated by FEMA’s Interagency Modeling and Atmospheric Assessment Center (IMAAC) after a fire in Portland, OR dispersed asbestos-containing material over a wide area. We will show how results from SWMM modeling can be used as inputs for the EPA’s Waste Estimation Support Tool (WEST), illustrating the significant impact that contaminant fate and transport can have on decontamination and waste management strategies.

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Wash Penalty Factors: Insight into the Effects of Water Wash Down of Building Materials for RN Decontamination

Michael Kaminski | Argonne National Laboratory

The release of radiological material to the urban environment can have devastating socio-economic impact. In an urban release scenario, areas around the dispersal epicenter and any areas contaminated via atmospheric deposition may require extensive decontamination. Most recently, our group reported the decontamination efficacy of pressurized water washing of common porous building materials and compared the penetration depth of the contaminations before and after exposure to pressurized tap water. Here, we continue evaluation of the decontamination efficacy of wash solutions based on K+ salt for cesium, strontium, and europium contaminations on common building surfaces. The surfaces included: the cement used in concrete, the aggregate used in concrete, intact concrete, roadway asphalt, asphalt shingles, and latex paint. We deposited solutions of 137Cs, 85Sr, and 152Eu onto a number of common building materials and exposed these to a static bath or low-pressure flow of tap water, 0.1 M KCl, and 0.5 M KCl. The decontamination efficacy and the depth profile for residual contamination was measured to determine the conditions for which applying a wash solution has benefit compared to physically removing the surface material. To aid in these analyses, we introduced a “wash penalty factor” to quantify the degree to which contamination migrated into the bulk material by the action of the wash method.

On asphalt, 70-80% of radionuclides were found to within 0.02 mm of the surface. Cs+ bonded to negative charge sites on the surface of mineral aggregate (used in concrete) so decontamination was improved by ion exchange with K+. Sr2+ is soluble and removed by water, while not bonding to aggregate or demonstrating solubility in the liquid asphalt. Eu3+ is precipitating and not removed in gentle wash but displays mobility within the pore space that suggests its presence as a colloid. Concrete is more porous than asphalt, and 80% of radionuclides were within 0.2 mm of the surface for 137Cs and 152Eu and 50-80% for 85Sr. On concrete, Cs+ bonds similarly as with asphalt. Sr2+ bonds to the cement or precipitates from the alkaline pore water. Eu3+ sorbs to the cement and then precipitates. In brick, the results for Cs+ and Sr2+ suggested that diffusion of ions from deeper in the coupon was important. Eu3+ is removed poorly due to precipitation. Water effectively removed all contaminants from hard, non-porous surfaces. Desorption from latex paint and asphalt shingles follows ion exchange mechanisms, so Cs+ and Sr2+ desorption improves with presence of K+ ion. We will explain and report example wash penalty factors for the various methods and its implications on deciding when to implement wash down method.

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Logistics Modeling of a Wide Area Decontamination Operation Using Wash Down Techniques

Katherine Hepler | Argonne National Laboratory

In the event of wide-spread nuclear contamination, there is a need for established recovery plans using quick, non-destructive decontamination techniques. Such techniques help minimize the detrimental economic, social, and psychological effects of wide-spread contamination. Much of the current literature focuses on the early response but provides little guidance on the details of late-phase recovery.

To address the need for adaptable and rapid decontamination/remediation techniques following a large-scale nuclear contamination incident, particularly in the urban environment, the Integrated Wash Aid Treatment Emergency Reuse System (IWATERS, Fig. 1) has been described. There are three primary steps in IWATERS: 1) an ionic wash solution, termed “wash-aid”, is applied to a surface via hosing, pressure washing, or another mechanism; 2) the contaminated wash solution is collected and fed into ad hoc filtration beds with readily-available infill material; and 3) the treated wash solution is recycled throughout decontamination operations, thereby preserving the water resource. Work characterizing the system was comprised of lab-scale experimentation, filtration bed simulations, and several field demonstrations.

We employed Analysis of Mobility Platform (AMP) and GoldSim software to model the logistics of deploying materials to implement the Integrated Wash Aid Treatment Emergency Reuse System (IWATERS) in a hypothetical cesium-contamination scenario covering a four-block strip of downtown Chicago, IL. In this deployment of IWATERS, buildings were washed down via fire-hosing and contaminated wash solution was collected in the city’s waste/storm water collection system. The contaminated wash water was treated to remove cesium via ad hoc sand/clay filtration beds, and the treated wash solution was recycled during continuing decontamination operations. A detailed task timeline for the IWATERS deployment and information (or assumptions) on the availability and location of required resources for operations provided input parameters, as well as a framework, to enable the AMP and GoldSim simulations. From the decision to deploy IWATERS to the end of operations, including the completion of processing all contaminated wash water, took 49 days with decontamination teams active for 35 days and treatment bed teams active for 37 days. The modeling results showed the availability of vermiculite clay (based on data supplied by its commercial vendors/distributors) as the limiting factor for deploying treatment bed teams and, consequentially, the recycling rate of wash water and the timeline for decontamination operations. These simulations represent the first attempt at understanding the material and personnel requirements for large-scale IWATERS operation.

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Water-On-Wheels (WOW) Emergency Water Treatment System Cart

James Goodrich | U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency’s (EPA) Homeland Security Research Program partnered with WaterStep, a NGO, to develop and deploy a mobile emergency water treatment system utilizing a Federal Technology Transfer Act Cooperative Research and Development Agreement (CRADA). The purpose of this study was to design, build, evaluate, and deploy a mobile emergency water treatment system capable of treating a wide variety of contaminated water following a natural or man-made disaster. Most emergency water treatment systems are very large and expensive tractor-trailer mounted systems. They can be complicated to operate and maintain (very high pressures and concentrated wastes) given their use of reverse osmosis water treatment technology. Therefore, an emergency water treatment system must be designed and built so the treatment train can be configured on-site to treat a broad spectrum of contaminants without utilizing other unnecessary and costly unit processes and without producing large amounts of contaminated wastes. The system must also be easy to operate by quickly trained first responders. The system integrated two washable pre-filters with additional media filtration (e.g., granular activated carbon) and on-site chlorine gas generation with options for UV LED and/or ultrafiltration membranes, which are all stored and transported on a wheeled, powder-coated steel frame about the size of a shopping cart. This WOW Cart also has (1) multiple power supply options that can be operated from the electrical grid (110v AC), (2) a duel-fuel generator, or (3) peripherals with a 12v DC deep cell marine battery (with solar recharge). There are also additional electrical outlets and USB ports for phones, computers, etc. The WOW Cart can also produce liquid bleach for sanitation purposes. Portions of the WOW Cart were quickly deployed in Puerto Rico following Hurricane Maria. Within weeks, nearly all 78 Provinces were equipped with the water treatment systems providing water to tens of thousands of people. Challenges at the USEPA Water Security Test Bed and the Test & Evaluation Facility successfully treated secondary wastewater, water contaminated with *Bacillus globigii* (an anthrax surrogate), and a surface water simultaneously contaminated with *E. coli* and diesel fuel. The WOW Cart can be fabricated for about $20,000.

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Concurrent Session 5 – Biological Agent Decontamination

Decontamination Studies Related to Vehicles in a Biologically-Contaminated Wide Area: Interior Vehicle Decontamination Using Vapor Phase Hydrogen Peroxide

William Richter | Battelle

Contamination of an urban area following a biological incident would have a crippling effect on a city’s economy and stability and could result in hundreds of thousands of vehicles becoming contaminated and potentially abandoned. Rapid decontamination following such an incident is paramount for mitigating the potential spread of contamination and returning to normalcy. To facilitate a rapid implementation of a decontamination strategy following a large-scale incident, the U.S. EPA, in partnership with Battelle, studied the utilization of readily and widely available approaches that could be sourced locally and implemented in situ. This approach would mitigate some of the logistical challenges posed by the alternative: transportation of large numbers of contaminated vehicles to a centralized collection point for decontamination.

Field-scale efficacy tests evaluated the performance of vapor phase hydrogen peroxide (H2O2) dispersed using a simple home humidifier for decontamination of the interior of a passenger vehicle (2015 Chevy Malibu sedan) contaminated with *Bacillus globigii* (*Bg*) spores, a surrogate for virulent *Bacillus anthracis*. Decontamination efficacy was determined based on log reduction (LR) in viable spores recovered from the aerosol inoculated sample locations (with and without exposure to disinfectant and after cabin air recirculation). Efficacy of 3 percent (%) H2O2 against *Bg* was evaluated at target delivery volumes of 1.5 and 3 liters (L) per trial, uncontrolled average temperature that ranged from 5 to 27 degrees Celsius (°C), uncontrolled relative humidity (RH) that ranged from 59 to 98%, 10 unique sample locations, and a contact time of six days.

Initial decontamination efficacy using a 3% H2O2, 1.5 L volume loaded into the humidifier yielded high efficacy on glass reference coupons but also residual spores on 6 out of 10 interior locations. Efficacy increased when the volume was increased from 1.5 to 3.0 L, resulting in 10-of-10 non-detects. Recirculating cabin air through the vehicle’s HVAC system during the H2O2 decontamination run did not appear to affect efficacy on the cabin filter but resulted in zero locations being re-contaminated. A 6-LR was achieved on the cabin filter only when removed and placed into the cabin of the vehicle during H2O2 decontamination treatment. While some tests were conducted at lower temperatures (down to 5°C), efficacy remained high with 8-of-10 locations resulting in non-detects for both conditions. Re-contamination was observed within the vehicle interior post HVAC recirculation for these tests, indicating that circulation of H2O2 through the vehicle HVAC system is needed to sufficiently inactivate spores contained within the HVAC duct. Collectively, the data from this project may help guide decontamination approaches during remediation following a wide area contamination incident.

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Virucidal Efficacy of DiKlor® Chlorine Dioxide on Diverse Vehicle Surface Materials in an Automated Commercial Truck Wash under Field Conditions

Julian Rosenberg | Sabre Companies

Agricultural vehicles contaminated with biological pathogens pose potential risks to human and animal health. The operational procedures for decontaminating vehicles exposed to viruses and bacteria are challenging and knowledge gaps currently exist. Under agricultural outbreak scenarios, viable options for returning vehicles to pre-incident risk levels are of immediate need to meet biosecurity requirements. Furthermore, there is strong motivation to implement effective and efficient perimeter biosecurity systems at farm entry points to prevent the transmission of foreign animal diseases. In the present study, a field test was conducted to compare the virucidal efficacy of two vehicle decontamination treatments that are currently commercially available: [1] application of an aqueous chlorine dioxide (ClO2) sanitizing solution; and, [2] physical removal of pathogens with a high-pressure water rinse alone. Water rinsing has long been used for the decontamination in the livestock industry to clean cages, stockyards, and animal pens mainly by physical removal of debris and other material. Chlorine dioxide solutions were used to assist in the national response to 2001 *Bacillus anthracis* releases and have been more recently implemented as a biosecurity measure following the outbreak of highly pathogenic avian influenza (HPAI) in 2015.

In this study, the non-enveloped bacteriophage MS2 served as a viral surrogate. MS2 shares a similar viral structure with viral threat agents such as foot and mouth disease virus (FMDV) and exhibits comparable resistance to disinfection. Due to its robust non-enveloped capsid, MS2 phage poses a greater challenge to decontamination compared to many animal diseases caused by enveloped viruses, including HPAI, porcine reproductive and respiratory syndrome (PRRS), porcine epidemic diarrhea (PED), and African swine fever (ASF). The field test took place at a commercial vehicle wash system at a commercial poultry farm in Fort Dodge, Iowa. During the experimental treatments, the viral surrogate was inoculated onto different representative surface materials (painted metal, glass, plastic, and rubber), attached to set locations on a commercial box truck, and subjected to each wash condition. A synthetic grime comprised of poultry manure was applied to one set of material coupons to simulate a heavily soiled condition. Log reductions in viable bacteriophage particles, enumerated as plaque forming units (PFUs), were calculated for each wash condition and statistical analysis was applied to account for the randomized distribution of materials across each placement location on the vehicle.

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Decontamination of Category A Viruses on Porous Surfaces and Sensitive Equipment Using Chloride Dioxide

Daniel Lorch | METSS Corp

The need for an on-site decontamination technology for Category A viruses became critically evident after Ebola cases were confirmed in the United States in 2014. Although some hospitals are equipped to handle patients who are infected with Category A viruses including filoviruses (e.g., Ebola and Marburg), arenaviruses (e.g., Lassa, Machupo), and Smallpox, there are very few decontamination options to address the rooms and vehicles that the patient occupied before they were admitted. Autoclaving and incineration, the two most common treatments for disposing of infectious waste, are generally impractical for large furniture and vehicles. In addition, many commercial disinfectants are corrosive or incompatible with sensitive equipment. Decontamination of porous materials, like textiles, upholstery, and carpet is particularly challenging, and transporting large volumes of Category A infectious waste to an off-site treatment facility has inherent safety risks and costs.

In this study a safe, robust, cost-effective, and patented method for generating pure ClO2 gas was evaluated for its ability to non-destructively decontaminate hard surfaces, porous materials, and sensitive equipment. A novel gas dispersion system using a ClO2 generating micro-reactor was developed and tested under a simulated setting. Full-scale ClO2 demonstrations showed consistent inactivation of >4-logs of Phi6 bacteriophage virion (a surrogate of the Ebola virus) within 10 hours on contaminated porous and non-porous materials. The process was also shown to be non-destructive to sensitive items including a lap top computer and mobile phone. Such a system could be utilized for room decontamination for Ebola treatment centers within the U.S., interior decontamination of emergency medical service (EMS) vehicles used to transport Ebola patients, interior decontamination of infectious waste transport vehicles, and decontamination of residences (home or hotel room) used by an Ebola patient. In comparison to other fumigation technologies, the proposed ClO2 generation method is easy to transport, relatively inexpensive, and requires no special training to operate. While the initial targets are Category A viruses, which are rarely seen in the U.S., the technology is applicable to numerous pathogens and markets such as health care, food safety, sports/fitness, and military sustainment.

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Novel Methods for Environmental Remediation of *Bacillus* Species

Christine Tomlinson | U.S. Environmental Protection Agency

Decontamination and remediation of environments contaminated by the members of the *Bacillus cereus* group, particularly, *Bacillus anthracis* spores, are difficult, costly and potentially damaging to the environment. Development of novel decontamination strategies that have minimal environmental impacts remains a high priority. Several recent studies will be reviewed that have highlighted the potential use of bacteriophages to eliminate *Bacillus* sp. from contaminated environments.

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ANNOUNCEMENT: Call for a CBRN Mitigation and Recovery International Technical Working Group

Michael Kaminski | Argonne National Laboratory

For decades, the use and threat of chemical, biological, and nuclear weapons has prompted the collection of data, development of methods and publication of technical documents that address issues related to mitigation and recovery. Such information has primarily been derived from military research or doctrine and so has limited applicability to the more complex issue of civilian protection. The current volatility of international relationships has intensified the likelihood of a CBRN event involving civilian casualties and national infrastructures. Research and development reported at this conference over the past decade has identified many promising technologies and approaches for responding to CBRN incidents and, correspondingly, the need to develop a common approach and harmonized guidance. However, a global consensus based on such evidence has yet to be established.

The international community has important precedence in establishing technical working groups to address related topics in CBRN preparation and response. The intricacy of these topics requires a unique panel of expertise to navigate the breadth of data, coordinate dissemination, assess ‘perceived best practices’, assist in the design and evaluation of exercises and provide evidence-based guidance. For example, the Chemical and Biological Working Group of the World Health Organization and the Nuclear Forensics International Working Group grew out of a natural progression in the state of knowledge and a recognition by international technical leadership that a critical gap in preparation and response to radiological and nuclear threats existed. Therefore, we propose the formation of an international working group on CBRN mitigation and recovery to foster collaboration, share recent experiences, develop and reinforce evidence-based best practices and coordinate an international effort to close identified, critical gaps in our knowledge and capabilities. This Conference marks our initial effort in garnering support and participation from the international community to form such a working group.

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 Day 3

Concurrent Session 6 – Chemical Agent Research

Development and Application of Unventilated Monitoring to Recovery following a Chemical Release

David Bradley | U.S. Department of Homeland Security

During operations to dispose of the U.S. stockpile of chemical munitions, various monitoring methods are used to ensure workers are dressed in appropriate personal protective equipment (PPE) and to ensure that decontamination of areas and equipment has been adequately performed. One monitoring technique that has been successfully employed is unventilated monitoring testing (UMT). In UMT, areas or equipment are tented or enclosed such that there is no air exchange with adjacent volumes. The tented volume is then monitored to measure the agent vapor concentration. To ensure adequate mixing in large volumes, fans are used to circulate the air in the volume being monitored. UMT methods have been developed that ensure that the volume is uniformly mixed and that the monitoring hold time is sufficiently long to ensure a steady concentration has been reached. UMT could be a useful monitoring method to augment wipe samples following a chemical attack or an accidental chemical release. For example, it could be used to quickly identify “hot spots” (i.e., more contaminated areas) in order to reduce the number of wipe samples that are needed. It could also be used to determine the effectiveness of decontamination.

The paper will describe the technical basis for the UMT concepts employed in the Army’s chemical weapon disposal program and will provide examples of how it has been used in the past and could be used in the event of a future chemical attack or accidental release. Specifically, it will describe the requirements for ensuring adequate mixing in the volume and for the monitoring hold time. It will also describe the relationship between the limits of detection and quantitation of the monitoring equipment, and the level of agent contamination that can be reliably measured by this technique.

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Establishing Risk-Based Action Levels for Unique Exposure Scenarios in Response to Illegal Pesticide Applications

Kristen Keteles | U.S. Environmental Protection Agency

EPA regulates pesticides so that there is no unreasonable risk when used according to the label directions. However, situations arise when pesticides are misused or illegally applied resulting in potential exposures that may threaten human health. In these situations, risk-based action levels must often be established to protect law enforcement, emergency response officials, and the public and from adverse health effects from exposure to pesticides. Illegal pesticide applications may present unique and challenging exposure scenarios where default exposure assumptions or generic health-based action levels are not applicable or useful. Therefore, site-specific action levels must be calculated for unique exposures scenarios by determining risk based upon site-specific exposure parameters and the chemical hazard. Two case studies will be presented to demonstrate how standard risk assessment methodology can be applied to determine risk and establish action levels that are protective of human health. In one scenario, a herd of 850 bison was potentially exposed to chlorophacinone, an anticoagulant rodenticide. Products that contain chlorophacinone are not registered for use near crops or where livestock may graze. Furthermore, a reference dose and a food tolerance have not been established for chlorophacinone. In response to this incident, a reference dose of 0.005 µg/kg/day was calculated using standard uncertainty factors and a risk-based screening level of 0.2 µg/kg was calculated using conservative exposure assumptions based upon reasonable maximum exposure for a subsistence population. Because the screening level is below analytical detection limits, residue levels in bison were modeled using worst case scenario exposure parameters. Based on the modeled residue levels and the half-life of diphacinone from a ruminant exposure study (Crowell et al. 2013), a hold time of 16 months for the potentially exposed bison was calculated to ensure that the risk-based screening levels were not exceeded. In another case, the application of the unregistered pesticide, Doom (76% active ingredient dichlorvos) in the Knights Inn, Michigan City, Indiana and the Super 8 Motel, Howe, Indiana posed risks of concern to motel guests and employees. Risk-based surface clean up levels for porous and nonporous surfaces were calculated using the EPA Integrated Risk Information (IRIS) reference dose and by estimating exposure from oral and dermal contact for both workers and motel guests. These case studies demonstrate how standard risk assessment principles can be applied to unique exposure scenarios to establish action levels that are protective of public health.

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Evidence-Based Mass Casualty Decontamination Strategies for Responding to Chemical Incidents

Joanne Larner | University of Hertfordshire

New federal guidance (Primary Response Incident Scene Management; “PRISM”) emphasizes the rapidity of the initial operational response to improve casualty survival following a chemical incident [1]. The development of such guidance necessitates a robust evidence base. Here we summarize the outcome of a large-scale exercise [2] performed at the University of Rhode Island involving ~ 300 Fire Department, EMS and support staff to evaluate the “Triple Protocol” of dry, ladder pipe and technical decontamination. The exercise included a proportion of volunteers who self-identified as “non-ambulatory”, representing the 20% of the current U.S. population who have a disability.

Clinical efficacy was determined by recovery of a chemical warfare agent simulant from the hair, scalp and various skin sites of the volunteers (n=86). GPS trackers were used to provide information on casualty flow and provided an objective measure of operational effectiveness. Post-exercise questionnaires were used to collate information from the perspective of volunteers and incident response personnel.

The PRISM decontamination protocols were shown to be effective individually and were synergistic when performed in combination (Triple Protocol). The introduction of an immediate disrobe and dry decontamination stage for casualties waiting for wet decontamination offers a rapid and effective initial response with minimal operational impact. The effectiveness of dry decontamination was shown to be dependent on casualty compliance, highlighting the need for clear instructions from first responders. Processing of non-ambulatory volunteers through dry and LPS decontamination stages was significantly slower than ambulatory volunteers and potentially represented a bottle-neck, indicating a potential need for a revised response strategy for this group of casualties.

Overall, this large-scale exercise confirmed numerous laboratory and human volunteer studies and collectively represents a comprehensive body of evidence to support implementation of the PRISM federal guidance.

[1] R.P. Chilcott, J. Larner and H. Matar, www.medicalcountermeasures.gov/barda/ cbrn/prism/

[2] R.P. Chilcott, J. Larner, A. Durrant, et al., 2018. Ann Emerg Med. 73(6):671-684. doi: 10.1016/j.annemergmed.2018.06.042.

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Systematic Optimization of High Activity Neutralization Materials for Bulk Chemical Agent Detoxification

Patrick Burton | Sandia National Laboratories

Bulk detoxification of chemical warfare agents (CWAs) presents unique operational and logistical challenges. Typical surface decontamination processes rely on large excesses of reagents to fully neutralize CWAs; however, at large scale, the quantity of decontaminants (bleach, oxidizers, etc.) becomes prohibitively cumbersome. Meanwhile, high-activity neutralization reagents can reduce the overall logistical burden. Ideally, such materials would be sufficiently stable and safe for operators to use/transport, while being easy to introduce to bulk CWAs without requiring additional infrastructure. The 12 Principles of Green Chemistry were used to evaluate candidate processes and determine the most operationally effective method. Prevention of exposure is the cardinal goal, supported by reaction optimization to minimize product toxicity. Operational goals were addressed by optimizing for atom economy to minimize operator and environmental exposure, at the expense of using small quantities of highly reactive metal salts (Li3N). The efficacy of this system, evaluated against other options such as amine substitution using the 12 Principles of Green Chemistry, will be discussed in detail.

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Relating Laboratory-Scale Dispersion Experiments to Full-Scale Field Data from Jack Rabbit II

Michael Pirhalla | U.S. Environmental Protection Agency

Urban areas create complex turbulence, dispersion, and flow patterns that affect downwind and ground level pollutant concentrations. The urban canopy also alters atmospheric boundary layer wind profiles due to wake turbulence generated from wind flow around buildings and within street canyons. This can result in challenging situations for local officials or emergency responders who must plan for or remediate infrastructure after major chemical, biological, or radiological (CBR) incidents. While many dispersion models can capture the downwind effects from buildings, some fall short in terms of accuracy or ease of use. As a result, field and laboratory tests are often employed to simulate releases and are critical in refining current dispersion models. This project leverages data from the Special Sonic Anemometer Study that occurred as part of the 2016 Jack Rabbit II (JRII) field study. JRII was conducted at Dugway Proving Ground (DPG), UT, where large releases of chlorine gas were dispersed within an array of 83 CONEX shipping containers of various sizes. The CONEXs were meant to mimic buildings within an urban area, with the goal of providing information to improve models and emergency response techniques. During the Special Sonic Anemometer Study, flow and turbulence around the obstacles were measured from a network of 30 sonic anemometers dispersed around the CONEX array. An upwind 32m sonic tower at the JRII test site was also analyzed for near neutral atmospheric conditions. A 1:50 scaled model of the JRII study area and neutrally buoyant boundary layer has been developed and tested within EPA’s Fluid Modeling Facility (FMF) Meteorological Wind Tunnel (MWT) to examine the complex flow and dispersion patterns within this scaled mock urban environment. Flow visualizations were conducted to observe the localized effects of the buildings, which also help to interpret quantitative data gathered within the wind tunnel lab. These data include wind velocity flow measurements collected through Laser Doppler Velocimetry (LDV), as well as neutrally-buoyant tracer concentrations that simulate ground-level and elevated releases. This presentation will discuss current and ongoing wind flow data analyses from the sonic anemometers and the scaled wind tunnel study, with an emphasis on microscale processes occurring between and in lee of buildings. The ultimate goal is to use the wind tunnel and field datasets to improve urban parameterizations in Gaussian dispersion models, which are important tools for efficient and precise emergency preparation and response applications.

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Concurrent Session 6 – Waste Management

Responding to African Swine Fever (ASF): Research to Develop New Methods to Manage ASF Infected Animal Carcasses

Gary Flory | Virginia Department of Environmental Quality

Over the past 12 months, African Swine Fever has spread rapidly throughout Asia. It has now impacted all parts of China and Vietnam and is being detected in new parts of Southeast Asia. International travel and trade put the United States at a significant risk to infection. To mitigate this risk, federal, state and industry partners are conducting a number of research projects to find new and better ways to manage ASF infected swine carcasses. Methods being considered include whole carcass composting, ground carcass composting, whole carcass mesophilic static pile composting and ground carcass mesophilic static pile composting.

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Assessment of the Biosecurity of Animal Mortality Size Reduction Using Horizontal Grinders Prior to On-Farm Composting

Paul Lemieux | U.S. Environmental Protection Agency

There is currently an outbreak of African Swine Fever Virus (ASFv) in Asia, a hemorrhagic fever virus, which only affects pigs. The U.S. Department of Agriculture (USDA), several states, and the pork industry are concerned that if ASFv were to spread to the U.S. it could cause significant damage to the $40B pork industry and create a public health and environmental risk if the large numbers of pig carcasses resulting from the disease and subsequent response are not quickly managed. Estimated disposal capacity that may be needed is on the order of 3,000,000 lb/day.

On-farm management of infected carcasses is preferred over offsite transport to landfill or incineration to help prevent the spread of the virus to other premises that might occur while carcasses are being transported. On-farm composting is one preferred method of on-farm carcass management since it kills the virus, produces a potentially useful by-product and has been successfully used in past responses to High Pathogenic Avian Influenza (HPAI) outbreaks. Unlike with poultry, however, whole-swine composting requires 6-12 months, resulting in the farm being quarantined for up to a year. Grinding of the animal carcasses into smaller pieces along with vegetative debris as a carbon source enables pig carcasses to fully compost in approximately one month and provides a means to perform on-farm disposal without having to transport infected material over public roadways. Unfortunately, traditional industrial-scale animal carcass grinding equipment is not widely available and therefore impractical for emergency response.

An alternative means to achieve the required throughput for carcass disposal operations is to utilize “horizontal grinders” – large commercial woodchippers that are typically used for vegetative debris management. These units are readily available around the country and could be rapidly deployed for swine carcass grinding. Unfortunately, these devices have never been used for processing animal carcasses, and their operational effectiveness has not been evaluated, nor has the potential for aerosol release of virus particles from the process been assessed.

This presentation describes a series of tests to operationally assess the biosecurity of using horizontal grinders to perform size reduction on swine mortalities. Porcine DNA was measured in coarse particle fractions and fine particle fractions, to estimate an emission factor from horizontal grinders, which was then utilized with air modeling to estimate atmospheric transport of potentially infectious particles. The results from these tests will be used to help USDA/APHIS develop standard operating procedures for these operations.

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Simulation of Incineration of Waste Generated from Cleanup following Chemical/Biological Incidents

Martin Denison | Reaction Engineering International

For chemical and biological (CB) threat agents, incineration is a likely treatment technology that would be used either on-site or off-site to destroy residual agents and to reduce the volume of the waste streams. Past experiments and operational performance have demonstrated that incineration is an effective technology for destroying chemical and biological agents; however, the substrates on which these agents will be bound have a profound impact on the behavior of the waste streams in the incinerators. Full-scale testing may not be able to encompass the variety of materials and agents that might be generated in a real-world CB incident, and logistical and public perception issues may make it very difficult or impossible to do testing at a specific incineration facility with the specific types of materials that would be containing these trace level contaminants.

The Configured Fireside Simulator (CFS) was originally developed for the Department of Defense to evaluate operations of the chemical demilitarization incinerators processing the U.S.’s chemical warfare agent stockpile. It was later adapted to provide for the ability to run “what if” scenarios of waste streams contaminated with CB agents. This included the EPA’s pilot-scale Rotary Kiln Incinerator Simulator facility, as well as three commercial incinerators based on design criteria for actual operating facilities, including a Medical/Pathological Waste Incinerator, a Hazardous Waste Burning Rotary Kiln, and a Waste-to-Energy Stoker type combustor. CFS uses chemical kinetic data for destruction of chemical warfare agents, coupled with biological agent destruction kinetic data derived from bench- and pilot-scale experiments performed at EPA’s Research Triangle Park, NC facility.

This presentation will describe the operation of the CFS software and will highlight new enhancements that have recently been added to expand the capabilities of the simulation.

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Control of Emissions from Combustion of Cesium-Contaminated Biomass via Sorbent Injection

Paul Lemieux | U.S. Environmental Protection Agency

In the aftermath of a wide-area radiological contamination incident, there is the potential for the generation of significant quantities of contaminated biomass waste. For example, the 2011 nuclear power plant accident at the Fukushima Daiichi plant in Japan resulted in an estimated 7.8 million cubic meters of combustible waste, most of which was biomass. These wastes are likely candidates for incineration as a means of volume reduction, due to the costs associated with disposal of low-level radioactive waste. Cesium (Cs), an alkali metal element, is a radionuclide that might possibly be used in a radiological dispersal device or may be the predominant long-term radionuclide contaminant from a nuclear power plant accident. Cs presents problematic behavior in combustion systems due to its volatility and water solubility. Although high-temperature combustion or incineration systems cannot destroy the elemental metal constituents, these environments may induce metal transformations that exacerbate difficulties in controlling the emissions of radionuclides of interest because many of the metal species, including Cs, vaporize readily within combustion environments. This saturated metal vapor will subsequently nucleate and condense downstream of the flame, forming an aerosol with a mean volume aerodynamic diameter between 100 and 200 nanometers (nm). These condensed particles, because of their small size, are difficult to collect in air pollution control systems, particularly those using an electrostatic precipitator.

A series of experiments was performed to investigate how well the use of in-furnace kaolinite sorbent injection captured Cs emissions from combustors. The experiments were performed in a rotary kiln incinerator simulator firing pelletized biomass fed into the rotating drum section of the combustor. In these experiments, the biomass material was doped with non-radioactive Cs in the form of aqueous CsCl (cesium chloride). A MOUDI spell out impactor was used as the primary sampling device, where success of capture was assessed by whether the Cs predominated in the smaller-particle-size impactor stages or whether the Cs was caught on the impactor stages corresponding to the larger sorbent particle size, an indication that the Cs was associated with the sorbent particles. The larger particle size would be more amendable to capture by a particulate matter filtration system.

Without sorbent injection, Cs was almost totally associated with the particle size fraction exhibiting an aerosol diameter less than 180 nm. With injection of the sorbent, approximately 91% of the Cs was shifted to the supermicron particle size fraction. This presentation will describe these experiments and results.

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Disaster Waste Management (WM) Tools – Improving Their Effectiveness While Minimizing Resource Needs

Timothy Boe | U.S. Environmental Protection Agency

Natural disasters occur frequently, generating volumes of waste and debris that are difficult for states, locals, tribes, and territories (SLTT) to manage. Disaster waste and debris management tends to be the most complicated and resource-intensive process in response and recovery, especially during large-scale incidents like the Hurricanes of 2017. Disaster incidents involving extremely hazardous contaminants (e.g., resulting from a wide-area chemical, biological, radiological, nuclear [CBRN] incident), would create even larger challenges for waste management (WM). Further compounding these challenges are the lack of a federal regulatory framework for biologically-contaminated waste (e.g., anthrax-contaminated waste), the limited disposal capacity for radiologically-contaminated waste, and the SLTT WM decision maker’s lack of experience with these types of waste. Additionally, the WM industry does not typically deal with this type of waste and are resistant to accept and handle it. Regardless of disaster type, there are numerous interrelated activities just within debris and waste management. For this reason, there is a need for tools to assist SLTT and federal WM decision makers in disaster pre-planning, mitigation, response, and recovery WM decisions.

In response to these needs, several EPA programs and regions have developed WM and sustainable materials management (SMM) related decision support and planning tools. These tools support decisions like where to dispose or recycle the waste and debris, where to stage the waste, and for a single building impacted by a CBRN incident, what remediation strategy is best both in terms of effectiveness of decontamination and in the types and volumes of waste generated. These capabilities have been demonstrated in responses and exercises, making these tools an integral part of EPA’s disaster planning resources.

During recent EPA planning activities, tool developers continued to examine how they could improve the usability, functionality, and accessibility of their tools as well as reduce their maintenance costs. To meet these goals, they realized the need to work together on a developing a vision for a single tool set supporting disaster debris and waste management activities. This prompted the WM and SMM tool developers, in partnership with their EPA stakeholders, to construct a roadmap outlining the path forward for this tool set, including how to address emerging stakeholder requirements.

This presentation will outline the current state of the tool set, recommendations to improve usability, functionality and accessibility of the tools, progress made so far on these recommendations, and lessons learned during the development of the roadmap.

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Concurrent Session 7 – Radiological Agent Research

Overview of the MACCS Consequence Analysis Computer Code

AJ Nosek | U.S. Nuclear Regulatory Commission

MACCS (MELCOR Accident Consequence Code System) is a consequence analysis computer code to simulate the offsite impacts of an atmospheric release of radioactivity from a potential nuclear power plant accident. MACCS integrates models for atmospheric dispersion, short- and long-term protective actions, dose assessment, deterministic and stochastic health effects, and economic impacts. Decontamination is one of the protective actions that MACCS models, which is an important consideration in calculating long-term doses to the public and economic impacts.

Since the weather during an accident on a future unknown day and time cannot be known, MACCS samples from a full range of weather conditions and gives a distribution of potential consequence results. The offsite consequences computed include doses and health effects, land contamination, displaced individuals, and economic impacts. In addition to decontamination, MACCS models other protective actions as well, including the effect of sheltering, evacuation, relocation, and temporary and permanent land interdiction.

There are no other codes currently in use in the United States that combine the set of capabilities found in MACCS. As such, it has a wide user base including the Nuclear Regulatory Commission (NRC), the nuclear power industry, Department of Energy, Defense Nuclear Facilities Safety Board, and members of the academic community. NRC distributes the MACCS code suite for domestic use and to over 500 international users in 28 countries as part of the Cooperative Severe Accident Research Program, and there are hundreds of users worldwide.

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Effective RN Decontamination of Sensitive Equipment Method Formulation Using Non-Radiological Surrogates

Zakir Kazi | Defence Research and Development Canada

Decontamination of Sensitive Equipment (DOSE) is a big challenge to the Canadian Armed Forces (CAF) and NATO allies. Electronics (e.g., radio, computer) and optical (e.g., camera, lenses) equipment which have special cleaning instructions and a delicate nature are examples of sensitive equipment. Optimization of a decontamination method for sensitive equipment is much desired.

Defence Research Canada (DRDC)’s Ottawa Research Centre (ORC) has conducted radiological and nuclear (RN) decontamination research, including the DOSE project for quite some time until its closure in 2017. Some of the results were presented in the 2016 EPA conference. Suffield Research Centre (SRC) now has the mandate to continue the DOSE work for the CAF. Their recommendation was to use commercial-off- the-self (COTS) agents to find an efficient decontamination formulation for sensitive equipment. From this motivation, we are revisiting the DOSE project previous results, and making recommendations to push the project forward. To this end, here we present the findings of different decontamination techniques that had been tested using non-radioactive surrogates at ORC. The aims of this work were twofold: (1) Equipment functionality testing; and (2) Estimation of decontamination efficiency. Non-rad surrogates give indications of post-decon equipment damage and functionality issue; but these are not suitable for the estimation of decontamination efficiency. Therefore, estimation of decon efficiency is beyond the scope of this presentation.

The non-radioactive surrogates that had been used included cesium chloride, cobalt and iridium metals and strontium nitrate. In these tests, sensitive equipment (specifically Raspberry Pis and gun parts) were contaminated using Shake N Bake and micro-spray techniques. Decontamination techniques employed included vacuum, duct-tape, wet wipes, compressed air, and cyber putty. Method evaluation was governed by criteria such as visible signs of chemical reaction, equipment damage and functionality testing of the equipment. Post-decontamination survivability and damage of the sensitive equipment were monitored by functionality testing visual inspection and microscope imaging. Based on the tests results and the ease of operation, cyber putty technique has been scored the highest caliber.

In addition to the above results, we are currently pursuing DOSE experiments towards the above criteria evaluation for sensitive equipment using RDS2000 reagent. The results from these experiments will be compared with the previous techniques and presented during the conference.

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Assessment of Non-Destructive Decontamination Methodologies for Mixed Porous Surfaces under High Humidity and UV Conditions

Ryan James | Battelle

EPA’s Office of Research and Development and Battelle have conducted experimental work to evaluate the efficacy and applicability of several radiological decontamination technologies for deployment in response to a wide-area event, such as a radiological dispersal device (RDD) scenario. The work described here evaluates the decontamination efficacy of two commercial strippable coating decontamination technologies for removal of cesium (Cs)-137 from mixed and non-mixed brick surfaces typically found in urban buildings and infrastructure. These technology testing experiments were conducted using brick surfaces that were stored throughout the duration of the testing (up to one year) in elevated temperature (T) and relative humidity (RH) conditions. A subset of baseline experiments was done in ambient T and RH. In addition, a subset of experiments conducted with elevated T and RH using UV light during the strippable coating drying phase to simulate sunlight.

Exterior bricks were collected from buildings that were being demolished in Columbus, OH. These buildings (and hence the brick) were approximately 55 years old at the time of demolition. Approximately 2 microcuries (µCi) of Cs-137 in aqueous solution were applied to the exterior surface of the brick and placed in elevated humidity storage. The one-year elevated T and RH study included application and removal of strippable coatings after 0, 3, 6, and 9 months of elevated T and RH storage to determine the timeframe where humidity affects the removal of the strippable coating. Preliminary results have indicated that percent removals across the two strippable coating products range from 21%-47% and that the physical removal process gets easier after storage in elevated RH for 6 months. The UV light drying component of the study included application and removal of strippable coatings after 0, 3, 6, 9 and 12 weeks of elevated T and RH storage. Preliminary results indicate that elevated UV has minimal impact to ease of physical removal. Results covering the percent removal of Cs-137 are still pending.

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EPA’s Integrated Rad Remediation Decision Support Tool (IRRD-ST) to Optimize Radiological Cleanup Decisions

Bruce Letellier | Serco Inc.

As part of its mission to protect human health and the environment, the U.S. Environmental Protection Agency (EPA) conducts characterization efforts to understand the type, extent, and level of contamination resulting from a chemical, biological, or radiological (CBR) incidents. For radiological incidents, gamma-ray cameras are a prompt and easily field deployable solution that combine wide-angle optical images with radiation intensity contours. The composite images provide intuitive evidence of contamination location and magnitude within a room, but optical distortion complicates visual interpretation of size and scale. EPA uses the Hot Spot Calculator (HSC) to optimize radiological cleanup decisions in conjunction with composite images to estimate contaminated areas and identify isotopes and surface types affected in support of estimating costs associated with various decontamination technologies needed to remediate the contaminated area.

Currently, the HSC requires extensive external computer-aided design (CAD) manipulation to process the composite images. This presentation will describe an enhanced approach that combines semi-automated image processing with radiation physics to achieve greatly improved accuracy while minimizing the need for manual manipulation. Contaminated area estimates that account for optical distortion, geometric attenuation, scattering in air, and oblique source planes are more representative and accurate. A software-based utility feature is being developed to streamline the processing of the 2-D gamma-ray imagery for the purpose of obtaining more accurate and more efficient contamination area estimates. The improved methodology for processing composite gamma-ray camera images and extracting contamination area estimates reduces the amount of user input and minimizes the number of user decision steps and supports accuracy and efficiency improvements that can be implemented during future field survey data collection.

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Concurrent Session 7 – Biological Agent Decontamination

Efficacy of Waterless Spray on Sensitive Equipment Decontamination System

William Guglielmo | ITL Solutions

Traditional decontamination methods are often ineffective at removing contamination from high value sensitive equipment which cannot come in contact with water or aggressive decontamination agents. This has created a need for a viable methodology for removing contamination for sensitive equipment. Additionally, with the advent of more and more technology integration into everyday items, a larger body of items contain internal circuit card assemblies along with small and inaccessible locations which become difficult to remove chemical, biological and radiological contamination further showing the need for effective decontamination which will not damage or affect sensitive electronics. This presentation will evaluate 4 efficacy studies carried out on a waterless spray on vacuum off decontamination system to assess the system’s ability to remove Chemical, Biological and Radiological contamination from sensitive equipment such as cameras, optics, radios, computers and circuit card assemblies.

This waterless decontamination for sensitive equipment system is a spray decontaminant with a chemical solution containing an absorbent, solvent-cosolvent, water-free organic substances and a catalyzer to propel the reaction. The system encapsulates the Chemical, Biological, and Radiological agents and the agents are easily removed perpendicularly from the surface using a special vacuum device which safely holds all contamination for safe neutralization or disposal. The system minimizes off-gassing and cross contamination through vertical removal of the agent. With a 4 phase procedure of spraying the system onto the contaminated surface, a dwell time to allow for agent solubilization and diffusion into the decontamination layer, vertical removal with special vacuum device and finally safe disposal, the system is designed as a robust and rapid capability for contamination removal on sensitive electronics. This presentation will show the efficacy of the system through chemical (GD, VX, HD), biological (*Yersinia pestis*, *Bacillus anthracis*, and Vaccinia virus) and radiological (Ra-226) live agent testing to remove contamination on a variety of materials which are commonly used in sensitive equipment manufacturing as well as one test performed on the removal of biological agents from commonly used detection equipment (Smiths LCD 3.3 CWA and TIC detector). A real world case study using the waterless decontamination system for decontamination of an aircraft after transporting an Ebola effected patient will also be included in the presentation.

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The Use of Low Concentration Hydrogen Peroxide Vapor for the Inactivation of Ebola Virus Surrogates MS2 and Phi6 Bacteriophages

Joseph Wood | U.S. Environmental Protection Agency

Past and current Ebola virus (EBOV) disease outbreaks, as well as the ability of the virus to persist in the environment under certain conditions, highlight the need to develop effective and easy to use environmental decontamination techniques against such a lethal virus.

We evaluated the efficacy of hydrogen peroxide vapor (HPV) to inactivate MS2 and Phi6 bacteriophages, potential surrogates for the EBOV. The phages were inoculated onto six material types (both porous and nonporous), with and without the presence of human whole blood. (Decontamination efficacy is strongly dependent on the material with which the microorganism is associated, and human blood has also been shown to diminish efficacy of several liquid disinfectants in inactivating the EBOV.) The inoculated materials were then exposed to either a high or low concentration of HPV, and the phages were recovered from the materials at several elapsed times. The phages were also recovered from the inoculated positive controls (not exposed to HPV) at these same elapsed times. A plaque assay was used to enumerate the phages.

Without the presence of blood, both phages from the positive controls persisted over 8 hours on several materials. The persistence of the Phi6 phage was prolonged in the presence of blood (> 72 h), but the presence of blood did not affect the persistence of the MS2 phage.

Low concentration hydrogen peroxide vapor (LCHP; selected as 25 parts per million by volume for this study) is an inexpensive decontamination technique and was effective against both phages without the presence of blood after a few hours contact time. LCHP was ineffective against the phages in the presence of blood with a 3-day contact time. High concentrations of HPV (> 400 ppmv) with contact times of 24-32 h achieved 4-6 log reduction of the phages in the presence of blood. The benefit to using LCHP is that it may be generated through simple, inexpensive means such as commercially-available, off-the-shelf humidifiers using 3 or 8% aqueous solutions of hydrogen peroxide. This “low tech” approach would be advantageous where specialized equipment and financial resources are limited.

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Evaluation of an Electrostatic Sprayer for Personnel PPE Bio Decontamination – Mannequin Testing

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, 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 liquid waste and may lead to migration of biological agents. A previous EPA study was conducted to compare the efficacy and performance of an electrostatic sprayer to a conventional backpack sprayer for PPE decontamination with 10% diluted bleach, using 14- by 14-in PPE-covered coupons inoculated with 1 × 10^7 spores of *Bacillus atrophaeus* var. *globigii* (*Bg*), a surrogate for *Bacillus anthracis*. 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. However, the electrostatic sprayer generated substantially less liquid runoff (~75X), which would substantially minimize waste generation and disposal costs.

As a follow-on pilot-scale study, surface decontamination efficacy for mannequins in PPE was evaluated using the same conventional and electrostatic sprayers to simulate a personnel decon line. A decontamination test chamber was used to evaluate both sprayers used on mannequins donned with modified Level C PPE including Tychem® SL suits, nitrile gloves, chemical-resistant rubber boots, powered air purifying respirator (PAPR), and ChemTape® at suit interfaces. Mannequins were also inoculated with 1 × 10^7 *Bg* spores in seven distinct areas; respirator mask, ChemTape® anterior suit midline, left torso, ChemTape® left wrist, outer left-hand glove, left leg knee, and left boot. Tests were conducted using both liquid and aerosol inoculation of spores to evaluate efficacy, runoff, and reaerosolization potential. Mannequins were sprayed with either sprayer type for a prescribed time period (2 or 4 min), using 10% diluted bleach. Wipe samples were then collected to evaluate efficacy from PPE surfaces. Liquid runoff samples were also collected, immediately neutralized, and analyzed, as well as high-volume air samples to evaluate spore reaerosolization from the decon process. Decontamination efficacy was determined by comparing the average number of CFUs observed for inoculum controls to the average number of CFUs observed for decontaminated test areas of the mannequins.

Results from the aerosol inoculation indicate full decon (no detectable CFUs) was achieved with the conventional backpack sprayer and several positive “hard-to-reach” areas were observed for the electrostatic sprayer, with a 2-min spray time. Comparable results were obtained for both sprayers with greater than 5 LR when liquid inoculation was used. Reaerosolization of spores from the conventional backpack sprayer was up to three orders of magnitude higher than the electrostatic sprayer, which demonstrates the potential for spore migration during the decon process.

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The D7 Decontaminant: Results of Recent Laboratory Tests and Field Applications Against Toxic Chemicals and Biological Pathogens

Mark Tucker | Decon7 Systems, LLC

D7 is an aqueous-based decontaminant that can rapidly neutralize highly toxic chemical and biological materials. The formulation:

* is effective for neutralizing both chemical and biological warfare (CBW) agents which has been demonstrated in testing at approved U.S. government facilities;
* is effective at neutralizing toxic chemicals such as fentanyl, methamphetamine, cyanide, and phosgene and killing pathogenic organisms including vegetative and spore-forming bacteria, viruses, and fungi;
* utilizes very mild chemical ingredients that gives it very low toxicity and corrosivity properties and makes it benign to the environment; and
* can be deployed as a foam, liquid spray, or fog on a wide variety of materials and surfaces.

The D7 chemistry is licensed by Decon7 Systems from Sandia National Laboratories where it was originally designated as DF-200. Although Sandia’s initial objective for the formulation was to decontaminate CBW agents, Decon7 Systems has greatly expanded its use to many other applications.

D7 contains surfactants, mild solvents, inorganic salts, a low concentration of hydrogen peroxide (~3.5%), a hydrogen peroxide activator, and water. For toxic chemicals, the surfactants help solubilize the compound where it is attacked and neutralized by the activated peroxide. For biological pathogens, the surfactants soften the cell walls of the microorganisms which allows the activated peroxide to penetrate to the interior for complete kill. This unique combination of mild ingredients works synergistically to neutralize highly toxic chemical and biological materials which has been demonstrated in testing at numerous government and private facilities and in many field applications – outperforming formulations that are made up of much harsher chemical ingredients.

D7 is proven to be highly effective against traditional CBW agents. Recent laboratory testing and field applications have also demonstrated that D7 has high efficacy against other materials of concern to the military, first responders, the healthcare and agricultural/food processing industries, and other organizations. This includes tests against fentanyl (conducted by MRI Global), tests against carcinogens deposited on firefighter turnout gear (conducted by Baylor University), tests and field applications against the African Swine Fever virus (conducted by China Southern University), and tests and numerous field applications against pathogens of concern in healthcare, agriculture, and food processing (e.g., *Listeria*, *E. coli*, *Salmonella*, MRSA, Porcine Epidemic Diarrhea Virus, and others tested in biofilms/organic matter by Oklahoma State, Iowa State, Baylor, and Kansas State Universities). These and other successful laboratory tests and field applications demonstrate the capability of D7 to significantly improve both human and animal health and well-being.

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Closing Remarks

Sarah Taft | U.S. Environmental Protection Agency

Dr. Sarah Taft will conclude the conference by presenting closing remarks.

Poster Session

General Poster Session

 Potential Local to Regional Scale Impacts from Wildfire Re-emission of Hypothetical Radiological Contamination Incidents

1

Kirk Baker | U.S. Environmental Protection Agency

An 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 followed by subsequent contamination of forested areas in Denver, CO and Los Angeles, CA. Radiological release events can potentially contaminate wide areas with radiological materials and decontamination efforts are typically focused on populated areas potentially leaving radionuclides in forested areas for long periods of time. Large wildfires in contaminated forested areas have the potential to reintroduce these radionuclides (most notably Cesium-137 [Cs-137] due to its long half-life) into the atmosphere and cause exposure risk to first responders and downwind communities. The Community Multiscale Air Quality (CMAQ) model version 5.2 was applied to an area covering Colorado and 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 (wildland fire) sources. Emissions from a large hypothetical wildfire were introduced into the wildland-urban interface (WUI) near Denver and Los Angeles and included fine and coarse fraction particulate matter Cs-137 emissions. PM Cs distribution values were obtained from a recent laboratory simulation study that examined the partitioning of Cs-133 (a non-radioactive isotope of cesium) between airborne particulate matter (>10 µm, between 2.5 and 10 µm, and <2.5 µm in aerodynamic diameter) and residual non-entrained ash when pine needles and peat were doped with Cs. The photochemical model was applied for an extended period to capture a wide range of meteorological flows common to each area to capture impacts in downwind large populated areas. Additional model simulations were done for an area immediately around these fires at finer (1 km) resolution to provide a better estimate of potential impacts to first responders. Modeled post-incident ambient levels of Cs-137 both near these wildfires and further downwind in nearby urban areas were well below levels that would necessitate population evacuation or warrant other protective action recommendations such as shelter-in-place. These levels also suggest expensive remediation efforts of contaminated forests would not be considered a high priority based on potential exposure from future wildfire smoke.

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 Combining Spore Germination and Heat Inactivation to Decontaminate Materials Contaminated with *Bacillus anthracis* Spores

2

Tony Buhr | Naval Surface Warfare Center Dahlgren Division

Aims: To add a spore germination step in order to reduce decontamination temperature and time requirements compared to the current hot, humid air decontamination parameters, which are 75-80°C, ≥72 h, 70-90% RH, down to ≤60°C and ≤24 h total decontamination time.

Methods and Results: Spore germination with L-alanine, inosine and calcium dipicolinate was quantified at 0-40°C, several time points, and spore concentrations of 5-9 log10mL-1. A single germinant application followed by 60°C, 1-h treatment consistently inactivated >2 log10 (>99%) of spores. However, a repeat application of germinant was needed to achieve the objective of ≥6 log10 spore inactivation out of a 7 log10 challenge (≥99.9999%) for ≤24 h total decontamination time for nylon and Aircraft Performance Coating. Characterization of alanine racemase and inosine hydrolase mutants will assess the impact of those signaling molecules on heat sensitivity.

Conclusions: High efficiency germination (>99% of a spore population) and a post-germination, treatment of 60°C, 1 h, no RH control, followed by a second application of germinant was able to trigger germination of persister spores to achieve ≥6 log10 inactivation over a wide germination temperature range (0-40°C).

Significance and Impact of the Study: Germination expands the scope of spore decontamination to include any materials from any industry sector that can be sprayed with an aqueous germinant solution. The decontamination time and efficacy requirements will determine if a heating step is required.

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 Analysis of Chemical Warfare Agents by GC-MS Using Multimode Inlet for Large Volume Injection

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Julia Capri | Consolidated Safety Services, Inc.

A Multimode inlet (MMI) system was implemented to increase sensitivity through a large volume injection technique (LVI) to achieve lower detection limits for the identification of Chemical Warfare Agents (CWA) using GC with Quadrupole Mass Spec (GC/MS). The Agilent 7890 instrument employed an upgraded injection MMI port to perform LVI in solvent vent mode. The initial inlet temperature of the MMI was set at 20°C, lower than the solvent’s boiling point, using liquid CO2. In performing the analysis, sample injection is performed slowly while the inlet vent opens. Once the injection is completed the inlet switches to splitless mode as the inlet temperature rises vaporizing and transferring analytes into the column.

Samples were extracted using a micro-extraction preparation technique. Soils samples required two extraction procedures. For VX, 10g of sample was extracted with 30 mL of tris (hydroxymethyl) aminomethane (Tris buffer) and shaken for 15 minutes on a shaker table at 1500 rpm following a solvent exchange with 5 mL of methylene chloride. Extract was taken to a final volume of 1 mL. For the extraction of GF, HD, GB and GD 10 g of sample were shaken for 15 minutes with 25 mL of Methylene chloride and taken to a final volume of 1mL. 35 mL of water samples were extracted using 2 mL of Methylene chloride and shaking for 2 minutes. Wipe samples were extracted using 10 mL of methylene chloride and shaken for 15 minutes.

The Agilent 7890B with 5977B MSD Instrument was equipped with an MMI inlet with liquid CO2 coolant system. The inlet was programmed with an initial temperature of 20°C for 0.38 minutes, then a temperature ramp of 600°C/minute until 352°C for 5 minutes. A 25uL injection was performed. The temperature program for the GC started at 40°C for 2.95 minutes followed by a temperature ramp of 25°C/minute until it reaches 320°C, hold it for 1 minute. Replicates for each matrix were analyzed on SCAN mode. The resulting statistical calculations were in accordance with 40 CFR 136, appendix B, revision 2.0. Detection limits were improved over non MMI techniques at a minimum by a factor of 5.

Installation of a guard column from the injector port will protect the analytical column during large volume injections and will provide additional improvement with resolution and detection limits.

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 Preparation and Analysis of Opioids in Environmental Samples

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Julia Capri | Consolidated Safety Services, Inc.

Objective: The purpose of this study was to develop a method for the extraction of Opioids, which included fentanyl, carfentanil, heroin and oxycodone from aqueous, solid and wipe matrices, and the subsequent analysis using Gas Chromatography / Mass Spectrometry – Time-of-Flight (GCMS-TOF).

Significance: Microextraction techniques were utilized to facilitate relatively short sample preparation times and minimal use of solvent, equipment and space to eliminate potential for laboratory contamination. This procedure allows for the detection of opioids, in the sub-nanogram range which equates to reporting limits for aqueous, solid and wipe matrices of 2ug/L – 3.0ug/L, 3.3ug/Kg – 6.0ug/Kg and 0.1ug/wipe – 0.3ug/wipe respectively.

Experimental procedures and equipment used: GCMS-TOF instrumentation utilizing a pulsed splitless injection. The GC run time was 7 minutes which allows for 3.5 injections per hour.

Preparation of aqueous samples: A 50 mL aqueous sample was basified and extracted with 5 mL of methylene chloride – 3x, by separatory funnel. The methylene chloride phase was collected in a 40 mL VOA vial by passing it through a glass funnel containing sodium sulfate and glass wool. The methylene chloride extract was concentrated to 1 mL by TurboVap®.

Preparation of solid samples: 30 grams of sample was extracted with 30 mL of Tris buffer solution (tris-hydroxymethyl aminomethane) for 15 minutes on a shaker table. Following the extraction, the Tris buffer solution was extracted with 5 mL of methylene chloride 3 consecutive times by separatory funnel. The methylene chloride phase was collected in a 40 mL VOA vial by passing it through a glass funnel containing sodium sulfate and glass wool. The methylene chloride extract was concentrated to 1 mL by TurboVap®.

Preparation of wipe samples: A sample wipe was extracted with 30 mL of methylene chloride, by shaker table, for 15 minutes. The methylene chloride extract was concentrated to 1 mL by TurboVap®.

Results: MDL studies (40CFR136, appendix B) were prepared and analyzed for aqueous, solid and wipe matrices, validating the documented method reporting limits.

Conclusions: Data from calibration curve and MDL studies analyzed by the developed method validate the method as a time, resource and laboratory space saving alternative to traditional methods.

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 Evaluation of Emergency Skin Decontamination Protocols in Response to an “Acid Attack”

5

Joanne Larner | University of Hertfordshire

The continuing weaponization of corrosive substances has resulted in a 40% increase in the incidence of “acid attacks” in the UK over the past year. The consequences of these attacks can leave victims with lifelong physical and psychological disorders. The purpose of this study was to evaluate the effectiveness of different emergency skin decontamination protocols against concentrated (>99% pure) sulphuric acid to identify an effective treatment window and protocol.

The study was performed using dermatomed (500 µm) porcine skin mounted in standard diffusion cells. Treatment groups comprised a negative control (not exposed), positive control (exposed, no decontamination), dry decontamination (absorbent tissue paper), wet decontamination (water irrigation for 90 seconds), combined dry & wet decontamination and decontamination using a layer of clean clothing. A total of n=6 replicates were used per treatment group, each challenged with a 20 µL droplet of sulphuric acid. Decontamination was performed 10 seconds, 30 seconds and 30 minutes post exposure, after which the skin surfaces were blotted with cotton and 100 µL of tritiated water (3H2O) was applied for 20 minutes to directly measure skin barrier function. Photometric stereo imaging (PSI) was performed to quantify surface tissue loss. The pH of water effluent (from water irrigation) and receptor fluid chambers was also measured.

Significant damage to skin barrier function occurred from 10 seconds and no decontamination method was significantly effective in reducing damage to skin barrier function. These data correlated with the PSI data in that there was significant loss of superficial tissue from 10 seconds. Interestingly, the area of tissue loss appeared to be exacerbated by rubbing (i.e., dry, dry+wet, and clothing treatments). However, all forms of decontamination significantly reduced the penetration of acid through the skin when performed at 10 seconds (but not thereafter), with water irrigation being the most effective treatment. The pH of water effluent indicated complete removal of acid from the skin surface after 45 seconds.

These data clearly demonstrate the deleterious consequences of dermal exposure to concentrated sulphuric acid. There is no effective window of opportunity for acid decontamination: physical damage is virtually instantaneous. However, irrigation with water for a minimum of 45 seconds may limit burn depth. Dry decontamination methods which involve rubbing the skin appears to be contraindicated for acid exposures.

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 Decontamination of Hair and Related Issues Following a Mass Casualty CBRN/HazMat Incident

6

Joanne Larner | University of Hertfordshire

Previous studies have demonstrated that the “triple protocol” comprising dry (DD), ladder pipe system (LPS) and technical decontamination is highly effective in removing chemicals from the skin of exposed casualties [1]. The purpose of this ex vivo study was to evaluate various strategies for hair decontamination and to investigate the fundamental interactions between chemicals and hair to underpin recommendations for managing casualties following decontamination. Three experiments were performed:

1. Evaluation of the efficacy of DD, LPS and TD, alone or in combination, on skin and hair contaminated with liquid droplets of methyl salicylate (MS), phorate (PHR), sodium fluoroacetate (SFA), or potassium cyanide (KCN).
2. Investigation of residual hair contamination following decontamination with the Triple Protocol (DD+LPS+TD) performed at regular intervals (0 – 240 minutes) post exposure.
3. Off-gassing of hair exposed to MS and PHR following Triple Protocol decontamination (performed 0 – 240 minutes post exposure) was measured at regular intervals over 5 days.

Decontamination protocols were highly effective in removing contaminants from the surface of skin and hair. However, up to 80% of the applied dose of the lipophilic compounds (MS and PHR) remained within the hair. This was tentatively ascribed to rapid partitioning of the contaminants into the lipophilic domains of the hair strands which consequently impeded the effectiveness of the decontamination protocols [2]. In the case of MS (a medium volatility chemical), this resulted in significant off-gassing over five days. The difference in cumulative off-gassing between control (untreated) and decontaminated hair decreased as the delay between exposure and decontamination increased.

These studies demonstrate that, unless performed immediately following exposure, current hair decontamination protocols are relatively ineffective in removing lipophilic contaminants from within the hair. Correspondingly, consideration should be given to removing hair following exposure to toxic chemicals [3,4].

[1] R.P. Chilcott et al., Ann Emerg Med (2018), DOI: 10.1016/j.annemergmed.2018.06.042

[2] H. Matar et al., Sci Rep (2018), DOI: 10.1038/s41598-018-35105-z

[3] R.P. Chilcott, J. Larner and H. Matar, www.medicalcountermeasures.gov/barda/ cbrn/prism/

[4] M. Spiandore et al., Chem Biol Interact (2016), 267, 74-79.

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 Development of a Rapid, High-Throughput Method for Quantifying Residual Caesium in Building Materials as Part of a Decontamination Evaluation Procedure

7

Joanne Larner | University of Hertfordshire

An attack on infrastructure mediated via a radiological dispersion device (RDD) remains a credible threat, with radioactive caesium (137Cs) being of particular concern. Therefore, it is imperative to identify and assess available equipment and develop appropriate strategies to safely remove radiological contamination. Laboratory-based evaluation of building decontamination procedures can be assessed using stable Cs to avoid environmental, cost and safety constraints associated with the radioactive isotope. A commonly used analytical technique for Cs is inductively coupled plasma mass spectrometry (ICP-MS), which is highly sensitive but involves a time consuming, labour intensive, expensive and potentially hazardous sample preparation that can slow efforts the evaluation of decontamination products and methods.

The aim of this initial study was to assess ion-exchange liquid chromatography mass spectrometry (IE-LC-MS) as a potential high throughput replacement for ICP-MS. Concrete was chosen as a test substrate, given its prevalence as a building material. The experiment involved exposing concrete bricks to a 20 µL droplet of aqueous CsCl (11 mg mL-1). After a delay of 0 – 20 days, the bricks were decontaminated (by one of three methods) or remained untreated (control). The exposed surfaces of the bricks were then drilled to a depth of 10 mm to generate powder samples which were subject to a standard ICP acid digestion protocol [1]. The resulting acid solutions were filtered and analysed by ICP-MS or IE-LC-MS.

There was a good correlation (p<0.0001 to p=0.0298) between Cs quantified by ICP-MS and IE-LC-MS. The limit of detection for the IE-LC-MS method was 20 ppb which contrasted poorly with ICP-MS (LoD = 0.1 ppb). However, the lower sensitivity of the IE-LC-MS method would be sufficient for the initial screening of decontamination products.

The next stage of the project will determine if cement powder samples can be extracted using just water prior to quantification by IE-LC-MS, to avoid the acid digestion process and thus significantly reduce the time, cost and hazard of Cs sample analysis.

[1] U.S. EPA. 2007. Method 3051A (SW-846). Revision 1. Washington, DC.

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 Lilliput or Brobdingnag: Does Scale Influence Decontamination Studies?

8

Joanne Larner | University of Hertfordshire

There are a multitude of scaling aspects that need to be considered when extrapolating the results of laboratory decontamination studies to real life incidents. Two such factors relate to the contamination density (dose) and geometry (droplet number) of test contaminants. In other words, will a particular decontamination method be equally effective against single droplets of varying size (dose) or multiple droplets of the same dose? This is a critical consideration, as many decontamination test methods employ a standard contamination density and there is an assumption that the test results will be applicable to a wide range of exposure scenarios. In this study, we utilised a previously validated test model [1] to assess the effectiveness of gross (Ladder Pipe System; LPS) decontamination (against chemical warfare agents, simulants and toxic industrial chemicals) applied to porcine skin either as a single droplet over a range of doses (equivalent to 0.1 – 10 mg cm-2) or when applied as 1 – 10 separate droplets at constant overall dose (10 mg cm-2).

The results of both studies were identical in that the effectiveness of gross decontamination was constant and so independent of contamination density and/or application geometry. However, differences were observed in the extent to which each contaminant spread over the skin surface in relation to the number of applied droplets: large numbers of small droplets undergo more rapid dermal absorption and so confirms the need to perform decontamination as soon as practically possible. Additional studies have subsequently confirmed that the effectiveness of dry decontamination is also independent of contamination density and application geometry [2].

[1] M. Matar H, J. Larner J, S. Kansagra et al., 2014. Toxicol In Vitro 28(4):492-501. doi: 10.1016/ j.tiv.2014.01.001

[2] R.P. Chilcott, J. Larner and H. Matar, eww.medicalcountermeasures.gov/barda/ cbrn/prism/

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 Derivation and Use of an Empirical, Time-Resolved Model for Predicting Residual Skin Contamination as a Decision-Aiding Tool for First Responders (“ASPIRE”)

9

Joanne Larner | University of Hertfordshire

The use of water is a well-established means of performing mass casualty decontamination and, after emergency dry decontamination, form the second and third components of the “Triple Protocol” recommended in current U.S. federal guidance [1]. However, the use of water may result in hypothermia and may raise compliance issues with patients. Therefore, the clinical benefit of proceeding from dry to wet decontamination needs to demonstrably outweigh any attendant risks and disadvantages. The “Algorithm Suggesting Proportional Incident Response Engagement” (ASPIRE) decision-aiding tool was developed to assist first responders ascertain the need to perform wet decontamination.

Derivation of the algorithm: A study was performed to measure the rate of evaporation of a wide range of liquid chemicals (n=58) from clothed or unclothed synthetic skin surfaces using different droplet sizes. The evaporation rates of each chemical were subject to a correlation analysis with commonly available physicochemical properties. The best fit (p<0.0001) was related to ∆Hevap (heat of evaporation) and was used in a four parameter logistic regression analysis to predict an evaporative half-life (T½) from which a simple exponential decay function was used to predict the fraction of an applied dose of chemical remaining on the skin at any given time post exposure.

ASPIRE has been fully integrated into the National Library of Medicine’s CHEMM and WISER digital systems for emergency responders [2] and requires two end-user inputs: the time elapsed since exposure and the identity of the chemical (selected from a pull-down menu) from which the algorithm is populated with the appropriate ∆Hevap value. Where the identity of the contaminant is not known, an estimate of volatility can be input using a slider bar. The ASPIRE system then indicates if wet decontamination is required.

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 Primary Response Incident Scene Management (PRISM): New U.S. Federal Guidance for Responding to a Chemical Incident

10

Joanne Larner | University of Hertfordshire

The Primary Response Incident Scene Management (PRISM) guidance was written to provide authoritative, evidence-based guidance on mass patient disrobe and decontamination during a chemical emergency. The guidance [1] was recently updated to incorporate revised decontamination strategies, recommendations for treating contaminated hair, use of an on-line decision support tool (ASPIRE) [2], new approaches to patient management, advice on communication and confirmation of the scalability of the incident response process. In addition, the second edition now contains detailed instructions for first responders which provides detailed training material for performing dry, gross and technical decontamination on ambulant and non-ambulatory casualties.

PRISM is structured into three documents: strategic (Volume 1), tactical (Volume 2) and operational (Volume 3). The strategic guidance reviews the technical evidence, identifies capability gaps and describes the corresponding rationale which underpins the revised incident response process. The tactical guidance focuses on the practical aspects of the incident response with an accompanying rationale for the main processes. The operational guidance summarises only critical, practical elements of the response process and so provides a readily retrievable source of information during an incident response.

The PRISM guidance is supported by a comprehensive series of laboratory, volunteer and field trials which have addressed individual components of the incident response, as well as taking a more holistic, systems approach to confirm that the overall process is optimized from both operational and clinical perspectives [3,4,5].

[1] R.P. Chilcott, J. Larner and H. Matar, www.medicalcountermeasures.gov/barda/ cbrn/prism/

[2] U.S. Department of Health and Human Services, Chemical Hazards Emergency Medical Management, available at https://chemm.nlm.nih.gov/aspire.htm

[3] R.P. Chilcott, J. Larner, A. Durrant, et al., 2018. Ann Emerg Med. 73(6):671-684. doi: 10.1016/j.annemergmed.2018.06.042.

[4] J. Larner, A. Durrant, P. Hughes, et al., 2019. Prehosp Emerg Care. 19:1-14. doi: 10.1080/10903127.2019.1636912.

[5] M. Matar, A. Pinhal, N. Amer, et al., 2019. Toxicol Sci. doi: 10.1093/toxsci/kfz145.

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 Downstream Hazards Associated with Mass Casualty Decontamination can be Contained or Minimised by Adoption of the PRISM Triple Protocol

11

Joanne Larner | University of Hertfordshire

The Primary Response Incident Scene Management (“PRISM”) guidance incorporates evidence-based protocols that focus on the initial operational response to a chemical incident in order to prioritise casualty survival [1]. The PRISM guidance incorporates a “Triple Protocol” approach for ambulatory casualties, involving (i) immediate disrobe and dry decontamination, (ii) gross decontamination (Ladder Pipe System; LPS) and (iii) technical decontamination. The clinical effectiveness of the process has been confirmed in laboratory and field trials [1-3]. It can be reasonably anticipated that first responders will be exposed to vapour and/or contaminated materials discarded by casualties during the decontamination process. However, characterisation of the nature and extent of these secondary hazards has not previously been addressed. Therefore, a human volunteer study (n=115) was performed to assess the impact of the individual and combined decontamination procedures on the secondary hazard posed by contaminated materials using a chemical warfare agent simulant (methylsalicylate; MS).

Recoveries of MS demonstrated a substantial reduction in downstream contamination when the Triple Protocol was employed compared to individual decontamination procedures. Dry decontamination materials were found to be grossly contaminated. Prompt disrobing and use of suitable dry decontamination materials significantly reduced the subsequent contamination of towels and washcloths resulting from the wet decontamination processes. Perhaps most importantly, a significant reduction in atmospheric contamination within the technical decontamination units was observed when preceded by dry and LPS procedures. To put this in context, when technical decontamination was used as a stand-alone method, the concentration of MS vapour within the enclosed structure was equivalent to a dose of sulphur mustard exceeding the IDLH (immediately dangerous to life or health) threshold. In contrast, the Triple Protocol reduced vapour concentration below the IDLH threshold.

In summary, this study has demonstrated that the Triple Protocol reduces contaminant exposure in downstream operational processes associated with a chemical incident response.

[1] R.P. Chilcott, J. Larner and H. Matar, 2018. www.medicalcountermeasures.gov/ barda/cbrn/prism/

[2] R.P. Chilcott et al., 2018, Ann Emerg Med, DOI: 0.1016/j.annemergmed.2018.06.042

[3] Larner J, Durrant A, Hughes P, et al., 2019. Prehosp Emerg Care. 19:1-14. doi: 10.1080/10903127.2019.1636912.

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 A Novel Method Using Phycoremediation to Reduce Toxic Metals in Surface Waters

12

Noah Craft | Virginia Wesleyan University

Previous research has demonstrated the effectiveness of phycoremediation, the use of algae to take up pollutants from the environment. The questions that served as the basis for this research were 1) whether filamentous algae could be an effective method for phycoremediation and 2) if that algae could be broken down by worms and used as vermicompost to create safe and fertile soil. A mesocosm experiment was conducted first, which evaluated the uptake of metals by a natural consortium of filamentous algae. It was demonstrated that the algae in the mesocosms that had been spiked with heavy metals (Cu, Cd, Hg, Pb and Zn) retained higher concentrations of said metals than the algae in mesocosms without spikes. The concentrations decreased in the water of the mesocosms without algae, though there was a 150-185% improved reduction of heavy metals in the mesocosms with the algae addition. A vermicompost experiment was then initiated using these algae samples and nine worm compost bins. There were three treatments: bins with (1) high-metal algae, (2) low-metal algae and (3) no algae. The worms successfully decomposed filamentous algae, which was mixed with food waste, demonstrating that filamentous freshwater algae can be used as a vermicompost feedstock. The metal concentrations in the finished compost, including that with the high-metal algae treatment, were well within limits laid out by European compost rules, except for mercury. The vermicompost was nutrient-rich compared to typical expectations for compost and was consistent across all three treatments. To our knowledge, this was the first study to evaluate freshwater algae as a vermicompost amendment and demonstrate its potential for managing nuisance algal blooms. This research suggests that the removal of filamentous algae from surface water is an effective, easily-implemented and eco-friendly means to reduce toxic metals in water bodies. (Supported by: U.S. Environmental Protection Agency’s People Prosperity and the Planet program and Virginia Wesleyan University's Undergraduate Research Program).

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 Decontamination Systems for First Responders

13

Brian France | TDA Research, Inc.

TDA Research, Inc. has recently developed two complementary systems for decon of hazardous chemical and biological threats. Here we describe their application by first responders, including recent efficacy test data and system modifications to improve ease of use.

One component of the system is the detergent SSDX-12®, which is both qualified for use in cleaning military aircraft per MIL-PRF-87937 and proven effective in removing a wide range of threat agents from surfaces. A second component of the system is TDA’s electrochemical generation of chlorine dioxide (eClO2) technology. Decontaminants used to treat surfaces that are contaminated with chemical and biological warfare agents must be stable so they can be stored for long periods of time and stockpiled for times of need, environmentally benign with no hazardous residue, safely handled by personnel and easily transported. At the same time, the decontaminant must be very reactive upon use so that they can quickly detoxify chemical warfare agents and sterilize bacterial spores. TDA’s eClO2 technology elegantly addresses these conflicting requirements for stability and reactivity, by storing and transporting a solid salt, which when needed is dissolved in water and activated just as it is applied to produce a reactive, fast acting, decontaminant solution.

This eClO2 technology has demonstrated efficacy against live chemical warfare agents and is registered with the EPA under FIFRA as effective against bacterial spores, including anthrax (EPA Reg. No. 85797-1). Scientists at the Naval Surface Warfare Center Dahlgren Division completed efficacy testing against a 1x107 CFU *Bacillus anthracis* Ames (anthrax) spore challenge. The virulent anthrax was eliminated within one-minute contact time (Buhr et al. 2011).

These two systems are complementary, with SSDX-12® providing effective cleaning (physical removal) of contaminants with maximum materials compatibility, and the eClO2 system rapidly neutralizing both CW agents and other toxins. It has recently been evaluated against fentanyls and other commonly encountered hazardous materials. We will present data describing how SSDX-12® and eClO2 are useful to first responders.

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 Examining the Extent of Environmental Compliance Requirements on Mechatronic Products and their Implementation through Product Lifecycle Management

14

Vukica Jovanović | Old Dominion University

The present mixed-methods study examined the opinions of industry practitioners related to the implementation of environmental compliance requirements into design and manufacturing processes of mechatronic and electromechanical products. It focused on the environmental standards for mechatronic and electromechanical products and how Product Lifecycle Management software tools are used to facilitate environmental compliance of such products. Both qualitative and quantitative data were collected during the study and they included perceptions of people who work on design and development of those products. Use of the constant comparative method with data retrieved from interviews in the study revealed that environmental compliance standards related to mechatronic and electromechanical products can be grouped in the following four categories: standards related to hazardous substances, standards related to the end of the product lifecycle, standards related to energy efficiency and standards that deal with environmental impact on nature. Other conclusions are that Product Lifecycle Management tools are mostly used to support material tracking of hazardous substances in the company and that there are many problems related to that. The most important problem is related to resources, such as cost and time, for which a company needs to manage environmental compliance information. Integration of environmental compliance also has caused new job openings and changes in participants’ daily job activities. Quantitative portion of the study included data gathered from 103 industry practitioners with the original survey instrument consisting of 66 items, five of which included 30 Likert-type response items of which 25 were used in Exploratory Factor Analysis and one was used as a response variable. Statistical analysis of qualitative data revealed that the greatest influence on the level of customer satisfaction related to environmental compliance of mechatronic and electromechanical products have neutral collaboration and data exchange. Constraints related to the environmental compliance, along with other four predictors identified in the study are effective product data management, location, consequences of non-compliance, and global supply chain. Results of the stepwise linear regression lead to the conclusion that the major influence on the level of customer satisfaction related to environmental compliance of mechatronic and electromechanical products are location, global supply chain and constraints related to environmental compliance.

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 The Argonne SuperGel for CBRN Decontamination

15

Michael Kaminski | Argonne National Laboratory

The Argonne SuperGel was developed between 2003 and 2015 to fill a gap in our nation’s capability to quickly decontaminate important structures following a radiological or nuclear release event. Specifically, the decontamination technology was developed to minimize damage to monuments, high valued structures, and critical infrastructure while reducing environmental and health impacts. Over the years, two formulations of the Argonne SuperGel have been developed to specifically target radioactive cesium contaminations and then, more generically, actinide and fission product contaminations. An important criteria during its development, common reagents were employed that could be easily acquired in order to minimize the timeline for its deployment. Its current formulation uses off-the-shelf superabsorbing hydrogels common to the food and agricultural industry and common salts. A biodegradable derivative of phosphoric acid is used in small amounts to promote the removal of insoluble actinide species. Since its development, we have had the opportunity to test the SuperGel in the removal of legacy contaminations in hot cell facilities and former glovebox facilities at Argonne. This has provided a unique opportunity to evaluate the SuperGel on a range of contaminants outside the original specifications for its use. We will report on the origin of the gel formulation, some highlighted experimental data, and its efficacy for removing alpha contaminations and its potential use for removal of chemical and biological hazardous agents.

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 Radiological Recovery Logistics Tool

16

Michael Kaminski | Argonne National Laboratory

Argonne is building and testing a tool, the Radiological Recovery Logistics Tool (RRLT), that can be used during the response and recovery from a radiological or nuclear incident to effectively allocate appropriate commercial and public works equipment to mitigate, remove, and contain radiological contamination. The requirements for this tool—as well as development of the resulting software—is overseen by a steering committee of stakeholders from DHS's National Urban Security Technology Laboratory (NUSTL), the Federal Emergency Management Agency (FEMA), and the Environmental Protection Agency (EPA).

RRLT's Knowledge Base will contain details on dozens of Equipment Types and facilitate the Operator's discovery and consumption of these details most pertinent to a dynamically selected subset of goals. The core of its Domain Model is based on a report authored by this team. This report [1] contains a comprehensive list of proposed equipment to accomplish various missions or scenarios that might arise after a large-scale radiological contamination incident in an urban environment or critical infrastructure:

RRLT is driven by use cases. A use case is an intention with which a user approaches the software. Use cases are grouped into delivery increments to schedule development, testing, and presentation to stakeholders. This model partitions the system into seven increments: User Arrival and Authentication, Search and Navigation, Equipment Recommendation, Plan Management, Content Management, and Expanded Access. Once a user is authenticated, RRLT will present the user with a dashboard that allows them to explore or search RRLT's content. The dashboard will also include a "Plan" panel for collecting decisions and relevant observations about an incident at hand to facilitate development of an Equipment List.

RRLT will offer three general modes of access to items in the knowledge base:

* Keyword search for direct discovery of items,
* Navigation along predetermined paths from recovery goal towards equipment types, and
* Interactive guidance towards equipment types by an autonomous software agent: the Equipment Recommendation Wizard.

Progress in the development of the RRLT will be presented and opportunity will be given to those interested in providing feedback on its content and functionality.

[1] Municipal and Commercial Equipment for Radiological Response and Recovery in an Urban Environment: State of Science, Research Needs, and Evaluation of Implementation Towards Critical Infrastructure Resilience,"" Argonne National Laboratory Report, ANL/NE-35-17, 2018

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 Intelligence Database and Tools for Chemical Hazards – A Program to Develop Tools to Assist Soldiers in an Environment with Toxic Industrial Chemicals

17

Jacob Lalley | U.S. Army Engineer Research and Development Center

Toxic industrial chemicals and material (TIC/Ms) can be defined as chemicals with industrial value that can be used to create hazardous situations during emergency responses, or worse, used in improvised chemical attacks. For these reasons, TIC/Ms represent a significant threat to civilians, emergency responders, and warfighters. Some TIC/Ms are highly toxic and can be more environmentally problematic than typical chemical weapons. Furthermore, the broad spectrum of TIC/Ms often renders simple decontamination solutions ineffective. In recent years, the U.S. Army has encountered TIC/Ms used in improvised chemical attacks. Advanced planning and mitigation resources for TIC/Ms would be valuable to minimize potential exposure and health risks.

The purpose of our project is to provide planning tools to anticipate and address the potential for TIC/Ms encounters in order to minimize impacts to health and mission success. We are approaching this goal by first developing a dynamic database, the toxic industrial chemicals and material intelligence (TICM-INT) that includes physical-chemical data to allow calculations of contaminant migration and transformation. The database also includes data that allow the user to predict presence of TIC/Ms associated with industries, dynamic environmental chemistry of TIC/Ms, and hazard data linked to maximum exposure limits. The integration of this data is being used to develop probabilistic risk models for mission planning purposes. Although the TICMINT is focused on disaster responses and military applications, it may also have great value in homeland security and anti-terrorism applications.

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 Decontamination through a One Health Lens

18

Tonya Nichols | U.S. Environmental Protection Agency

In an increasingly connected world, integrating a One Health approach is needed to better assess risks posed by biothreat agents and for developing effective, environmentally-sustainable response strategies. One Health recognizes the interaction and interconnectedness of human, animal, and environmental health, allowing for a systemic approach to decontamination activities with multiple points of intervention. The potential impact of such methods is amplified when applied to decontamination of urban environments. Urban populations are at greater risk during bioincidents due to their significantly higher density relative to rural counterparts. However, this is not the only risk factor for increased virulence. In the built environment, pathogens have greater opportunity for fomite mobility via mass transit, building ventilation, and water and wastewater systems. Animals tend to exacerbate these issues. In a bioterrorism event, contaminated buildings may be off-limits to humans, but animals (such as rodents, dogs, cats, birds, bats, etc.) and insects still have access to the building and could transmit disease to surrounding human and animal populations. For example, the AMI building in Boca Raton, Florida was contaminated when an anthrax-laden letter was opened. The building was quarantined for months awaiting decontamination. In the meantime, city wildlife could have moved in and out of the contaminated area. Without addressing the movement of city wildlife, bioincidents cannot be fully addressed, and in turn decontamination of the urban environment cannot be achieved, thus human health remains at risk. Medical countermeasures are insufficient to combat environmental persistence of harmful microbes in potential epidemic or pandemic scenarios. Additional understanding is needed of the complex relationships at the human-animal-environment interface, to develop environmental countermeasures to effectively stop the chain of infection is vital to effective decontamination.

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 "Smart Water Ions Filtration Technology" (SWIFTTM) "Ecology Healer Filter Reactor" (EHRTM)

19

Michael Omary | APD Clean Water Technologies Group

California State University Channel Islands (CSU-CI) piloted SWIFT TM/EHR TM and tested its effectiveness in Mitigating CSU-CI Campus Source Surface Water Runoff for Pollutants Reduction/Elimination and treatment of the following:

1. Storm Water Capture & Treatment;
2. Electric Generator Cooling Waste Water Treatment
3. Tertiary Treated Sewer Water Polish Treatment;
4. Impaired River Water Treatment;
5. Treatment of Cement Wash Water for PH Control/Heavy Metals Removal &
6. Treatment of Agriculture Vegetable Wash Water.

A portable SWIFT TM/EHR TM unit on wheels was utilized to test SWIFT TM performances. In addition a SWIFT TM Modular was deployed permanently on campus to service one acre parking lot watershed, has been in operation since Winter of 2014/15 without needing any maintenance to system's pre-filtration or the EHR .

Results of over 60,000 data points reveal consistent disinfection and high water contaminants reductions across all NPDES top 40 pollutants of concern ; and deliver/ out-put ultra clean, healthy drinking water quality.

SWIFT TM Testing and Evaluations Directed by DR. Sean Anderson PhD; Dean of CSU-CI Department of Environmental Sciences and Resource Management.

SWIFT TM Harvests WEAK ENERGY FORCES, Electro Magnetic Field and Gravity to Treat/Ionize/Heal Urban, Industrial and Drinking Water contaminants and disinfect, without energy or chemicals in-put. SWIFT TM operate at high flow-through rates, and output ultra clean local water suitable for recycling to ground water recharge or storage in drinking water reservoirs .

In water, free EHR TM organic ions exist largely as dipolar ions, that carries an equal number of positive and negative charges (Iso-Electric Form) during Operation.

EHR TM properties contain structures that complex metals, sequester anthropogenic organic compounds, oxidize, reduce and adsorb elements from toxic forms; photosensitize chemical reactions and enhance or retard the uptake of toxic compounds or micronutrients to plant, microbial organisms and disinfect water from pathogens. An organic process of molecular transformation without chemicals.

EHR TM has been documented to interact (ionize) in some manner with over 50 elements from the periodic table. These include nutrients, toxic metals, radionuclides, title 22 metals, anthropogenic organic compounds such as polycyclic aromatic hydrocarbons, including the known carcinogen benzene(a) pyrene; again altering the chemical reactivity of these toxic chemical pollutants in water and soil. EHR TM Ions Iso-Electro-Magnetic Vacuum disinfect water from pathogens and viruses to none detectable levels.

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 Research on Low Level Hydrogen Peroxide Fumigation for Remediation of Indoor Environments

20

Lukas Oudejans | U.S. Environmental Protection Agency

The imminent threat of a chemical warfare agent (CWA) release in infrastructure, building or transportation hub is driving U.S. EPA’s Homeland Security Research Program (HSRP) to develop research that evaluates potential decontamination technologies for chemical agents. The use of low-concentration hydrogen peroxide vapor (LCHPV) fumigation has gained attention as hydrogen peroxide is readily available, efficacious, green technology, and relatively easy to implement as a decontamination approach. The goal of this research is to determine conditions under which LCHPV fumigation can be used to decontaminate CWAs or selected pesticides from interior structures containing porous materials that are hard to clean using traditional surface decontamination approaches. This study will assess LCHPV decontamination on four material surfaces that have been contaminated with the CWAs O-ethyl S-[2-(diisopropylamino) ethyl] methylphosphonothioate (VX) and potentially C4H8Cl2S (Sulfur mustard, HD). The surfaces types to be tested are 1) stainless steel, 2) painted wood, 3) vinyl tile, and 4) rubber. Testing will be performed using coupons of fixed size in an environmental test chamber with controlled air flow rates, temperature and LCHPV levels. Testing and analysis will determine efficacy for various LCHPV treatment durations for each material type. This poster describes work currently under way at the Southwest Research Institute, funded by the National Homeland Security Research Center.

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 A Stochastic Model for Evaluating Interconnected Critical Infrastructure Decontamination and Recovery​

21

Barrett Richter | Battelle

Large-scale chemical, biological, radiological, and nuclear (CBRN) incidents have the potential to impact a wide area that would include core infrastructure assets. In such an event, the impact may extend beyond directly affected infrastructure sectors due to the interconnected nature of critical infrastructure systems. For example, an event damaging an electric power plant may reduce the ability of dependent infrastructure (e.g., transportation systems, communications facilities, hospitals, etc.) to operate at full capacity. In order to more effectively respond to CBRN events and efficiently bring services back online, an in-depth understanding of the dependencies and interconnections of infrastructure systems is necessary. Existing modeling tools in this field provide estimates of the immediate losses in connected infrastructures after a disruption, but the restoration process of infrastructure sectors has not been modeled in both a dynamic and interconnected manner. We have developed a framework for modeling the time-dependent process of critical infrastructure restoration within an interconnected system of infrastructure sectors. The model uses the Gillespie algorithm to stochastically simulate the use and production of infrastructure assets based on a network of infrastructure nodes and one-way connections. The process of infrastructure restoration is modeled as reactions, where resources from one or more infrastructure sectors are used to restore service in another sector. The model also accounts for a decrease in productivity due to injuries and/or temporary relocation of the population as a result of the CBRN event and an increase in productivity due to input from external forces (e.g., government involvement) to repair damaged critical infrastructure. This provides an opportunity to analyze the allocation of government resources and assess response strategies in the restoration effort. The stochastic nature of this algorithm enables the model to account for discrete events and capture the inherent uncertainty in the infrastructure restoration process. In this study, the model is applied to notional biological contamination scenarios, where the direct impact on critical infrastructure assets is assessed using data from FEMA’s HAZUS database overlaid on a GIS map of a metropolitan area.

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 Physical Removal Options for Porous/Permeable Materials Contaminated with a Persistent Chemical Warfare Agent

22

David See | Battelle

In the event of a chemical release incident involving chemical warfare agents (CWAs), porous building materials and permeable coatings may become contaminated with CWAs that absorb into the materials and coatings. Reversal of absorption may not be possible and absorbed CWA may become inaccessible to surface decontaminants that cannot penetrate into those materials or coatings. The best course of remediation may involve physical removal of contaminated materials or coatings. The ideal process would eliminate contamination while minimizing contaminated waste production and irreparable damage to the structure or surface. Following physical contamination removal, surfaces could be restored and returned to service.

Literature searches were performed to identify physical contamination removal technologies that generate minimal waste and avoid irreparable damage. A technology compendium was developed to collate and present the data. Two technologies/approaches were selected for bench-scale laboratory studies followed by subsequent experimental evaluation of physical removal efficacy using two different techniques: grinding and chemical stripping. Grinding involved application of an angle grinder to remove layers of VX-contaminated limestone and sealed concrete (porous materials) at successive 0.25-inch depths. Chemical stripper was applied to remove VX-contaminated paint (permeable coating) from low-carbon steel and hardwood. Ground aggregate and stripped paint samples were analyzed via liquid chromatography-tandem mass spectrometry (LC-MS/MS) to quantify VX. A method for dissection of porous materials to quantify VX depth penetration extent was also developed (referred to as the “core sampling approach”).

The majority of VX recovered using the core sampling approach was collected from the topmost 0.25-inch material layer. Similarly, most of the VX recovered from materials via grinding was also recovered from the topmost 0.25-inch ground layer sample. Most of the VX contamination was removed from coated steel by a pre-stripping surface wipe followed by strip-removal of the permeable coating, suggesting that remediation may be possible though repeated wipes and chemical stripper applications. Both approaches demonstrate that physical removal of VX is feasible without loss in functionality of the material and with limited amount of generated waste.

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 Fate and Transport Modeling of Urban Radiological Contamination

23

Jonathan Shireman | APTIM Federal Services

The objective of this work is to model the unique precipitation-driven transport characteristics of radiological contaminants dispersed in a ground deposition plume following the detonation of a radiological dispersal device (RDD) in an urban setting; i.e., the U.S. National Planning Scenario #11. Specifically, this case study investigates techniques for mapping overland transport, quantifying residual hotspots for various storm intensities, and estimating volumes of contaminated water produced. The case study model was developed using the EPA Stormwater Management Model (SWMM v5.1) engine implemented within a proprietary software (PCSWMM) that includes a quasi-2D module. To explore the impacts of different precipitation events on the spread of radiological contamination, the case study modified a SWMM model from a combined sewer system from an urban center in the U.S. and used both an MSE Type 3 24-hour 2-year storm and an actual storm with a hourly 2-year return frequency. The multistep modeling process required to develop and implement the case study will be discussed in this presentation as well as a literature review of washoff coefficients for radiological contaminates. The study found that the greatest area of uncertainty in the modeling is associated with the estimates of washoff parameters. Experimental washoff data for radioactive fallout components is available from studies conducted in the 1960s, and there has been considerable data accumulated from areas proximal to recent reactor accidents. The presentation will describe the authors’ process for assigning coefficients using historical data and land-use features. Overall, this work illustrates the process of characterizing washoff behavior for a ground deposition plume in an urban setting developed from existing SWMM subcatchments and available urban planning data. The model can provide insights to overland transport pathways and mass flux of contaminants in response to high return frequency rain events. These results provide a functional conceptual model of surface movement of the contaminant and a process that can be applied to other urban and suburban settings.

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 Evaluation of Altered Environmental Conditions as a Decontamination Approach for Non-Spore-Forming Biological Agents

24

Michelle Sunderman | Battelle

The persistence of biological agents outside a host is influenced by environmental conditions and the materials with which they are in contact. To adequately design decontamination efficacy tests, as well as to plan for response or remediation following intentional releases of biological agents or naturally occurring events, scientifically defensible persistence and decontamination efficacy data are needed. Several decontamination approaches have been shown to be effective for inactivation of biological agents. However, when wide outdoor areas or large buildings are affected, the logistics of scaling these technologies can become challenging and often involve fumigants or liquids that are dangerous to human health, impactful to the environment, or deleterious to the materials being decontaminated. The purpose of this study was to evaluate the persistence of *Francisella tularensis* (*Ft*) and Venezuelan Equine Encephalitis virus (VEEV) under various environmental conditions, over time, on both glass and paper surfaces. In addition, an alternative approach to chemical inactivation was studied whereby the temperature and relative humidity (RH) were increased to determine if these altered conditions would increase the rate of attenuation. Data on *Ft* and VEEV persistence under ambient laboratory conditions and attenuation under elevated environmental conditions are presented as both recovery and decimal reduction time (D-value).

*Ft* and VEEV were inoculated as a liquid suspension (approx. 1 x 108 CFU or PFU), dried onto porous and nonporous fomites (glass and paper), and exposed to various combinations of altered environmental conditions ranging from 22 to 60°C and 30 to 75% relative humidity. Attenuation of test organism was assessed after contact times ranging from 30 minutes to 10 days.

*Ft* and VEEV can persist for extended periods (6 to 10 days) on both porous and non-porous fomites under ambient conditions. Efficacy of the altered environmental conditions resulted in D-values ranging from 0.2 to 75.6 hours for *Ft* and 1.6 to 24.9 hours for VEEV. The effect of increasing both the temperature and RH typically increased the rate of attenuation for both organisms, and a greater than six log reduction was accomplished in as little as six hours by elevating temperature to approximately 60°C. These results provide information for inactivation of non-spore-forming select agents using elevated temperature and humidity which may aid incident commanders following a biological contamination incident by providing alternative methods for remediation.

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 E.coREADi: Automated Microbiological Water Analysis

25

Nathaniel Talley | Luna Innovations Inc.

Identifying microbiological contamination is critical to evaluating the safety of potable water. The ability to detect viable indicator organisms, including *E. coli* and coliform bacteria, in near real-time has been identified as critical to mission success by the U.S. military. There is a defined need by the U.S. Army for analysis technologies that reduce the time-to-detection (standard EPA test methods are currently 18-24 hours), as well as a need for improved operational characteristics to enable portability for field use and operation by non-experts. To meet this need, Luna Innovations is developing the E.coREADi™ technology for the presence/absence detection of viable coliforms and *E. coli* in drinking water. The E.coREADi technology integrates proprietary enzyme-substrate based detection methods within a disposable and low-cost microfluidic cassette, with an E.coREADi instrument operating the cartridge and enabling complete automation of the water analysis for the end-user. The system is being designed to be portable (less than 2 cubic feet and 20 pounds), battery-operable, and allows analysis of up to 16 samples simultaneously. To date, Luna has demonstrated presence/absence detection capabilities in 10 hours with chlorine-stressed bacteria using the E.coREADi method. Prototype automated systems and microfluidic cassettes are currently being manufactured for final validation work prior to submission of a study plan for EPA Alternative Test Protocol (ATP) testing and approval. With complete automation, rapidity, and minimal operator training requirements, the E.coREADi technology is anticipated to have private sector applications in municipal water facilities, environmental testing laboratories, disaster relief missions, and food and beverage manufacturing facilities.

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 Are You Properly Assessing Risk when the Call Comes in?

26

Scott Vogel | American Bio Recovery Association

Too often in the cleaning industry, we see many companies trying to tackle a project that is completely outside of their “wheelhouse.” The lure of making a profit on a job is always there but what are the exposures?

Even in the Bio Recovery industry, we find responders that jump at the chance of a job, after all, the industry is usually 100% event driven. By the time an insurance carrier arrives to evaluate the claim, mitigation is finished or almost completed. Many cleaning company owners think it is “just blood” but, when you look at the variables that can arise, one can quickly become overwhelmed.

In 2016, The American Bio Recovery Association (ABRA) embarked on developing a guidance document to help responders understand the perils they face regarding Bio Recovery mitigation projects. In fact, the Bio Recovery industry is getting more and more dangerous for contractors.

Recently, I was a keynote speaker at the World Congress on Infectious Diseases and heard another presenter outline the terrifying reality that the very threats we are attempting to mitigate are becoming more resistant to existing prophylaxis. Variations of virus are putting us at risk for pandemic conditions – we are only a plane, train or subway ride away and pharma research is running out of new antibiotics.

To add insult to injury, ABRA-member companies and technicians are faced with a new threat – Fentanyl and Carfentanil are being pumped into the United States at an alarming rate. Throughout the United States, the DEA and DHS have had major busts with exposure threats. Now we have contamination from a decomposing body and cross-contamination from a potential killer throughout a dwelling. In addition, several properties have been used as clandestine laboratories with compounding pill press operations, the pill usually disguised as an over-the-counter product.

To address this threat, ABRA has been reaching out to individuals with experience in Bio Recovery, Biological Safety and Clandestine drug labs to develop a new guideline to help contractors develop a scope of work to mitigate the risk to their response crews. These guidelines will help a contractor determine if they can accept a project or need to refer it to a more specialized provider.

Key Takeaways:

Similar in set up to an Infection Control Risk Assessment in a healthcare setting, process details include:

* Intelligence gathering on the call – front end management
* Determine the type of risk present – determination of risk group
* Identify the risk-group impacted area
* Determine class (I – IV) of required risk mitigation measures
* Risk mitigation guidelines/precautions/engineering controls/cross-contamination prevention
* Life safety assessment
* Response team sign-off

While there are always variables that fall outside of written guidelines, this will, at a minimum, offer a framework for safety and proper mitigation techniques. This will not, however, replace formal education or certification of your technicians.

Visit the American Bio Recovery Association website at www.americanbiorecovery.org for more information. The BSRA Guidance Form can be found under “Education/Guidelines and Standards.” The document is free to download and can be used by anyone entering the Bio Recovery industry. ABRA welcomes constructive criticism for BSRA as our goal is to offer and promote education for best industry practices.

Thomas Licker is the Director of Infection Control Technologies, a division of Insurance Restoration Specialists, Inc. He is the current President of the Board of Directors of the American Bio Recovery Association (ABRA) and is the current Chairman of Outreach for the AIHA Opioid Working Group. He holds a Bachelor of Science Degree in Environmental Science from Slippery Rock University. Thomas holds an Accredited Certification as an ACAC Certified Environmental Infection Control Remediator (CEICR) designation and is an ABRA Certified Bio Recovery Master (CBRM) Technician.

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Student Poster Competition

 Analyzing U.S. Coast Guard Facilities for Operational Resiliency

27

Owen Gibson | U.S. Coast Guard

The U.S. Coast Guard (USCG) is on the front lines of our Nation’s effort to protect the American people, homeland, and way of life. As a Service, the USCG is responsible for the maritime safety, security, and environmental stewardship of U.S. ports and protects and defends more than 100,000 miles of U.S. coastline and inland waterways. In addition to a fleet of ships and aircraft, the USCG maintains and operates numerous waterfront installations. Following a wide-area contamination event at a port city, the USCG (due to their geographic jurisdictional authority and location) is in a position to be the lead federal agency for response activities.

Through a Department of Homeland Security (DHS) funded research study, the U.S. Coast Guard is working with Homeland Security Research Program at the EPA Office of Research and Development on an effort to build capabilities to predict water-driven biological contaminant movement in a wide-area environment. Such predictive capabilities will enhance response operations (time, cost, effectiveness, etc.) by allowing responders to more effectively utilize sampling, decontamination, and mitigation resources. This effort will focus on landforms and terrain characteristics of USCG facilities and adjacent maritime areas. To gather information about current USCG facility capabilities with respect to stormwater response, information from Facilities Engineers at facilities throughout the Coast Guard is being gathered. The information collected will inform the study and assist the research team in understanding the current capabilities of USCG facilities in terms of controlling stormwater and mitigating pollutant dispersion. While some gaps and needed capabilities may be specific for the USCG, in general these largely align with gaps and needs for response and recovery to any wide-area biological contamination incident in an urban environment. The information obtained in this study will be used to provide an informed recommendation as to what stormwater modeling tools and containment strategies would be rapidly deployable during an incident for the remediation of USCG facilities and assets, as well as the wide-area urban scenario.

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 The Effects of Contaminant-Aging on Decontamination Efficacy for Rapid Remediation of Concrete Surfaces

28

Katherine Hepler | Argonne National Laboratory

The time between contamination and decontamination allows contaminants to chemically bind to contaminated surfaces and/or penetrate into the subsurface of contaminated materials. These processes, herein referred to as contaminant aging, pose a problem for effectively decontaminating porous urban materials. In this work, we evaluated the decontamination efficacy of two decontamination methods on concrete samples contaminated with soluble cesium and silica particles with 0.5 μm and 2 μm diameters. Concrete samples were aged between 1 and 59 days, with half of the coupon receiving 1 mL of artificial rainwater about once every three days. After aging, coupons were either decontaminated or analyzed to determine contaminant penetration depths. Decontamination methods were performed in quintuples for two decontamination methods: 1) flowing 0.1M KCl wash solution across coupon surfaces for 15 min or 2) pressurized washing with 0.1M KCl solution using a 2000psi/1.2GPM power washer fitted with a 15 degree nozzle held 27 cm above coupon surfaces for about 5 seconds per coupon. Contaminant depth profiles were created by removing the top surface of the coupon at least 20 times, measuring the activity in each removed layer, normalizing the total activity removed to the measured decontamination efficacy following the last layer removal, and determining the penetration thickness using the coupon dimensions, bulk density, and mass of material removed for each layer.

Soluble cesium removal steadily decreased over the first ten days until it reached low values (<10% removal) for samples aged without precipitation events and decontaminated by flowing solution across their surfaces. Introducing precipitation events halved the time to reach the lowest removal values. Particulate removals were mostly constant for the entire aging time and pressurized washing outperforming flow decontamination. A slight decrease in particle removal was observed after samples were exposed to the solution. We suspect particle decontaminated decreased following the initial exposure to solution either because particles settled into depressions along the coupon surface or migrated into the concrete subsurface via capillary pores. Overall, this study aims to provide additional insight on predicted decontamination efficacy over time and through that understanding aid in creating effective remediation strategies.

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 The Impact of Antecedent Growth Conditions and Primary Effluent Derived Test Organisms in Point-of-Use Disinfection Testing

29

Collin Knox Coleman | University of North Carolina at Chapel Hill

Introduction: Waters impacted by improperly treated or untreated human excreta, such as high risk human wastes and wastewaters discharged from hospitals, waters in close proximity to open defecation sites, or urban areas with combined sewerage can contain high levels of pathogens. Poor quality wastewaters, such as those contaminated by human feces, can contain high levels of suspended solids and organic loads that prevent on-site decontamination by traditional treatment technologies, such as chlorine dosing, by rapidly reducing disinfectant concentrations before target microbial reductions are achieved.

Objectives: Evaluate and quantify inactivation of *E. coli*, *S. typhimurium*, *R. terrigena*, *Clostridium sporogenes* spores, MS2 and ΦX174 coliphages, and *Cryptosporidium parvum* oocysts by Peracetic Acid (PAA) in hospital sewage and feces.

Methods: Evaluation of microbial reductions in pasteurized hospital sewage and a fecal matrix consisting of 33% feces in hospital sewage was performed in batch lab-scale experiments seeded with microorganisms. Seeded test waters were dosed with PAA concentrations ranging from 4 mg/L to 4000 mg/L and neutralized at time points up to 30 minutes. Influent and effluent *E. coli*, *S. typhimurium*, and *R. terrigena* were enumerated by spread plate method on Bio-Rad Rapid’*E. coli* 2 agar. *C. sporogenes* spores were assayed by spread plate method on reinforced clostridial medium and anaerobically incubated in jars. MS2 and ΦX174 coliphage were enumerated by DAL plaque assay method, EPA method 1602, with *E. coli* Famp and CN13 hosts, respectively. *C. parvum* infectivity was assayed for infectious focus-formation in HCT-8 mammalian cell cultures and enumerated by immunofluorescent microscopy.

Results: An Initial PAA dose of 4000 mg/L gave greater than 4 log10 (99.99%) inactivation by 10 minutes in the hospital sewage and the fecal matrix for *E. coli*, *S. typhimurium*, *R. terrigena*, *C sporogenes* spores, and ΦX174 coliphage; for MS2 coliphage and *C. parvum* greater than 2 log10 (99%) inactivation was achieved by 10 minutes. PAA concentration x contact time (CT) values of 2960 and 16,939 min\*mg/L were reached at 10 minutes of exposure for 400 mg/L and 2000 mg/L initial PAA doses, respectively in hospital sewage. A CT value of 17,083 and 34,167 min\*mg/L was reached at 10 minutes for 2000 mg/L and 4000 mg/L initial PAA dose respectively in the fecal matrix. This research demonstrates that rapid and effective disinfection of highly infectious hospital waste is achieved by mixing 1% PAA (15% stock PAA concentration) by volume directly into the toilet or other container.

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 Relating Laboratory-Scale Dispersion Experiments to Full-Scale Field Data from Jack Rabbit II

30

Michael Pirhalla | U.S. Environmental Protection Agency

Urban areas create complex turbulence, dispersion, and flow patterns that affect downwind and ground level pollutant concentrations. The urban canopy also alters atmospheric boundary layer wind profiles due to wake turbulence generated from wind flow around buildings and within street canyons. This can result in challenging situations for local officials or emergency responders who must plan for or remediate infrastructure after major chemical, biological, or radiological (CBR) incidents. While many dispersion models can capture the downwind effects from buildings, some fall short in terms of accuracy or ease of use. As a result, field and laboratory tests are often employed to simulate releases and are critical in refining current dispersion models. This project leverages data from the Special Sonic Anemometer Study that occurred as part of the 2016 Jack Rabbit II (JRII) field study. JRII was conducted at Dugway Proving Ground (DPG), UT, where large releases of chlorine gas were dispersed within an array of 83 CONEX shipping containers of various sizes. The CONEXs were meant to mimic buildings within an urban area, with the goal of providing information to improve models and emergency response techniques. During the Special Sonic Anemometer Study, flow and turbulence around the obstacles were measured from a network of 30 sonic anemometers dispersed around the CONEX array. An upwind 32m sonic tower at the JRII test site was also analyzed for near neutral atmospheric conditions. A 1:50 scaled model of the JRII study area and neutrally buoyant boundary layer has been developed and tested within EPA’s Fluid Modeling Facility (FMF) Meteorological Wind Tunnel (MWT) to examine the complex flow and dispersion patterns within this scaled mock urban environment. Flow visualizations were conducted to observe the localized effects of the buildings, which also help to interpret quantitative data gathered within the wind tunnel lab. These data include wind velocity flow measurements collected through Laser Doppler Velocimetry (LDV), as well as neutrally-buoyant tracer concentrations that simulate ground-level and elevated releases. This presentation will discuss current and ongoing wind flow data analyses from the sonic anemometers and the scaled wind tunnel study, with an emphasis on microscale processes occurring between and in lee of buildings. The ultimate goal is to use the wind tunnel and field datasets to improve urban parameterizations in Gaussian dispersion models, which are important tools for efficient and precise emergency preparation and response applications.

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 Conceptual Development and Testing of a Chitosan/Graphene Oxide (CSGO) “Bandage” to Isolate and Remove Chemical Contamination from Surfaces

31

Jessie Pope | Mississippi State University

This study describes the conceptual development and testing of a protective “bandage” prepared of a composite chitosan/graphene oxide (CSGO) material that can be applied over surfaces to isolate contamination, such as that occurring from a chemical weapon attack. The bandage can be applied either as a wet dispersion or as a dry, preset membrane. Dry bandage application can be implemented by wetting the material with acetic acid and setting on the surface, or the bandage can be placed on the surface and acetic acid brushed over the bandage. The bandage isolates the contaminant by covering the contaminated area and preventing exposure, or by absorbing the contaminant into its structure. The bandage can then be removed, thereby, removing the contaminant. The efficacy of this approach was demonstrated with experiments on metal coupons using methylene blue as a simulant for a contaminant. Applications on government/military vehicles are also presented. The goal is to develop a means in which vehicles contaminated with chemical agents can be treated with minimal water and returned to service quickly without any spread of contamination or damage to the vehicle.

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 Temperature Controlled Radiological Decontamination

32

Nicolas Santiago | Argonne National Laboratory

For an effective recovery effort following a nuclear or radiological release event, there is need for an immediate response plan to reduce or eliminate contamination in a quick and efficient manner. The Integrated Wash Aid Treatment Emergency Reuse System (IWATERS) has been described at this conference and in the open literature. IWATERS uses water wash down techniques to quickly reduce contamination levels. To improve the efficacy of the wash down techniques. This study tested the effect of temperature the decontamination of urban materials.

The approach of this study was to use the IWATERS system to decontaminate Cs-137 from Concrete at 5°C, 20°C, 40°C, 60°C, and 90°C, in order to establish the most effective temperature. This study was performed primarily on concrete coupons and separated components of concrete. When separating the components of concrete, they were sifted into 2 measurements: coarse aggregate, which was anything above 2mm sieved out, and fine aggregate, which was anything between 710 µm to 2 mm. Studies have shown these sizes of aggregate most conducive to the sorption of Cs-137.

This study also used temperature control to establish the most effective means to clean concrete, in order to create a detailed explanation to how one would perform decontamination when on site. A static test was performed at the same temperature intervals was performed on concrete coupons, as well as a flow test. This study will inform on the best practices when decontaminating a concrete surface.

All studies were established following guidelines of realistic situations. Temperature were chosen to be minimum and maximum values that could realistically be chilled or heated to if necessary. Concrete coupons were made under the same guidance that one would use when creating a driveway or sidewalk. These precautions were made to eliminate as many unrealistic methods for emergency decontamination, so that results could be achievable in actual situations.

To that end, this study evaluates methods of decontamination to develop a clear and orderly approach to emergency radiological decontamination in urban environments, as well as establish a clear procedure to implement an effective plan.

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 Personnel Decontamination: Understanding the 90% Solution

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Emily Titus | AFIT

Chemical and biological attacks, while uncommon, are possible in the modern world. After a chemical mass casualty incident, decontamination of people, equipment, and the environment is critical in order to prevent deleterious effects and secondary contamination of first responders and bystanders. The first step in personnel decontamination is considered to be disrobing, which is stated to remove between 70-90% of contamination. This assumption of 90% removal is the basis for disaster response and decontamination guidelines throughout both the military and civilian sectors, although a scientific basis is lacking. Intuition suggests that this is likely a reasonable assumption, however there are many other factors which would affect this statistic. These include the population targeted, the characteristics of the chemical agent used, and the disrobing and decontamination procedures followed. If the target of an attack is a military group, then 90% may be much closer to the true removal than it would be for a civilian population. However, even if 90% removal is achieved, chemical warfare agents can cause significant injury or mortality at very low concentrations so 90% may not be sufficient to consider a person fully decontaminated. This research aims to establish a scientific basis for this assertion by quantifying whole body contamination of a mannequin before and after a decontamination procedure. In order to accomplish this goal, this work aims to translate the traditional research methods from small skin swatches to an entire mannequin. An aerosol chamber was built and characterized for this purpose. A mannequin clothed in JSLIST suit will be contaminated inside this chamber. The contaminant used will contain an ultraviolet fluorescent tracer. The mannequin will be photographed under UV light before and after disrobing or other decontamination procedures and these images will be analyzed to quantify the percent of body surface area contaminated. This research aims to develop a new decontamination research methodology as well as validate the 90% solution.

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