



SYNOPSIS OF CURRENT RESEARCH OF THE

Decontamination and Consequence Management Division

Office of Research and Development

National Homeland Security
Research Center



DECONTAMINATION AND CONSEQUENCE MANAGEMENT DIVISION'S

Synopsis of Current Research

Decontamination and Consequence Management Division
National Homeland Security Research Center
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268



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Table of Contents

Introduction	vi
Detection Research	1
Indoor Surfaces Sampling and Analysis to Support Decontamination.....	1
Task 1.2 - Toxicity-Based Chemical Agent Detection Systems: Continuous Monitoring and Exposure History	1
Task 1.3 - Real-Time Detector for Chemicals, Biological Agents, and Toxic Industrial Chemicals.....	2
Task 1.4 - Rapid Determination of Viability of Spores in Disinfectant-Treated Samples.....	3
Task 1.5 - Rapid Airborne Chemical Contaminant Detection.....	4
Task 1.6 - Evaluating the Sampling Efficiency of <i>Bacillus Anthracis</i> Spore Sampling Techniques	4
Task 1.7 - Characterizing Building Surfaces for Reoccupation Following Chemical Attack.....	5
Technology Evaluations.....	6
Task 1.1 - Evaluating Commercial Detection Devices and Systems - Technology Testing and Evaluation Program (TTEP)	6
Task 1.8 - Center for Expertise on Sentinel Animals	6
Containment Research.....	8
Effects of Building Design and Operation on Contaminant Dispersion.....	8
Task 2.3 - Impact of HVAC Design and Operation	8
Task 2.4 - Residential Safe Havens.....	9
Task 2.6 - Protection by Building Shell.....	10
Sources and Dispersion of Attack Agents Indoors and Outdoors.....	10
Task 2.1 - Emissions Models for Liquid Chemical Spills and Compressed Gas Releases	10
Task 2.2 - Indoor Movement of Contaminants	11
Task 2.7 - Effects of Human Activities and Environmental Conditions on Dispersion of Agents after Indoor or Outdoor Release	11
Task 2.9 - Effects of Indoor Sinks on Reemissions of Chemical and Biological Agents.....	12
Commercial and Near-Commercial Systems for Building Protection	13
Task 2.10 - Air Cleaners and Filters for Chemical and Biological Threats ..	13
Task 2.11 - Evaluations of Commercial Containment Technologies	14
Guidance on Containment and Protection	15
Task 2.16 - Retrofitting Buildings for Protection against Chemical and Biological Attack.....	15

Task 2.22 - Training Programs and Materials.....	15
Decontamination Research.....	17
Standardized Decontamination Protocols.....	17
Task 3.1 - Decontamination Guidance.....	17
Task 3.2 - Sterilant Registration Protocol.....	17
Task 3.4 - Systematic Studies to Optimize Decontamination Methods.....	18
Task 3.5 - Evaluation of Commercial Decontamination Methods and Systems.....	19
Task 3.6 - Novel Methods for Decontamination of High-Value Materials.....	20
Assessment of Residual Effects of Decontamination Chemicals.....	21
Task 3.3 - Engineering and Economic Analysis of Decontamination Options.....	21
Task 3.7 - Lessons Learned from Building Decontamination Experience.....	21
Task 3.8 - Toxicity of Fumigants.....	22
Disposal Research.....	24
Thermal Destruction.....	24
Task 4.1 – Bench-Scale Investigations of Thermal Destruction Characteristics of Surrogate Biological Agents.....	24
Task 4.2 – Bench-Scale Investigations of Thermal Desorption and Destruction Characteristics of Surrogate Chemical Agents Adsorption/Desorption Studies.....	25
Task 4.3 – Pilot-Scale Studies of Thermal Destruction, Permitting Issues, and Modeling.....	26
Landfills.....	27
Task 4.6 - Permanence of Disposal: Assessing Conditions for Safe Landfilling of Building Decontamination Wastes.....	27
Task 4.13 - Bench-Scale Investigations of Transport of Surrogate Biological and Chemical Agents between Landfill Residue, Leachate, and Gas.....	28
Sampling/Analytical Methods.....	28
Task 4.8 - Sampling/Analytical Methods for BW Contaminants.....	28
Disposal Guidance.....	29
Task 4.4 – Guidance Tool for Combustion of Building Decontamination Residues.....	29
Task 4.7 - Technical Resource Manual for the Consideration of the Protection of the Public and Workers.....	29
Task 4.9 - Guidance for Emergency Responders, Disposal Permitters, and Facilities.....	30
Task 4.10 - Disposal Workshop.....	30
Task 4.12 - Biocontaminant Laboratory Support for Tasks 4.1, 4.3, and 4.8	32
Risk Assessment and Communication.....	33
Appendix A: Acronyms List.....	34

Introduction

The U.S. Environmental Protection Agency's (EPA) National Homeland Security Research Center (NHSRC), Decontamination and Consequence Management Division (DCMD), one of three divisions of the NHSRC, is located in Research Triangle Park, North Carolina. The current focus of DCMD is on the decontamination of buildings that have been intentionally contaminated by biological or chemical agents. DCMD scientists study the chemical and biological contamination of air and indoor surfaces; provide methods for upgrading buildings in ways that increase occupant protection; supply information on decontamination methods, including safety, efficiency, cost; and analyze disposal options for decontamination wastes.

Much progress has been made by the DCMD; however, research and development (R&D) needs remain. Most of the current research has focused on anthrax, but there are still major concerns about smallpox, plague, tularemia, and biological toxins, such as ricin and botulinum toxin, as well as chemical warfare agents and toxic industrial chemicals. It is expected that a system that would kill anthrax would kill other biological organisms, but this expectation has not been tested. Although chlorine dioxide (ClO_2) has shown the most promise for use as a fumigant for biologically contaminated buildings and there have been significant advances in commercial systems for providing it for decontamination, there are still needs with regard to a system that would be safer, less destructive of interior materials, and less costly.

The information contained in this report is divided into four research areas: detection, containment, decontamination, and disposal. Included for each research area is a description of tasks. For each task, information is provided on the task objective, research partners, research location, task status, and associated products.

Detection Research

The primary objective of detection research is to ensure that the sampling and analysis tools necessary to support decontamination are available. Secondary objectives are to develop monitoring tools and networks that can be used to detect an attack, to inform containment and safe haven efforts, and to provide data on safe reoccupancy. Preference is given to detection systems that can detect multiple hazards, given the many possible scenarios.

Indoor Surfaces Sampling and Analysis to Support Decontamination

Task 1.2 - Toxicity-Based Chemical Agent Detection Systems: Continuous Monitoring and Exposure History

Objective

The objective of this task is to demonstrate the feasibility of technology that will introduce air samples into existing, multi-analyte, toxicity-based detection systems. The new system design will give near-real-time outputs and will have adequate sensitivity to detect most chemical threats. The results of this task will provide broad toxicological screening information to first responders and building decontamination personnel. The goal is to detect the presence of airborne chemical agents that could impair metabolic or neurological function. Determinations of duration of exposure and the prior hazard condition in the building can also be determined.

Partners

U.S. Geological Survey (USGS)

Location of Research

EPA research facilities in Las Vegas, Nevada, and the USGS's Columbia Environmental Research Center in Columbia, Missouri

Status of Research

Ongoing

A project within this task has demonstrated feasibility regarding sampling of chemical agents using Semipermeable Membrane Devices (SPMD). Ongoing research is focused on improving detection capabilities by developing methods to concentrate samples prior to analysis.

Products

2003 EPA Science Forum abstract, "Toxicity-Based Chemical Agent Detection Systems: Continuous Monitor Exposure History." This abstract can be found on the EPA's Science Forum Web site at:
http://www.epa.gov/ord/scienceforum/2003/abstracts_security.htm.

The results of this research will also be published as a journal article.

EPA Report EPA/600/R-04/069, "Vapor Sampling Device for Interface with Microtox Assay for Screening Toxic Industrial Chemicals."

Task 1.3 - Real-Time Detector for Chemicals, Biological Agents, and Toxic Industrial Chemicals

Objective

This task will demonstrate the combined application of three commercially available real-time technologies as a single, integrated, immediate warning device for detecting airborne biological and chemical contaminants in building air inlet systems. These technologies include SPI (Single Photon Ionization), Jet REMPI (Jet Resonance-Enhanced Multiple Photon Ionization) and LIBS (Laser-Induced Breakdown Spectroscopy). The integrated device, when tied to airflow control, could immediately cease air intake, eliminating contaminant spread. This task will test field-worthy components in the lab to develop a prototype field unit design. The same system will be used for rapid indoor surface sampling to locate contaminated areas and to inform cleanup personnel, eliminating the delays of field sampling and lab-based analysis.

Included in this task is an ongoing laser-related research project investigating the use of laser technologies as contaminant detectors. One such research project, the "Laser-Induced Breakdown Spectroscopy (LIBS) Analysis of Aerosol Agent Surrogate Project," will determine instrument sensitivity and evaluate potential interferences related to the use of this technology as a detector.

Partners

EPA research laboratories in Research Triangle Park, North Carolina, and Department of Defense (DOD)'s Army Research Laboratory (ARL)

Location of Research

Army ARL test facilities

Status of Research

Ongoing

Testing with anthrax surrogates showed functionality and the ability to discriminate from background. Further testing will study the detectability and discrimination of

other chemical and biological agents of concern relative to background. Improvements in software and in the ruggedness of the hardware will be made. A system design recommendation will be made and efforts to commercialize the unit will be supported.

Products

Research on this task has focused on adapting laser technologies, with the following laser-related research products having been completed:

LIBS library for biologicals. This library was completed as an EPA internal report.

“Resonance-Enhanced Multiphoton Ionization (REMPI) Feasibility Tests on Chemical Agents” was published as an EPA internal report.

A Single Photon Ionization (SPI) system has been built and is available at EPA’s Research Triangle Park facility.

Task 1.4 - Rapid Determination of Viability of Spores in Disinfectant-Treated Samples

Objective

The objective of this task is to evaluate Quantitative Real-Time Polymerase Chain Reaction (QRT PCR) analysis of biological contaminants. Standardized methods are needed to ensure rapid, accurate, and sensitive detection of bacteria after decontamination. Current methods require growth in lab media to tell whether decontamination was successful. These methods can take several days. This task will evaluate the use of (QRT PCR) analysis as a potentially more efficient and rapid analytical method.

Effects of residual disinfectant/fumigant on spore viability will also be assessed.

Partners

University of California, Irvine

Location of Research

EPA’s National Exposure Research Laboratory (NERL) in Cincinnati, Ohio

Status of Research

Ongoing

Quantitative PCR (QPCR) test methods have been developed for *Bacillus anthracis* and surrogate species of several other organisms of concern. A semi-automated culture method for detecting *Bacillus anthracis* by QPCR has been developed and tested. A semi-automated hard surface disinfection method has been developed and is undergoing testing. Methods for differentiating live from dead cells in *Staphylococcus aureus* and *Corynebacterim glutamicum* using QPCR have been identified. Future work will repeat the study with *Bacillus* spores.

Product

Method for detection and determination of viability of biological organisms, utilizing accelerated enrichment and QPCR techniques

Task 1.5 - Rapid Airborne Chemical Contaminant Detection

Objective

The objective of this task is to modify commercial Open Path-Fourier Transform Infrared (OP-FTIR) detectors for use as real-time sensors in large building spaces (e.g., airports) and in heating, ventilation, and air conditioning (HVAC) ducts. An additional objective is to modify these detectors for use as small, mobile detectors, mounted on robotic devices, for use in emergency monitoring or cleanup operations.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

Rapid airborne chemical contaminant research continues including preparation of a Fourier Transform Infrared (FTIR) selection guidance document (in progress) and real-time software for a mobile laboratory.

Products

Products from this task are under development and include:

Real-time sensors for large open spaces

Mobile sensors for use with robotics for unmanned entry into contaminated areas

Task 1.6 - Evaluating the Sampling Efficiency of *Bacillus Anthracis* Spore Sampling Techniques

Objective

This task assesses the recovery of anthrax spores collected from various indoor surfaces using various sampling methods to determine attainment of target cleanup levels. These studies will be used to produce an optimized protocol for indoor surface sampling.

Partners

DOD, National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC)

Location of Research

Sampling is being conducted at DOD's Dugway Proving Grounds in Utah. Analyses are being conducted at EPA's laboratory in Cincinnati, Ohio, and the CDC's laboratory in Atlanta, Georgia.

Status of Research

Ongoing

DCMD: SYNOPSIS OF CURRENT RESEARCH

A wind tunnel has been fabricated at Dugway to simulate the deposition of anthrax spores on surfaces. The efficiency of sampling methods is being tested. The first samples are expected to arrive in Cincinnati for analysis in late February 2005. Following the investigation of anthrax spores, similar studies will be performed on other biological organisms of concern.

Products

The following draft reports have been prepared:

A multi-laboratory study to validate methods for surface sampling for *Bacillus anthracis* spores

Standard Operating Procedure (SOP) for sample analysis of *Bacillus anthracis* spores

Reports on the success of sampling methods for detection of *Bacillus anthracis* and other organisms will be prepared throughout the study.

Task 1.7 - Characterizing Building Surfaces for Reoccupation Following Chemical Attack

Objective

This task will develop procedures to sample porous and nonporous indoor surfaces for the presence of toxic industrial chemicals, including pesticides. Liquid Chromatographic-Mass Spectrographic (LC-MS) and Gas Chromatographic-Mass Spectrographic (GC-MS) methods will be adapted for the chemicals of concern. The techniques will be published as SOPs.

Partners

None

Location of Research

EPA research facilities in Cincinnati, Ohio

Status of Research

Ongoing

A sensitive, rapid, and systematic sampling procedure has been developed that can be used to collect low concentrations of chemicals from surfaces. An LC-MS method has been developed for the determination of two pesticides, a carbamate and diphacine. A Gas Chromatographic system equipped with a Pulsed Flame Photometric Detector (GC/PFPD) has been developed for the determination of organophosphate pesticides. Testing of these methods and equipment will continue with a final report anticipated in 2005.

Products

Products associated with this task include:

Protocol for performing surface wipes with gauze pads

Protocol for sample handling and preparation for analysis

GC and LC analytical procedures for the determination of pesticides in surface wipe samples

Report summarizing the results of testing of procedures for sampling porous and nonporous surfaces

Technology Evaluations

Task 1.1 - Evaluating Commercial Detection Devices and Systems - Technology Testing and Evaluation Program (TTEP)

Objective

A critical element in the protection of buildings and building occupants is determining those technologies that can be used to detect, measure, and monitor contaminants in the air and on surfaces. These technologies are necessary to support research into early warning systems and to determine whether decontamination has been successful. The objective of this task is to develop test criteria and protocols, using stakeholder group input, and to evaluate commercially available detection devices and systems.

Partners

None

Location of Research

Research facilities in Columbus, Ohio, Research Triangle Park, North Carolina, and Las Vegas, Nevada

Status of Research

Ongoing

Technology evaluations will continue. Priorities for technologies to be tested will be determined with stakeholder input.

Products

One report has been completed:

- Technology Category - Surface Acoustic Wave Detectors
Microsensor Systems, Inc. HAZMATCAD™ Plus (November 2004)
available at <http://www.epa.gov/etv/verifications/vcenter12-2.html>.

Additional reports will be made available at <http://www.epa.gov/etv/verifications> as evaluations are completed.

Task 1.8 - Center for Expertise on Sentinel Animals

Objective

Historically, animals have been used as a measure of air quality. These animals, termed sentinels, have especially been used in mining. This task will convene expert panels to assess and formulate uses for sentinel animals in protecting buildings against indoor

chemical releases. Limited laboratory studies may be performed to optimize and validate promising sentinel systems.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

An expert panel has been convened. A literature search and review of work by other agencies has been conducted and a virtual library established. Ongoing efforts include 1) the reassessment of the use of birds and insects as sentinels, 2) modification of an existing electronic monitoring system for honeybees, and 3) a literature search on the sensitivity of songbirds in the vicinity of pesticide spraying operations.

Products

Completed products include:

An interim report on the current status of research and progress made in defining a method for using sentinel animals indoors

A listing of EPA and outside experts

A draft virtual library

Anticipated products include:

A guidance document containing a comparison between the selectivity and sensitivity of animal sentinels and detection instruments

Published papers repeating an early canary study, which either confirm or discount the study findings or suggests ways to improve the use of bird species as sentinels for airborne hazards

Containment Research

Containment research is focused on development and testing of methods for preventing the spread of contaminants and on protecting building occupants, emergency responders, and decontamination crews. The objectives of the containment research program are to provide tools, techniques, technologies, and guidance needed to reduce or eliminate the impact of chemical or biological (CB) attack on building occupants and to provide tools, techniques, and guidance necessary to determine the effectiveness and economics of CB protection measures for new and existing buildings.

Effects of Building Design and Operation on Contaminant Dispersion

Task 2.3 - Impact of HVAC Design and Operation

Objective

The objectives of this task are to determine the impact of HVAC design and operation on the indoor dispersion of contaminants and to develop improved designs and operational procedures to maximize containment. The products will consist of guidance manuals on design and operation of HVAC systems.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

Existing HVAC systems are under evaluation to determine opportunities to improve containment. Potential design and/or operational enhancements will be identified.

Products

The following products are either completed or under development:

Literature review and report is expected to be completed by March 2005.

A plan for filter testing has been approved.

Guidance manual on the design and operation of HVAC systems to maximize containment in the event of a contaminant release

Task 2.4 - Residential Safe Havens

Objective

Studies indicate that sheltering in place, safe rooms, and other protected areas are appropriate public protection tools when used under the right circumstances. The objective of this task was to evaluate the effectiveness of these residential safe havens, using the EPA indoor air quality research house.

Partners

Federal Emergency Management Agency (FEMA), Department of Homeland Security (DHS)

Location of Research

EPA indoor air quality research house at Cary, North Carolina

Status of Research

Completed

An improved method was developed to determine the airflow rate for a shelter inside a house. As part of the research, participants using DHS guidelines applied expedient sheltering measures (plastic sheeting and duct tape) to a room inside a test house. Airflow rates were measured to determine protection factors under various scenarios and were calculated both for the house and shelter under various occupancy times, weather conditions, and outdoor exposure times for hazardous agents.

Results of this research indicate that proper sealing is crucial to the effectiveness of the shelter. In addition, sheltering in place can be beneficial if people enter shelters before the arrival of an airborne plume of hazardous agent and exit shelters immediately after the plume passes. Sheltering in place can be detrimental if people enter or exit shelters too late. Carbon dioxide (CO₂) and oxygen (O₂) concentrations inside the shelter are not likely to reach dangerous levels under most scenarios but could reach dangerous levels under extended sheltering or affect individuals with respiratory problems.

Products

The following residential safe haven reports summarize the work completed:

The "Data Summary Report" was published as an internal report and is maintained as an electronic copy on file at EPA.

The results of a study of the effectiveness of in-house sheltering are to be published in a journal article, "Effectiveness of Expedient Sheltering in Place in a Residence," in the *Journal of Hazardous Materials*.

A project to study expedient sheltering in place in larger buildings will be conducted in February 2005.

Task 2.6 - Protection by Building Shell

Objective

This task will determine how well the building shell (exterior walls) functions as a filter to keep chemical and biological agents that were released outdoors from infiltrating a building. The results of this research will provide guidance on sheltering-in-place methods and safe haven protocols and will assist other groups in determining building vulnerability.

Partners

None

Location of Research

EPA research facilities in Cincinnati, Ohio, and Research Triangle Park, North Carolina

Status of Research

Ongoing

Experimental work will be completed by the end of February 2005. Data analysis and reporting will be completed by July 2005.

Products

A model for estimating the degree of protection afforded by a building is under development for use in the evaluation of the effectiveness of buildings as shelters.

Sources and Dispersion of Attack Agents Indoors and Outdoors

Task 2.1 - Emissions Models for Liquid Chemical Spills and Compressed Gas Releases

Objective

Researchers involved in this task will develop models based on volatility and gas-phase characteristics of contaminants to predict the spread of low-volatility chemical (i.e., nerve agent) contaminants in buildings. These methods and the models will be used to identify contaminated areas for evacuation and decontamination. These data will also be used to identify highest threat contaminants, based on their dispersion characteristics.

Partners

Department of Energy's (DOE) Los Alamos National Laboratory

Location of Research

EPA research facilities in Research Triangle Park, North Carolina

Status of Research

Ongoing

Research that is underway or has been completed to date includes the development and testing of several new emissions models.

Products

Products include:

An interim data summary report for emissions modeling for low vapor gases on solvent spills is to be published in May 2005 as an EPA internal report titled, "Modeling Liquid Spills inside the Building."

Additional reports and computer models will be available as research progresses.

Task 2.2 - Indoor Movement of Contaminants

Objective

The objective of this task is to study transport within buildings of nontoxic gases that have similar molecular weights as chemical contaminants of concern. Results of this study will be used by researchers to assemble information that will allow responders to predict the amount of time building occupants have to escape from a building or move to a designated safe haven.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park facility, North Carolina

Status of Research

Ongoing

Experimental work will be completed in February 2005 with data analysis continuing through 2005. The results of this work will be incorporated into indoor air quality models in 2006.

Products

A model capable of estimating the time required for dispersion of heavy gases within a building for varying building operation scenarios. This model will be used for assessing the dispersion of gaseous threat agents.

Task 2.7 - Effects of Human Activities and Environmental Conditions on Dispersion of Agents after Indoor or Outdoor Release

Objective

The objective of this task is to determine, through the use of fluid and aerosol dynamics, how chemical or biological agents released outdoors or indoors can disperse through or into a building and how human activities (e.g., opening an envelope, walking on a carpet) impact the dispersion of agents.

Partners

DOD's Technical Support Working Group (TSWG), DOD Defense Advanced Research Projects Agency (DARPA), DOE

Location of Research

The Aerosol Test facility at EPA's Research Triangle Park facility, North Carolina

Status of Research

Ongoing

A very low speed wind tunnel/visualization chamber and an indoor air dispersion test room have been constructed, and experiments and models of aerosol release tests have begun. Future studies will determine the impacts of varying humidity, temperature, surface materials, and surface and particle charge as well as the impact of human activity in the room.

Products

The following publications provide information on the research that has been completed for this task:

"Airflow around a Child-Sized Manikin in a Low-Speed Wind Environment," in *Aerosol Science and Technology Journal*, 2003 Volume 37, pages 303 – 314

Dispersion Analysis of the Simulation of Biological and Chemical Releases within Buildings: Guidance Document

"Monitoring Exposure to Point-Source Aerosolized Contaminants: Can We Continue to Assume They Are Well Mixed?", published by the Air and Waste Management Association (AWMA) with other papers from "The Symposium on Air Quality Measurement Methods and Technology – 2004"; April 19 – 22, 2004.

"Short-Term Dispersion of Indoor Aerosols: Can It Be Assumed the Room Is Well Mixed?" an article submitted to *Building and Environment* in 2004

"Transport of Airborne Particles within a Room," an article submitted to *Indoor Air* in 2004

Additional reports and computer models will be available as research progresses.

Task 2.9 - Effects of Indoor Sinks on Reemissions of Chemical and Biological Agents

Objective

This task will be used to determine the impact of indoor sinks (e.g., adsorbent or absorbent materials, such as upholstery and wallboard) on exposure to chemical and biological agents in buildings. Sink effects also impact the ability to decontaminate. This research will be closely coordinated with Tasks 2.7 and 2.1.

Partners

None

Location of Research

EPA facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

Model development and additional experimental work applying chemicals to indoor surfaces and measuring absorption and desorption will be conducted in 2005 and 2006 so that new sink models can be incorporated into indoor air dispersion models. Data are also being analyzed to determine the impact of sink effects on decontamination processes.

Products

The following reports describe the results of this research and the models that are under development:

“Indoor Sinks/Reemissions” will be published as an internal data summary in February 2005.

An EPA report, “Evaluation of Indoor Sink Models,” is in progress.

“Recent Advances in Filter Efficiency Test Methods for Electric Filters and Electronic Air Cleaners” was presented at the “9th World Filtration Conference,” New Orleans, Louisiana, April 19 – 23, 2004.

Additional reports and computer models will become available as research progresses.

Commercial and Near-Commercial Systems for Building Protection

Task 2.10 - Air Cleaners and Filters for Chemical and Biological Threats

Objective

Researchers involved in this task will determine the costs and effectiveness of in-room and whole-building air cleaners and filters and develop improved systems based on near-commercial concepts. The new air cleaners/filters will provide improved efficiency and/or reduced pressure drop, compared with existing technology. Emphasis will be on filters/cleaners that remove toxic industrial chemicals (TICs) from the air. Such technologies can also be used to provide staging areas for decontamination and restoration activities.

Partners

DOD’s TSWG and DARPA

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

This task has been combined with Task 2.3, "Impact of HVAC Design and Operation" research.

Products

See Task 2.3.

Task 2.11 - Evaluations of Commercial Containment Technologies

Objective

This task will evaluate the performance of commercial systems such as filters, HVAC system modifications, and agent destruction devices that are claimed to protect buildings in the event of the release of biological and chemical agents.

Partners

Research Triangle Institute, Research Triangle Park, North Carolina

Location of Research

Research Triangle Park, North Carolina

Status of Research

Ongoing

Ten filters have been tested and reports prepared. Following peer review, reports are posted on the EPA's ETV Web site. Future activities will include meeting with stakeholders to identify and prioritize additional technologies for testing. The technology areas of interest include capturing/containing/destroying gaseous warfare agents as well as warfare agents in their particle form.

Products

Air filtration and cleaning technology and ventilation media air filter verification study information is available on the ETV Web site. Reports on the following technologies can be found at <http://www.epa.gov/etv/centers/center10.html>.

AAF International BioCel[®] I (Type SH) (February 2004)

AAF International DriPak[®] 90/95% (November 2003)

AAF International PerfectPleat Ultra, 175-102-863 (September 2004)

Aeolus Corporation Synthetic Minipleat Panel, SMP-M12-2424 (February 2004)

Aeolus Corporation Synthetic Minipleat V-Cell, SMV-M13-2424 (November 2003)

Aeolus Corporation Synthetic Minipleat V-Cell, SMV-M14-2424 (November 2003)

Airflow Products AFP30 (February 2004)

Columbus Industries High-Efficiency Minipleat (February 2004)

Columbus Industries SL-3 Ring Panel (February 2004)

Filtration Group AeroStar "C-Series" Polyester Panel Filter (February 2004)

Filtration Group AeroStar FP-98 Minipleat V-Bank Filter (February 2004)

Glasfloss Industries, Inc. Excel Filter, Model SBG24242898 (February 2004)

Glasfloss Industries, Inc. Z-Pak Series S, Model ZPS24241295B0 (February 2004)

Tri-Dim Filter Corporation Predator II, Model 8VADTP123C23CC000 (September 2004)

Additional reports will be made available as testing progresses.

Guidance on Containment and Protection

Task 2.16 - Retrofitting Buildings for Protection against Chemical and Biological Attack

Objective

Researchers involved in this task will prepare guidance for building owners and facility managers on the installation of new technologies that can be used to upgrade protective systems in existing buildings. The guidance will address both technical and cost considerations.

Partners

National Institute of Standards and Technology (NIST)

Location of Research

NIST research facilities in Gaithersburg, Maryland, and EPA's Research Triangle Park facility in North Carolina

Status of Research

Ongoing

A technical feasibility study of building retrofit options that will increase protection from chemical and biological attack is underway.

Products

Guidance for retrofitting buildings to increase the effectiveness of protection from chemical and biological attack is under development.

Task 2.22 - Training Programs and Materials

Objective

The objective of this task is to develop programs for training building owners, facility managers, and building maintenance workers to utilize new technologies and to

DCMD: SYNOPSIS OF CURRENT RESEARCH

implement methods that would limit the spread of airborne contaminants released near or inside buildings.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

This task is in the beginning stages of development.

Products

Products from this task will include programs for training building owners, facility managers, and building maintenance workers.

Decontamination Research

Buildings contain significant areas of porous surfaces, such as carpet and ceiling tile, from which the removal of contaminants can be difficult. The decontamination research program will emphasize decontamination of porous surfaces. The most difficult to remove contaminant in each large category of contaminants (e.g., anthrax for biologicals, VX for nerve agents) is the focus of initial research.

Standardized Decontamination Protocols

Task 3.1 - Decontamination Guidance

Objective

The objective of this task is to develop a user-oriented technical guidance document that will provide information during the decontamination of buildings following a chemical or biological attack. The guidance document will synthesize available information and research findings.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

To be started

Research is anticipated to begin February 2005.

Products

A guidance document will be prepared.

Task 3.2 - Sterilant Registration Protocol

Objective

The objective of this task is to evaluate spore-killing methods for use by EPA's Office of Pesticide Programs and Toxic Substances (OPTTS) in developing registration and crisis exemptions under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

Partners

DOD

Location of Research

DOD's Fort Mead in Maryland; protocol validation will also be done at other federal laboratories

Status of Research

Ongoing

An Association of Official Analytical Chemists (AOAC) procedure and two alternative procedures for determination of sterilant efficacy have been evaluated in a round-robin study involving three laboratories. OPTTS will review the test results from evaluations made during this task for possible improvement through modification of procedures used for sporicide registration.

Products

The following products resulting from the testing of sterilant efficacy have been completed:

“Recommendations for Quantitative Method for Liquids and Surrogates on Hard Surfaces”

“Findings and Recommendations for Gases and Liquids,” issued as an EPA internal report

The following sterilant registration methods are under development:

Modified Association of Official Analytical Chemists (AOAC) International Sporicidal Activity Test (SAT) or AOAC SAT collaborative-validation of modifications

EPA and DOD training on test methods

Task 3.4 - Systematic Studies to Optimize Decontamination Methods

Objective

Researchers involved in this task will experimentally determine the performance of chemical and energy-based decontamination technologies for selected chemical and biological agents. In this research, key parameters (i.e., decontamination agent concentration, contact time, substrate type, environmental conditions, and energy input) are systematically varied to enable optimization of decontamination methods. Such studies also define the range of conditions under which a decontamination method can be used.

Partners

U.S. Army's Edgewood Chemical Biological Center (ECBC)

Location of Research

ECBC, Aberdeen Proving Grounds, Maryland

Status of Research

Ongoing

Testing is currently being conducted at ECBC. Two experimental systems have been constructed, and the first experiment on ClO₂ has been completed.

Products

Products will consist of reports on systematic studies to optimize chemical decontamination systems for biological agents by addressing the effects on decontamination efficacy using different concentrations, temperatures, humidities, duration of exposure, and surface types (e.g., carpet, wood, wallboard, concrete, and metal).

Task 3.5 - Evaluation of Commercial Decontamination Methods and Systems

Objective

Researchers involved in this task have developed standardized test protocols to verify the performance of commercial and near-commercial building decontamination technologies (both chemical and energy-based treatments) for chemical and biological attack agents. Technologies to be evaluated are prioritized based on stakeholder input.

Partners

None

Location of Research

Research facilities in Columbus, Ohio, Research Triangle Park, North Carolina, and Las Vegas, Nevada

Status of Research

Ongoing

Additional decontamination technologies will be tested.

Products

Evaluation results for the following technologies are available at <http://www.epa.gov/etv/verifications/verification-index.html#sbmdte>.

- Building Decontamination Technology Center - Chlorine Dioxide Decontamination Technology
CDG Research Corporation Bench-Scale Chlorine Dioxide Gas: Solid Generator (September 2004)
- Building Decontamination Technology Center - Hydrogen Peroxide Decontamination Technology
BIOQUELL, Inc. Clarus C Hydrogen Peroxide Gas (March 2004)
- Building Decontamination Technology Center - Paraformaldehyde Decontamination Technology

CERTEK[®], Inc. 1414RH Formaldehyde Generator/Neuralizer
(August 2004)

Additional reports will be made available as testing progresses.

Task 3.6 - Novel Methods for Decontamination of High-Value Materials

Objective

The objective of this task is to develop new methods for decontaminating high-value or special materials as well as for electronics. Special materials include items found in museums, historic homes, government buildings, or other significant buildings. As part of this task, ideas submitted by small-business owners will be screened. Promising ideas will be subjected to additional testing, resulting in the selection of usable technologies.

Partners

None

Location of Research

Research locations vary. Research is monitored by EPA

Status of Research

Ongoing

The evaluations of two products have been completed:

Development of a Portable Field Decontamination Unit

Whole-Structure Decontamination of *Bacillus* Spores by Methyl Bromide Fumigation

Evaluations of the following technologies are underway:

Compact Decontamination Device Using Cold-Plasma-Generated Singlet Oxygen

Electrostatically Charged Aerosol Decontamination (ECAD) System for Small Building Decontamination

Novel Bioterrorism Decontamination Systems

Ultra-Sensitive Toxic Chemical Detector

Reformulated NanoBio Nontoxic Hard Surface Sanitizer/Disinfectant Formulation to Inactivate and Kill *B anthracis* and Other Bio-Attack Pathogens

Self-Regenerating Filters for Decontamination of Chemical and Biological Agents in Building Ventilation Systems

Research is planned for the following projects:

Development of a Room-Level Protection/Containment System for Chemical/Biological Agents

Singlet Delta Oxygen Airflow Sterilization for Building Protection

Wireless Decontamination Gas Monitor

Products

Information on ongoing or completed evaluations is available on the EPA SBIR Web site at <http://es.epa.gov/ncer/sbir/>.

Assessment of Residual Effects of Decontamination Chemicals

Task 3.3 - Engineering and Economic Analysis of Decontamination Options

Objective

The objective of this task is to conduct an engineering and economic analysis of building decontamination alternatives. This analysis will consider the efficiency and applicability of decontamination systems under varying conditions. The purpose of this analysis is to facilitate the selection of efficacious, safe, and cost-effective decontamination approaches. Existing and developing technologies and systems will be studied.

Partners

None

Location of Research

Research facilities at Research Triangle Park, North Carolina

Status of Research

Planning was initiated early in 2005.

Products

Product will be an engineering and economic analysis of various decontamination options. This information will be incorporated into updates of the decontamination guidance (Task 3.1).

Task 3.7 - Lessons Learned from Building Decontamination Experience

Objective

This task will document EPA's experience and analyze data generated from in-field building fumigations for anthrax decontamination. The purpose of this research is to provide improved procedures for use in planning and conducting future decontaminations.

Partners

None

Location of Research

Research is conducted at EPA facilities, using information gathered in the field at sites that were affected by anthrax.

Status of Research

Ongoing

Anthrax decontamination data analyses have been completed for two sites. Additional analysis continues. Reports will be published as the analyses are completed.

Products

Researchers involved in this task have made the following presentations:

“Protecting Infrastructure: Learning from Anthrax Remediations” was presented at “Decon 2004” in Palm Harbor, Florida, on May 19, 2004.

- “Anthrax Remediations: Lessons Learned for Future Protection” was presented at the “International Physical Security Forum” in Oslo, Norway, on June 1, 2004.
- “Addressing Residual Risk Issues at Anthrax Cleanups” was presented at the “Toxicology and Risk Assessment Conference” in April 2004.

A report titled “Remediation of *Bacillus Anthracis* Contamination in U.S. Department of Justice Mailroom” has been completed.

- A report on remediation of the Department of State facility is completed in draft form.

Task 3.8 - Toxicity of Fumigants

Objective

Through animal exposure to low concentrations of selected decontamination fumigants, researchers will determine the inhalation dose-response relationship for these fumigants. This research will be used to better define acceptable exposure values for safe, long-term reoccupancy of a building after fumigation/decontamination.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

This project was withdrawn due to a lack of FY05 funding.

This research is related to Task 1.8.

Products

- Study implementation plans (Laboratory Animal Project Review Application, Institutional Research Protocol [IRP] Level 2).

A poster presentation was made in 2003 on the use of ClO₂ as a disinfectant for anthrax and on the use of sentinel animals to determine the effect of ClO₂.

An interim report will be prepared on research findings to date.

Disposal Research

The objectives of the disposal research program are to provide guidance for disposal of materials contaminated by CB attack or contaminated by the materials used to decontaminate a building. Additionally, the research will result in tools, techniques, and technologies needed to remove and transport materials contaminated by CB attack to a disposal site. The research will also provide information on the pollutants likely to be generated by disposal (i.e., incineration) and recommend methods for minimizing their impact on the environment.

Thermal Destruction

Task 4.1 – Bench-Scale Investigations of Thermal Destruction Characteristics of Surrogate Biological Agents

Objective

After decontamination of a building, there can be a significant amount of residual materials and wastes requiring disposal. These materials include such items as absorbents and other cleaning materials, building construction materials, carpets, and air filters. The objective of this task is to investigate the potential complexity and variability associated with thermal destruction of such diverse materials. The investigation will examine thermal destruction through the use of surrogate biological contaminants in a laboratory-scale reactor. Research results will enable the DCMD to understand time/temperature requirements for incineration of various building decontamination wastes.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

A report is being prepared describing the results of bench-scale thermal destruction research and the destruction of decontamination wastes.

Products

“Medical Waste Spore Survivability Results for the Bench-Scale Thermal Destruction Studies” was presented at the May 2004 “International Conference on Incineration and Thermal Treatment Technologies” (IT3) in May 2004.

Wood, J.P.; Lemieux, P.M.; Lee, C.W., “Destruction Efficiency of Microbiological Organisms in Medical Waste Incinerators: A Review of Available Data” was presented at the “International Conference on Incineration and Thermal Treatment Technologies” in Phoenix, Arizona, May 10 – 14, 2004.

Brown, P.; Rau, E.H.; Lemieux, P.; Johnson, B.K.; Bacote, A.E.; Gajdusek, D.C. (2004), “Infectivity Studies of Both Ash and Air Emissions from Simulated Incineration of Scrapie-Contaminated Tissues,” published in *Environmental Science and Technology*, Volume 38, pages 6155–6160.

A report summarizing the results of the bench-scale studies is under preparation.

Task 4.2 – Bench-Scale Investigations of Thermal Desorption and Destruction Characteristics of Surrogate Chemical Agents Adsorption/Desorption Studies

Objective

After decontamination of a building, there can be a significant amount of residual materials and waste requiring disposal. Included in these materials are absorbents and other cleaning materials, carpets, building construction materials, and air filters. This task uses bench-scale incineration processes to examine adsorption/desorption of TICs and of surrogate chemical warfare (CW) agents from activated carbon and other filter media in a laboratory-scale reactor. The research results will facilitate understanding of minimum time/temperature requirements that will ensure adequate destruction of contaminated filters and building decontamination residue during incineration.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

This task is being combined with Task 4.1 starting March 2005.

Products

See Task 4.1.

Task 4.3 – Pilot-Scale Studies of Thermal Destruction, Permitting Issues, and Modeling**Objective**

After decontamination of a building, there can be a significant amount of residual materials and waste requiring disposal. Included in these materials are absorbents and other cleaning materials, carpets, building construction materials, and air filters. Researchers involved in this task are investigating issues related to incineration of surrogate CW and biological warfare (BW) materials. Efforts will be directed at understanding incinerator operations with an emphasis on safe disposal of decontamination wastes and compliance with applicable environmental regulations.

Partners

None

Location of Research

EPA's rotary kiln incinerator simulator (RKIS), located at Research Triangle Park, North Carolina.

Status of Research

Ongoing

Testing is ongoing to assess emissions of conventional pollutants from the combustion of carpeting, ceiling tile, and wallboard. Testing is ongoing to evaluate spore destruction as a function of time and temperature in the rotary kiln. Modeling efforts are underway to scale-up results from projects 4.1 and 4.3 to full-scale incineration systems.

Products

A journal article on the results of pilot studies of the combustion of waste carpeting was published in the *Journal of Environmental Management*, Volume 70, Issue 1, pages 27–33 (January 2004). This article, titled “Emissions Study of Co-Firing Waste Carpet in a Rotary Kiln” is available on the Web at <http://www.sciencedirect.com/science/journal/03014797>.

“Carpet as a Fuel in Cement Kilns” was presented at the “8th Annual Conference on Recycling of Fibrous Textile and Carpet Waste” in Dalton, Georgia, May 12 – 13, 2003.

“EPA Safe Buildings Program: Protection and Decontamination of Indoor Environments” was presented at the “2003 Real-World Clean Air Symposium” in Seattle, Washington, May 19 – 22, 2003.

“Further studies of ash residues and air emissions from simulated incineration of scrapie-contaminated tissues” was submitted to *Proceedings of the National Academy of Sciences Journal* in September 2003.

“Destruction Efficiency of Microbiological Organisms in Medical Waste Incinerators: A Review of Available Data” was presented at the “23rd Annual International

Conference on Incineration and Thermal Treatment Technologies” in Phoenix, Arizona, May 10 – 14, 2004.

“Thermal Destruction of Animal Carcasses” was presented at the “Bovine Spongiform Encephalopathy (BSE) Meeting” in Washington, D.C., on March 10, 2004.

“Pilot-Scale Carpet Combustion” was presented at the “2004 American Society of Mechanical Engineers (ASME) Subcommittee on Municipal and Hazardous Waste Incineration” in Washington, D.C., on April 6, 2004.

“Advanced Modeling of Incineration of Building Decontamination Residue” was presented at the “Air and Waste Management Association’s 98th Annual Conference and Exhibition” in June 2004.

“Pilot-Scale Combustion of Building Decontamination Residue Air” will be presented at the “Waste Management Association Annual Meeting” in June 2005.

Landfills

Task 4.6 - Permanence of Disposal: Assessing Conditions for Safe Landfilling of Building Decontamination Wastes

Objective

The ultimate fate of contaminants associated with building decontamination wastes is a concern long after disposal. Decontamination wastes in which contaminants have been completely destroyed present little potential for problems; however, wastes that have residual levels of contaminants present a potential concern. Under this task researchers are investigating the survivability of various BW agents in a landfill environment and the behavior of various CW agents and their decomposition products in a landfill environment. This research will be used to determine possible modes of contaminant transport (e.g., air, water, and leachate) from landfills and how effective the landfill is in reducing the survival time of biological agents.

Partners

DOD

Location of Research

U.S. Army’s ECBC at Aberdeen Proving Grounds and EPA research facilities in Cincinnati, Ohio

Status of Research

Ongoing

Testing has been initiated to examine the long-term survival of live agents in a landfill leachate environment. These tests are being performed in a DOD Bio-Safety Level (BSL)-3 laboratory.

Products

The product will be an EPA report. Information from the study will be incorporated into a Disposal Guidance Tool (Task 4.9).

Task 4.13 - Bench-Scale Investigations of Transport of Surrogate Biological and Chemical Agents between Landfill Residue, Leachate, and Gas

Objective

This task investigates the fate and transport of CW and BW agent simulants in a landfill environment. These investigations will be used to determine the capability of these contaminant simulants, or their by-products, to migrate as leachate or as landfill gas.

Partners

North Carolina State University and EPA's Research Triangle Park facility in North Carolina

Location of Research

North Carolina State University at Raleigh

Status of Research

Ongoing

A literature search has been performed, and bounding calculations are being identified. Based on those bounding calculations, a series of experiments will be performed to assess the fate and transport of CW and BW agents in a landfill environment.

Products

A conference paper based on the bounding calculations is anticipated in 2005. A final report is anticipated in 2006.

Sampling/Analytical Methods

Task 4.8 - Sampling/Analytical Methods for BW Contaminants

Objective

The mobility of biological contaminants in landfills or in thermal devices has not been well explored. To develop an understanding, this task is expanding on preliminary sampling and analytical methods for measurement of BW contaminants from combustor stacks and landfills. Emphasis is on method validation, sample hold times, interferences, and detection limits. Researchers will produce bench- and pilot-scale investigations to support the development of methods to measure biological agents in combustor emissions.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

Testing is ongoing to evaluate several different sample train designs and their ability to successfully recover 100 percent of spores injected into a high temperature duct under a variety of conditions. The most successful of the sample trains will be selected for further studies in which large quantities of spores will be injected into the EPA rotary kiln incinerator simulator and sampled under a variety of conditions to assess sample recovery and spore survival.

Products

A draft sampling method is anticipated to be completed in 2006. A conference paper based on the initial results is also anticipated in 2006.

Disposal Guidance

Task 4.4 – Guidance Tool for Combustion of Building Decontamination Residues

Objective

The objective of this task was to provide guidance for disposal of building decontamination residues (BDR). It included the preparation of a Web-based guidance tool and handbooks on incineration of building decontamination wastes and on transportation, safety, and disposal capacity for landfilling.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Completed

Products

Research on the technical requirements for incineration of building decontamination-related wastes are included in a handbook titled “Building Decontamination Residue (BDR) Disposal Decision Tool” and as a Web-based computer tool, “BDR Disposal Decision Support Tool Version 1.0.” The handbook and Web-based tool are on a restricted access Web site available only to authorized account users.

Task 4.7 - Technical Resource Manual for the Consideration of the Protection of the Public and Workers

Objective

Under this task, researchers prepared technical guidance related to worker and public safety considerations associated with the transport, treatment, and disposal of waste materials generated from the decontamination of buildings.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Completed

Products

The product from this project is a compilation of information that will be added to the decision support tool under project 4.9.

Task 4.9 - Guidance for Emergency Responders, Disposal Permitters, and Facilities

Objective

Disposal of building decontamination wastes must be in accordance with environmental regulations. This task involves developing a consolidated guidance document that will address safety and regulatory issues associated with transport and disposal. These guidelines will inform selection of the best methods for disposal of building decontamination wastes and facilitate decontamination choices that do not produce disposal problems. The guidelines are being developed as an online decision support tool to address disposal of building decontamination residue.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

This task is an expansion of Task 4.4.

Products

See Task 4.4.

Task 4.10 - Disposal Workshop

Objective

The objective of this task is to hold workshops involving government, state, and private sector stakeholders to address issues related to building decontamination residue.

The first workshop was held in May 2003 in Cincinnati, Ohio. The objectives of this workshop were to:

Document the current understanding of the challenges faced when handling, storing, transporting, and disposing of wastes from the cleanup of public and private facilities contaminated with chemical and biological agents.

Identify research needs and opportunities for improving coordination among federal, state, and local government agencies and other stakeholders in order to fill gaps in the current understanding of these waste management challenges.

Partners

The workshop panelists included representatives from federal agencies (e.g., EPA, DOD, Department of Transportation [DOT], CDC, state agencies, local agencies, academia, and waste management companies).

Location of Research

The first workshop was held May 28 – 30, 2003, in Cincinnati, Ohio.

Status of Research

Ongoing

During the workshop, panelists gave presentations on specific topics, including the waste management challenges posed by the World Trade Center disaster and the anthrax contamination of office buildings in New York City and Washington, D.C. Following each presentation, the workshop panelists engaged in free-flowing discussions to elaborate upon the issues presented.

Additional workshops are anticipated.

Products

The report for the first workshop, “Report on the Homeland Security Workshop on Transport and Disposal of Wastes from Facilities Contaminated with Chemical or Biological Agents,” was published as an EPA report, EPA/600/R-04/065, in November 2003. Copies of this report are available at <http://www.epa.gov/ordnhsrsrc/pubs/reportFacilityWaste110104.pdf>.

This report summarizes discussions on the following seven topics: 1) classes of chemical and biological agents; 2) detection; 3) effectiveness of decontamination; 4) triaging of wastes; 5) handling, storage, and transport of wastes; 6) landfilling; and 7) incineration. For each topic, the report outlines the current state of knowledge, identifies associated research needs, and lists action items identified during the discussions. The technical content of this report is based entirely on discussions at the workshop.

In addition to the topics listed above, some cross-cutting themes emerged during the panelists’ discussions, including the absence of widely accepted standards for effective decontamination, federal involvement in transport infrastructure maintenance, and the possibility of EPA’s future development of relevant databases related to capacity and transportation routes. Future workshops will address these issues.

Task 4.12 - Biocontaminant Laboratory Support for Tasks 4.1, 4.3, and 4.8

Objective

The objective of this task is to provide technical support for inoculation and culturing activities required by bench- and pilot-scale research activities investigating the destruction of BW agents for Tasks 4.1, 4.3, and 4.8.

Partners

None

Location of Research

EPA research facilities at Research Triangle Park, North Carolina

Status of Research

Ongoing

Products

In support of this task, the biocontaminant lab facility manual expansion was completed in May 2004 as an internal EPA document.

Risk Assessment and Communication

Risk communication involves the development of guidance related to improved detection, containment, and decontamination methods for facility managers, for emergency responders, for those sampling and analyzing materials in the environment, and for decontamination crews. The communication of research findings is incorporated into each project.

Risk assessment efforts are performed in collaboration with the NHSRC's Rapid Risk Assessment (RRA) Team. The RRA is a component of the Threat and Consequences Assessment Division (TCAD). The objective of risk assessments for safe buildings is to determine the level of protection necessary to meet the objectives of the containment program, the risks from proposed decontamination and disposal procedures, and decontamination levels necessary before a contaminated building can be returned to normal service. In cases for which risk assessments cannot be conducted, the risk assessment program will develop recommendations for research necessary to develop data needed for the risk assessment.

Appendix A: Acronyms List

AOAC – Association of Official Analytical Chemists
ARL – Army Research Laboratory
ASME – American Society of Mechanical Engineers
AWMA – Air and Waste Management Association
BDR – Building Decontamination Residue
BSE – Bovine Spongiform Encephalopathy
BSL – Bio-Safety Level
BW – biological warfare
CB – chemical or biological
CDC – Centers for Disease Control and Prevention
CW – chemical warfare
DARPA – Defense Advanced Research Program
DCMD – Decontamination and Consequence Management
DHS – Department of Homeland Security
DOD –Department of Defense
DOE – Department of Energy
DOT – Department of Transportation
ECAD – Electrostatically Charged Aerosol Decontamination
ECBC – Edgewood Chemical Biological Center
EPA – Environmental Protection Agency
ETV – Environmental Technology Verification
FEMA – Federal Emergency Management Agency
FIFRA – Federal Insecticide, Fungicide, and Rodenticide Act
GC-MS – Gas Chromatographic-Mass Spectrographic
HVAC – heating, ventilation, and air conditioning
IRP – Institutional Research Protocol
IT3- Incineration and Thermal Treatment Technologies
LC-MS – Liquid Chromatographic-Mass Spectrographic
LIBS – Laser-Induced Breakdown Spectroscopy
NERL – National Exposure Research Laboratory
NHSRC – National Homeland Security Research Center
NIOSH – National Institute for Occupational Safety and Health
NIST – National Institute of Standards and Technology
OP-FTIR – Open Path-Fourier Transform Infrared

OPPTS – Office of Pesticide Programs and Toxic Substances

PFPD – Pulsed Flame Photometric Detector

QPCR – Quantitative Polymerase Chain Reaction

QRT PCR – Quantitative Real-Time Polymerase Chain Reaction

R&D – Research and Development

REMPI – Resonance Enhanced Multiple Photon Ionization

RKIS – rotary kiln incinerator simulator

RRA – Rapid Risk Assessment

RTP – Research Triangle Park

SAT – Sporidical Activity Test

SBIR – Small Business Innovation Research

SOP – Standard Operating Procedure

SPI – Single Photon Ionization

SPMD – Semipermeable Membrane Devices

TCAD – Threats and Consequences Assessment Division

TICs – toxic industrial chemicals

TSWG – Technical Support Working Group

TTEP – Technology Testing and Evaluation Program

USGS – U. S. Geological Survey



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