

Emerging Contaminants – SRP-Funded Research in Remediation Technologies Heather Henry Superfund Research Program, NIEHS





NIH Research Mission

Fundamental Knowledge		Health Outcomes
of living systems	National Institutes of Health (NIH)	reduced illness & disability
with environmental exposures	National Institute of Environmental Health Sciences (NIEHS)	caused by hazardous substances
including health effects, risk assessment,	Superfund Research Program (SRP)	relevant to Superfund stakeholders
remediation		



SRP Mandates under SARA

"SEC. 311. RESEARCH, DEVELOPMENT, AND DEMONSTRATION. "(a) HAZARDOUS SUBSTANCE RESEARCH AND TRAINING.— 1) AUTHORITIES OF SECRETARY.-The Secretary of Health and Human Services (hereinafter in this subsection referred to as the Secretary), in consultation with the Administrator, shall establish and support a basic research and training program through grants, cooperative agreements, and contracts) consist-"(A) Basic research (including epidemiologic and ecologic studies) which may include each of the following: ing of the following: (i) Advanced techniques for the detection, assess-ment, and evaluation of the effects on human health of "(ii) Methods to assess the risks to human health hazardous substances. resented by hazardous substances. "(iii) Me Health Effects substances chemical, and toxicil "(B) Training, which may "(i) Short courses and continuing edu and local health and environment agency person and other personnel engaged in the handling of has ardous substances, in the management of facilities a respect That of the and in the substances are located, and in the same v In F which h Assessing Risks evaluatio by such SECTION Vii) G This . public health and en "Viii) Graduate training in the geosciences, including hydrogeology, geological engineering, geophysics, geo chemistry, and related fields necessary to meet profes hydrogeology, geouged fields necessary to meet prove chemistry, and related fields necessary to meet private sectors sional personnel needs in the public and private sectors and to effectuate the purposes of this Act. The National Insti-"(2) DIRECTO 104. Resp 105. Natio 105. Natio 106. Reim 107. Liabi 108. Finan 108. Finan Detection tute for Envir with the relev or contract may be made or entered in (1) with an accredited institution of higher education. may carry out the research or training under the gran cooperative agreement, or contract through contracts, including contracts with any of the following: "(A) ("(R)) Remediation ous substances are (D) State and local gover

University-based basic research program established in 1986 under Superfund Amendments Reauthorization Act (SARA)

Mandates Call for the Development of:

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Biomedical and Risk Research

presented by hazardous substances

Methods and technologies to detect hazardous Environmental Science and Engineering Research

hazardous substances



NIEHS Superfund Research Program Highlights

- Since 1987, The Superfund Research Program (SRP) has:
 - Conducted work at 217 hazardous waste sites
 - Patented approximately 98 inventions
 - Produced approximately 8105 peerreviewed publications, which makes it one of the most productive programs ever funded by the federal government
- The SRP currently provides support to over 1400 professionals and more than 680 trainees involved in research





Where We Work...



U.S. Department of Health and Human Services



How SRP Defines Emerging Contaminants

- High Production Volume Information System (HPVIS)
- Rare Earth Elements (REEs)
- Provisional Peer Reviewed Toxicity Values (PPRTV)
- ATSDR emerging contaminants would include extremely data poor contaminants that ATSDR or National Center for Environmental Health (NCEH)
- Federal Facilities Restoration and Reuse Office (FFRRO) <u>Emerging Compounds</u>: FFRRO

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and the second second	High Production Volume Information System (H	PVIS)	Share	
	Contact Us Search: O All EPA O This Area Go			
ANAL PROTECTION	You are here: EPA Home » Prevention, Pesticides & Toxic Substances » Pollution Prevention & Toxics » High Prod System (HPVIS)	luction Volume (HPV) Chall	ence » High Production Volume Information	
		NITED STATE	U.S. ENVIRONMENTAL PROTECTION AGENCY	
PV Challenge	The High Production Volume Information System (HPVIS) is a database that provides acce		Federal Facilities Restoration and Reuse Office (FFRRO)	
Home	environmental effects information obtained through the High Production Volume (HPV) Cha		Recent Additions Contact Us Search: O All EPA O This Area	
	"challenges" companies to make this data publicly available on chemicals produced or impo	What protection	You are here: EPA Home * Federal Facilities Restoration and Reuse Office * Emerging Contaminants and Federal Facility Contaminants of Concern	
IPVIS Home	States in quantities of 1 million pounds or more per year.			
	On this Web site, HPVIS enables users to search for summary information, test plans, and	FFRRO Home	Emerging Contaminants and Federal Facility Contaminants of Concern	
Characterizations	chemicals as they are received by the Agency. Currently, the HPVIS database contains ove	Basic Information	You will need the free Adobe Reader to view some of the files on this page. See EPA's PDF page to learn more. If you need	
	representing almost 900 chemical substances, either as a single chemical submission or as category.	Federal Facility Site	assistance accessing any of the PDFs, please contact <u>Jvl Lapachin</u> at (703) 603-0046 or lapachin.jvl@epa.gov.	
bout Chemical prioritizations		Information	Click on a tab for related links and information.	
	EPA is carefully reviewing HPV chemical data to characterize the hazards and risks associat	Involvement		
lisk-Based	environmental effects data contained with each HPV Challenge Program submission. HPVIS	Information Resources	Federal Facility Contaminants of Emerging Contaminants Additional Concern Technical Fact Sheets Fact Sheets Information	
Prioritization Documents	Prioritization documents prepared from EPA's examination of HPV Challenge hazard data a	Federal Facilities Site		
	and exposure information collected from the 2006 Inventory Update Reporting (IUR). Thes	Evaluation Project (FESEP)	Federal Facility Contaminants of Concern Technical Fact Sheets	
	risks	Library	- The U.S. Environmental Destaction Accord (FDA) Endered Environmental Destaction and Device Office (EFDBO) whilehed the following technical fact shorts	



SRP Emerging Contaminants

Currently, SRP research of emerging contaminants includes:

Remediation and fate and transport studies

- 1,4-dioxane
- Nanoparticles
- Perchlorate
- Perfluorooctonic acid (PFOA)
- Phthalates
- Polybrominated flame retardants, including PBDE
- Triclocarban and triclosan

Health effects and exposure studies

- Environmentally persistent free radicals
- Nanomaterials
- Perchlorate
- Phthalates
- Polybrominated flame retardants, including PBDE
- Triclocarban and triclosan



Groundwater Bioremediation of 1,4-dioxane Lisa Alvarez-Cohen, UC Berkeley SRP (P42ES004705)

- Identifying and studying microbial communities (anaerobic and aerobic), that can remediate TCE and 1,4 dioxane
 - Degradation by both metabolic and cometabolic pathways
 - Identified signature genes that predict success in groundwater bioremediation
 - Studies on dioxane degradation pathway of *Pseudonocardia dioxanivorans* CB1190







Degradation of Dioxane in Superfund Site Soil

- Alvarez-Cohen applied her bioremediation work to soil from a Superfund site in CA with dioxane and other organic contaminants
- Researchers observed dioxane degradation by cometabolism with tetrahydrofuran (THF) or propane amendments

Environmental sample	Growth substrate	Dioxane degradation
Groundwater sample (MW-1)	Dioxane	-
Groundwater sample (MW-1)	THF	+
Groundwater sample (MW-1)	Propane	+
Groundwater sample (MW-2)	Dioxane	-
Groundwater sample (MW-2)	THF	+
Groundwater sample (MW-3)	Dioxane	-
Groundwater sample (MW-3)	THF	+
Groundwater sample (MW-4B)	Dioxane	
Groundwater sample (MW-4B)	THF	+
Soil sample (close to MW-2)	Dioxane	-
Soil sample (close to M-2)	THF	+
Activated sludge (from another site [site A])	Dioxane	-
Activated sludge (site A)	THF	+
Activated sludge (site A)	Propane	+
Activated sludge (site A)	Toluene	-
Activated sludge (from waste water facility [site B])	Dioxane	-
Activated sludge (site B)	THF	+
Activated sludge (site B)	Propane	+
Activated sludge (site B)	Toluene	-





Bioremediation of 1,4-dioxane

Microvi Technologies, Joseph Salanitro (R43/R44 ES022123)

- Remediation of 1,4-dioxane from water resources via a biological treatment pathway
- SBIR investigators are developing an engineered bioreactor called the MB-DX bioreactor
- High density of Rhodococcus sp. N21 fully integrated within the bioreactor material matrix





Scanning Electron Micrographs shows cross section of one biocomposite matrix (A), microbial integration throughout the pores and cavities of the material (B), and a high cell density contained within the matrices (B-D)

Map of the PLS Site and dioxane plume



ISCO with Persulfate/Iron for 1,4 Dioxane and PFOA David L Sedlak, Fiona M. Doyle, UC Berkeley (P42ES004705)

- Testing new approaches for oxidizing contaminants that are difficult to treat with existing technologies like PCBs, 1,4dioxane, and perfluorooctonic acid (PFOA)
- Applying these approaches to create treatment systems and develop kinetic models with persulfate and iron-containing solids
- Currently working with aquifer sediment collected from a series of different hazardous waste sites to understand the relationship between geochemistry and persulfate activation rates.
- Anticipated Outcome: Model that will predict the efficiency of systems used for in situ chemical oxidation of organic contaminants with hydrogen peroxide



PFOA





Direct-Push Oxidant Candles with Pneumatic Circulators Mark Christenson, Airlift Environmental (R41ES022530)

 To remove chlorinate solvents and petroleum products from contaminated aquifers – potential use for 1,4 Dioxane



On a simple burner, purple permanganate granules are mixed with paraffin to create candles

Mark Christenson shows how paraffin-based permanganate candles are prepped for lowering down a borehole at a Cozad landfill site.

(Photos by Steve Comfort)



Biochar Amendments for TCC/TCS Remediation Kate Scow, UC Davis (P42ES004699)

- Investigating how biochar application in soil may provide benefits through reduced contaminant mobility
- Biosolid land applications applications: TCC/TCS
- Wood and walnut shell biochar soil amendments effectively sequesters
- Also working with Ian Kennedy on NZVI for remediation.







Nanomaterial-based Remediation of Contaminated Sediments

Mark Weisner, Duke University (P42ES010356)

- Focus on polybrominated flame retardant **decabrominated diphenyl ether**, **BDE-209**, among other contaminants
- Researchers are studying nano-bio remediation using zero valent iron (ZVI) and titanium dioxide (TiO2) nanomaterials for contaminant degradation by:
 - Investigating the use of nanomaterials as catalysts for direct treatment of contaminated sediment and water
 - Assessing microbial degradation of the target contaminants by sediment microorganisms with and without nanomaterials
 - Uncovering possible synergies of nanoparticle-based remediation with natural microbial degradation processes





Detection Technologies to Improve Remediation of Perchlorate in Food and Water Supplies

Advanced Microlabs, Philippe Dekleva (R44ES017200)

- Online perchlorate analyzer to facilitate remediation efforts, allowing ionexchange resin bed reactors to operate more cost effectively and with greater public safety
- Online device taken to Southern CA to test remediated water
- Bench instrument taken to a hazardous waste site in Mississippi to test perchlorate
 - More amendable to field work and quickly assessing many wells within a short time
 - Requires less sample volume





Detection and Exposure Assessment Tools Northeastern University, Roger Giese, (P42ES017198)



- "Tea Bag" contains adsorbent(s)

- Concentrates analytes from large biological and environmental samples to make detection of the analytes easier.
- "Non-targeted" adsorbent collects suite of compounds (including phthalates) for later analysis.



Goal: Provide small, stabilized sample for long term storage and future testing of aliquots.



Bioavailability Assay Arizona State University and University of Florida

Rolf Halden and Nancy Denslow, (R01ES015445)

- Multi-analyte Sensor: in situ sampling/bioavailability determination (IS2B) tool
- Analytes: triclosan, triclocarban, fipronil, ppDDE, dieldrin
- Sites: Lake Apopka, FL Superfund Site









Environmentally Persistent Free Radicals (EPFRs) Louisiana State University (P42ES013648)

- LSU researchers have discovered chlorinated aromatic hydrocarbons and substituted phenols chemisorb to the surfaces of particulate matter where they reduce the metal and form a free radical
- LSU formed an interdisciplinary collaboration to explore the impacts of these emerging pollutant particle systems
 - EPFRs were shown to generate ROS, oxidative stress, and cardiopulmonary dysfunction in rat pups exposed by inhalation
 - Studies provide evidence that just measuring PM without considering EPFRs may lead to erroneous conclusions concerning toxicity of environmental PM



EPFRs form in combustion and thermal processes including hazardous waste incineration and diesel combustion.



Discovering EPFRs in Soil at Hazardous Waste Sites Detection at a Superfund Wood Treating Site

- Analyses of former wood treating facility containing pentachlorophenol (PCP) as a major contaminant revealed a 30x higher EPFR concentration in the PCP contaminated soils than in the noncontaminated soil.
- Recognition that EPFRs can be formed in PCP contaminated soils indicates EPFRs are not confined to combustion-generated PM and are more environmentally prevalent than originally suspected
- The existence of potentially toxic EPFRs questions the long held belief that sorption of an organic pollutant to a soil matrix is a method of mitigating its environmental impact





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Thank You!

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Searching for SRP Research

- SRP Website:
 - http://tools.niehs.nih.gov/srp/search/index.cfm

Search SRP by Keywords	Search SRP Projects by Topic		
The Search SRP by Keywords tool allows you to search SRP information (center,	The Search SRP Projects by Topic tool allows you to find projects related to specific		
program and project summaries; progress reports; Research Briefs; and research	topics.		
people;) for keywords or names.	Use the drop down box below to select a topic and click Go. This will open a page		
Simply type in your keyword, click in the checkboxes to choose the content you would	with subtopics to allow you to refine your search.		
like to search, and click on the Search button. You can get additional information by clicking on the Search Tips link.	Select Research Topic ** Select Research Topic ** Go		
Search Term			
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🛛 Research Briefs 🛛 📝 People	Simply type in your keyword and click on the Search button.		
Centers, Programs and Progress Projects (Currently funded) Reports	Please note: this tool searches only publication titles and author lists.		
Centers, Programs and Projects (Previously funded)	Publication litie and Author Search Term		
Search Search Tips	Search		

- NIH RePORTer:
 - <u>http://projectreporter.nih.gov/reporter.cfm</u>





PROJECT 6: OXIDATIVE REMEDIATION

SRP Funding Mechanisms

Multi-Project Centers (P42)

Designed for integration across disciplines: Biomedical and Non-Biomedical Research; Community Engagement, Research Translation, and Training. Basic and application-oriented.

Request for Applications. Annual RFA.

Small Business Research Grants SBIR/STTR (R41-44)

Foster the commercialization of technologies, relevant to hazardous substance clean-up and monitoring. Ongoing Funding Opportunity

Conference Grants (R13)

Provides funding for conferences related to SRP mandates. Ongoing Funding Opportunity

Individual Research Project (R01)

Designed to address specific issues to complement the multi-project research program; tackle issues of emerging concern for Superfund. Current solicitation:

Biogeochemical Interactions Affecting Bioavailability for in situ Remediation of Hazardous Substances (R01)

Occupational Training (R25)

Emerging issues in EHS training. Closed.

Supplement Awards

Trainee externships/work exchanges, technology transfer opportunities.

National Institutes of Health Funding Opportunities: http://www.niehs.nih.gov/research/supported/dert/cris/programs/srp/funding/index.ofmpes



SRP Scientific Topics and Approaches

Contaminants Studied

- •Dense non-aqueous phase liquids (DNAPL)
- Dioxins/Furans
- Fluoropolymers
- Metals
- Arsenic
- Cadmium
- Chromium
- •Lead
- Manganese
- Metal Mixtures
- Mercury
- Nickel
- Nanoparticles
- Organobromides
- Organochlorides
- Organophosphates
- Persistent Free Radicals
- Phthalates
- Polycyclic aromatic hydrocarbons (PAH)
- ·Polychlorinated biphenyls (PCB)
- Triclosan and triclocarban
- Volatile organic compounds (VOC)

Disease Endpoints

- •Cancer
- Bladder
- •Brain
- •Lung
- •Skin
- Dermal Toxicology
- Developmental Toxicology
- Immounotoxicology
- Nephrotoxicology
- Neurotoxicology
- Pulmonary/Cardiology Toxicology
- Reproductive Toxicology

Scientific Approaches

- Analytical Tool Development
- Animal Studies
- Bioavailability
- Biomarker Research
- Biomolecular Studies
- Community Engagement
- Data Analysis /Bioinformatics
- Ecology
- Epidemiology Studies
- Environmental Samples Studies
- •Air
- Groundwater
- ·Soil and Sediment
- Surface Water
- Fate and Transport
- Human Studies
- Modeling
- Remediation Technologies
- Bioremediation
- Chemical/Physical Remediation
- Nanoparticles for Remediation
- Phytoremediation
- Research Translation
- Risk and Exposure Assessment
- Susceptible populations
- Training