U.S. ENVIRONMENTAL PROTECTION AGENCY

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Plenary Talk 1 - Partnering for a Safer Tomorrow

Nitin Natarajan, Deputy Director for Cybersecurity and Infrastructure Security Agency | *Department of Homeland Security*

CISA’s Deputy Director, Nitin Natarajan, will discuss how CISA collaborates with the EPA to further both agencies’ missions, including how this partnership has strengthened our joint efforts to prevent future chemical-related disasters. Together with their partners within the scientific, research, governmental, and private stakeholder communities, this platform provides each area of expertise an opportunity to explore the challenges faced by regions, states, and local governments in responding to natural, accidental, or deliberate incidents to our nation’s infrastructure.

Lunch and Learn: Student Networking Session & Panel Discussion

Jonathan Essoka, Superfund & Technology Liaison, Region 3 | *U.S. Environmental Protection Agency*

Bray Fisher, Federal On-scene Coordinator, Region 6 | *U.S. Environmental Protection Agency*

Joi Chu-Ketterer, Oak Ridge Institute for Science and Education (ORISE) Fellow | *U.S. Environmental Protection Agency*

Marissa Lynch, Environmental Engineer | *U.S. Environmental Protection Agency*

Moderator: Anna Boegehold, ORAU Participant | *U.S. Environmental Protection Agency*

CONCURRENT SESSION 1 – DECISION SUPPORT

An AI Algorithm to Locate Waterborne Chemical Attacks in Water Distribution Systems

Ehsan Roshani | *National Research Council of Canada*

In the aftermath of the 9/11 terrorist attack, the possibility of non-state actors using the water distribution system (WDS) as a means to kill and terrorize civilian population received increased attention. Although water distribution systems were recognized as potentially vulnerable, most professionals perceived the risk as low because to be effective a chemical or biological agent had to be a. weaponized and produced in sufficient quantities, b. appropriate for water dissemination, c. infectious/virulent/toxic, d. effective over hours or days and e. resilient to water treatment. These five barriers may have been lowered with the introduction of super poisons, such as carfentanil. If these poisons are introduced into the WDS, it is imperative to understand the nature of the substance as well as identify the location(s) at which it was introduced. The most effective means to locate chemical intrusion are sensors that are placed in multiple locations throughout the WDS and are capable of real-time identification of the substance (i.e., active measures). Currently however, such sensors do not exist. Our approach suggest a “softer” methods that relies on using Artificial Intelligence (AI) to passively monitor events happening after chemical attack and use this information to locate point(s) of intrusion. It is reasonable to expect that a relevant event will trigger a wave of 911 calls, hospital reports, and other sources of potentially useful data. These data can be analysed in real time and used to discern useful knowledge about symptoms, locations, speed of spread, etc.

The proposed approach uses hydraulic and water quality simulation outcomes to mimic 911 calls’ location and timestamp, then creates a virtual map of contaminated area which is used to train an Artificial Intelligence algorithm. Our preliminary results indicate that the proposed approach is capable of locating the source point with 93% accuracy in a system containing 10,000 nodes.

Transparent Machine Learning for Disaster Damage Assessment using Earth Observation

Thomas Chen | *Academy for Mathematics, Science, and Engineering*

Natural disasters ravage the world's cities, valleys, and shores on a monthly basis. They cause the tragic loss of lives and economic loss, in addition to the contamination of buildings. Having precise and efficient mechanisms for assessing infrastructure damage is essential to channel resources and minimize the loss of life. Using a dataset that includes labeled pre- and post- disaster satellite imagery, the xBD dataset, we train multiple convolutional neural networks to assess building damage on a per-building basis. In order to investigate how to best classify building damage, we present a highly interpretable deep-learning methodology that seeks to explicitly convey the most useful information required to train an accurate classification model. We also delve into which loss functions best optimize these models. Our findings include that ordinal-cross entropy loss is the most optimal loss function to use and that including the type of disaster that caused the damage in combination with a pre- and post-disaster image best predicts the level of damage caused. The highest accuracy percentage on the testing set that we achieve is 74.6%; the non-optimal nature of this is largely attributed to the limited discernibility between the major and minor damage categories. We also make progress in the realm of qualitative representations of which parts of the images that the model is using to predict damage levels, through gradient class-activation maps. Our research seeks to computationally contribute to aiding in this ongoing and growing humanitarian crisis, heightened by climate change. Specifically, it advances more interpretable machine learning models, which were lacking in previous literature.

The Wide Area Decontamination Tool

Emily Peraza | *Battelle Memorial Institute*

There are many types of emergencies and disasters that threaten the stability of society. Among the most serious are biological incidents, for which government agencies have a specific interest in developing mitigation strategies. A methodology was developed to simulate the cost and time associated with the decontamination of wide-area indoor, outdoor, and underground biological incidents. This methodology has flexible definition of scenarios, configurable settings for various key parameters in the response such as decontamination efficacy and considers a wide range of potential decontamination strategies that could be employed. The methodology was incorporated into a software application, the Wide Area Decontamination Tool (WADT), allowing users to construct simulations and view results.

The WADT methodology is driven by a series of equations developed to characterize the cost and time associated with each step of the decontamination process, including: 1) the preliminary sampling of surfaces to define initial contaminant levels, 2) removal of waste from the site area to decrease the cost of decontamination, 3) the treatment of surfaces to remove contaminant, 4) the subsequent sampling of surfaces to determine the effectiveness of treatment, and 5) the sampling of waste materials to determine proper disposal procedures. The decontamination portion of the WADT methodology includes a series of equations and distributions developed to estimate the effectiveness of a decontamination treatment on a specific surface type, known as the Efficacy Model. The Efficacy Model was informed by an in-depth evaluation of decontamination treatment data compiled following an extensive literature search on the effectiveness of a number of decontamination treatment methods on various surface types. This evaluation consisted of two

rigorous statistical analyses resulting in multiple distributions from which an efficacy value can be estimated based on the specific decontamination method and surface type combination chosen. This model allows the tool to simulate decontamination in a more realistic way by enabling surfaces that may require multiple treatments to be fully decontaminated.

The WADT allows users to define parameters driving the methodology in terms of uncertainty. Using these uncertainty inputs, the tool provides users the ability to quickly simulate thousands of potential scenarios and identify the distribution of possible cost and time outcomes from the defined uncertainty in the scenario. The application provides the capability to analyze highly uncertain scenarios and determine the most effective mitigation and operationalization strategies in response to wide area biological contamination events.

Clean or Replace? Decontamination Framework for Firefighting Equipment and Hangers

Matthew Magnuson | *U.S. Environmental Protection Agency*

Introduction: Many aqueous film forming foam (AFFF) delivery systems in aircraft hangars and firefighting vehicles may require thorough cleaning to avoid ongoing environmental impacts from residual per- and polyfluoroalkyl substances (PFAS) within those systems. Though replacement AFFF formulations are being introduced, existing residuals and legacy contamination within these AFFF delivery systems are likely to continue to discharge PFAS. Anecdotal and vendor supplied cleaning methods exist, but it is unclear whether they are effective for the ultra-trace levels of concern. Thus, current operational parameters may need to be adjusted to meet the challenges presented by PFAS. Currently, no framework is available for evaluating the cost and environmental impact of cleanup compared to the costs of replacing components and systems.

https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER20-5361

Benefits: The primary goal of this project is to provide data and information to refine existing cleanup guidance for firefighting systems, specifically hangar systems and Aircraft Rescue and Firefighting (ARFF) vehicles impacted by PFAS. The expected overall benefit of this project is the development of a standardized cleanup framework based on a toolbox of options utilized across the DoD and civilian aviation firefighting community which could potentially lead to substantial cost savings.

Key aspects: (1) A project advisory workgroup consisting of experts from both the relevant DoD and civilian communities. The workgroup provides expertise and helps focus the project on its most beneficial endpoints; (2) Cleaning approaches, optimized for waste minimization by modeling the hydraulics of piping systems and the sorptive behaviors of PFAS to the firefighting systems. The developed modeling approach allows results to be extended to a multitude of systems in existence of varying ages, resulting in site- and vehicle-specific decontamination challenges; and (3) Sampling protocols designed to verify efficacy and avoid false assurance of cleanliness. These protocols address challenges caused by unique properties of persistent, ultra-trace contaminants such as PFAS.

ClearDecon: A Novel Surface Decontamination Solution for Chemical and Biological Warfare Agents

Joseph Myers | *Combat Capabilities Development Command, Chemical Biological Center*

Funded by the Defense Threat Reduction Agency (DTRA), a novel decontamination solution, called ClearDecon, has been developed for hardened surfaces through a collaborative effort between U.S. Army Combat Capabilities Development Command Chemical Biological Center (DEVCOM CBC) and Clear Scientific (Cambridge, MA). The formulation is a paint-like substance which readily adheres to vertical surfaces and can be applied through a variety of commercial off the shelf (COTS) paint sprayers. The formulation contains two complimentary reactive chemistries, which provide high levels of efficacy against several types of contaminants, such as sulfur mustard, Soman, VX, carfentanil, and biological spores, such as B. A. Sterne, in a single formulation. The formulation also contains a proprietary solvent blend which promotes the extraction of contaminants from sorptive materials, so that the reactive species can access and detoxify absorbed contamination. The reactive components have been shown to rapidly detoxify contaminants without producing toxic by-products. Application of the formulation for a little as 30 min produces a 10x reduction in both contact transfer and vapor emission measurements and a 4 h application produces a 1000x reduction in remaining contaminant measurements in small scale panel studies. After decontamination, the formulation can be simply rinsed away with water.

Dahlgren Decon Skin Soap, Development and Testing of a Safe Skin and Surface Decontamination Soap

Cory Collings | *First Line Technology*

Dahlgren Decon is established as a broad-spectrum, low-volume decontaminant which shows good reactivity and efficacy against a broad array of Chemical and Biological Warfare Agents, however is excessive for many common hazardous materials. A multi-phase research and development effort funded by the Irregular Warfare Technical Support Directorate (formerly Combatting Terrorism Technical Support Office)* examined a reformulated and diluted version of the Dahlgren Decon chemistry known as Dahlgren Decon Skin Soap (DDSS). This formulation seeks to provide a decontamination solution for use on a variety of common hazardous threat materials on all surfaces to include human skin. Hazardous materials of concern were chosen for testing by a stakeholder committee of military, federal, state and local agency representatives. These include ten Toxic Industrial Chemicals (TICs), each representing broader classes of hazardous materials, *Bacillus anthracis*, causal agent of anthrax, spores. While not included in the original planning, in response to the COVID-19 pandemic efficacy against SARS-CoV-2 was added as an additional test.

DDSS was evaluated against TICs by MRIGlobal in a stirred reactor at application rates of 1:10 and 1:50 target chemical to active decontaminant. DDSS showed activity against six of ten target chemicals at the 1:10 ratio, and showed activity against all targets at 1:50 ratio, reducing seven of ten by 95% or greater in 50 minutes or

less. Work also done by MRIGlobal demonstrated 99.99% efficacy on SARS-CoV-2 virus on stainless steel coupons with a one-minute contact time.

DDSS was evaluated by Naval Surface Warfare Center, Dahlgren Division against *B. anthracis* spores. The testing was conducted in accordance with ASTM E3178, a standard developed at NSWC Dahlgren for the purpose of testing advanced decontaminants against bacterial endospores like *B. anthracis*. Results showed DDSS yielded complete spore inactivation of ≥7 log10 of *B. anthracis* ΔSterne spores from all test coupons treated with DDSS at room temperature for a five-minute contact time.

The DDSS formula shows promise as an effective decontaminant which is also non-toxic, non-hazardous, non-corrosive, and environmentally friendly. Additional Phase 2 studies are ongoing which examine efficacy against emerging biological threats, toxicity, and skin efficacy.

*Financial support by IWTSD does not constitute an express or implied endorsement of the results or conclusions of the project by either IWTSD or the Department of Defense.

Inactivation of *Bacillus anthracis* Spores on Surfaces with Ultraviolet Light Produced with a Low-Pressure Mercury Lamp or Light Emitting Diode Lamp

Joseph Wood | *U.S. Environmental Protection Agency*

The U.S. Environmental Protection Agency's (EPA's) Homeland Security Strategic Research Action Plan (2019-2022) was developed to advance EPA's capabilities to recover from a wide-area contamination incident, such as from a biological agent release. The study and results summarized in this presentation help to fulfill that objective. Ultraviolet light in the C range, generated from either low-pressure mercury lamps or light emitting diodes, was evaluated for its efficacy in inactivating *Bacillus anthracis* (Ames) spores on several indoor types of materials. The study included *Bacillus atrophaeus* to confirm its use as a surrogate and evaluated two techniques for spore inoculation onto the materials (liquid vs. aerosol). Decontamination efficacy was nominally determined by comparing spore recoveries from the test and control materials. Efficacy varied by material and UVC dosage, and up to 5.7 log reduction was demonstrated. There was no statistical difference in efficacy between the two species or between inoculation methods. Efficacy improved for the LED lamp at lower relative humidity, but this effect was not observed with the mercury vapor lamp.

Outdoor Systems Trial Using Full-Scale Agricultural Equipment for Wide Area Decontamination of *Bacillus anthracis* Surrogate Spores

Ehsan Gazi | *Defence Science and Technology Laboratory, Salisbury, U.K.*

"*Bacillus anthracis* (*B. anthracis*) is widely regarded as an important biological warfare agent of both civilian and military concern. The attribute that sets it apart from other pathogenic micro-organisms is its ability to form highly resistant spores, which increases its environmental persistence and resistance to decontamination procedures. The only previous attempt to decontaminate open land contaminated with *B. anthracis* was at Gruinard Island, where 500,000 L per ha of formaldehyde (5% – 37 % v/v) was used [1]. However, such an

approach would pose significant logistic, technical and economic challenges if it was to be employed for the recovery of civil or military sites [2].

We intended to solve these challenges by developing a rapid and practical decontamination system for the operational recovery of contaminated installations using less than 3000 L/ha of decontaminant. To achieve this goal we exploited state-of-the-art spray application technologies and formulation chemistry used in the agricultural industry, spore germination techniques and a novel decontaminant based on the targeted release of chlorine dioxide. Spores of B. thuringiensis HD-1 cry- were employed as a surrogate for virulent *B. anthracis*. However, key performance attributes were validated against a range of virulent *B. anthracis*.

Preferred formulations for decontamination were developed through laboratory, environmental chamber, wind-tunnel and finally full-scale outdoor trials. During outdoor trials we achieved all essential success criteria on all surface types (4-Log10 reduction on wood, steel and cement). Results using steel surfaces approached that required for desirable performance (6-Log10 reduction). Significant loss of spore viability was found by environmental exposure alone (up to 3-Log10 over 72 h). However, active decontamination was more effective (up to a further 3.6-Log10 reduction in viable spores). Pre-germination before decontamination with chlorine dioxide was not found to have a benefit.

References

[1] Manchee RJ, Broster MG, Stagg AJ, Hibbs SE. Appl Environ Microbiol 1994; 60:4167–4171.
[2] Canter, D. A. Chem. Health Safety 2005; 12:13-19.

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POSTER SESSION

1 A Film-forming, Biocidal Strippable Coating for Subway Car Biocontaminant Mitigation

Kevin Beltis | *TIAX LLC*

"Railway/Subway cars present a particularly unusual scenario for bio-decontamination due to their complexity of construction and, given their function for mass transport, for the unpredictable potential to affect nearby resources. TIAX has developed a liquid spray-applied coating that forms a strippable film to encapsulate both liquid and particulate hazards. Upon curing the film is readily removed for disposal. For a US EPA-Office of Homeland Security project, we focused on an adaptation incorporating a quaternary ammonium compound (Quat) as an active biocide to address the scenario of a powdered biological threat settling onto subway car interior surfaces.

This spray-on system can mitigate contaminant exposure by immediate encapsulation, preventing cross-contamination and minimizing the quantity of hazardous waste generated. Incorporating a Quat into the coating provides permanent encapsulation with excellent biocidal activity. The removal technique provides for rolling

the contaminant inward as it is stripped from the surface. This results in the contaminant being sequestered within the solid, rolled material, ready for disposal without special handling.

The subject study used replicate evaluation of 1-mg quantities of benign, powdered bacilli onto 25-cm2 area test coupons from subway cars corresponding to 8x107 CFU/m2 inoculant. Bacillus thuringiensis and Bacillus atrophaeus were used as surrogate inoculants against several non-porous surfaces found in subway cars. The technique demonstrated the following benefits:

- 97% removal efficacy with 2+ log kill of powdered, aerosol-deposited bacilli
- No secondary containment required ahead of treatment (i.e., no enclosure of contaminated equipment)
- Minimum manpower: one or two technicians for coating application and subsequent removal
- Minimal outside logistical support (no special tools, electrical, external water supply, etc.)
- Reduced risk to the hazmat responders, public and environment by immediate encapsulation of the hazard
- No water washdown, no ground containment devices (e.g., booms - especially difficult for railcars)
- Encapsulation allows time for subsequent, more complete action planning (e.g., either complete treatment in place or move the hazard to a better location for further remediation)
- Application uses inexpensive, commercially available, battery-operated, hand-held paint sprayer
- Treatment materials are non-toxic, and environmentally safe
- Highly compatible with all non-porous materials of construction
- Minimal solid waste generated for a 60-ft subway car is approximately 15-25 kg, no liquid waste
- Produced a one-year shelf-stable formulation with 2-log biohazard reduction (removal + kill)
- Formulations capable of 5-log biohazard reduction possible, but result in shorter shelf life".

2 Decontamination of Triclosan, but at Cost of Increase in Antibiotic Resistant Genes?

Vrinda Sharma, student | *Cornell University*

Triclosan is a broad-spectrum antimicrobial agent with wide applications including household, drug and personal care products. Despite the recent ban by FDA in over-the-counter personal care products, triclosan is a persistent contaminant in the environment especially soil and wastewater. We recently found that triclosan enriched for the 16S rRNA genes of Stenotrophomonas populations in soil. Based on these results, a follow-up study Stenotrophomonas in soil spiked with triclosan concentrations were enumerated on selective media (VIA). The addition of 100ppm triclosan to soil led to a 200-fold increase in Stenotrophomonas. Sequencing of the 16s rRNA genes of isolates confirmed that 21 out of 22 were Stenotrophomonas species which are known for their antibiotic resistance. This suggests that while native Stenotrophomonas can decontaminate triclosan in soil, this appears to incur an increase in the pool of antibiotic resistant genes (ARGs) which poses harm to human health.

3 Development of a Chemical Wide Area Decontaminant

Neil Hawbaker | *Combat Capabilities Development Command, Chemical Biological Center*

Release of a chemical warfare agent, either accidental or deliberate, is a deadly, tragic, and chaotic event. Contamination of a key points of infrastructure, including airports and seaports, can hinder life-saving response by medical and military personnel and can slow evacuation efforts. This program aims to develop a rapid, cost effective way of decontaminating large scale infrastructure and minimize the risk for vehicles and personnel which must traverse through a contaminated area. Use of traditional decontaminants is not feasible for wide area applications due to cost, preparation, storage, and efficacy limitations associated with scale up. This work explored the use of reactive formulations based on widely available commodity chemicals for direct remediation and the use of chemically used agricultural and construction polymers for encapsulation of the contaminant. A large variety of reactive chemicals were screened for their ability to remove CWAs from concrete and asphalt surfaces. The best performers were then downselected based on logistics considerations, including price, environmental impact, health and safety, scalability, and material compatibility. Of these chemicals, peroxysulfate oxidants provided the best profile of efficacy and logistics over other chlorinated oxidants and caustic bases. Current efforts focus on refining and evaluating a formulation based on these underlying chemistries. Barrier polymers for encapsulation have been studied and evaluated by testing the reduction in the contact (dermal) hazard and vapor (inhalation) hazard. Polymers such as bitumen sealcoats, acrylic soil stabilizers and methyl cellulose stockpile sealant proved to be moderately effective at encapsulation of contaminated concrete and asphalt. Both encapsulation and direct remediation are being further explore as options for chemical wide area decontamination. This technology aims to fit an unfilled need and enable first responders, victims and military personnel to more safely operate in a contaminated environment. Approved for public release: distribution unlimited.

4 Mitigating Cytotoxicity for Anti-Viral Disinfection Studies

Sarah Nelson | *Battelle Memorial Institute*

Determining effectiveness of new and commercially available disinfectants against SARS-CoV-2 requires the ability to quantify recovered infectious virus in cell culture assays (TCID50). However, the active ingredients in disinfectants are often inherently cytotoxic to mammalian cells in culture. One method of mitigating cytotoxicity is by diluting the sample prior to testing; however, this reduces the dynamic range within which product efficacy can be evaluated. Preserving a window of at least 3-log10 can be challenging for viruses such as SARS-CoV-2 which may have low titer due to loss from drying during testing or from extraction procedures. Several different methods were assessed to mitigate cytotoxicity induced by chemical products, with the intent of preserving a 3-log10 window for efficacy testing against SARS-CoV-2 (or Murine Hepatitis Virus [MHV-A59] as a surrogate coronavirus). Chemical products included in this study included quaternary ammonium compounds (QACs), oxide-based disinfectants, detergents, and household bleach prepared according to manufacturer specifications. The neutralization methods explored in this study included adding Letheen or Dey-Engley neutralizing broth to extraction media, Sephadex G-25 column filtration, increasing surface area to volume ratio with 48-well TCID50 assays, media replacement, and dilution. After neutralization, extracts were plated onto either L2 or Vero cells and incubated for 2 or 5 days, respectively, at 37°C, 5% CO2. Cytotoxicity was quantified by lactate dehydrogenase (LDH) release using a commercial kit. An average LDH release of <10%

per well indicated successful chemical neutralization. For 48-well plate assays, MHV was adsorbed for 2 hours at room temperature, while SARS-CoV-2 was adsorbed for 30 minutes at 37°C; fresh media was added post-adsorption to dilute cytotoxic components while maintaining viral titer. Sephadex filtration in combination with a 48-well TCID50 assay was successful at neutralizing several QACs, detergents, and bleach solution. Oxide-based disinfectants and QACs containing >0.5% 3-(trihydroxysilyl) propyldimethyloctadecyl ammonium chloride remained cytotoxic to cells without at least a 1:10 sample dilution. Overall, Sephadex filtration combined with a 48-well TCID50 assay format with media addition was the best option to mitigate cytotoxicity and evaluate the effectiveness of disinfectants against MHV and SARS-CoV-2.

5 Evaluation of Street Sweeper Spray Systems for Effective Decontamination of Fixed and Loose Radioactive Contaminations

Michael Kaminski | *Argonne National Laboratory*

"Wide-area contamination of paved surfaces could challenge our ability to conduct evacuations or remediate for long-term restoration. Methods for decontaminating paved surfaces proposed or practiced in field trials or following actual release events include fire-hosing, pressure washing, surfacing removal, and surface stabilization. Engaging common equipment and familiar operations that are designed for roadways would expedite decontamination activities. Street sweepers generate minimal amounts of wastewater and can cover long expanses of road if their operations can be proven effective. To this end, this study partnered with a world-wide supplier of street sweepers to mimic the operation of their sweeper at the laboratory scale in order to study its capabilities and evaluate its efficacy against contaminated dust and dissolved forms of radioactive contamination. Although the study focused on radioactive contamination, the results might also be informative when street sweeping particulate forms of chemical and biological contaminants or contaminants that have similar interaction with the paved surface.

Concrete (Quikrete® standard 27.5 MPa concrete mix, Atlanta, GA, USA) and asphalt coupons (Hanover Architectural Products, Hanover, Pennsylvania, USA) were contaminated with Cesium (Cs)-137 solution, 0.5 µm silica particles labeled with Gadolinium (Gd)-153, and 2 µm silica particles labeled with Europium (Eu)-152 (prepared in-house with a technique reported previously to tag uniform silica microspheres) and monitored by gamma-ray spectroscopy (Maestro Ortec HPGe Detector). Using an in-house, automated spray chamber, the system was set to operate at street sweeper pressures and volumetric rates. It was equipped with the spray nozzle (SN 4004, 40°angle fan-spray pattern and orifice size of 4.0) and programmed to pass tap water or sodium dodecyl sulfate (SDS) over each coupon with the pressure systematically varied from 60 psi (410 kPa) to 135 psi (930 kPa) in successive tests. Additional tests included a second decontamination of coupons with tap water, adding the larger particles before the smaller particles during contamination, and using a dry or wet wipe for contaminant removal.

Results from concrete samples show that increasing pressure increases the removal of both Gd-153 and Eu-152 particles. The removal of 2 µm Eu-152 particles was greater (about 90% removal for all pressures and decontaminants) than the removal of 0.5 µm Gd-153 particles for all pressures. Interestingly, the removal was

higher with tap water than with SDS. Expectedly, the removal of Cs-137 was less encouraging with tap water at both 100 psi and 135 psi.

Several formulations of asphalt samples showed greater removal of larger 2 µm Eu-152 particles than the smaller 0.5 µm Gd-153 particles when using tap water at 100 psi. The removal of Cs-137 was greater in smooth samples coated with a thin layer of liquid asphalt, as opposed to asphalt having an abundance of aggregate revealed.

When comparing decontamination results of asphalt and concrete using tap water at 100 psi, the removal of both 0.5 µm Gd-153 and 2 µm Eu-152 particles was greater in concrete than asphalt. However, Cs-137 removal was greatest in the smooth asphalt sample rather than concrete."

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6 The WASP 2.0: A Water Assessment and Sustainability Purification and Decontamination System Designed for the Temperate and Sub-Arctic Environments

Clint Smith | *U.S. Army Engineer Research and Development Center*

The world's ultimate weapon, the Warfighter, runs on water; everything else runs on fuel (Balling, 2009). The Water Assessment and Sustainment Purification (WASP) 2.0 system will provide backup water generation and bleach generation for decontamination on DoD installations to produce potable water in times of need to meet 14-day sustainment periods and extreme cold temperatures. The system provides a mobile water production and decontamination system that provides 10-gallons per minute (gpm) of potable water for contingency operations, disaster response, training, and austere water supply with a focus on temperate and sub-arctic environments. Realizing this vision is essential and driven by policy such as the Assistant Secretary of the Army Installation Energy and Environment (ASA(IE&E)) 2025 strategy and the Army Energy and Water Security Planning goals outlined in Army Directive 2020-03, Installation Energy and Water Security Policy. The WASP 2.0 will help to circumvent the use of appropriated fund requests for bottled water in all environments thereby reducing waste build up. DoD installations must provide water security for 14-day sustainment periods when water supply infrastructure fails. The small form factor system is planned to undergo ruggedization and safety confirmation for use. The WASP 2.0 has two major components, one designed for the Environmental Protection Agency (EPA) Office of Research and Development-Center for Environmental Solution and Emergency Response Programs; and the second designed by the ERDC's Geospatial Research Laboratory, the WASP 1.0 system. The EPA licensed their technology with the Waterstep Organization. The WASP 1.0 was successfully demonstrated with the Navy's Naval Information Systems Warfare Command (NAVWAR) and licensed to Newcomer Arms LLC. Through an interagency agreement, memorandum of understanding, and past collaborative work on water production and monitoring systems, EPA and ERDC are planning to collaborate to deliver the WASP 2.0 system to Army Installations for water security and potentially other Civil Works decontamination applications.

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7 Monitoring Storm Water Flow via VIPER

Joshua Steenbock | *U.S. Environmental Protection Agency*

The continued development of real time stormwater monitoring has allowed for faster response as well as better containment and mitigation efforts concerning potential contamination events. The purpose of this experiment is to develop a system of deployable sensor stations that will remotely record various water quality parameters and report these values back to a central server. All data collected was transmitted to the EPA's data collection and viewing service, known as VIPER. After each rain event the sensor stations will be monitored and evaluated for their accuracy as part of a larger coastal resiliency project. The instruments used include an ISCO autosampler, soil moisture probes, a Parsivel weather sensor, and water velocity, and depth sensors. Each set of sensors were set out at sites chosen for their ability to produce large amounts of runoff during rain events. The sample locations included a telemetry unit that served as a data-logger, communications hub, and power source for the sensor groups. The telemetry units contain a teensy microcontroller and a cellular modem that allow for wireless connection back to the VIPER server. Readings were programmed to report back every five minutes allowing VIPER to create real time graphs of each data point. The ISCO samplers were programmed to accept SMS commands in order to remotely control sampling interval as well as allow for any potential remote troubleshooting. Researchers would use said commands to trigger the ISCO to take samples as often as needed per rain event. Utilizing the EPA's data collection and online interface, VIPER, we were able to successfully monitor and record samples remotely during rain events in Elizabeth City, NC. The presentation will not only summarize the setup and deployment of the sensors, but describe the use of telemetry using VIPER, which will be helpful for ORD users.

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8 The Influence of Exposure Duration and Dwell Time on the Skin Decontamination Effectiveness of Particulate Zirconium Hydroxide

Nevine Amer | *Toxicology Research Group, University of Hertfordshire*

"It is a long-established fact that the efficacy of decontamination is inversely proportional to the duration of exposure, hence all evidence-based guidance emphasises the importance of rapid decontamination (e.g., [1]). However, the influence of the duration of decontamination has not been thoroughly investigated. Here, we report the effect of product dwell time on the decontamination efficiency of zirconium hydroxide (Zr(OH)4) as a function of exposure duration (time post contamination).

The study was performed using bespoke, OECD-compliant diffusion cells [2] containing dermatomed porcine skin. Droplets of radiolabelled chemical warfare agent simulants (diethyl malonate; DEM), methyl salicylate (MES) or phorate (PHR) were applied to the skin. The simulants were left on the skin ("exposure duration") for 2 or 60 minutes. Within each exposure duration, decontamination was performed by the application of Zr(OH4)

particles for 0.5, 2 or 8 minutes ('decontaminant dwell time'; TD). At the end of each experiment, a full dose distribution was performed by calibrated radiometric analysis.

For short exposures (2 min), there was a linear correlation between decontamination efficiency and TD for all three simulants, equating to ~ 1%/min TD. Consequently, overall decontamination increased from ~90% (TD = 0.5 min) to ~98% (TD = 8 min), indicating a reasonable TD-associated enhancement in performance.

At the longer exposure duration (60 min), a dwell time effect was not observed for the more volatile simulants DEM and MES. However, the overall performance for PHR (a non-volatile simulant) increased from 84% (TD = 0.5 min) to 99% (TD = 8 min), representing ~ 2%/min TD increase in decontamination efficiency.

These data suggest that the duration of contact between a decontaminant product and contaminated skin represents an additional, significant factor which may affect the clinical outcome of personal decontamination, particularly following delayed treatment.

This project was funded by the US Army Research Office under agreement number W911NF1920248.

[1] Chilcott, R.P., J. Larner, and H. Matar, Primary Response Incident Scene Management: PRISM Guidance. 2nd ed. 2018, Washington DC Office of the Assistant Secretary for Preparedness and Response, Biomedical Advanced Research and Development Authority.

[2] Matar, H., et al., Design and characterisation of a novel in vitro skin diffusion cell system for assessing mass casualty decontamination systems. Toxicol In Vitro, 2014. 28(4): p. 492-501.

9 Development of Methods and Comparative Analysis of NGA compound by GCMS-TOF and UPLCMSMS

Tom Fowler | *CSS/U.S. Environmental Protection Agency*

"Objective: The purpose of this study was to develop methods for the analysis of Novichoks (A-230/232/234) using GC-TOF Mass Spectrometry (GCTOFMS) and UPLCMSMS. The goal was to develop methods that are amenable to rapid turn-around-times while preserving data quality. In addition, a comparison between GCMS-TOF and UPLCMSMS preparation times, analysis times, and reporting limits is explored.

Significance: One aspect PHILIS's mission is to provide the EPA with legally defensible data in a rapid turn-around-time environment. The procedures developed for GCMSTOF and UPLCMSMS allow for the detection of Novichoks, in the low picogram/ femtogram range respectively. Preparation and analysis times are relatively short and preparation is performed via microextraction.

Experimental Procedures and equipment used: Equipment used: LECO Pegasus BT and Thermo ALTIS UPLC triple Quad. Wipe samples were prepared for both methods by extracting wipes with MeCl2 (GCMSTOF) or Water (UPLCMSMS). The extraction was performed using a shaker table (15 min.) with concentration for GCMS-TOF and dilution for UPLCMSMS.

Results Obtained: The results range from low ng/wipe for GCMS-TOF to low pg/wipe for UPLCMSMS. Sample preparation via UPLC is significantly less time consuming than for GCMS-TOF (30 min. total/ 1.5 hours total),

because UPLC does not require concentration during prep. Reporting Limits are approximately100x lower via UPLC.

Conclusions: Both UPLC and GCMS-TOF methods are viable quick turn methods capable of producing legally defensible data. UPLC affords quicker prep times and significantly lower reporting limits."

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10 Safety Profiling of a Candidate Decontamination Product: Assessing the Dermal Absorption of Particulate Zirconium Hydroxide through Dry and Sweat-Covered Skin

Andreia Pinhal | *Toxicology Research Group, University of Hertfordshire*

"Following operational deployment, residues of personal decontamination product may persist on exposed human skin surfaces and thus represent a potential hazard due to the inherent toxicity of the decontamination product and/or as a potential vehicle for the constitutive transdermal delivery of contaminants such as chemical warfare agents.

As part of a safety profiling exercise, the dermal absorption of a candidate decontamination product (particulate zirconium hydroxide; Zr(OH)4) was compared against FAST-ACT® and A-200 (derived from a M295 personal decontamination kit). The study was performed in accordance OECD guidelines [1] using excised porcine skin under normal (dry) and sweat-covered conditions. The rationale for using artificial sweat was to mimic conditions reported to enhance metal particle absorption through skin [2, 3]. The products (applied as a 90 mg bolus over a skin surface of 1.77 cm^2) were retained on the skin for 24 hours, after which a full dose distribution was performed using ICP-OES to quantify residual zirconium, aluminium and magnesium as surrogates for Zr(OH)4, FAST-ACT® and A-200, respectively.

Penetration of the three test items into the receptor chamber fluid bathing the excised skin under both experimental conditions was below the limit of detection (<10-9 % of the applied dose). Under dry conditions, the vast majority (>99%) of all three decontamination products were recovered from the skin surface. When applied to sweat-covered skin, there was an increase in all three test products recovered from the epidermis and superficial dermal tissue. However, this equated to <0.05 % of the applied dose.

These data indicate that particles of zirconium hydroxide do not penetrate the skin. The marginal enhancement in recovery of all three decontamination products detected in the skin tissue under sweaty conditions are likely due to the dissolution of metal ions from within each formulation. Overall, there is a high probability that the test item (Zr(OH)4) will not pose an additional hazard under anticipated conditions of use. However, further work is required to identify more effective methods to optimise removal of decontamination products after use to fully eliminate potential adverse effects.

This project was funded by the US Army Research Office under agreement number W911NF1920248.

[1] OECD, Test No. 428: Skin Absorption: In Vitro Method. 2004.
[2] Midander, K., et al., Testing in artificial sweat–is less more? Comparison of metal release in two different artificial sweat solutions. Regulatory Toxicology and Pharmacology, 2016. 81: p. 381-386.
[3] Sartorelli, P., L. Montomoli, and A.G. Sisinni, Percutaneous penetration of metals and their effects on skin. Prevent Res, 2012. 2(2): p. 158-164."

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11 Evaluation of Temporary Coatings to Alter Agent Resistivity of Polyurethane Coated Materials

Janlyn Eikenberg | *Combat Capabilities Development Command, Chemical Biological Center*

"Military polyurethane-based coatings are designed to adhere to several different requirements, ranging from camouflage to agent resistivity. The ability to increase the agent resistivity of these polyurethane coatings without drastically altering the other required characteristics is greatly desired by the Department of Defense. A temporary coating that can be applied over the base polyurethane to increase the agent resistivity would allow for the reduction in Mission Oriented Protective Posture (MOPP) as well as reduce the logistical burden of in-field decontamination efforts.

Vendors from across academia, industry, and US government laboratories supplied over 40 temporary overcoat candidates for evaluation of agent resistivity and other characteristics. The supplied coatings cover a wide range of chemistries including, omniphobic and anti-corrosion technologies, which may improve the agent resistance of the coated asset. Temporary coating candidates were also evaluated for gloss, IR reflectance, and other anti-corrosion properties. Initial results for each temporary overcoat display a range in agent resistance across multiple chemical warfare contaminants (sulfur mustard, Soman, and VX). Agent resistance increased between 8 and 379x compared to a polyurethane reference coating.

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12 Improved Assessment of Skin Decontaminants: Development and Validation of a Robotic System for the Accurate and Reproducible Dermal Application of Candidate Products

Devanya Mahalingam, student | *Toxicology Research Group, University of Hertfordshire*

"The skin presents a complex surface structure for effective decontamination. For example, ridges, sulci and hair follicles can present physical challenges which may affect the effectiveness of decontamination procedures [1]. However, there are very few studies comparing different decontamination techniques. Moreover, previous studies rely on the manual application of decontamination products (for example, blotting and rubbing [2]). This reliance on manual application will necessarily lead to variability in measured decontamination efficacy due to differences in applied pressure, application time, consistency of technique, area of application, etc. Therefore, the purpose of this study was to develop and validate an automated system for the accurate and reproducible application of decontamination products to excised skin.

A robotic arm was purchased with a reported accuracy and precision of ± 1.0 mm and ± 0.5 mm, respectively. An effector piece was 3D printed in-house to connect a decontamination product (M295 mitt) to the robotic arm. The system's downward pressure and 2-dimensional vector coordinates on sections of excised porcine skin (20cm2 diameter) were recorded during wiping, blotting and circular motions (and combinations thereof).

All motions were successfully validated within an acceptable range of downward pressure [3]. Some minor variations in pressure were noted during circular motions that was likely attributable to the natural elasticity of the skin and the presence of hair: this was negated by reprogramming the robotic arm to compensate for these

deviations. The accuracy and precision of the decontamination mitt position on the skin surface agreed with the manufacturer's reported specifications.

Further work is in progress to compare the efficacy of decontamination products following robotic or manual application and to determine the optimal application technique for a range of decontamination products against various CW agents and simulants.

This project was funded by the US Army Research Office under agreement number W911NF1920248.

[1] Chilcott, R.P., Cutaneous anatomy and function, in Principles and practice of skin toxicology, R.P. Chilcott and S.C. Price, Editors. 2008, John Wiley & Sons Ltd: Chichester. p. 3-15.
[2] Amlot, R., et al., Volunteer trials of a novel improvised dry decontamination protocol for use during mass casualty incidents as part of the UK'S Initial Operational Response (IOR). PLoS One, 2017. 12(6): p. e0179309.
[3] Lalain, T., et al., Chemical Contaminant and Decontaminant Test Methodology Source Document, Edgewood Chemical Biological Center, ECBC-TR-980, Second Edition, 2012."

13 The Decontamination of Chemical Warfare Agents from Canine Test Substrates

Stefanie Smallwood | *Combat Capabilities Development Command, Chemical Biological Center*

"Military working dogs (MWDs), along with their handlers, are deployed worldwide to safeguard military bases, detect bombs and other explosives and support the Warfighter. Because of their increased importance in the field, protecting them from enemy threats has become a priority. While current readiness efforts largely support detection, decontamination, and treatment of chemical, biological, radiological and nuclear (CBRN)-contaminated Warfighters, tactical guidance and support for MWDs is limited. There is currently no protection for MWD's from a nuclear, biological or chemical attack and a data gap exists regarding how chemical warfare agents (CWAs) interact with canine fur and skin. DEVCOM Chemical Biological Center Decontamination Sciences Branch (DEVCOM CBC DSB) was tasked with understanding how CWA's interact with different areas of the MWD and evaluating the efficacy of multiple decontamination treatments to remove HD and VX contamination from canine (multiple breeds) excised fur and skin test substrates. Decontamination testing against neat HD and VX contamination were completed to compare the efficacy of three decontamination treatments- the standard rinse-wash-rinse method for MWD's as written in ATP 4-02.85 Appendix H; a novel low-water field expedient method; and treatment of wiping with only a microfiber towel. The decontamination treatments were evaluated on three breeds of typical MWDs and a mixed breed (mongrel). The resulting data indicate that the top performing treatment for VX samples was the standard rinse-wash-rinse method, followed by the microfiber towel wipe and the field expedient method, respectively. The top performing treatments for HD, the standard rinse-wash-rinse and the microfiber towel wipe method, showed similar performance. These efficacy trends were similar across each breed.

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14 Scenario Based Opioid Detection 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 criteria. 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 fields. The survey was funded by JPEO-CBRND under contract # FA807514-D-0006.

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15 Analysis of EA 6162 in Drinking Water

Thomas Malloy | *Battelle Memorial Institute*

Fourth Generation Agents (FGAs) have emerged as a new class of toxic chemicals that represent a potential significant homeland security, chemical warfare, and terrorism threat. The U.S. EPA is responsible for preparing for, responding to, and recovering from threats to public health, welfare, or the environment caused by actual or potential hazardous materials incidents. Towards addressing such threats, the FGA EA 6162, was evaluated in drinking water. Testing was based on EPA Method 538, a direct aqueous injection liquid chromatography (LC) - tandem mass spectrometry (MS/MS) method for the determination of selected non-volatile chemical contaminants in drinking water. Minor modifications made to the experimental conditions in Method 538 to improve EA 6162 sensitivity and chromatography will be presented. A deuterated analog of EA 6162 was used as an internal standard. The method was evaluated for efficacy in determination of EA 6162 in samples of water received from three public drinking water utilities. All water samples were preserved upon receipt. Four different tests were performed: 1) an initial demonstration of capability, 2) sample analysis efficacy for each water source, 3) EA 6162 stability for each water source stored at 4°C with analysis time points at Day 0, Day 7, Day 14, Day 28, and 4) method detection limit (MDL) determination for each water source as well as HPLC grade water per 40 CFR Part 136 Appendix B Revision 2. This research effort will

directly enhance the Agency's capability to prepare, respond to, and recover from an incident involving Fourth Generation Agents.

16 Evaluation of Electrostatic Sprayers and Foggers for the Application of Disinfectants in the Era of SARS-CoV-2

Joseph Wood | *U.S. Environmental Protection Agency*

Although research has shown that the COVID-19 disease is most likely caused by airborne transmission of the SARS-CoV-2 virus, disinfection of potentially contaminated surfaces is also recommended to limit the spread of the disease. Use of electrostatic sprayers (ESS) and foggers to rapidly apply disinfectants over large areas or to complex surfaces has emerged with the COVID-19 pandemic. ESSs are designed to impart an electrostatic charge to the spray droplets with the goal of increasing deposition of the droplets onto surfaces, thereby promoting more efficient use of the disinfectant. The purpose of this research was to evaluate several spray parameters for different types of sprayers and foggers, as they relate to the application of disinfectants. Some of the parameters evaluated included the spray droplet size distribution, the electrostatic charge, the ability of the spray to wrap around objects, and the loss of disinfectant chemical active ingredient due to the spray process. The results show that most of the devices evaluated for droplet size distribution had an average volume median diameter ≥ 40 microns, and that four out of the six ESS tested for charge/mass produced sprays of at least 0.1 mC/kg. A minimal wrap-around effect of the spray deposition onto a cylindrical object was observed. The loss of disinfectant active ingredient to the air due to spraying was minimal for the two disinfectants tested, and concurrently, the active ingredient concentrations of the liquid disinfectants sprayed and collected 3 feet away from the spray nozzle do not decrease. Results will be presented either through an oral presentation (preferred) or poster.

17 Efficacy of Residual Antimicrobial Products Against SARS-CoV-2

Rachael Hardison | *Battelle Memorial Institute*

The COVID-19 pandemic has accelerated the need for proven effective surface antimicrobials, particularly those which offer prolonged protection through longer-term residual activity. There are many products registered by EPA as microbiostatic agents that inhibit the growth of odor- and stain-causing bacteria, fungi, and algae. Many of these products claim effectiveness as residual coatings, providing protection on surfaces for days to weeks to months. However, products registered as microbiostats do not necessarily protect against food-borne or disease-causing pathogens. Products or surfaces which provide residual efficacy against disease-causing pathogens (e.g., SARS-CoV-2) could be a highly useful supplement to current disinfection strategies. This study evaluated the residual efficacy of commercially available antimicrobial coatings, films, and copper alloys against SARS-CoV-2 on nonporous surfaces. Products were applied to stainless steel (SS) or acrylonitrile butadiene styrene plastic (ABS) coupons and dried overnight. On the following day(s), coupons were inoculated with SARS-CoV-2 in the presence of 5% fetal bovine serum as a soil load. Recovered infectious SARS-CoV-2 was quantified by TCID50 assay on Vero cells after a 5-day incubation at 37°C. Tested product efficacies ranged from <1.0 to >3.0 log10 reduction at a 2-hour contact time. The log10 reduction in

recovered infectious SARS-CoV-2 ranged from 0.44 to 3 log10 reduction on SS and 0.25 to >1.67 log10 on ABS. Differences in observed efficacy may be due to variation in active ingredient formulation, though it is difficult to predict based upon the listed active ingredient and its concentration. This study highlights formulation-specific efficacy of several products against SARS-CoV-2 and may inform future development of residual antiviral products for use on nonporous surfaces. The identification of antimicrobial coatings or films showing promise to inactivate SARS-CoV-2 suggests that these products may be worth future testing and consideration.

18 Evaluating Efficacy of UVC Light for Inactivation of SARS-CoV-2, MS2, and Phi6 on Surfaces

Lukas Oudejans | *U.S. Environmental Protection Agency*

Motivated by the COVID-19 pandemic, the United States Environmental Protection Agency (EPA) is conducting research to evaluate the efficacy of devices for the inactivation of SARS-CoV-2 on surfaces in addition or as an alternative to chemical-based disinfectants. Devices that emit ultraviolet-C (UVC) light can offer some advantages over liquid disinfectant products in that they do not leave a chemical residue, and they can be conveniently applied for disinfecting liquids, solid surfaces, and contaminated air. Partnering with large transit agencies, EPA has been evaluating the efficacy of different UVC devices, against SARS-CoV-2 and bacteriophages MS2 and Phi6 as potential surrogate viruses. SARS-CoV-2 experiments were conducted with virus inoculated in either cell culture media or simulated saliva onto frequently encountered materials, and then either immediately exposed to UVC light or after the inoculum had dried. A range of dose conditions were evaluated by changing the distance between the light and the surfaces and the time of exposure. Additional experimental conditions were evaluated using MS2 and Phi6, including other dose conditions, impact on disinfection of inoculum applied as a droplet vs. spread on the coupons, and different materials. For all conditions and viruses evaluated, the dose-response curves were nonlinear, such that the dose required to achieve a 1-log (or 90%) reduction could not be linearly extrapolated to predict a 3-log (or 99.9%) reduction. UVC light is more effective against SARS-CoV-2 on hard nonporous surfaces vs. thick fabric, in an inoculum matrix of cell culture media vs. simulated saliva, and in wet droplets vs. dry droplets. Los Angeles County Metropolitan Transportation Authority measured UVC doses from a specific pulsed xenon light configuration at various locations in one of their subway cars. The range in measured UVC doses from this configuration in combination with 30 min or shorter exposure time demonstrated that a 3-log reduction in SARS-CoV-2 would not have been achievable based on our laboratory experiments.

19 Heat Inactivation of SARS-CoV-2 to Streamline RT-qPCR for SARS-CoV-2

Jacob Beaver | *Battelle Memorial Institute*

The current global COVID-19 pandemic has required an unprecedented throughput of molecular testing to determine SARS-CoV-2 viral titer in clinical or decontamination study samples. Achieving this high level of throughput requires effective methods of inactivating live SARS-CoV-2 to allow samples to be processed outside of a Biosafety Level 3 (BSL-3) laboratory. The efficacy of heat-based viral inactivation of SARS-CoV-2 was evaluated. Testing utilized a standard dry heat-block to inactivate 300 µL aliquots of SARS-CoV-2 at 75 °C

and 95 °C at both 45 and 60 minutes. Prior to inactivation studies, heat blocks were evaluated by forward-looking infrared (FLIR) thermal imaging to ensure consistency in temperature range (within 1°C) across all wells. Heat inactivation of SARS-CoV-2 was successful across all times and temperatures tested as measured by the absence of cytopathic effect on Vero E6 and Vero cells incubated in 6-well plates (37°C, 5% CO2) after visual evaluation every day for up to 5 days. No difference was observed between samples which were centrifugal clarified and those that were not. To minimize RNA damage, the recommended conditions for heat inactivation of SARS-CoV-2 is 75 °C for 45 minutes, which had little effect on the sensitivity of RT-qPCR (≤0.5 average Ct value increase from reference standard). This protocol provides rapid and effective inactivation of live SARS-CoV-2 in samples for RT-qPCR testing. Heat inactivation may be performed in the BSL-3 laboratory to allow samples to be transferred into a lower containment (BSL-2) laboratory for RT-qPCR or other downstream applications. This approach reduces exposure of laboratory staff to live SARS-CoV-2 during sample processing and avoids bottlenecks in testing due to containment requirements.

20 Factors Affecting UV Decontamination of FFRs

Castine Bernardy, student | *University of New Hampshire*

"UV is a proven decontamination tool for microbial pathogens, including the SARS-CoV-2 virus. As a result of the COVID-19 pandemic, the UV device market has expanded dramatically. However, comparisons between devices and interpretation of their reported performance suffers from the lack of a standard, detailed validation protocol. The presentation will focus on experimental results which demonstrate the importance of understanding the optics employed by the UV device. The benefit of creating UV irradiance maps using modeling techniques such as FLUENT and MATLAB will be demonstrated and highlight the presence of ‘cold spots’ indicative of poor optics. The models have demonstrated the importance of lamp geometry, positioning as well as reflective surfaces.

In addition to the importance of understanding irradiance distributions, research will also be presented on the impacts of the surface type on UV efficacy. Surfaces with higher porosity exhibited the ‘Canyon Wall’ effect, resulting in lower log inactivation of test organisms than would have been predicted by aqueous-based UV dose-response data for MS-2 and E. coli. Results have demonstrated that hydrophilic and hydrophobic materials yield varying results in terms of effective disinfection in experiments conducted on KN95 and N95 face respirators. The observed log inactivations produced by UV devices when treating PPE were lower than predicted by the aqueous UV dose-response curves. In addition, the dose-response curves did not follow the trends commonly observed with aqueous data. In general, dose-response curves increase until they reach a maximum inactivation, where they plateau. The dose-response curves for the respirators had a semicircle shape, where the inactivation reached a peak and then decreased. This decrease in UV inactivation is thought to be due to the degradation of the fibers of the FFR, allowing for more viral and bacterial cells to wash through the layers of the FFR. This degradation phenomenon was observed at UV doses at and above 2 J/cm2.

To further test the degradation theory, the N95- 8210 and KN95-B FFRs were cut into coupons, where the layers were separated. These experiments used a collimated beam, where the penetrated irradiance value and

the ability of each layer to retain MS-2 were quantified. The results of the experiments varied from the intact FFR degradation experiments but displayed some data to support the degradation theory.

Below is a summary of key findings:

1. The lack of uniform testing or validation protocols makes a comparison of results between different groups and published reports very difficult. The development of a standard validation protocol is recommended.
2. The degree of decontamination required lacks any fundamental risk reduction basis resulting in different initial levels of viral contamination being applied successful performance being claimed at levels between 2-log (99%) and 6-log (99.9999%) inactivation. The development of a Quantitative Microbial Risk Assessment (QMRA) approach is recommended.
3. Commercially available UV disinfection devices span a wide range of design specifications and costs. Eleven of the sixteen UV devices tested in our laboratory lack proper photonic design and have regions of little to no UV irradiance (cold spots).
4. Commonly used FFRs, N95s and KN95s, exhibit a wide range of construction materials and qualities leading to significant variations in UV decontamination performance model to model and batch to batch within a model.
5. Evidence of FFR degradation measured as the maximum amount of viable MS-2 virus recovered was observed repeatedly in experiments that used a full-scale UV device at doses above 2 J/cm2 (2000 mJ/cm2).
6. Significant differences in results were observed between testing with a full-scale UV device on intact FFRs and laboratory-scale testing with a collimated beam device on sample coupons cut from the FFRs."

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21 Cleaning and Disinfecting of Personal Protective Equipment (PPE) for Effective Reuse

John Archer | *U.S. Environmental Protection Agency*

"The COVID-19 pandemic has caused unprecedented disruption in supply chains across multiple sectors including the shortage of critical personal protective equipment (PPE). In addition to hand washing and surface disinfection, various PPE items are used to prevent contact with the virus via droplet/aerosol transmission, thereby reducing potential exposure to SARS-CoV-2, the virus that causes COVID-19. Effective, low-technology, disinfection methods for certain specialized-use items, such as filtering-facepiece respirators (e.g., N95), medical-use masks, face shields, and body coveralls, as well as non-specialized items, like procedural masks, face coverings, clothing, and shoes, are limited outside of healthcare setting applications. EPA researchers have undertaken research evaluating the effectiveness of selected low-tech disinfection/cleaning technologies and commercial off-the-shelf products for these PPE items for potential reuse during the

pandemic. Disinfection technologies tested included a bleach-based spray, quarternary ammonium compound (QAC) spray, alcohol-based wipe, low concentration hydrogen peroxide vapor (LCHPV) and laundering.

Viral resistance to low-tech disinfection methods applied to small swatches of PPE materials varied by organism (Phi6 and MS2), with Phi6 being easier to disinfect than MS2, as expected. Both the laundering and LCHPV technologies were very effective (> 3 Log reduction) for Phi6, but not as effective for MS2. Diluted bleach and QAC spray disinfectants demonstrated increased efficacy for non-porous PPE materials. Full-scale results for laundering, QAC spray and LCHPV demonstrated effectiveness against Phi6 for all PPE materials. PPE integrity and wear testing were also completed to evaluate the effect of low-tech disinfection on degradation of PPE.

This research on the evaluation of disinfection techniques and cleaning protocols can be used for the disinfection of disposable and reusable PPE contaminated with viruses. It is intended to assist responders and the general public in understanding what type of low-tech disinfection/cleaning is most effective. "

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22 Open-Air Hazardous Waste Incineration in Colfax, LA

Chloe Tucker, student | *Tulane University*

"The EPA's Resource Conservation and Recovery Act (RCRA) delineates national frameworks to manage hazardous waste within the United States. Within its permitting structure, there is only one commercial incineration facility that holds an RCRA Part B, Subpart X permit, which allows the incineration of hazardous waste in the open air. This facility is located just outside of Colfax, Louisiana.

In 2016, the Colfax facility began to increase its activity significantly, disposing of hazardous chemicals, unexploded military ordinance in the open air. Since that increase, residents living in the facility's (majority African-American) fenceline community of The Rock have experienced increased incidence of cancers, respiratory ailments, and thyroid conditions. The local coalition organizing for containment technology at the Colfax disposal site argues that a responsible society must take responsibility for hazardous wastes throughout their lifecycle such that they do not cause further harm or contamination."

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23 Addressing Socio-Environmental Injustice, and Flood Risk with a Design-based Approach

Eliza Breder | U*niversity of Florida, Florida Institute for Built Environment Resilience*

"Communities of color and low-income live disproportionately closer to areas with environmental hazards than white communities. Additionally, these same communities are more likely to live in areas at high risk of flooding from natural disasters than white and Asian people. Addressing the risks of flooding and environmental contamination at the community level can improve overall environmental quality and community wellbeing.

Port St. Joe is a small coastal city on the Panhandle of Florida, and North Port St. Joe is a historically segregated Black neighborhood located in the northern part of the town. North Port St. Joe has been separated from the rest of town by what historically was the Joe Company, a timber mill that closed in the 1990, and now remains a vacant. In 2018, Hurricane Michael hit Port St. Joe as a category 5 storm and the

community is still continuing its recovery efforts from the storm and from ongoing economic depression, with a focus on affordable housing, stormwater planning, and community unity.

My research is concerned with the long-term stormwater issues, as impacted by historical environmental hazards, present nuisance flooding, and future sea level rise in the North Port St. Joe community. North Port St. Joe has a history of environmental injustice through environmental dumping from the timber company, which has created the present issues of land subsidence and flooding. Additionally, the brownfield sites near and in North Port St. Joe pose health risks to the community. The Joe company dumped mulch in areas of lower elevation and on top of streams, changing the neighborhood's topography and hydrology. The land has since been subsiding causing structural instability of homes, stormwater flooding, as well as exposure to toxic chemicals in the soil in a predominantly Black community.

To better understand and address these issues the relationships between subsidence, flooding, toxic waste, sea level rise, and marginalized communities were analyzed based on case studies and peer reviewed literature. The site of North Port St. Joe and its relationship of flood areas and sea level rise to toxic waste sites was analyzed in GIS for proximity and seepage. The analysis led to design solutions for the site, addressing the multiple overlapping community disparities. Understanding the relationship between these issues has been paramount to creating design solutions that can address the overall environmental injustice the community has suffered."

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24 Use of Service Vehicles to Sample and Determine Extent of Contamination During a Response to Biological Incidents

Kent Hofacre | *Battelle Memorial Institute*

"The management of response and recovery operations from a biological contamination incident is complicated by the fact that contamination may spread following the incident and subsequent initial extent-of-contamination characterization efforts due to impacts of wind, precipitation, vehicle and personnel movement. The gypsy moth is an invasive insect with larvae that feed on the foliage of many North American trees and plants, having the potential to cause much damage to vegetation. Many communities in the Northern U.S. have programs that spray pesticides for gypsy moths to control their population and by extension, limit the damage they cause. Frequently, *Bacillus thuringiensis* subsp. kurstaki (Btk) is used as the pesticide for these programs. Btk is also an effective non-pathogenic surrogate for *Bacillus anthracis* (Ba), the anthrax-causing bacteria that mimics many of the aerosol formation and transport phenomena associated with a Ba incident.

In the case of a biological contamination incident, outside the contaminated zone, municipalities will be attempting to conduct business as usual for the residents in that area. Services including mail delivery, trash removal, and buses utilize fleets of vehicles that have relatively static routes that they follow on a day-to-day basis. For the purposes of this study, a scheduled aerial spraying of Btk for gypsy moth control provided an opportunity to assess the feasibility of using engine air filters from these service vehicles that may be driving near the aerial spray area after the spray event to identify the presence of Btk. Subsequent recovery and analysis of the vehicle filters, if positive for Btk, would suggest that the contamination might have moved

outside the initially contaminated area, and this information could be used to inform additional characterization sampling activities to track the spread of the contaminated area over time.

This presentation will discuss the results of the study and future efforts".

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25 Dirty Drinking Water: Ethnography/Science of Contamination from Arsenic and Iron in Groundwater

Luisa Cortesi | *Erasmus University, Freiburg Institute of Advanced Studies, Cornell University*

In the realm of drinking water, what is a contaminant? This research questions the definition of ‘contaminant’ and ‘toxicity’ through the case of Arsenic and Iron pollution in groundwater used for drinking purposes in the Indian Subcontinent. Ethnographic and water quality research conducted since 2007 reveals that iron and arsenic share an interesting and complicated relationship--while arsenic is mostly found in local groundwater when iron is also present, the presence of iron doesn’t always signal arsenic. Yet this also means that iron, considered an aesthetic contaminant, may be helpful to reveal the presence of arsenic, a pollutant whose effects on human health are considered pernicious, yet whose presence remains imperceptible to the senses. How are contaminants understood when present together? The two contaminants seem to have specific health impacts when occurring together, a consideration which may suggest the possibility of modifying their individual categorization. At the same time, however, iron can be, and is, used in arsenic remediation in the area and elsewhere, so considering their co-presence highlights the conflicting perspectives that need to be examined when attempting to label contamination. Exploring the complex relationship between these two substances as pollutants in groundwater, the paper aims to think through categories of contamination, and what they reveal about our understanding and governance of water quality. Finally, the ethnographic grounding of this work also permits us to turn the point of view away from science or policy experts towards the perspective of those who drink the water, the supposed beneficiaries of our expertise. For whom is the category of contaminant useful, and how are water-drinkers using it?

PLENARY SESSION

Welcome & Introduction

Christopher Frey, Deputy Assistant Administrator for Science Policy for the Office of Research and Development | *U.S. Environmental Protection Agency*

Plenary Talk 2 - Social Science in Disaster: Tactics, Innovations, Results

Kim Fortun | *University of California - Irvine*

Social science research draws out both historical and proximate factors that produce contamination and disaster vulnerability, how these are experienced and perceived as they unfold, and the tangle of factors that complicate decontamination and recovery. Social science can be holistic, contributing insight on social, cultural and political dynamics while also treating inputs from other fields of knowledge and practice as part of (not objectively distant from) phenomena of concern. Social science is useful in both problem characterization and for identifying possible points of intervention and variables to consider in recovery assessment. In this presentation, I'll share examples that illustrate the potential roles of social science in response to contamination and disaster, highlighting a need for methodological innovation within and across disciplines as conditions productive of compound disaster intensify.

CONCURRENT SESSION 2 – INSIGHTS AND APPLICATIONS OF SOCIAL SCIENCE TO DECONTAMINATION

Social Vulnerability and Resilience in Decontamination Research

Kate McCarthy-Barnett | *Department of Homeland Security/Federal Emergency Management Agency*

"In response to the increase of Chemical, Biological, Radiological and Nuclear (CBRN) threats and HazMAT incidents, this presentation will focus on how decontamination capabilities can intersect with the CDC/ATSDR Social Vulnerability Index and the Socioeconomic Index to enhance an equitable and accessible response for the whole community.

The two main US federal guidance documents which relate to management of populations during a CBRN or HazMat incident are "Patient Decontamination in a Mass Chemical Exposure Incident: National Planning Guidance for Communities" ('NPG') and Primary Response Incident Scene Management (PRISM). Both NPG and PRISM guidelines highlight the needs of at-risk individuals and adaptations of standard procedures.

Consequently, there are no 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. Research to evaluate the effectiveness of current decontamination procedures

demonstrated that current disrobe and decontamination procedures lack technical evidence and are based on perceived best practices, relying on an incorrect assumption that the needs of all casualties can be met using the same patient protocols. As a result, the throughput of at-risk populations was 10 times slower and the delays associated with processing had a negative impact for all casualties in terms of clinical and operational effectiveness.

The implementation of the CDC/ATSDR Social Vulnerability Index using 15 U.S. census variables and the Socioeconomic Index help responders to identify communities requiring additional support and provides a new strategy to combat CBRN and HazMat incident response inequalities. In order to effectively respond to a CBRN or HazMat incident, community resilience to such catastrophes needs to systematically and deliberately address the social vulnerability and inequities of the incident 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.

This session will provide participants the forum to review and discuss the impacts of social vulnerability and equity in the decontamination of at-risk populations. In addition, this session will review the use of Social Vulnerability Index and the Socioeconomic Index as an integral response strategy. In addition, this session will also review the direct application and direction of future research requirements aimed at removing the inequalities and fully integrate an evidence-based response for all members of the community during a CBRN incident. "

Getting to Know Communities and Cultures for Remediation and Removal Actions

Brittany Kiessling | *U.S. Environmental Protection Agency*

Remediation and removal actions at contaminated sites, including decontamination after an emergency, take place in diverse socio-cultural contexts. Cleanup practitioners work in communities with different ethnic identities, languages, histories, values, and ideologies. Understanding these contexts and incorporating cultural knowledge into cleanup approaches can improve cleanup processes and outcomes. However, it can be a challenge for On-Scene Coordinators and other practitioners to quickly identify and assess these contexts. For example, how might local language proficiencies affect communication plans? How might historical land use affect redevelopment priorities? How might past experiences with racism and trauma impact the ability to build trust in communities with environmental justice concerns? To address these challenges, we developed a methodology for getting to know communities, cultures, and affected populations at contaminated sites. The methodology derives from a scientific literature review and from interview and survey data collected from cleanup practitioners at the US Environmental Protection Agency (EPA). This presentation summarizes the methodology and gives an overview of its five steps: 1) familiarize with relevant community characteristics, 2) prioritize learning needs, 3) learn about the community, 4) analyze for cross-cultural understanding, and 5) plan for ongoing learning. These components are customizable to different contamination scenarios and community types. Going through these steps provides a foundation for bridging cultural differences in community engagement, participation, and risk communication. It will help project managers for remediation

and removal work carry out culturally informed cleanups, fostering increased community buy-in, trust building, conflict resolution, and positive social outcomes.

Building Equity in Resilience Planning

Emily Eisenhauer, post doc | *U.S. Environmental Protection Agency*

"States and localities are looking for ways to integrate climate resilience and environmental justice into how they prepare, respond, mitigate, and recover from disasters. These efforts require effective and inclusive engagement with many broad constituencies. The research presented here uses human-centered design to develop the Equitable Resilience Builder, a social science-informed tool and process for under-resourced communities to measure their resilience and vulnerability in a holistic and inclusive manner and to identify actions to build resilience centered on equity. Identifying and taking actions to build equitable resilience before disaster strikes can reduce negative human health and environmental impacts of an incident, in particular impacts on a community's most vulnerable populations.

This presentation summarizes the findings from the two workshop with resilience planners to learn about their recent experiences with hazards and disasters and their key needs for building equitable resilience. In a second workshop, the team engaged practitioners in co-designing potential solutions for their communities two workshops. Takeaways from the workshops that informed the design of the tool were the need to acknowledge emotions and trauma, and the potential for storytelling to build relationships and complement resilience data. These takeaways will inform conference participants on the issues of equity and trust related to decontamination and the impacts on community resilience.

The Equitable Resilience Builder utilizes social science research on vulnerability and resilience in all aspects of the tool and approach, including the content, indicators, and the process of engaging community members and stakeholders, local data gathering, and identifying actions. A literature review of social vulnerability to hazards and disasters has informed the development of a framework for identifying the specific pathways of exposure and impacts for different social and cultural groups. The indicators emphasize locally meaningful, cross-scalar measures of resilience, social vulnerability, actionability. The Equitable Resilience Builder is an all-hazards tool, including indicators relevant for chemical, biological, radiological incidents as well as extremes associated with climate change.

The views expressed in this abstract are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency."

Water (De)contamination and the Cultural Construction of Risk in Urban Disadvantaged Unincorporated Communities

Christian Wells | *University of South Florida*

"This research examines contrasting ways in which residents and utilities authorities construct risk regarding water quality, contamination, and decontamination in the Tampa Bay Area, Florida. Recent social science research reveals growing numbers of U.S. households with inconsistent or unreliable access to safe and clean water. While much of this research has focused on water contamination in rural and indigenous settings, and

occasionally large-scale problems in metropolitan areas (e.g., Flint, MI), new studies are exposing water quality challenges in urban disadvantaged unincorporated communities — high-poverty, high-density residential neighborhoods lying just outside the border of an incorporated municipality. In these predominantly minority neighborhoods that often originate as unregulated subdivisions of unincorporated land, inadequate public investment in housing and water infrastructure has led to a range of water contamination challenges—for those with access to centralized water treatment and delivery systems as well as those reliant on private ground water wells. These challenges have led residents to develop local understandings of risk and uncertainty that contrast with understandings by outside authorities.

This research explores how various stakeholders perceive risk and how these perceptions sometimes lead to misunderstandings, miscommunications, and lack of trust in water quality among residents of the University Area Community located on the northern edge of Tampa, Florida. Drawing on 135 hours of participant observation, 28 rapid field assessments, and 24 in-depth semi-structured interviews with local residents, representatives from area nonprofits, and city and county water utilities staff, our research reveals that water utilities apply a techno-scientific approach to risk in water management. Risk is understood as a phenomenon that can be identified and measured empirically. With this view, “experts” assess, measure, and calculate risk as a probability that can be used to inform decision making. In contrast, local residents’ understanding of risk is often less related to scientifically calculated hazards and is instead a manifestation of broader social and historical processes. For these stakeholders, notions of risk are cultural constructions deeply embedded in the varying ways in which different understandings of purity, pollution, and danger are expressed and experienced by people. In some cases, water is perceived as unclean but not necessarily unsafe per existing regulations while, in other cases, decontaminated water, while safe to drink, may not be seen as drinkable water. These perceptions often lead to tap water mistrust. We argue that to be successful and sustainable, interventions to contaminated water must be socially context-sensitive and must consider the cultural construction of risk."

CONCURRENT SESSION 2 – COVID-19 RESEARCH EFFORTS

Development of Rapid Viability RT-PCR (RV-RT-PCR) Method for Detection of Infectious SARS-CoV-2

Sanjiv Shah | *U.S. Environmental Protection Agency*

"The ongoing COVID-19 pandemic caused by the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) continues to consume many lives worldwide. One of the potential ways this virus can spread is through direct contact with an infectious person or with a contaminated article or surface. Although transmission of SARS-CoV-2 via surfaces is not thought to be the primary way the virus spreads, one could get infected by touching the virus contaminated article or surface and then touching one’s own mouth, nose, or eyes. Along with symptomatic patients, pre-symptomatic, asymptomatic, and convalescence phase carriers of SARS-CoV-2 can shed the virus. The environment and surfaces surrounding such virus carriers can get contaminated by droplets (coughs, sneezes, and other exhalations) and/or surface contact in healthcare and non-healthcare settings. Depending on the material, type of surface, and environmental conditions used in experimental studies, surface stability of SARS-CoV-2 virus has been reported from a few hours to days and even up to 28 days in some conditions. To expedite studies on understanding potential surface transmission of the virus and to aid environmental epidemiological investigations, we developed a rapid viability reverse

transcriptase PCR (RV-RT-PCR) method that detects viable (infectious) SARS-CoV-2 from swab samples in <1 day compared to several days required by current gold-standard cell-culture-based methods. The method integrates cell-culture-based viral enrichment in a 96-well plate format with gene-specific RT-PCR-based analysis before and after sample incubation to determine the cycle threshold (CT) difference (ΔCT). An algorithm based on ΔCT ≥ 6 representing ~ 2-log or more increase in SARS-CoV-2 RNA following enrichment determines the presence of infectious virus. The RV-RT-PCR method with 2-hr viral infection and 9-hr post-infection incubation periods includes ultrafiltration to concentrate virions, resulting in detection of <50 SARS-CoV-2 virions in swab samples in 17 hours (for a batch of 12 swabs), compared to days typically required by the cell-culture based method. The SARS-CoV-2 RV-RT-PCR method may also be useful in clinical sample analysis and antiviral drug testing, and could serve as a model for developing rapid methods for other viruses of concern. "

Environmental Surface Sampling for SARS-CoV-2

Christine Tomlinson | *U.S. Environmental Protection Agency*

In the beginning of the COVID-19 pandemic, transmission and infection characteristics of SARS-COV2 was not fully understood. In the spring of 2020, EPA's Office of Emergency Management (OEM), set-up Inter Agency Agreements with the Department of Defense (DoD) and Department of Energy (DoE) to establish the ability to perform environmental surface sample analysis for SARS-COV2. These partnerships advance OEMs capability and capacity to have the relevant reagents, base-line assays and funding in place, in order to support the response to SARS-COV2 and future biological threats. This effort required evaluation of the RT-PCR assays developed for clinical samples to be adapted for analysis of environmental surface samples. Optimizing how specific sample types are processed and what possible inhibitors may need to be neutralized in order to determine viability is an underpinning to meet federal mandates for EPA. OEM, working with the U.S. Army Combat Capabilities Development Command Chemical Biological Center (CBC) and the DoE's Lawrence Livermore National Lab (LLNL), successfully set up the capability to analyze the genetic material of SARS-COV2 from surface samples using Real-Time RT-PCR. LLNL also established the capability to analyze surface samples for infectious virus. Additionally, through our membership with the Integrated Consortium of Laboratory Networks (ICLN), both labs participated in The Inter-laboratory Comparison Exercise: Round-2 for COVID (ICE2) study organized by the FDA's Veterinary Laboratory Investigation and Response Network (Vet-LIRN). Approximately sixty laboratories were asked to analyze prevalent and emerging SARS-COV-2 variants, and animal non-SARS-CoV-2 coronaviruses. The results of this study are expected to provide information to each laboratory regarding the performance of their method and to help identify opportunities to improve method performance.

Evaluating Aerosol Treatment Methods for Reducing the Risk of Exposure to Airborne Pathogens

Katherine Ratliff | *U.S. Environmental Protection Agency*

The COVID-19 pandemic has highlighted the role that airborne transmission can play in the spread of disease. Consequently, there has been an increasing focus on technologies that claim to reduce or eliminate

aerosolized pathogens in indoor occupied spaces. There are many different types of air treatment methods and technologies, including ultraviolet (UV) light devices, ionization devices, photocatalytic devices, chemical products, mechanical air filtration, and combinations thereof. The efficacy of many of these emerging technologies has not been well characterized, because few independent studies have been conducted. Most testing to date has been conducted at a small scale relative to real-world conditions, making it difficult to extrapolate results to spaces where these technologies would be deployed. Moreover, there is no standard test method or protocol for evaluating these aerosol treatment devices and products, which complicates comparing efficacies across technology types and different laboratory studies. Here, we present research conducted in a large-scale EPA test chamber (3000 ft3) using a standardized testing approach to evaluate the efficacy of different types of aerosol treatment technologies. Testing was conducted using the non-pathogenic bacteriophage MS2, which is a non-enveloped virus that is expected to be more resistant to inactivation than enveloped viruses (e.g., SARS-CoV-2). This presentation will focus on comparing results generated while testing different components of a 3-stage air cleaning system that has been proposed for use in transit vehicles to testing with more traditional mechanical filters. The 3-stage system contains an actively charged electrostatic filter, a UV-C radiation component, and a bipolar ionization component. With the input of stakeholders (including large transit agencies), different combinations of these components were evaluated, as were different types of mechanical filters provided by transit agencies (including those that have been in service). This research informs what added benefit the various components of the 3-stage system and different filter types may have as part of an overall strategy to reduce aerosolized pathogens in a mass transit setting.

Swab and Stick Sponge Sampling for SARS-CoV-2 Detection on Surfaces

Sang Don Lee | *U.S. Environmental Protection Agency*

Effective surface sampling of SARS-CoV-2 is important to determine disinfection efficacy or as part of environmental surveillance of surface contamination. This study evaluated the sampling efficiency and limits of detection (LOD) of swab and stick sponge sampling methods for recovering infectious SARS-CoV-2 and viral RNA from surfaces. Swabs or stick sponges were evaluated for virus collection from 6”x6” coupons composed of four materials: stainless steel (SS), ABS plastic (ABS), bus seat fabric, and Formica. SARS-CoV-2 suspended in simulated saliva (1.0 mL final volume) was inoculated dropwise onto each coupon. For each material, multiple spike levels were assessed to determine the lowest level of inoculum to be recovered (limit of detection, LOD). At 0- or 3-hours post-inoculation, coupons were sampled using either Sanigen macrofoam swabs (pre-moistened with Phosphate Buffered Saline) or Hygiena stick sponges (pre-moistened with neutralizing buffer). Swabs were expressed onto the side of a conical tube containing cell culture media and extracted by vortex. Stick sponges were extracted by stomaching in cell culture media. Recovered infectious SARS-CoV-2 was quantified by TCID50 assay on Vero cells by evaluating cytopathic effect after a 5-day incubation at 37°C. Recovered SARS-CoV-2 RNA was also extracted and quantified by RT-qPCR targeting the N1 region of the nucleocapsid gene. Sampling method efficiency was determined by percent recovery of infectious virus or viral RNA from each sample. The relationship between the number of inoculated versus recovered infectious virus particles or genome copies per sampling area was determined using x-y plots. The LOD of each method and material was determined from the quantified infectious virus and viral RNA recovered from all materials at both time points. Porous seat fabric resulted in a higher LOD for both infectious virus and

viral RNA compared to the non-porous materials (SS, ABS, Formica). A comparison of both sampling methods as well as efficacy of recovery of infectious virus versus viral RNA will be discussed.

CONCURRENT SESSION 3 – BIOLOGICAL AGENT SAMPLING & ANALYSIS METHODS

Human Safe, Near-Field Infection Protection (NIP) for Continuous Pathogen Inactivation in Air and On Surfaces

Ernest R. Blatchley III | *XCMR Inc*

"The COVID-19 pandemic caused by SARS-CoV-2 has exposed weaknesses in society's ability to rapidly respond to a global public health crisis. SARS-CoV-2 and its variants are highly contagious and can cause mild to extremely severe disease and death. It is believed that the main route for transmission is aerosol droplets naturally discharged from an infected person. Experts now believe SARS CoV-2 will become endemic in humans and animals and continue causing disease each year. XCMR is developing breakthrough respiratory protection from infectious diseases by commercializing a new generation of devices for safe, continuous use utilizing Far UV-C radiation (222 nm). This shorter wavelength offers effective microbial inactivation typically associated with conventional germicidal UVC lamps (254 nm) but without the corresponding human health hazards since it does not penetrate the human skin or outer tear layers of the eye. While some companies are using UV-C to treat indoor environments, none are focused on protection devices for an individual's personal workspace. Expected uses of XCMR's Near-field Infection Protection (NIP) devices include biosafety protection during interpersonal interactions in a variety of stationary settings found generally in offices, schools, healthcare, hospitality, retail, transportation and many others. Biosafety tools, specifically NIP devices, are expected to greatly reduce PPE environmental waste (single-use masks) and lower incidence and prevalence of respiratory diseases (e.g., seasonal flu, RSV, hMPV). These tools have the potential to become universal safety devices akin to seat belts and complement more traditional medical countermeasures (i.e., antibiotics and vaccines) in a far more capital and time efficient manner. XCMR has assembled a highly experienced team of experts to incorporate this novel technology into a versatile desktop device for personal protection (e.g., inactivation of microbes present on surfaces and in air surrounding the face and eyes) of those individuals within the controlled irradiation zone created and defined by the placement of the NIP unit. Currently, XCMR is using existing commercial 222 nm excimer sources, to design, model, and test prototype devices that integrate various form-factors of geometry and exposure to achieve rapid microbial inactivation during respiration within the confined near-field spatial environment surrounding an individual. Surrogate microorganisms (e.g., bacteriophage) for SARS CoV2 will be employed to assess the effectiveness of the configurations in inactivation of the microbes. With this backdrop, XCMR proposes to discuss advancements in decontamination methodologies and processes, using software models and simulations that can inform the future direction of innovation in decontamination."

Evaluation of Outdoor Surface Sample Collection and Analysis Methods for USCG Assets

Scott Nelson | *Battelle Memorial Institute*

Following a bioterrorist attack, materials contaminated with biological agent pose significant health threats. EPA is expected to respond to outdoor contamination incidents to characterize and remediate the impacted sites, and thus, determining the performance of available sampling and analysis methods for outdoors is a high priority need. The performance of the methods may, in part, depend on the outdoor surface being sampled and analyzed. The United States Coast Guard (USCG) bases and assets may become contaminated during a large-scale outdoor biological incident. To determine compatibility with currently existing sampling approaches, and to develop improved (i.e., non-traditional) sampling methods, surfaces common to USCG assets (marine grade aluminum, non-skid tread, glass, gravel, and bilge water) were sprayed or directly spiked with barcoded *Bacillus thuringiensis* subspecies kurstaki (Btk T1B2) spores. Surfaces were then exposed to outdoor environmental conditions (but not direct sunlight or precipitation) for up to 180 days, then sampled using traditional methods. Prior to outdoor exposure (Day 1), Btk T1B2 spore recoveries from inoculated surfaces using traditional sampling methods (e.g. sponge-sticks, vacuum filter cassettes, grab samples) were 37 – 41 % (sponge-sticks), 25 – 26 % (gravel and bilge water), and < 1 % (vacuum filter cassettes). Spore recovery from surfaces using non-traditional sampling methods was highest when a physical wiping of the surface was incorporated with the washdown method, 18 – 19% recovery with squeegee or bristle brush compared to < 8% for washdown methods without a physical wipe. Detection and/or quantification of Btk T1B2 via either culture or Rapid Viability PCR (RV-PCR) method was adversely affected between the 30-day and 90-day sample collections. Non-traditional methods are plausible sample collection methods that can yield a composite sample over a relatively larger surface area than traditional sampling methods.

Sampling of Waste Materials from a *Bacillus anthracis* Release Incident

Ryan James | *Battelle Memorial Institute*

"As part of the response and recovery operations following a wide-area biological contamination incident, such as an aerosol release of *Bacillus anthracis*, environmental sampling will play a prominent role in response activities. This need for environmental sampling will extend to the materials destined for treatment and disposal as waste. Sampling of the waste materials presents particular challenges, including: 1) the potential need to open sealed bags containing waste that was packaged at the original site of contamination and later moved to a staging area for collection and possible on-site treatment (because waste acceptance criteria [WAC] and number of samples required to meet WAC likely will have not been established at the time of collection), and then re-seal the bags following sampling; 2) the need to minimize the possibility of cross-contamination of the staging area where bagged waste is being handled; 3) the need to maximize worker safety for those managing the waste; 4) the need to be flexible in how many waste bags get sampled and how many samples need to be acquired per bag to satisfy appropriate waste acceptance criteria as defined by the state regulatory agencies and/or the receiving facility; and 5) the need to acquire samples in a form that facilitates eventual laboratory analysis using standard methods that are approved by the Laboratory Response Network (LRN).

This presentation will discuss a block of work that evaluated the performance of potential methods to acquire samples from bagged waste materials in such a way as to minimize cross-contamination of nearby areas,

maximize worker safety, and generate samples that are compatible with LRN analytical procedures. This project focuses on likely waste streams that might be generated from cleanup activities at U.S. Coast Guard (USCG) bases and ports. Model waste streams used for these tests include different sized mooring lines (rope), personal protective equipment (PPE), and materials commonly used in seats for marine response boats and vessels. This study will help the USCG to recover rapidly following a biological contamination incident and returning assets to duty."

Use of Innovative Packaging to Facilitate On-Site Treatment of Waste from a *Bacillus anthracis* Release Incident

Abderrahmane Touati | *Jacobs Technology, Inc.*

"A wide-area release of a persistent biological agent such as *Bacillus anthracis* (Ba) and subsequent response and recovery activities will likely generate large quantities of waste that will require treatment and disposal. It is likely that most of the waste will be packaged in bags at the contaminated site (either before or after decontamination activities) and moved to a nearby staging site for collection, possible on-site treatment, and shipment to one or more treatment/disposal facilities. If the waste can either be treated in situ as part of decontamination operation or treated on-site through a separate operation, and the waste can be demonstrated to not have detectable levels of viable Ba spores, then the waste may be able to be disposed of as conventional solid waste, which would greatly facilitate disposal activities.

This presentation will discuss ongoing work to utilize innovative semi-permeable non-woven packaging materials that could be made into bags to hold the waste materials. These semi-permeable materials would allow gaseous fumigants such as chlorine dioxide (ClO2) to pass into the bags but would not allow residual spores to penetrate the walls of the bags and exit into the atmosphere. Testing is currently occurring at the bench-scale, using permeation chambers, to assess the ability of the materials to allow ClO2 to penetrate through the bag material and, using established fumigation criteria, to provide sufficient concentration-time exposure of the waste inside the permeation chamber. A separate set of experiments are ongoing to confirm that spores on one side of the material barrier cannot pass through the barrier.

This work will eventually culminate in a field demonstration simulating a wide-area contamination incident at a US Coast Guard facility. A successful demonstration in the field will enable federal and state responders to add a useful tool to their response toolbox to facilitate the management of waste from biological agent incident."

CONCURRENT SESSION 3 – CHEMICAL AGENT SAMPLING & ANALYSIS METHODS

Strippable Coatings for Collection of Surface-Borne Trace Chemicals

Kevin Beltis | *TIAX LLC*

"Collection of trace surface-borne chemical analytes from porous and irregular surfaces has typically proven difficult. Wipes are quickly eroded by rough surfaces, often resulting in significant sample loss. TIAX LLC has developed a strippable surface sampling method for the collection of trace chemicals for various purposes

(e.g., forensic, environmental, industrial hygiene determinations). The low-interferent, liquid spray-applied coating forms a solid film that encapsulates target analytes (liquid and particulate), which is then peeled from the surface. Chemical analytes are recovered from the film using a suitable solvent (e.g., acetonitrile or acetone) with simple sonication or other extraction technique. The method is compatible with many chemical analysis methods including LC-MS.

Recoveries from porous media have been evaluated in recent activities. Raw pine and painted wood have demonstrated ranges up to six times better than standard wipe sample methods. In the most recent efforts, the focus has been to improve collection from porous surfaces such as concrete block. The spike-recovery evaluation used a solid powder rather than a liquid spike where solvents can transport target analytes into the porous media, making them unavailable for collection. Replicate 20-milligram weights of a 1000ppm standard containing target analytes on talc (i.e., 20 micrograms of each analyte), were deposited and then brushed into the concrete surface pores. Data from use of the recovery method demonstrated 55+% for standard explosive compounds. The technique also expands the surface area that may be sampled (i.e., from the standard 100cm2) to any size deemed necessary/appropriate and with expectations for improving detection capabilities by increasing the amount of analyte recovered from a larger area.

The original technique was developed by TIAX working with the US Air Force for surface decontamination of the exterior of aircraft. In those early evaluations, we conducted mass balances to verify efficacy and found nearly quantitative recovery from non-porous surfaces, raising the possibility of the method's use for sample collection. The mass balances of several of our early studies show that the extractable recovery from surface via the polymer from non-porous surfaces was frequently near quantitative (i.e., 80-100%). Two different strippable formulations have been produced using fast-drying organic solvents (5-minute dry time). One formulation was prepared specifically for forensic teams that need to use air transportation, where flammable solvents are restricted. The method is presently being readied for commercialization under an SBIR effort for the Defense Forensics and Biometrics Agency (DFBA)."

Development of Methods and Comparative Analysis of Opiates by UPLC-MSMS and GC-TOF

James Garcia | *CSS/U.S. Environmental Protection Agency*

"Objective: The purpose of this study was to develop methods for the analysis of opiate analogs extracted from various environmental matrices utilizing UPLC-MSMS and GC-TOF. The goal was to develop methods that are amenable to rapid turn-around-times while preserving data quality. In addition, a comparison between GCMS-TOF and UPLC-MSMS preparation times, analysis times, and reporting limits is explored.

Significance: One aspect PHILIS's mission is to provide the EPA with legally defensible data in a rapid turn-around-time environment. These procedures allow for the detection and quantitation of opiate analogs in the low picogram range. Preparation and analysis times are relatively short, and preparation is performed via microextraction.

Experimental Procedures and equipment used: Equipment used: ThermoFishers ALTIS triple quad mass spectrometer (UPLC-MSMS) and LECO's Pegasus BT time of flight (TOF) Extraction procedures for the ALTIS:Water samples were prepared by passing an aliquot through a filter for direct injection on the ALTIS. Soils were extracted using a 50/50 (v/v) mix of methanol/water, shaken and passed through a filter for direct

injection on the ALTIS. Wipes were extracted with a 50/50 (v/v) methanol/water, shaken and passed through a filter for direct injection on the ALTIS. Extraction procedures for the TOF:Wipes were prepared by extracting with 100% methanol via a pressurized solvent extractor and concentrating to 1.0 mL

Results Obtained: ALTIS peliminary data supports sub pg/uL recovery levels for aqueous samples. Preliminary data supports sub ug/Kg recovery levels for solid samples. Data supports sub ng/wipe recovery levels for wipe samples TOF: Data supports sub ng/wipe recovery levels for wipe samples. It was also shown that the ALTIS was about 100x more sensitive for fentanyl from wipe matrices. Sample preparation time for wipes to be analyzed by the ALTIS was about 20 mins from sample container to injection, vs the BT-TOF which was about 120 mins from sample container to injection.

Conclusions: Both ALTIS and BT-TOF methods are viable quick turn methods capable of producing legally defensible data. The ALTIS has shown higher sensitivities and quicker sample prep time over the BT-TOF."

Soldier Vulnerabilities to Toxic Industrial Chemicals/Materials While in MOPP Gear

Philip Gidley | *U.S. Army Engineer Research and Development Center*

"Soldiers are vulnerable to industrial chemicals. Modern warfare is increasingly involving urban environments, and because of this, soldiers could encounter industrial facilities while deployed in theater. Soldiers must be prepared for the environments they encounter. Typically, soldiers will be equipped and trained with Mission Oriented Protective Posture (MOPP) gear (https://www.remm.nlm.gov/MOPP.htm), which has been designed for common chemical warfare agents. However, industrial facilities may have a much wider range of chemicals that the soldier can be exposed to. Some of these chemicals are especially problematic, and these may be defined as Toxic Industrial Chemicals/Materials (TICMs).

The U.S. Army Public Health Command has performed and provided an “Environmental Health Risk Assessment and Chemical Exposure Guidelines for Deployed Military Personnel” (https://phc.amedd.army.mil/topics/envirohealth/hrasm/Pages/TG230.aspx), which was last updated in 2013. The Military Exposure Guidelines (MEGs) associated with this study provide concentrations in air, water, and soil that can be tolerated by soldiers. The air MEGs are available for 3289 chemicals.

This study considers situations where soldiers could become vulnerable to TICMs. This includes fording situations, where soldiers will be immersed in water (contaminated with TICMs) and limits of the C2A1 gas mask canister (containing ASZM-T activated carbon) when TICMs are present in the air as a gas or vapor.

This effort is associated with the development of an online tool: the Engineer Research and Development Center’s (ERDC) Toxic Industrial Chemicals/Materials Intelligence Tool (TICMINT) (https://toks.erdc.dren.mil/)."

Benzene Contamination of Drinking Water Systems following Wildfires: Remediation Research and Decision Support

Matthew Magnuson | *U.S. Environmental Protection Agency*

"In recent years, several drinking water systems in California have experienced benzene contamination following wildfires. Examples of affected systems include Santa Rosa (2017-2018), Paradise (2018-2019), and Riverside Grove (2020). The source of the benzene has not yet been definitively characterized. However, current research is shedding light on the interactions of the benzene with surviving infrastructure, and the implications for sampling and decontamination. Since benzene is soluble in polyethylene, high-density polyethylene service lines and polyethylene premise plumbing pipes can act as reservoirs for benzene contamination. The relatively slow transport of benzene through pipe walls brings several complications for decontamination and sampling which are not widely understood.

Using a combination of numerical modeling, laboratory experiments, and pipes harvested from affected areas, the work presented here seeks to answer several questions about sampling strategies and selection of remediation methods. Samples may be collected many weeks or months after the contamination or following flushing, and the reported concentrations will only represent what is in the water, not necessarily what is in the pipes. Further, communities may wish to understand how likely a building will be to exceeding a certain threshold of benzene or under what conditions. This presentation will include information from studies that can be used to help estimate the duration and cost of flushing programs given a specific contamination timeline and concentration measurements.

This presentation will also introduce a decision support tool for selection of remediation technologies most suited to a contaminated system’s specific conditions and the contaminant of concern, in this case benzene. Technology selection often involves balancing competing priorities. Multi-Criteria Decision Analysis (MCDA) is a promising approach that has been used extensively in other industries but not yet in drinking water system remediation. This paper discusses development of a computer-based tool that allows practitioners to leverage the Analytical Hierarchy Process (AHP), a well-established method of MCDA, to select remediation technologies based on their effectiveness and their compatibility with the practitioner’s project objectives.

Because the use of plastic pipes is increasing, and severe wildfires are expected to continue, the topics in this presentation are expected to become increasingly important for decision-makers."

PLENARY SESSION

Welcome & Introduction

U.S. Environmental Protection Agency

Plenary Talk 3 - Water Sector Risk & Resilience: Successes and Challenges

Kevin Morley | *American Water Works Association*

Over the last 20 years the understanding of risk and resilience has evolved to demand an all-hazards approach. This includes considerations for how the water sector tackles complex incident responses related to contamination from wildfires to intentional acts. No matter the cause, the principal objective is restoration of the critical lifeline services provided to a community by drinking water and wastewater systems. These challenges require research to provide stakeholders with the knowledge to make risk informed decisions. Much has been done and more is needed, including ensuring that we have clearly defined roles and responsibilities. Several examples will be offered to demonstrate success and where challenges remain.

CONCURRENT SESSION 4 – WATER RESEARCH AND OIL SPILL RESPONSE

Advances in Underwater Oil Plume Detection Capabilities

Robyn Conmy | *U.S. Environmental Protection Agency*

"Historically, visual observation is an emergency responder's first 'tool' in identifying spilled oil. Optical detection has since expanded to include a myriad of signals from space, aircraft, drone, vessel and submersible platforms that can provide critical information for decision-making during spill response efforts. Spill monitoring efforts below the air-water interface have been vastly improved by advances with in situ optical sensors and vehicle platform technology. Optical techniques using fluorescence, scattering, and holography offer a means to determine dissolved versus droplet fractions, provide oil concentration estimates and serve as proxies for dispersion efficiency. For subsurface spills over large space and time scales, Autonomous Underwater Vehicles (AUVs) can be used to provide subsurface plume footprints and estimate oil concentrations. For smaller, more frequent spills, tethered compact Remotely Operated Vehicles (ROVs) may be more appropriate as they are easy to deploy for rapid detection.

Two underwater oil detection technologies have been developed: (1) A Remote Environmental Monitoring UnitS (REMUS-600) AUV equipped with fluorescence and backscatter SeaOWL UV-A (Oil-in-Water Locator; Sea-Bird Scientific WET Labs Inc.), holographic imager (HoloCam; SeaScan, Inc), hydrographic information, video camera, CTD and a water/oil sampler. (2) A tethered ROV system (DTG2, Deep Trekker Inc.) equipped with video camera, UviLux (Chelsea Technologies Group, Inc) fluorometer, a CTD and water/oil sampler.

Calibration and validation tests of the sensor suite were conducted at the Coastal Response Research Center flume tank (NH, USA). Oil concentration estimates were verified by chemical analysis of hydrocarbons and particle size analysis (LISST 200X, Sequoia, Inc). Operational performance of the ROV platform and sensors was evaluated at the Ohmsett wave tank (NJ, USA). Field performance of the REMUS and sensor suite was evaluated at natural seeps near Santa Barbara, CA. This research demonstrates the forensic value of in situ optical data for improved understanding of the behavior and transport of spilled oil below the air-sea interface."

Understanding Hazards of Petroleum and Spill Response Agents in Inland Spills

Mace Barron | *U.S. Environmental Protection Agency*

Preparing for and responding to inland oil spills requires an understanding of the hazards and ecological risks of using spill response agents in freshwater environments. The majority of oil products and spill response agents have insufficient toxicity data for assessing hazards to freshwater environments, typically relying on a few standard test species. In the U.S., product listing currently only requires testing with two saltwater species, an estuarine fish (*Menidia beryllina*) and crustacean (*Americamysis bahia*). The acute toxicity of oil spill response agents can vary across product type and species, and even within specific categories of agents such as dispersants. Current U.S. EPA research is expanding the knowledge base on the effects of oil and spill agents in freshwater environments, including assessing the hazards of unconventional oils such as dilbits in water and sediment, and surface washing and herding agents to a greater diversity of species (*S. capricornutum, P. promelas, C. dubia*). Better understanding the hazards of oil and spill agents will provide for more informed regulation, preparedness, and spill response in inland waters.

Differences in the Inactivation of *Legionella pneumophila* Serogroups Using UVC-LED Technology in Drinking Water

Helen Buse | *U.S. Environmental Protection Agency*

Legionella pneumophila (Lp) is an opportunistic pathogen that causes respiratory infections primarily through inhalation of contaminated aerosols. Lp can colonize premise plumbing systems due to favorable growth conditions found within those environments (e.g. lower disinfectant residual, stagnation, warm temperatures). There are 15 serogroup(sg)s of Lp, all of which have been associated with clinical cases, but sg1 is the predominate disease-causing sg. UV light emitting diodes (UVC-LEDs) are an emerging water treatment technology and have been shown to effectively inactivate various drinking water pathogens. In this study, inactivation of four Lp strains (three clinical sg1, 4, and 6 isolates and one sg1 drinking water isolate) were evaluated using a UVC-LED collimated beam device. Three wavelengths (250, 265, and 280nm) and six fluence rates (0.5-34 mJ/cm2) were evaluated for each strain in drinking water. Efficacy testing was also performed using a UVC-LED point-of-entry (POE), flow-through device. Based on the log inactivation curves, at 255nm, the sg4 and sg6 clinical isolates were more susceptible to inactivation compared to the two sg1 isolates. However, at 265 and 280nm, the sg1 and sg4 clinical isolates were more resistant to inactivation compared to the sg6 clinical and sg1 drinking water isolates. Additionally, the POE device, operated at 3 gallons-per-minute with cold-tap water, reduced sg1 levels from 5.9 to 2.4 log10 CFU/mL. Results from this study indicate that although UVC-LED disinfection is effective, variations in Lp inactivation, wave lengths, and

technology applications should be considered, especially when targeting specific serogroups and isolates within premise plumbing systems.

AMI for Detecting and Responding to Backflow and Tampering in a Water System

Nelson Mix | *U.S. Public Health Service*

Advanced Metering Infrastructure (AMI) technology can be leveraged to detect contamination in a water distribution system. AMI can provide alerts about backflow and tampering. EPA has published new guidance about AMI as a part of a Water Quality Surveillance and Response System. This presentation will provide an overview of the new guidance.

CONCURRENT SESSION 4 – COVID-19 DECONTAMINATION RESEARCH EFFORTS

Disinfection Efficacy Studies with HuCoV-229E, a Surrogate for SARS-CoV-2

Vipin Rastogi | *U.S. ARMY, Combat Capabilities Development Command, Chemical Biological Center*

SARS-CoV-2, a novel coronavirus responsible for the ongoing COVID-19 pandemic, was first detected in Wuhan City, Huber Province, China. The novel virus is a betacoronavirus, like MERS (Middle East respiratory syndrome) and SARS (severe acute respiratory syndrome), all of which originated in bats prior to becoming transmissible in humans. Human coronavirus strain 229E (HuCoV-229E) is an alphacoronavirus that has been used as the regulatory strain for emerging pathogen claims in EPA List N development. The enveloped virion is 80-120 nm in diameter, with club-like projections of the spike protein and contains positive-sense RNA genome of this surrogate is 27.6 kb. In this study, HuCoV-229E was used as a surrogate for SARS-CoV-2 in evaluating virucidal efficacy of List N disinfectants, Calla 1452 (EPA Reg # 1839-168) and Lysol (EPA Reg # 777-89), as well as a few other experimental test substances, such as Bioxy-S, DiChlor, and OxiClean. Human lung fibroblasts, MRC-5 cell line, were used for propagating this virus, and for quantifying the number of infectious virions. A quantitative test method, based on draft MLB SOP MB-29-01, was used for this study to determine efficacy based on log reduction in the number of infectious virions. Three surfaces relevant to DOD operations- aluminum, nylon webbing and keyboard plastic- were included in this study. Efficacy results will be presented for the surrogate virus in the presence or absence of a complex bioburden.

Disinfection of N-95 Filtering Facepiece Respirators

Leroy Mickelson | *U.S. Environmental Protection Agency*

"Problem Statement: The COVID-19 pandemic resulted in limited availability of personal protective supplies, including N-95 respirators. Many hospitals and health care professionals were required to reuse N-95 respirators without disinfection, which could result in contraction of the disease.

Until the COVID-19 pandemic, there had been little reason to disinfect disposable respirators. Now there are several ways that have been proposed to disinfect disposable N-95 respirators. This presentation will describe an efficacious method to disinfect N-95 respirators using commercial off the shelf equipment.

Approach: The methodology is based on research which demonstrated that low concentrations of hydrogen peroxide (HP) vapor held for a cumulative concentration-time of 50 ppm-hours were efficacious for inactivating MS2 and Phi6 bacteriophages, surrogates for viruses such as Ebola and SARS, on several materials, including N-95 respirators.

Twelve N-95 respirators were suspended inside a sealed plastic bin where hydrogen peroxide liquid was held in equilibrium with its vapor. A small fan was placed in the bin to help the process quickly reach equilibrium and to keep the HP vapor concentration constant throughout the bin. A one-dollar paper chemical indicator strip (the one item that is not purchased at a local store) provided a visual indication that the concentration-time was met for each disinfection cycle. At room temperature (21 °C), using 3% HP liquid, purchased at a drugstore, the process was completed in 24-hrs. Using 6% HP liquid, purchase at the beauty solon, reduced the required time to 12 hours (overnight). Real-time HP chemical sensors were also used to monitor HP vapor concentrations inside the bin during these tests. "

Mitigating Transmission by Maximizing Decontamination Resources in Response to the COVID-19 Pandemic: One Healthcare Coalition's Strategic Response

Frances Grinstead | *CURIS System, LLC*

Selecting decontamination tools with the highest efficacy, broadest uses, and ease of implementation, along with pre-emergency training on technology and well-planned effort coordination, can make all the difference between a successful response and catastrophic failure. As emergency responders and healthcare facilities around the world scrambled to battle the pandemic, Georgia Healthcare Coalition (HCC) Region K was prepared to meet the needs of its community. In March 2020, HCC Region K, which includes rural and economically challenged areas, became a hotspot with a 600-700% increase of COVID-positive cases in just five days in one hospital. Six months earlier, the GA Healthcare Coalition made use of Federal funding designated to prepare for Ebola, and Region K, via State of GA Hospital Preparedness Program, applied its collaborative skills gained from ASPR TRACIE and training from CDC/Emory University to bolster its outbreak response. Region K researched the needs of healthcare providers and determined need around reducing spread of infectious diseases through high-level
disinfection. Maximizing funds, they implemented systems that provided both versatility and efficacy against C. diff to affect a wide range of pathogens and environments. Region K-HCC purchased, trained on, and implemented hybrid hydrogen peroxide (HHP™) fogging systems in area hospitals. Throughout, Region K-

HHC capitalized on regional partners, communication, and strategic loaning of equipment and training to accommodate shifting needs in the community. Hospitals disinfected ERs and patient rooms after each COVID positive or person under investigation (PUI) patient release and made HHP systems available for on-site ambulance disinfection. Devices were loaned to long-term care facilities, and when needed, disinfection shifted to police, fire stations, testing/vaccine administration sites, and even community locations like churches and daycares to help protect personnel and keep key infrastructure open. By creating a resource hub, the Region K-HCC helped every sector overcome COVID challenges. Pre-emptively shifting disinfection resources led to fewer patients entering an already over-burdened healthcare system. Focusing on effective and versatile disinfection, with strategic communication and resource distribution, the Region K-HCC achieved dynamic success in mitigating the challenges of a prolific COVID-19 outbreak. This case study examines one Healthcare Coalition's community approach to preparing for future pandemics, gives an overview of its implementation during the COVID-19 pandemic, and provides key takeaways for mitigating the spread of COVID-19 and future infectious disease through disinfection.

Decontamination of Covid-19 Vaccine Production Facility

Emily Lorcheim | *ClorDiSys Solutions, Inc.*

"A pharmaceutical company in the United Kingdom previously produced cephalosporins and contained possible residuals within their facility. Beta lactams derived from cephalosporin production within their facility would need to be inactivated prior to any other non-beta lactam containing products being produced.

The United States Food and Drug Administration (FDA) requires a separation in manufacturing of non-beta-lactam containing drugs and beta-lactam containing drugs. This is due to the danger initiating in the sensitizing effect and the possibility of a patient's allergic shock reaction if an individual were to be exposed to a beta-lactam containing product. It is estimated 3%-10% of all adults in the United States have experienced an allergic response to penicillin (CDC, 2006). Reactions to these allergies can range from rashes to life-threatening anaphylaxis (Romano et al., 2002). This includes blood pressure dropping to dangerous levels, causing lightheadedness and loss of consciousness (Barza, 1985).

Due to the strict requirements set forth by governing bodies, many pharmaceutical firms resort to demolishing buildings or ridding themselves of equipment used during beta-lactam production. However, a study completed within the United States Pharmaceutical Industry alongside ClorDiSys Solutions, Inc established evidence that chlorine dioxide gas has the capacity to inactivate beta-lactams. The tests consisted of nine inactivation cycles, with five passing the acceptance criteria of achieving a 3-log reduction of the eight beta-lactams to beneath U.S. Food and Drug Administration (FDA)-required 0.03 ppm residue detection level. Successful inactivation cycles that achieved a 3-log reduction of all eight beta-lactam compounds all had cumulative exposures of over 7,240 ppm-hours. These results can conclude that to achieve a 3-log reduction of beta-lactams, an inactivation cycle consisting of a 30-minute conditioning phase at 75% relative humidity, followed by an exposure to chlorine dioxide gas of at least 7,240 ppm-hours, is required. Chlorine dioxide destroys the beta-lactam ring and inactivates the compound, in similar fashion to the manner in which penicillin-resistant organisms act.

With the urgency to increase Covid-19 vaccine production, the facility in the United Kingdom realized the necessity to shift focus towards this effort. The facility needed to be repurposed to begin vaccine production

and storage to address world-wide concerns. However, due to the previous production of beta-lactams, the firm was required to ensure inactivation of cephalosporins or any other residues that may possibly be present. To allow for that assurance, the initiation of a chlorine dioxide gas decontamination of the facility was implemented. Once successful, production in the plant could then begin to turn towards producing and storing the vaccine.

The chlorine dioxide gas inactivation of beta-lactam ring antibiotics consists of exposing the target beta-lactam to Chlorine dioxide gas at a concentration of 5mg/L with a contact period of 7,240 ppm-hrs where the target is exposed to the gas. The facility contained a total volume of 247,203 cubic feet and was decontaminated with chlorine dioxide gas generated utilizing 120 chlorine gas cylinders with proprietary CD generating cartridges produced by ClorDiSys. The gas was generated on demand and fed into the space via tubing injected in various locations which, alongside sample tubing, was pre-determined to ensure the entire area was evenly distributed to. Sample tubing allows for continuous monitoring and control of the gas concentration. The EMS monitors the concentration by utilizing a calibrated photometer which can accurately read Chlorine dioxide gas concentration. The continuous monitoring ensures a successful cycle and that the desired dosage is achieved throughout. During the entire exposure, personnel are able to secure a safe environment by utilizing an ATi Portasens that can monitor chlorine dioxide levels and determine if there are any leaks present. Once the entire gassing area reached the desired dosage of 7,240 ppm-hours, the space could then be aerated by exhausting through carbon scrubbers to eliminate the gas. Once aerated, personnel then use the ATi Portasens to ensure the final internal and external chlorine dioxide concentration levels are below the HSE TWA of 0.1ppm. Once verified, the production facility was safe to reenter and the company could again resume operations.

Due to the success of the inactivation, the plant could venture forward with utilizing the building to manufacture and store the Covid-19 vaccine. Repurposing the space thanks to the chlorine dioxide gas decontamination expedited the logistical and practical distribution of the vaccine to those in the United Kingdom and throughout the world."

TECHNOLOGY CAFÉ: SESSION A

1 Water Contaminant Information Tool (WCIT): A Tool for Water Contamination Incident Preparedness and Response

Veronica Aponte-Morales | *U.S. Environmental Protection Agency*

"Drinking water and wastewater systems face major challenges when confronting intentional, unintentional, or natural water contamination incidents. An effective and fast response is necessary to limit the impact on public health and water systems in general. Water utilities and responders require tools that can be adapted to specific incidents as appropriate. To address the needs of the Water Sector, the Environmental Protection Agency's Office of Water, Water Security Division has and continues to develop tools and resources to aid the Water Sector in their emergency response and preparedness activities. An example of such a resource is the Water Contaminant Information Tool (WCIT). WCIT is a secure online database that contains comprehensive information on chemical, biological, and radiochemical contaminants of concern for the water sector. It was

designed to help support vulnerability assessments, and assist in planning for, and responding to, water contamination threats and incidents.

There are more than 800 contaminants listed in WCIT with valuable information. Of these, 113 contaminants are “comprehensive” profiles. This type of profile include data on contaminant names (including CAS numbers and synonyms), contaminant usage and sources, fate and transport, health effects and toxicity, medical information, early warning indicators, drinking water treatment, sampling and analysis, helpful response considerations for utilities, and several other categories of information, such as infrastructure decontamination. The predominant (more than 700 contaminants) profile type is a “lab methods” profile that provides summaries for field and laboratory analytical methods.

WCIT’s wide range of information makes it a tool applicable to a wide range of users and activities, for example:

- Laboratories – to search for analytical methods and identify any potential safety risks associated with handling samples.
- Emergency Responders – to obtain appropriate field methods and identify proper sample collection and transport.
- Medical and Public Health Officials – to assist with diagnosis and treatment of anyone who a contaminant might have exposed.
- Utilities – to learn about a contaminant’s persistence, fate & transport, and other properties, and identify treatment and decontamination options.
- Public information officer – gather information that can be used for briefings and communicate with the public and media.

This presentation will include a brief overview of the tool’s main features, a walkthrough demonstration of the database and examples of real experiences users have had with WCIT. "

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2 Stochastic Infrastructure Remediation Model

Tanvi Joshi | *Battelle Memorial Institute*

"Wide area chemical, biological, radiological, and nuclear (CBRN) incidents, whether products of terrorism, war, or accidents, have the potential to damage core infrastructure assets. The Stochastic Infrastructure Remediation Model (SIRM) was developed to prioritize remediation of critical infrastructure sectors during such incidents, implementing a stochastic modeling process that simulates the complicated interactions among different sectors during the remediation process.

The SIRM considers each of the infrastructure sectors as an operating efficiency percentage and models the restoration of services in each sector as a set of reactions that use resources from one sector (e.g., Energy) to restore services in other sectors (e.g., Healthcare and Communications). This process models the time required to repair an infrastructure sector, while also allowing the user to consider changes in resource allocation based on user-defined repair factors. The SIRM can dynamically model all the desired sectors and allows the user to draw statistical conclusions specific to a CBRN incident.

There are four key algorithm elements involved in SIRM: 1) the infrastructure interactions, which describe how the sectors interact with each other 2) the repair factors, which model the rate at which external resources are

used to bring services back online after outages 3) the rates of reactions, which govern the speed of the response, and 4) critical infrastructure efficiency over time. These parameters, particularly the output parameter of the efficiency over time, allow the SIRM to assist in emergency response and decision making in several ways. The estimated recovery time can be assessed based on the initial scenario parameters and can be adjusted and recalculated as new information becomes available. The repair factors can also be adjusted to model the prioritization of infrastructure recovery by setting higher relative repair factors for higher priority infrastructure sectors. Finally, sensitivity analyses can be used to determine the most influential sectors and possible resource allocation. "

3 U.S. EPA's Waste Estimation Support Tool (WEST)

Paul Lemieux | *U.S. Environmental Protection Agency*

EPA's Waste Estimation Support Tool (WEST) is a GIS-based decision support tool for estimating the characteristics, amount, and residual contaminants of waste generated from remediation and cleanup activities after a biological or radiological contamination incident. WEST consists of a GIS module that estimates the infrastructure and urban surfaces affected by a wide-area contaminant release, and a calculator module that estimates waste amounts and characteristics as a function of decontamination approaches. WEST has been released to the public and has been used in numerous national level exercises and planning scenarios; however, it continues to be improved and refined to add additional functionality and performance. The most recent version of WEST included the ability to substitute the Federal Emergency Management Agency (FEMA) infrastructure databases that WEST normally uses with user-defined infrastructure databases so that communities with high resolution infrastructure databases or international partners could use WEST.

4 U.S. EPA's Disaster Debris Recovery Tool

Lucy Stanfield | *U.S. Environmental Protection Agency*

"The U.S. EPA Disaster Debris Recovery Tool provides emergency planners and responders at the federal, tribal, state, and local levels with a tool to plan and implement proper recovery, recycling and disposal of disaster debris. Once a regional tool, EPA expanded and launched a national version in 2020. The expanded tool includes accurate location and contact information of over 20,000 facilities including composters, demolition contractors, transfer stations, landfills, household hazardous waste collection sites, and facilities recycling construction and demolition debris, electronics, metals, tires and vehicles. Current users include emergency planners and responders as well as staff working in green remediation and sustainable materials management. This presentation will feature an overview of the national data and tool along with a brief demo showing the search and export features.

DDRT website: https://www.epa.gov/large-scale-residential-demolition/disaster-debris-recovery-tool

A short overview video is available online at: https://www.youtube.com/watch?v=VVvGT2xJPc4"

5 The EPA Flooded Homes Website

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

This tech café demonstration previews the U.S. Environmental Protection Agency's flooded homes website. Getting people back into their homes quickly and safely is central to household and community resilience after a flood. However, flooded homes present indoor air quality and other risks individuals coming back in to remove damaged household items, muck out, gut, and begin to repair their home. Risk communication around how to stay safe while cleaning out and fixing up flooded homes needs to be conducted in a way that meets people where they're at socially, emotionally, and financially after a flood. The website is intended to help make EPA become a trusted source of technical information about safely remediating flooded homes. It contains how-to videos and graphics to help homeowners, renters, and volunteers take action to clean up and repair flooded homes. Development of the website drew on human-centered design and disaster anthropology to make sure that its design and content reflect its audience's needs, values, and constraints.

TECHNOLOGY CAFÉ: SESSION B

6 Electrons Dispersion Filtration

Michael Omary | *APD Clean Water Technologies Group*

7 Immersive Modular Preparedness Intelligent Tutor (IMPRINT)

Austin Crumpton | *Charles River Analytics*

"IMPRINT aims to enhance trainee performance and set operational expectations outside of the hot zone in hyper-realistic exercises that challenge physical and psychological capabilities. To do this, we use virtual reality (VR) modules that seamlessly integrate with existing HAZMAT and CBRNe training curriculums and lead to improved outcomes using insights from behavioral science.

Unique challenges to training and trainee engagement have developed in response to the ongoing COVID-19 pandemic. Organizations must offer a combination of in-classroom, online, and hybrid training further challenging the feasibility and sustainability of skills and competencies developed through PowerPoint and Zoom-based case study simulations. As disasters become more numerous and complex (e.g., wildfires during a pandemic) demands for effective training technologies will increase. Matured VR systems enable low-cost, repeatable, functional, targeted exercises. IMPRINT provides a physically immersive mission rehearsal experience that simulates equipment configurations and high-risk scenario settings to support mission

readiness. Fully immersive VR exercises additionally benefit trainees beyond standard physical FTX by enabling training in simulated high-risk scenarios within a safe and controlled setting.

While many activities must be performed during hands-on exercises, there are instances in current practice where virtual training must adopt innovative training techniques to remain effective.

IMPRINT provides training organizations with a library of VR case studies that augment standard paper and PowerPoint scenario-based activities used to prepare trainees. IMPRINT VR case studies enhance training organizations' abilities to provide high-quality HAZMAT and CBRNe training to a broad audience at a low cost. IMPRINT extends our existing modules to integrate with physical personal protective equipment (PPE), extending our 3D object haptic interaction and natural walking capability to support spatial skill development, and provide peer user support to allow collaborative learning. Using initial feedback from trainers and trainees we are enhancing our ITS to develop an innovative Behavioral Intelligent Tutoring System (BITS) that augments the development of procedural skills using behavioral science. Additionally, we are enhancing instructor tools to tailor training to curriculum and worksite-specific training needs.

IMPRINT is a complementary training tool to enhance training organizations' e-learning capabilities. By focusing on the integration IMPRINT provides a solution to the developing market demand of hybrid HAZWOPER training. Delivered through the Oculus Quest VR headset IMPRINT closes the gap created by remote learning environments, time constraints, and inadequate access."

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8 U.S. EPA's Incident Waste Decision Support Tool (I-WASTE)

Paul Lemieux | *U.S. Environmental Protection Agency*

EPA's Incident Waste Decision Support Tool (I-WASTE) provides important information to support planning and response decision-making and features calculators to generate waste quantity estimates, provides databases of treatment and disposal facilities, and includes a quick reference to technical information, regulations, and guidance to address the safe and efficient removal, transport, and disposal of waste materials. The objective of I-WASTE is to help reduce restoration time and expense by providing quick access to information that will inform the decision-making process for incident waste management. I-WASTE supports EPA's goals to strengthen resilience to disasters and complements other EPA tools such as the Disaster Debris Recovery Tool and the All-Hazards Waste Management Planning Tool. I-WASTE has recently undergone a significant modernization effort and has been moved to cloud.gov servers to facilitate data exchange with other waste management tools developed by HSRP, OLEM, and the Regional Offices.

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9 U.S. EPA's Waste Staging and Logistics Tool

Tim Boe | *U.S. Environmental Protection Agency*

Large-scale disasters have the potential to generate significant amounts of waste. For example, Hurricane Katrina and the Joplin, Missouri tornado resulted in 100 million and 1.5 million cubic yards of waste, respectively. Man-made chemical, biological, radiological, or nuclear (CBRN) incidents, either by way of terrorism, war, or accident, have the potential to generate as much or potentially even more waste. Both natural and man-made incidents are also prone to generate some form of hazardous waste that is more

complicated to remediate or dispose. Recovery is largely impacted by waste management issues. The quantification, segregation, transportation, and storage of waste can be an arduous and costly undertaking. Furthermore, these processes are intricately linked with other decisions made throughout the recovery timeline. Therefore, the remediation, including waste management, must be holistically considered. Understanding these complex interactions can be facilitated by using models and tools that adhere to the "system-of-systems" approach.

To better understand and predict waste management issues, the Environmental Protection Agency's (EPA's) Homeland Security Research Program (HSRP) is developing a suite of tools and resources for planning, response, and recovery purposes, including two newly developed GIS-based tools. EPA's Waste Staging and Storage Site Selection Tool uses spatial information and analysis techniques to help identify and prioritize potential locations for staging and storing waste. The tool analyzes siting criteria for a specified geographic area to identify candidate sites and their total available land surface areas. The tool was developed to help decision makers better understand the potential options for staging and storing waste, and to illuminate potential capacity constraints when conducting planning efforts. Aside from identifying where waste may be staged or stored, the need to evaluate resource demands associated with the transportation and disposal of waste is also crucial. EPA's All Hazards Logistics Tool calculates the cost and time to manage a user-specified quantity of waste and allows users to run routing scenarios with user-defined destinations. Factors specific to waste type, hauling rates, and acceptance rates allow users to explore options and evaluate constraints to improve preparedness for managing large volumes of waste. This presentation will provide an overview of both tools that integrate GIS-based visual analyses to inform planning and response efforts.

10 The Feedback Loop in Decon - The Missing/Broken Link

John Zour

"A review of OSHA regulations along with applicable NFPA standards reveals extensive procedures related to decon. While the different types of decon present different elements and challenges, a post decon assessment is necessary. This important aspect, the feedback loop, is often overlooked and/or dismissed. Violent protests across the United States combined with an increase in acid attacks around the world continue to change the response world landscape. A 911 based haz mat team continues to play a vital role in successful outcomes when a chemical is involved. This specialty team typically has: more training, better equipment and a greater number of available resources than the. first arriving responders. Their greatest deficiency, is simply the fact that they are likely not on the scene when emergency/mass decon takes place. While decon runoff is normally not contained during emergency/mass decon, the effectiveness NEEDS to be monitored. A first arriving paramedic crew needs information as they start treating an acid attack victim. A police officer splashed with an unknown chemical would benefit from knowing if the liquid was hydroCHLORIC or hydroFLUORIC acid. An operator of a military drone would benefit from knowing if their drone has flown through a nerve agent dispersion. In all of these "scenarios" the first arriving unit/crew/partner will not likely be the haz mat team equipped to the hills and trained just shy of a chemical engineer. The feedback loop associated with any action taken by these crews is a vital aspect and an existing by gap in most response type organizations. In Our Gear has developed a user friendly, reliable, cost effective tool that can be used by first arriving crews to categorize the chemical hazard and check the effectiveness of any emergency/mass decon efforts. This tool, ZMac card, is now fully patented with a utility and design patent. The user peels the protective film, exposes the chemical

paper to the hazard and interpret the results printed on the card. The intellectual property associated with the ZMac card allows In Our Gear to write words around any chemical detection paper. The key messages are keyed to 911 based responders but can easily be tailored to military and private companies. There has been a missing link between cheap reliable chemical detection and action items. As an example, a first responder needs to know that a green color change on nerve agent paper is significantly different than pH paper turning green. Reference documents that list chemical physical properties at a set temperature do little for the first arriving first responder in a significantly warmer environment. Any chemical mixture that occurs during an accident and subsequent 911 request will present a significant challenge to any responder. Predicting the byproduct of a chemical reaction is a daunting task for the most seasoned haz mat technician. Variable environment conditions add to this difficulty. Our ZMac card was patented in 2019 and puts chemical classification in the hands of those that need it most - the first arriving response crews. Our multi function ZMac card, allows a feedback loop to be easily implemented in an emergency/mass decon situation when waiting for the haz mat response team is simply unacceptable."

TECHNOLOGY CAFÉ: SESSION C

11 Radiological Decontamination of Electronic and Opto-electronic Equipment

Zakir Kazi | *Defence Research & Development Canada (DRDC)*

"Raspberry Pi- an open electronic and night vision device- an opto-electronic equipment represent Sensitive Equipment (SE) in terms of their decontamination preferences according to Canadian Armed Forces (CAF) and NATO allies. SE includes those items that cannot be decontaminated by commonly used methods such as aqueous- and organic-based liquid decontaminants without degradation of the items performance and require special treatment. These equipment have significance on military mission success due to their critical role and availability for re-use.

Defence Research Canada (DRDC)'s Ottawa Research Centre (ORC) and Suffield Research Centre (SRC) has conducted radiological decontamination of SE research over the past decade. Some of these results were presented in the 2019 EPA conference. The main objective of the decontamination of SE project was to establish effective radiological decontamination methods for SE using commercial-off- the-self (COTS) agents and tools. The objective includes higher rate of decontamination and retaining the functionality of the test pieces. Decontamination of Raspberry Pi coupons from two shorter-lived radioisotopes namely, 99mTc and 67Ga using putty, gel and RDS 2000 have been conducted. The isotopes are gamma emitters; relatively easy to characterize using gamma spectrometry. The short-lived 99mTc and 67Ga have half- lives of 6h and 78h, respectively. The radioactive wastes generate from these tests decay to ambient activity within a month leaving less waste management burden. These radioisotopes are available relatively easily. The above noted merits justify the use of the isotopes. The test pieces were contaminated by mist dispersion in a confined chamber. Decontamination rates and post-decontamination functionality of the Raspberry Pi coupons were examined. Results from the three different methods such as (a) use of putty, (b) use of gel and (c) use of RDS 2000 were

analyzed and compared. The results concluded that the use of putty was the best choice in terms of decontamination efficiency and survivability of the electronic coupons.

Based on the above observation, decontamination work was extended to night vision device. Preliminary results show an effective decontamination of both radioisotopes on the device from all the three decontaminants noted above. Post- decontamination functionality testing for night vision devices are in progress. These results will be presented and discussed in detail in the conference."

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12 A Web-based GIS Application for Creating, Evaluating and Operationalizing Sampling Designs

Molly Rodgers | *Eastern Research Group*

"EPA's Center for Environmental Solutions and Emergency Response's Homeland Security Research Program tasked Eastern Research Group (ERG) to develop a solution to support analyzing tradeoffs among sampling designs and to operationalize sampling maps to support characterization and clearance sampling. A large-scale contamination event would require significant time and resources for recovery. EPA planners and response personnel need to quickly analyze trade-offs to inform characterization and clearance sampling plan designs. Building on previous research conducted to quantify resources demands associated with various biological sampling designs, an interactive web-based application was developed to facilitate comparing the costs and time required to implement various characterization and clearance sampling plans.

A custom geographic information system (GIS)-based web application—EPA's Trade-off Tool for Sampling (TOTS)— is now available and allows users to create sampling designs, configure and include custom sampling methods, visualize sampling plans, share sampling plans, and operationalize sampling plans to use with field data capture technologies. TOTS is used to support emergency response training and bioterrorism simulations and exercises. Decision-makers can use the tool's resource demand estimates to inform selecting an appropriate sampling technique based on an informed evaluation of established sampling and data quality objectives to identify contamination that could impact human health. In addition to generating resource demand estimates, TOTS also operationalizes sampling plan maps by enabling field response personnel to leverage a web-based map, real-time navigation, and field data capture while sampling in the field. TOTS outputs include geospatial assets that can be saved and shared for reuse. This presentation will provide an overview of TOTS using a case study to illustrate key features, example applications, and future enhancements."

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13 U.S. EPA's All Hazards Waste Logistics Tool

Anna Tschursin | *U.S. Environmental Protection Agency*

Past experience has shown that communities with comprehensive and well-coordinated WMPs recover more quickly and at less cost from these incidents, making these communities more resilient. Unfortunately, planning

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

To assist emergency managers, planners, and responders in the public and private sectors in creating or updating a comprehensive plan for managing waste generated from manmade and natural incidents, the OLEM/ORCR Materials Recovery and Waste Management Division, in collaboration with Regions 3 and 5, the Office of Homeland Security and The Office of Research and Development's Center for Environmental Solutions and Emergency Response, is developing an interactive on-line waste management planning tool to aid federal, state, local, tribal, and territorial planners in developing a preliminary waste management plan. A "quickstart" version of this tool is already online and has recently been upgraded. It can be found at wasteplan.epa.gov

ORCR is working on expanding this quickstart into a more robust tool to provide step by step advice on creating a comprehensive pre-incident WMP. This tool will provide a framework to help managers, planners, and responders initiate plan development, providing variable degrees of assistance from providing a simple outline of plan contents, to creating customizable language, to providing scenario-specific waste quantity value estimates to use in developing a plan. The tool will not only provide an adaptable format for drafting the plan itself but is integrated with other online tools such as I-WASTE to allow for easy data flow between the tools, as well as links to other resources such as fact sheets, and databases.

Additionally, future improvements to the tool are envisioned to provide users with the ability to securely upload information to a plan, view plans developed and shared by other users, further improve waste volume estimates, and serve as a launchpad for access to many other waste management related tools across EPA.

14 The Environmental Resilience Tools Wizard

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

This tech café demonstration will walk participants through the Environmental Resilience Tools Wizard. The U.S. Environmental Protection Agency (EPA) created this online wizard to help end users find EPA resources that help build resilience to disasters. The wizard contains publicly available resources produced by EPA that address how to reduce disaster risks to the environment and human health during disaster mitigation, preparedness, response or recovery. It is designed to be used state and local emergency managers, environmental and health agencies, and other users who may not be familiar with EPA resources. It may also be useful to cities, counties, or tribes implementing resilience or hazard mitigation plans; researchers analyzing environmental or ecological aspects of disasters; drinking water and wastewater utilities; and community and environmental organizations working to build resilience. The Tools Wizard helps users find EPA resilience resources and figure out which one best meets their needs depending on the type of incident and environmental concern at hand.

PLENARY SESSION

Welcome & Introduction

Bruce Rodan, Associate Director for Science for the Office of Research and Development | *U.S. Environmental Protection Agency*

Plenary Talk 4 - Disaster Predictions in Support of Response Preparedness in the Coastal Zone

Rick Leuttich | *University of North Carolina*

Many coastal cities exist under the significant threat of flooding and are facing growing flood risk due to factors that include relative sea level rise, increasingly virulent storms and human development. Risk mitigation planning and design in coastal areas such as these are dependent on the delineation of flood hazards by sophisticated computer models such as ADCIRC. The Hurricane Storm Damage and Risk Reduction System around New Orleans is a preeminent example of risk mitigation infrastructure designed using this model. I will provide an overview of ADCIRC capabilities, its uses from forensic studies to mitigation design, and the development and application of the ADCIRC Prediction System (APS), which provides a new generation, event-based, coastal flood prediction capability for use in response preparedness.

CONCURRENT SESSION 5 – CHEMICAL AGENT DECONTAMINATION RESEARCH

The Assessment and Decontamination of an Opioid Contaminated Site and Establishment of California's Standards

Michael Polkabla | *BioMax Environmental, Inc.*

This presentation will focus on a case study involving the assessment and decontamination of a property that was used as an illegal opioid (fentanyl and carfentanil) handling, processing, and pill packaging site. This case study will detail the environmental site assessment and sampling procedures, the residues and contaminant findings, and the decontamination methods that were developed and used to successfully mitigate the property. This effort required the development of a post-mitigation clearance assessment criteria level that was created through toxicological consultation and modeling based on an EPA reference dose algorithm. This case (and others at the time, in California) led to enhanced awareness of the hazards associated with opioid contaminated sites and resulted in the establishment of current assessment and regulatory cleanup standards

in California for the re-occupancy of opioid-contaminated properties after law enforcement and first responders depart.

The Decontamination of Chemical Warfare Agents from Skin Using Zirconium Hydroxide

Shawn Stevenson | *Combat Capabilities Development Command, Chemical Biological Center*

In the event of a chemical warfare agent (CWA) release, there is a likelihood of CWA deposition on exposed skin of an unprotected population, whether it is during a military or civilian scenario. Zirconium hydroxide has been identified as a reactive “dry” skin decontamination technology that can be used to mitigate skin contamination without the use of water. In collaboration with the University of Hertfordshire Research Centre for Topical Drug Delivery and Toxicology, a unique diffusion cell test capability was used to assess the decontamination effectiveness of the technology on contaminated skin. The CWA’s HD, GD, and VX and simulants methyl salicylate, diethyl malonate, and phorate were applied to excised porcine skin and decontaminated with zirconium hydroxide or a water shower after a 5 minute contaminant-skin interaction period. The resulting data indicate that the performance of the zirconium hydroxide is similar to that of the water shower. Other results will also be presented to showcase the reactivity of zirconium hydroxide with liquid HD, GD, and VX, as well as a study of the skin absorption potential of zirconium hydroxide.

Model Simulations of Contaminant Dispersion through an Irregular Building Array

Michael Pirhalla | *U.S. Environmental Protection Agency*

Urban areas create complex wind flow patterns that can affect contaminant dispersion downwind of a harmful release. 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. Fast-response dispersion models are frequently used to simulate the expected plume propagation following these incidents; however, results may fall short due to simplicity in model formulations, especially within complex environments. Field, laboratory, and computer modeling experiments that simulate these types of releases are critical in advancing characterizations in current dispersion models. This project leverages the configuration of buildings used in a full-scale, mock urban field study (Jack Rabbit II) to examine the concentrations of a neutrally buoyant tracer in a series of meteorological wind tunnel and Embedded Large Eddy Simulation (ELES) experiments. After demonstrating good comparisons between the wind tunnel and ELES via lateral and vertical concentration profiles, we show that the standard Gaussian plume equation, which is fundamental to most dispersion models, represents the profiles well despite the buildings and network of street canyons. The initial plume dispersion, however, depends strongly on the structures immediately adjacent to the release. Further ELES experiments show that slightly oblique incoming wind directions cause additional off-axis channeling of the plume, which demonstrates how building structures can cause considerable plume drift, especially under greater incoming wind obliquity. To represent the class of fast-running, Gaussian dispersion models, AERMOD was run to inform where these types of models may be usefully applied within urban areas or groups of buildings. Using an urban wind speed profile and other parameters that may be locally available after a release, AERMOD was shown to qualitatively represent the ground-level plume (albeit overestimating lateral

plume spread) while somewhat underestimating peak concentrations. The addition of a turbulence profile (extracted from the ELES data) into AERMOD's meteorological input improved model estimates of lateral plume spread and centerline concentrations, although peak concentration values remained underestimated in the far field. Observations and suggestions for Gaussian dispersion modeling are then offered based on this mock urban modeling exercise.

In Vivo Efficacy of Rapid Skin Decontamination Protocols using the Reactive Skin Decontamination Lotion (RSDL) Kit Against VX

Vivian Lau | *Defence Research and Development Canada*

"The Reactive Skin Decontamination Lotion (RSDL) kit is a skin decontaminant product consisting of a viscous liquid that can chemically neutralize chemical warfare agents and a non-reactive sponge that aids in the physical removal of contamination. Package directions for using the RSDL kit recommend that the lotion be left on the skin for two minutes prior to removal with soap and water when conditions permit. Under austere conditions, it may not be feasible to achieve the recommended RSDL residence time and to remove the residue with soap and water. Decreasing the time required for decontamination with RSDL can also limit the risks of exposure such as hypothermia in casualty decontamination.

In this study, the RSDL kit was used to decontaminate anaesthetized swine following percutaneous application of the nerve agent VX (0.4 mg/kg, neat). Animals were decontaminated either 5 or 30 minutes after application of VX by scrubbing the site of contamination with a RSDL-saturated sponge for 10 seconds. The residual RSDL was immediately removed by wiping with either dry cotton gauze, or cotton gauze wetted with water. The rapid decontamination procedure was completed within 1 minute.

Animals that were not decontaminated showed >80% acetylcholinesterase (AChE) inhibition and required ventilation within 2 hours. Milligram-quantities of intact VX were recovered from the skin after 6 hours. When RSDL decontamination was initiated 5 minutes post-exposure, removal of residual RSDL using a dry wipe resulted in less AChE inhibition (mean = 22.4% at 6 hours) and lower concentrations of plasma VX compared to wet RSDL removal. This corresponded to fewer signs of nerve agent poisoning. The amount of intact VX recovered from the skin differed between the two RDSL removal conditions (mean = 72.5 µg, wet; 3.4 µg, dry). The mode of RSDL removal did not result in significantly different outcomes for animals decontaminated 30 minutes following VX exposure. After either wet or dry removal of RSDL, AChE inhibition was delayed and concentrations of VX in blood plasma were lower compared to control animals. The amount of VX remaining on skin was also similar using either dry or wet removal (mean = 16 µg, wet; 8.8 µg, dry).

The results demonstrate that rapid decontamination using the RSDL kit leads to improved outcomes when performed at either 5 or 30 minutes following dermal VX exposure. Differences between wet and dry protocols for RSDL removal suggest that "wash-in" effects may be significant and have implications for best practices for skin decontamination. "

Identifying and Improving Disaster Waste & Debris Management Decisions

Marissa Matsler | *Oak Ridge Institute for Science and Education Research Participant with U.S. Environmental Protection Agency*

Disaster Waste and Debris Management (DWDM) can place significant logistical, emotional, and financial burdens on communities, impeding response efforts and prolonging the time to recovery. Each step of the technical processes of DWDM (e.g., sorting, staging, transporting, treatment, disposal) involves decision points by varied social actors (e.g., families decide what to keep or throw away; waste haulers determine which route to take on a given day; municipalities sign contracts). However, the social dynamics surrounding these decisions are understudied and represent a gap in the literature. Analysis of social drivers and decision-making processes of DWDM is important because of the need to coordinate among multiple social actors, resolve social conflicts that may arise, and make sure that DWDM does not exacerbate environmental injustices. During an incident, the U.S. Environmental Protection Agency's on-scene coordinators (OSCs), response corps, and their federal, state, and local partners may encounter distinct decision-making cultures and organizational structures, as well as varying ideas about what "waste" and "debris" are and what associated risks might be. Being able to resolve these challenges requires insight into how and why DWDM decisions are made. The objective of this research is to gain a better understanding of the various DWDM decision points, actors, and social conflicts. By mapping these variables across disaster types, community types, and waste material types, we will 1) add to social science theory regarding decision-making in disasters and about waste; and 2) determine potential points of intervention to build capacity and improve DWDM outcomes. Here, we report findings from initial focus groups with emergency managers and waste professionals exploring what on-the-ground DWDM decisions are and strategies for overcoming impediments to decisions and action.

Evaluation of Whole-Carcass Composting as a Disposal Option for African Swine Fever Virus (ASFV)-Infected Swine

Lindsay Gabbert | *Department of Homeland Security, Science & Technology*

An outbreak of African Swine Fever (ASF) on U.S. soil would be detrimental to swine producers and disrupt international trade of pork products. Globally, ASF outbreaks have resulted in the deaths of millions of pigs, prioritizing the need to better understand carcass disposal methods capable of ASF virus (ASFV) elimination. In this study we evaluated whole-carcass composting as a disposal option for ASFV-infected swine in a BSL3-Ag high-containment laboratory. Four swine were composted in a windrow constructed according to USDA Agriculture Livestock Mortality Composting Guidelines. Windrow internal temperatures were monitored over 37 days both manually and with Hobo data loggers. Infected spleen samples were removed from the compost windrow at days 0, 1, 3, 5, 7, 10, 14, 21, and 28. At the study conclusion, skin, muscle, and bone marrow tissues were collected from the decomposed carcasses in addition to sentinel carbon materials. All samples were processed and tested for the presence of viral DNA via RT-PCR and for infectious ASFV by viral isolation. Windrow temperatures >130ºF were recorded for >14 days. Experimental results demonstrated that infectious ASFV was rapidly eliminated in spleen samples by day 5. After 37 days, no live virus was detectable

in any remaining tissues. While ASFV DNA degraded significantly over time, it remained detectable in swine tissues and sentinel compost samples at the conclusion of the study.

Bio-Inspired Engineering for Sustainable Remediation of Hazardous Waste

Rouzbeh Tehrani | *Temple University*

Biological systems have been used for remediating sediments, soil, and water in the past decades. However, there is an immediate need to introduce new remediation technologies to meet the current and future environmental challenges. Recent advances in science and engineering allow the development of new technologies that are more cost-effective, sustainable, and suitable to address the current and future regulatory expectations. Synthetic biology and biomimetic engineering approaches have the potential to revolutionize the remediation industry in a feasible manner. Here, two examples of such engineered systems are presented 1) nano-enhanced dialytic purification systems for selective removal of targeted contaminants from complex mixtures, and 2) an engineered biological system using bacterial communities and a robust hyperaccumulator plant for remediation of highly contaminated sites under extremely harsh environmental conditions. In these efforts, nanoscience, biology, and engineering are all combined into developing new engineering solutions. The objective is to offer the industry in-situ remediation technologies that are cost-effective and self-sustained with the lowest ecological footprint.

Assessment of Biosecurity of Using Horizontal Grinders to Enhance Composting to Improve Preparedness for African Swine Fever Virus

Paul Lemieux | *U.S. Environmental Protection Agency*

"There are currently outbreaks of African Swine Fever Virus (ASFv) in Asia and Europe. ASFv has recently been confirmed in The Dominican Republic, the first ASFv outbreak in the Western Hemisphere in 80 years. ASFv is 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 are not quickly managed. Estimated disposal capacity that may be needed is on the order of 3,000,000 lb/day.

On-farm composting is one preferred method of on-farm carcass management because it can inactivate the virus, produces a potentially useful by-product as a natural fertilizer and has been successfully used in past responses to Highly Pathogenic Avian Influenza (HPAI) and other outbreaks in the US. Unlike with poultry, however, whole-swine composting requires 6-12 months, resulting in the farm potentially being quarantined for up to a year. Grinding of the animal carcasses into smaller pieces along with a carbon source such as wood mulch 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. It may be that successful demonstration of the effectiveness of grinding as part of an

animal disease response may present an opportunity for commercial development of low-cost grinders for this purpose.

This presentation describes a series of tests to operationally assess the biosecurity of using more readily available horizontal grinders primarily used in the forest industry to perform size reduction of swine mortalities. Porcine DNA was measured in a variety of particle size fractions, to estimate an emission factor from horizontal grinders, which was then utilized with air dispersion modeling to estimate atmospheric transport of potentially infectious particles. Testing was also performed to assess the effectiveness of cleaning and disinfecting the grinding equipment following its use in an ASFv response. The results from these tests will be used to help USDA/APHIS develop standard operating procedures for these operations."

CONCURRENT SESSION 6 – BIOLOGICAL AGENT DECONTAMINATION

Decontamination of a U.S. Coast Guard Vessel Contaminated with *Bacillus* Spores

Shannon Serre | *U.S. Environmental Protection Agency*

"The Analysis for Coastal Operational Resiliency (AnCOR) project is an interagency collaboration between the Environmental Protection Agency (EPA), Department of Homeland Security (DHS) Science and Technology Directorate (S&T), and United States Coast Guard (USCG). One of the main goals for USCG following a biological agent incident impacting a USCG base or station would be the rapid return to service of their marine assets such as their smaller patrol boats up through their larger cutters.

The study was conducted to gain field-scale information on the use of methyl bromide (MB), low concentration hydrogen peroxide vapor (LCHPV), and peroxyacetic acid (PAA) fog for the decontamination of a decommissioned USCG 25' Response Boat Small I. Non-pathogenic *Bacillus* spores, including *Bacillus thuringiensis* subsp. *kurstaki* (Btk), *Bacillus anthracis* (Ba, Sterne strain), and *Bacillus atrophaeus* var. *globigii* (Bg) were used as the surrogates for virulent *Bacillus anthracis* in this field study.

Prior to the application of each decontamination procedure, pH-adjusted bleach (PAB) was applied to the exterior surfaces of the vessel. This procedure was conducted for each of the three rounds to evaluate the operational- and material-compatibility aspects of the vessel materials with PAB. Larger USCG vessels have external wash-down systems; a sporicidal solution like PAB could potentially be used in these spray systems to decontaminate the exterior areas of the vessel.

Several interior and exterior surfaces of the vessel were inoculated with Bg and Btk spores for each of the three rounds of this study. Inoculated surface types were marine grade aluminum, non-porous seat material, anti-slip plate, bumper material, marine grade carpet, painted outboard motor cowling, and glass. In addition, coupons (15 mm samples of material) were made from several boat materials and inoculated with 106 CFU surrogate spores (Ba Sterne, Bg and Btk). These test coupons were placed in various locations throughout the vessel for each of the 3 rounds.

All of the 90 coupons for the MB round had no detectable spores following treatment. In addition, all of samples from the 11 inoculated areas were non-detect following treatment with MB. Following treatment with LCHPV, 12 of the 90 coupons contained viable spores. Five out of 16 of the sponge-stick samples and 2 out of 6 of the micro-vacuum samples were also positive following LCHPV treatment. All of the 90 coupons for the PAA fog

round also had no detectable spores following treatment. In addition, all of samples from the 11 inoculated areas were non-detect following treatment with PAA. "

Efficacy of Household Disinfectants and Detergent-Based Cleaning Methods Against Coronaviruses

Rachel Hardison | *Battelle Memorial Institute*

Transmission of SARS-CoV-2 primarily occurs via close contact with respiratory aerosols from an infectious individual, though transmission through contaminated surfaces cannot be ruled out. The 2021 CDC guidelines for surface cleaning and disinfection of SARS-CoV-2 state that routine detergent-based cleaning of high-touch surfaces is sufficient in most cases; however, chemical disinfectants are recommended when individuals in household or community locations were infected with SARS-CoV-2. This study evaluated the efficacy of commercially available household disinfectants and detergent-based cleaning methods against Murine Hepatitis Virus A59 (MHV, 5% soil load in culture medium or simulated saliva) as a surrogate coronavirus for SARS-CoV-2 on coupons of high-touch surfaces [stainless steel (SS), ABS plastic (ABS), Formica, bus seat fabric (SF), Styrene Butadiene Rubber (SBR) or Latex-painted drywall tape (Paint)] at T0 or T2 hours post-inoculation. Four disinfectants (Bleach solution, Clorox Total 360, Vital Oxide, and Peroxide Multi-Surface Cleaner (Peroxide)) and two detergents (Tide Plus Bleach Alternative and Dawn Ultra Dishwashing Liquid) were evaluated against MHV. Disinfectants were applied by trigger-pull or electrostatic sprayer (ESS) and either held for recommended contact times or immediately wiped with a Kimwipe. To evaluate detergents, inoculated coupons were cleaned (damp wipe wiping) with and without pre-treatment with detergent solution or 375 ppm OECD hard water alone. Recovered infectious MHV was quantified by TCID50 assay. Cleaning methods were less consistent than chemical-based disinfection at eradicating MHV from high touch surfaces. Physical removal (wiping only, no pre-treatment) removed >2.3 log10 MHV on ABS, SS, and Formica when virus was cleaned immediately. Pre-treatment with detergent significantly increased ($p \leq 0.05$) removal of MHV in simulated saliva (but not in culture media) over hard water pre-treatment (Formica and ABS). Bleach solution, Clorox Total 360, and Vital Oxide were all effective (>3-log10 reduction) on SS, SBR and paint when used at recommended contact times, while Peroxide showed limited inactivation against MHV on SS within the recommended contact time. As expected, removal of MHV from SF was challenging. Cleaning was ineffective on SF under all conditions, while chemical disinfection was partially effective. The only products to achieve a 3-log10 reduction on SF were Vital Oxide and Clorox Total 360; however, efficacy of Vital Oxide against MHV on SF was reduced below 3-log when applied by ESS. This study highlights the importance of considering material, product, and application method when developing a SARS-CoV-2 cleaning and disinfection strategy.

Environmental Influences on the Resuspension of *Bacillus thuringiensis kurstaki* Spores

Jonathan Thornburg | *RTI International*

"Controlled resuspension experiments were performed to understand how the rate of *Bacillus* spore resuspension changes over time and under the influence of variable meteorological conditions following an urban release of a persistent biological agent like *Bacillus anthracis*. Two coupon types (concrete and asphalt,

66 of each type) representing surfaces typically found in an urban setting were pre-loaded with 107 colony forming units per square centimeter (CFU/cm2) of *Bacillus thuringiensis kurstaki* (BtK) spores. Coupons were stored in either an environmentally controlled chamber or an outdoor chamber under ambient environmental conditions. Coupons stored inside the environmental chamber were designated as control coupons or “misted” coupons. The “misted” coupons were wetted with a fine water mist to simulate light rain. Coupons in the outdoor chamber were subjected to naturally fluctuating meteorology, but were protected against wind, rain, and other precipitation. Spore resuspension fractions were determined at four timepoints (0, 4, 10, and 18 weeks).

Within an aerosol wind tunnel using aggressive air sampling, resuspension fractions were determined at two forces (0.86 lbf and 1.2 lbf) applied by a leaf blower from triplicate control, misted, or outdoor coupons at each time point. The coupons that previously underwent resuspension tests were tested again at 4-, 10-, and 18-weeks post-inoculation, such that any one coupon underwent a maximum of four resuspension tests. Resuspended spores were collected on polyester fiber felt filters, extracted, plated, and enumerated. An analysis of variance identified coupon type, exposure condition, and number of resuspension events as statistically significant variables that affect spore resuspension. The initial resuspension fraction for each coupon material and exposure condition did not vary between the four timepoints. The resuspension fraction from the control and misted concrete varied with coupon material. For the control coupons, mean resuspension fraction values for concrete were ~5X10-3 versus ~1X10-4 for asphalt. For misted coupons, concrete coupon mean values were ~5X10-4 compared to ~7X10-5 for asphalt coupons. Concrete and asphalt coupons exposed to environmental conditions had similar resuspension fractions of ~5X10-7 and were similar and constant over time. The control and misted coupons of both material types exhibited an exponential decay in resuspension fraction. In general, the asphalt control and misted coupons had 10 times less resuspension than the concrete and control coupons, respectively. It is likely that the resuspension fraction reduction over time was due to a decrease in spores on the coupon surface that were “available” for resuspension. The results from these experiments provided quantitative data measuring the impact of the various factors on *Bacillus* spore resuspension fraction and can be used to inform sampling and remediation efforts following an outdoor urban biological release."

Novel Technology to Reduce Risk of Viral Transmission in Enclosed Occupied Environments and Room Disinfection in Unoccupied Spaces

Dan Lorch | *METSS Corporation*

METSS has continued the development of a novel chlorine dioxide (ClO2) gas dispersion system under a current EPA-sponsored Phase II SBIR project (Contract Number 68HERC-20-C-0005). The system design offers a safe and effective means to rapidly generate ClO2 vapor for on-site room decontamination in hospital and non-hospital settings. This technology is intended to meet the demands of health care markets committed to decontaminate porous materials and sensitive equipment in rooms or vehicles used for care or transport of Ebola-exposed patients. This technology gap was especially evident during the care and treatment of patients in the United States circa 2014. In addition, the current COVID-19 pandemic has demonstrated a clear need for technologies aimed at occupied spaces to reduce or prevent the spread of transmissible diseases through air or contact with surfaces contaminated with infectious microdroplets. Although social distancing, wearing masks, and routine hand washing does significantly reduce the risks associated with disease transmission

from respirable droplets, METSS' developmental aerosol generation device delivers less than 0.1 ppm ClO2 in occupied spaces. The low concentrations of ClO2 were chosen based on IR&D efforts performed in METSS' Biosafety Level 2 (BSL-2) laboratory. During repeated trials, METSS demonstrated the efficacy of low level ClO2 against Pseudomonas aeruginosa, Staphylococcus aureus, and Klebsiella pneumoniae. Additional efficacy testing was performed using MS2 (non-enveloped) and Phi6 bacteriophage (enveloped) as surrogates to SARS-CoV-2 and other human viruses. Each of these organisms represent good models for evaluating respiratory pathogens and healthcare-associated infections through person-to-person contact. And, to the extent that fomite surfaces harbor and spread disease, low concentrations of ClO2 vapor have shown net positive benefits. METSS intends to transition this technology towards real-time protection against transmission of airborne pathogens and deposition of infectious virus particles on surfaces using low concentrations of ClO2 vapor.

CONCURRENT SESSION 6 – RADIOLOGICAL RESEARCH STUDIES SESSION

Laboratory Study on the Efficacy of Air Phase Decontamination of Radioactive Particles

Jose Mattei-Sosa | *U.S. Army, Engineer Research and Development Center*

"Response to Chemical, Biological, Radiological, Nuclear (CBRN) events tend to require large quantities of water and the infrastructure to support it according to the size of the event. However, depending on the location and damage caused by said CBRN event there may not be the water infrastructure needed to adequately respond or it may fall below the temperature guidelines to deploy such systems safely and effectively.

For these types of situations we have designed, constructed, and tested an air jet based approach for decontamination of the subject and recovery of the particulate matter. Pork skin and Cesium Chloride (CsCl) were used as a skin analog and contaminant to test the system. Using gravimetric analysis it was found that the jet of air at 20 psi was able to remove 100% of the CsCl from the skin analog and that a negative pressure environment is able to capture dislodged particulate matter. More research is needed to explore this the area with different contaminants and analogs however the current set results are promising and may lead to new innovations in the field."

Decision Tool to Support Objectives, Strategies, and Tactics in a Radiological Mitigation and Recovery Event

Michael Kaminski | *Argonne National Laboratory*

Argonne National Laboratory is building and testing a computer tool 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, contain, and monitor radiological contamination. Based on a report by Argonne , the tool's knowledge base is hierarchically structured with five top-level support goals, each containing

several scenarios; subsequently, each scenario is tied to one or more recovery methods, and each recovery method is associated with one or more equipment types contained in this report. The tool, through an intelligent Wizard, facilitates the operator's discovery and consumption of these details most pertinent to a dynamically selected subset of goals. We will present a demonstration of the tool (Fig. 1) for a hypothetical use-case within a discussion-based exercise. We will summarize the five support goals contained within the tool, introduce several scenarios within each, and show how the tool's wizard suggests various recovery methods along with the associated municipal and commercial equipment and data to support their proper use. In all, this presentation will familiarize the audience on the decision support tool's overall versatility and breadth to which it can support objectives, strategies, and tactics not only for nuclear and radiological releases, but also chemical and biological threat agents.

Re-aerosolization of dense metal oxide simulating radiological contamination from military clothing

Jeremy Slagley | *Air Force Institute of Technology*

"Background: Contamination of patients and their clothing following a radiological or sub-critical nuclear incident is a concern for the patients as well as attending medical personnel. A radiological event would disperse dense aerosol material contaminating many people. Clothing removal is expected to remove more than 80-90% of contamination, however the removal of this clothing presents a risk of resuspending hazardous aerosols and cross-contaminating people and equipment. While this re-aerosolization from clothing has been studied for biological agents such as anthrax spores, less is known about re-aerosolization of dense aerosols from clothing contaminated with radiological materials or other dry toxic industrial chemical aerosols.

Purpose: The purpose of this study was to characterize inhalable dense aerosols generated during clothing removal, a first step in decontamination of a contaminated manikin.

Methodology: A flow-through aerosol test chamber was setup with HEPA filtered supply air and exhaust. A clothed manikin was placed in the chamber and contaminated with copper oxide particles (density=6.315g/cc) as a surrogate for Strontium-90 (density=5.11g/cc), via a rotating brush generator. After contamination, the clothing was vigorously shaken multiple times to simulate expedient decontamination and rapid clothing removal. Aerosol measurements were collected using an Institute of Medicine (IOM) inhalable aerosol sampler with filter. IOM samplers were analyzed using energy dispersive x-ray microscopy that allowed for elemental analysis and identification of inhalable sized copper oxide aerosol particles produced from clothing removal. This allowed for inhalable cooper oxide to be differentiated from other aerosols generated during clothing removal such as lint and other fibers. A total of 11 copper-oxide contamination trials were conducted. These were compared to the airborne IOM measurements of particles in 7 trials without contamination. The trial order was randomized to investigate chamber cleaning efficiency in limiting cross-contamination between trials.

Results: Inhalable copper oxide aerosol was detected in all contamination trials and at levels significantly higher than in background trials. A statistically significant difference (p=.01) in the number of particles on the IOM filter was found between the contamination trials and background trails. The IOM on average collected

31,600 particles/cc during the contaminated clothing removal trials. The Energy Dispersive X-Ray Spectroscopy showed that 80% of the particles on the IOM filter were copper oxide.

Discussion/Recommendations: This study demonstrated that significant quantities of inhalable dense aerosol are generated during simulated patient decontamination (i.e., clothing removal). This has important implications for both decontamination of personnel exiting a “hot zone” and for patient decontamination following a radiological incident. While personnel actively performing decontamination are provided particulate respiratory protection, personnel in more distant areas may not be. Patient decontamination must either include measures to contain generated aerosols."

10 Years of Remediation Efforts in Fukushima

Sang Don Lee | *U.S. Environmental Protection Agency*

March 11, 2021, marked the 10-year anniversary of the accident at the Fukushima Daiichi Nuclear Power Plant in Japan which was caused by an initial earthquake and subsequent tsunami. This was the most significant accident at a nuclear power plant since the Chernobyl disaster in 1986. The Fukushima Daiichi Nuclear Power Plant accident resulted in radioactive contamination over a wide area and environmental remediation was necessary to protect public health. The scale of contamination was unprecedented in Japan and their efforts to effectively remediate the contaminated environment have identified many valuable lessons. This presentation covers how Japan conducted remediation of the off-site contaminated environment focusing on their preparation and implementation. Throughout Japan’s remediation efforts, several challenges have been identified and this presentation will share experiences and lessons that will greatly benefit decision makers and responders who have to prepare for wide area environmental remediation to respond to and recover from radiological contamination events.

PLENARY SESSION

Welcome & Introduction

Kathleen Salyer, Director of the Office of Emergency Management in the Office of Land and Emergency Management | *U.S. Environmental Protection Agency*

Plenary Talk 5 - CDC COVID-19 Response: Grand Princess

LCDR Elizabeth Wittry | *Centers for Disease Control and Prevention*

During February 11–21, 2020, the Grand Princess cruise ship sailed roundtrip from San Francisco, California, making four stops in Mexico (voyage A). Most of the 1,111 crew and 68 passengers from voyage A remained on board for a second voyage that departed San Francisco on February 21(voyage B), with a planned return on March 7. On March 4, a clinician in California reported two patients with COVID-19 symptoms who had traveled on voyage A, one of whom had positive test results for SARS-CoV-2. CDC notified the cruise line, which began cancelling group activities on voyage B. More than 20 additional cases of COVID-19 among persons who did not travel on voyage B have been identified from Grand Princess voyage A, the majority in California. On March 5, a response team was transported by helicopter to the ship to collect specimens for SARS-CoV-2 testing from 45 passengers and crew with respiratory symptoms for SARS-CoV-2 testing; 21 (46.7%), including two passengers and 19 crew, had positive test results. Passengers and symptomatic crewmembers were asked to self-quarantine in their cabins, and room service replaced public dining until disembarkation.

Beginning on March 7, Vessel Sanitation Program (VSP) staff and others from the Water, Food, &Environmental Health Services Branch deployed to California to support the Grand Princess disinfection and quarantine and to conduct environmental assessments. There was coordination with a variety of agencies shoreside—Disaster Medical Assistance Teams, Public Health Service, US Customs and Border Protection, the Port of San Francisco, US Department of Health and Human Services/Assistant Secretary for Preparedness and Response, US Department of State, US Coast Guard, local law enforcement, San Francisco Bar Pilots Association, and many others. Following docking in Oakland, California, on March 8, passengers and some of the crew were transferred to land-based sites for a 14-day quarantine period or isolation. Persons requiring medical attention for other conditions or for symptoms consistent with COVID-19 were evaluated, tested forSARS-CoV-2 infection, and hospitalized if indicated. Most crew remained onboard. During land-based quarantine in the United States, all persons were offered SARS-CoV-2 testing. Repatriation flights for foreign nationals were organized by several governments in coordination with U.S. federal and California state government agencies. On March 9, CDC issued a No Sail Order for the Grand Princess because CDC had reason to believe that crew members serving onboard may have been infected with or exposed to the virus that causes COVID-19. Subsequently, on March 14, CDC issued a No Sail Order for all cruise ships operating in US jurisdictions to prevent all new passenger embarkations. With remote support from nondeployed VSP staff, the team worked with the ship's public health team to finalize their disinfection

and quarantine plans. The team also monitored the Grand Princess' implementation of the quarantine plan, the disinfection plan, and "routine" ship operations related to food safety, water safety, ventilation, infection control, vector control, and housekeeping and laundry operations.

This presentation will cover the logistics for the disembarkation process, the ship disinfection and quarantine procedures, and the shipboard environmental assessment.

CONCURRENT SESSION 7 – COVID-19 TRANSPORTATION RESEARCH EFFORTS

LA Metro's Journey Through COVID – Exploring Technologies & Finding Practical Solutions

Bob Spadafora | *LA Metro Rail Fleet Services*

"As the case with many other Transit Agencies in the US and around the world, the Los Angeles County Metropolitan Transportation Authority (LACMTA) has had to manage the COVID-19 pandemic while continuing to operate and maintain the transit systems for both bus and rail. During the span of 2+years which is still evolving, LACMTA tested cleaning products, developed applications of new technologies to our transit vehicles and adopted the latest most effective strategies to battle this pandemic. This presentation will take the audience through the various stages and steps taken to help reduce COVID exposure, how best to evaluate and apply technologies for both bus and rail as well as building assets to prevent the spread of COVID and provide realistic data and expectations achieved.

During the onset of the pandemic, LACMTA began exploring various disinfection technologies and chemical-based disinfectants. The disinfection technologies included ultraviolet-C (portable and built-in), chemical misting units (portable and built-in), air filtration units, and antibacterial coating material. Each technology was researched for both efficiency and efficacy and a cost-benefit-analysis was performed. By partnering with the Environmental Protection Agency (EPA), value was brought to LACMTA's decision making process and the technologies were tested in a controlled lab environment for efficacy prior to being tested on rail vehicles, buses, stations, etc. The EPA has helped to eliminate risk decisions and significant expenditures on technologies that do not meet a 3-log (or 99.9%) reduction of virus/bacteria.

Along with the technical evaluations of these technologies comes the real-life applications and implementation into the day-to-day operations and maintenance activities. Management of scope, schedule, budget, and resources become key factors for consideration and actual deployment. The importance of doing things right the first time without adding more stress on the organization is critical in the successful deployment and sustainability of the strategies used during this pandemic. LACMTA use of lessons-learned and best practices along with a dedicated team working and focusing our efforts collectively with the EPA's support has produced a no nonsense approach with clear expectations and positive results."

Rapid Military Aircraft Decontamination Technologies Innovation and Testing to Address COVID-19

Michael Horenziak | *711 Human Performance Wing of the U.S. Air Force*

"The Air Force (AF) has invested in technologies for chemical/biological (CB) decontamination that are safe for use on sensitive aircraft systems. When COVID-19 threatened to degrade military aircraft availability, an immediate research need emerged to counter a low-likelihood, high-consequence event. In response, the AF Research Laboratory (AFRL) initiated a multi-facetted, rapid response, research effort to implement a field-ready rapid decontamination capability for military aircraft contaminated with SARS-COV-2 virus. Early in the pandemic, AFRL initiated a team of experts from across the AF and DoD to examine a wide range of disinfection and sanitization methods, and products offered to help the military quickly eliminate infectious levels of the virus. Although, hundreds of products were identified, most posed unacceptable risks to the aircraft. As the AFRL team recognized Corona viruses are quite susceptible to heat neutralization; heat-based decontamination approach appeared to be the safest option. AFRL's CBRN research team quickly prototyped an in-house methodology that resulted from building on prior research to decontaminate biological weapons. The joint CB Defense community took an early lead in responding and fast tracked new modular patient transports for use on transport aircraft; however, there was still a need for whole aircraft decontamination, and tests were conducted to assess employing a modified Joint Biological Agent Decontamination System (JBADS). Based on these tests, the modified JBADS did not meet DoD's need and a novel approach using generally issued AF equipment was needed.

The research demonstrated 120-130 degrees F. along with 20% or higher relative humidity effectively reduced viral load to safe levels within hours. Further field tests confirmed a C-17 could be decontaminated in near freezing environmental conditions using 8 generally issued heaters and custom-made humidifier rings. Decontamination could be accomplished within one day allowing for set-up, treatment, cool down, and returning the aircraft to flight-ready status."

CONCURRENT SESSION 7 – HAZARD RESPONSE

Hazardous and Contaminated Sites within Salt Marsh Migration Corridors in Rhode Island

Erin Burman | *Oak Ridge Institute for Science and Education Research Participant with U.S. Environmental Protection Agency*

As salt marshes migrate upland due to sea level rise, they will encounter many kinds of coastal development and infrastructure. Hazardous and contaminated sites (HCSs) -- facilities and infrastructure that store, use, or release toxic substances -- are particularly concerning obstacles to salt marsh migration because of their potential to release toxic contaminants. Understanding their presence within migration pathways is needed to inform coastal resilience planning. To understand what kinds of HCSs may encounter migrating marsh in Rhode Island, we inventoried sites from federal and state sources and overlayed them with projected marsh migration corridors. We found that HCSs are extensive across marsh migration corridors in the state, especially in urban areas. Among the most common HCSs in and around Rhode Island salt marshes are

stormwater outfalls; underground storage tanks; and facilities registered with EPA's Resource Conservation and Recovery Act (RCRA), EPA's National Pollutant Discharge Elimination System (NPDES), or Rhode Island Department of Environmental Management's Site Investigation and Remediation (SIR). Decisions to either allow marsh migration or erect physical barriers at these sites will influence future salt marsh extent, marshes' ability to provide ecosystem services, and public health exposures to toxic releases. As Rhode Island works to promote coastal resiliency, this inventory can inform decisions about which HCSs to prioritize for remediation, and which marshes to prioritize for conservation and restoration.

Environmental Justice, Climate Catastrophe, and the Newark Water Crises

Melinda Gonzalez | *Institute for the Study of Global Racial Justice, Rutgers University*

Beginning in 2016, a public health crisis was declared in the city of Newark, NJ when high lead levels were found in the water supply of Newark public schools. Since then, over 200,000 Newark residents (more than half the city population) have relied on bottled drinking water to meet their daily water needs. This environmental crises is compounded by the ongoing impacts of Climate Change through storm and flood frequency in the North East. In this paper, based on ethnographic research with the Newark Water Coalition (NWC), a grassroots community-based activist organization working to educate the public and provide water to city residents, I discuss how Black & Latinx artivists are raising awareness about the health impacts of the ongoing lead crisis in Newark and how they are working with community members to mitigate harms to an already vulnerable population.

Stabilization/Containment of RDD/IND Particle Contamination to Enhance First Responder, Early Phase Worker, and Public Safety

Ryan James | *Battelle Memorial Institute*

"In the event of large-scale radioactive contamination, whether from accidental dissemination or intentional dispersion from a radiological dispersive device (RDD) or improvised nuclear detonation (IND), remediation will follow. It is desirable to minimize resuspension and tracking of radioactive particles during remediation to protect against further harm to the public, environment, and to protect the health of workers performing remediation. The objective of this study was to assess commercially available stabilization technologies used in other industries, such as construction, for their ability to prevent resuspension and tracking of radioactive particles from common outdoor surfaces.

Test surfaces included concrete pavers, asphalt pavers, and soil. Simulated fallout material (SFM) was generated by spraying an aqueous solution of strontium chloride (Sr-85) onto a mix of equal parts ultrafine test dust and coarse test dust, mixing well, and allowing the mixture to dry. Following application of SFM to test surfaces, stabilization to minimize resuspension and tracking of SFM was achieved by applying either aqueous calcium chloride (CaCl2), Phos-Chek® MVP-Fx flame retardant, or Soil2OTM dust control. Gamma emission was measured before and after tracking of SFM with a sodium iodide (NaI) spectrometer. Tracking of SFM was achieved by walking and rolling of a weighted simulated vehicle across contaminated test surfaces. Surfaces measured after tracking include the contaminated test surface, boot bottoms or tires, and previously uncontaminated surfaces to which SFM was tracked. During walking experiments, resuspended SFM was

collected onto 47 mm glass fiber filters via a high-volume air sampler. Percent removal (%R), percent transferred (%T), and percent residual (%Res) of radiological activity were calculated for trials of stabilized surfaces and compared to those of non-stabilized control (NSC) trials to evaluate effectiveness of tested technologies to minimize tracking of SFM.

All tested technologies reduced, or eliminated, resuspension of SFM when walking through soil. For simulated vehicle tracking with a weighted simulated vehicle, CaCl2 and MVP-Fx, in most cases, did offer lower average %R and %T when compared to NSC. In some instances, no improvement was demonstrated by tested stabilization technology. For walking experiments, performance is similar to simulated vehicle tracking with some technologies, such as CaCl2 resulting in improved average %R and %T on concrete. MVP-FX resulted in improved average %R and %T on asphalt, while some combinations of surface and stabilization technology offered no improvement when compared to NSC."

Repurposing Commercial-Off-the-Shelf (COTS) 3D Game Engines to Improve the Effectiveness and Efficiency of EPA's Response Efforts

Timothy Boe | *U.S. Environmental Protection Agency*

"The ability to implement full-scale disaster response exercises with minimal resources and maximum control and realism is of great interest to the emergency response community. The significance of disaster response training and exercise activities on emergency personnel are well documented throughout literature. They encourage teamwork, increase training and equipment adequacy, and develop realistic perceptions of job risk. Emergency responder expertise is the cumulative result of actual response experience as well as periodic training and exercise. The impacts of the latter activities are bolstered with increasing realism.

Currently, the U.S. Environmental Protection Agency (EPA) needs to improve the ability to test, train, and evaluate strategic approaches to CBRN response and cleanup scenarios outside of large-scale demonstrations or real-world incidents. In place of in-person exercises, simulated training amplifies real-world experiences, providing a means to evaluate problem-solving and decision-making skills, technical and functional expertise, and communication and team-based competencies. This means there is a significant need for developing a simulator capable of visually depicting hypothetical CBRN disaster response and recovery scenarios and using these simulations to train federal and state responders/decision makers. The potential application and impact of this simulation tool would be far reaching. In addition to training personnel, response procedures could be reviewed prior to being implemented in the field, computer-assisted strategies could be developed with the use of artificial intelligence, and personnel could be trained on the use of EPA modeling and decision support tools in simulated environments.

In support of improving simulated training, EPA is evaluating the use of three-dimensional commercial-off-the-shelf (3D COTS) game engines for facilitating modeling, training, and exercise efforts for CBRN incidents. Today’s 3D COTS game engines rival (if not exceed) the capabilities of traditional research modeling platforms. These engines are capable of modeling physical systems and conditions in real time, such as entity collision, fluid, particle, and light dynamics. The modification of these engines to simulate dispersion, fate and

transport, explosive models, and radiation attenuation could offer significant cost savings in the development of future decision support systems, environmental modeling tools, and training platforms.

This presentation will summarize: 1) EPA's efforts to evaluate the use of 3D COTS game engines as potential modeling platforms; 2) their application in training emergency response personnel; and 3) the development of a next-generation modeling platform for holistically simulating large-scale contamination incidents and subsequent cleanup efforts."

STUDENT POSTER AWARD CEREMONY & CLOSING

Closing Remarks

Shawn Ryan, National Program Director for Homeland Security Research
U.S. Environmental Protection Agency

Join us as we announce the winners of the student poster competition!