The NIEHS Superfund Research Program (SRP)

SRP enables university-based scientists, engineers, and public health workers, along with community members, to lessen the environmental health effects of hazardous waste sites across the nation.

THE UNIVERSITY OF ARIZONA

University of Arizona (UA)

Hazardous Waste Risk and Remediation in the Southwest

The arid climate of the U.S. Southwest and areas close to the U.S.-Mexico border bring unique challenges when it comes to environmental contaminants.

The UA SRP is addressing the health effects resulting from exposure to contaminants in these areas, while also working to characterize, contain, and remediate hazardous waste sites.

Led by Raina Maier, Ph.D., researchers at the University of Arizona (UA) SRP Center want to understand:

- How low-level arsenic exposure affects development of bladder cancer, as well as lung and cardiovascular development and disease.
- How genetic variation may increase sensitivity to arsenic, and how arsenic exposure can impact gene expression.
- The processes that govern how arsenic interacts with soil and water.
- How to enhance the accuracy of risk assessments and improve the effectiveness of remediation strategies for sites contaminated by chlorinated solvents.
- The role that particle size plays in dispersing and transporting metal contaminants in wind-blown dust from mine waste.
- How plants can be used to stabilize mine waste and limit arsenic exposure, and how interactions between plants, metals, and microbes affect revegetation of former mining sites.

UA SRP is strengthening the ability of the U.S. and Mexico to jointly address common hazardous waste problems by providing training, education, and teaching tools in English and Spanish. They are also bolstering partnerships with Mexican universities and research institutes to create a functional and permanent binational consortium that deals with environmental health issues along the U.S.-Mexico border.

Regional Research Has Global Implications:

- One-third of land surfaces in the world are arid or semiarid. This proportion is expected to increase with climate change. Findings from UA studies can help solve problems faced in other arid regions of the world.
- Arsenic and chlorinated solvents are of significant concern throughout the world. UA SRP is working to understand principles of toxicology and remediation that can be applied both nationally and internationally, regardless of climatic conditions.

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Revegetation of Mine Tailing Sites

Mine tailings, materials left over after removing the valuable portion of the ore, cover thousands of acres in the Western United States. These finely crushed waste rocks are often acidic, contain harmful metals, and are barren of vegetation. Raina Maier, Ph.D. and her colleagues are assessing a strategy for long-term management of mine waste sites, using revegetation. In collaboration with the U.S. Environmental Protection Agency.

Specific types of plants and soil conditions are being investigated for their ability to stabilize areas contaminated with mine tailings. *(Photo courtesy of University of Arizona SRP)*

Region 9 and the site owner, the researchers initiated a field trial at the Iron King Mine and Humboldt Smelter Superfund site in Arizona. This work, the first to quantify how revegetation affects particulate emissions from a mine tailings site, suggests that the vegetation significantly reduces dust from the site.

A New Mechanism Proposed for Arsenic Toxicity

Arsenic is thought to contribute to a diverse range of diseases from cancer to heart disease to diabetes. Despite having such a wide impact, the way in which arsenic exerts its toxic effects has remained a puzzle. Walt Klimecki, Ph.D, Bernie Futscher, Ph.D., and trainees Fei Zhao and Paul Severson, Ph.D. have found that chronic, low-dose arsenic exposure causes human cells to change their cellular metabolism, specifically in regard to how they process sugar for energy. The cells are using a special process normally reserved for conditions of oxygen starvation. This suggests that arsenic "tricks" the cells by triggering their sensors for low oxygen conditions, even when the cells have abundant oxygen. This may have important consequences for arsenic-associated disease, since a similar shift in sugar metabolism has been observed in diseases such as diabetes and cancer.

Exposure to arsenic causes changes in cellular metabolism, visualized in the laboratory as color changes in the medium. *(Photo courtesy of University of Arizona SRP)*

Community Engagement Along the Border

The 2,000-mile border between the U.S. and Mexico is a unique arid region spanning four U.S. and six Mexican states. People residing along the border are at risk of exposure to a variety of environmental contaminants, including arsenic, trichloroethylene, lead, pesticides, and air pollutants.

Since 1990, the UA SRP has worked to build an outreach effort to address U.S.-Mexico border health issues. UA scientists partner with scientists in Mexico to exchange and transfer environmental expertise and to develop coordinated strategies to assess exposure and characterize health effects. The partners are also developing preventive measures that both countries can use to reduce exposure, as well as remediation technologies to treat hazardous wastes.

The UA SRP has partnered with *promotoras* (female Hispanic community health workers) who provide environmental health information in primarily Spanish-speaking neighborhoods. In the photo, *promotoras* from the Regional Center for Border Health, Inc. and Sunset Community Health Center participate in a hands-on activity that helps them visualize dispersion of a contaminant. *(Photo courtesy of University of Arizona SRP)*

For more information on the National Institute of Environmental Health Sciences, visit **http://www.niehs.nih.gov**

For more information on SRP, visit **http://www.niehs.nih.gov/srp**

For more information on the University of Arizona Center, visit **http://superfund.pharmacy.arizona.edu**

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Boston University (BU)

Receptor-based Developmental and Reproductive Toxicity of Superfund Chemicals

Interdisciplinary scientists conduct and communicate research on the effects of improperly managed hazardous wastes. Specifically, they study how exposures to substances commonly encountered in hazardous waste disposal affect reproduction and development in humans and wildlife.

Led by David Ozonoff, M.D., researchers at the Boston University (BU) SRP Center are:

- Studying risk of birth defects in a population exposed to perchloroethylene (PCE), a neurotoxicant, in drinking water.
- Developing improved methods for mapping epidemiologic and chemical mixture data on reproductive and developmental outcomes, while adjusting for known risk factors.
- Determining the molecular mechanisms by which individual and complex mixtures of environmental chemicals, including flame retardants and tributyltin, impair the development of the mammalian immune system and accelerate bone aging.
- Understanding the effects of long-term, multigenerational exposure to high levels of contaminants on natural populations of animals inhabiting Superfund sites.
- Using fish models to conduct a comprehensive study of the effects of ortho-PCB on development, which may be relevant to broader questions about developmental consequences of chemical mixtures in the New Bedford, Mass., area.

The BU SRP partners with Alternatives for Community & Environment (ACE) and the Toxics Action Center to provide expertise to communities affected by exposures to hazardous substances, with the goal of reducing those exposures and preventing adverse health outcomes.

More About the Harmful Chemicals Under Investigation:

- PCE remains a commonly used commercial solvent that may contaminate drinking water from groundwater sources. Epidemiologic work linked exposure to PCE in drinking water in the 1960s and 1970s to increased breast cancer.
- BU SRP researchers found that risky behaviors, particularly drug use, are much more frequent among adults who were exposed to high levels of PCE-contaminated drinking water during gestation and early childhood.
- Even though they were banned in 1977, PCBs are persistent and common environmental contaminants and accumulate in animals and humans through the food chain. Exposure is associated with liver cancer, kidney damage, and thyroid problems.

BOSTON UNIVERSITY

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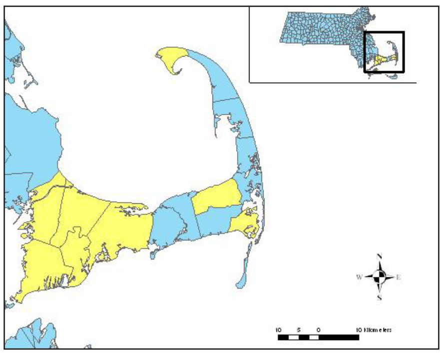
Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Linking PCE and Health Effects

Prenatal and early-life exposures to PCE have been linked to a variety of adverse health effects in children and adults. Ann Aschengrau, Sc.D., investigated PCE exposure in a group of people born between 1969 and 1983 in the Cape Cod region of Massachusetts. In eight areas studied, a vinyl liner containing PCE was applied to pipes in the drinking water distribution system. The vinyl liner was improperly cured, leaching PCE into the water supply. The study found that prenatal PCE exposure was linked to an increased risk for birth defects.



Eight Cape Cod areas, highlighted in yellow, were in Aschengrau's study.
(Figure courtesy of Ann Aschengrau)

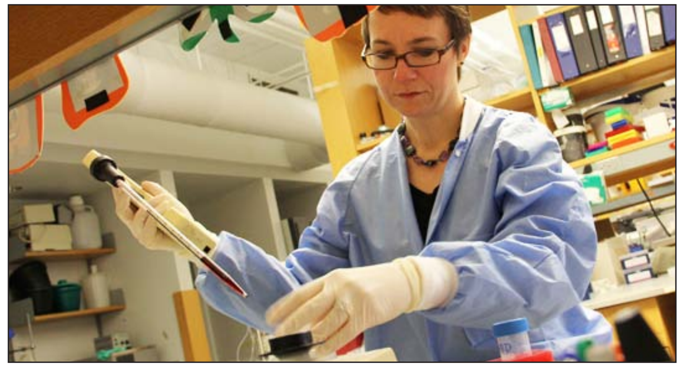
Other studies led by Aschengrau associate prenatal and early postnatal PCE exposure to problems with vision and adverse neurological effects, such as decreased attention and memory, in adulthood. The studies also uncovered a possible dose effect of PCE – higher early exposure may contribute to greater visual and neurological impairment.

Providing Insight into Environmental Causes of Disease

Since 1995, BU SRP researchers have used Geographic Information System (GIS) data and increasingly sophisticated statistical methods, to examine the geographic distribution of disease, which may provide important clues to the origins of the disease.

Research teams have developed new approaches that allow them to:

- Map disease hot and cold spots while accounting for known risk factors such as age and smoking. Using these tools, they identified lung and breast cancer hot spots associated with two pollution plumes near the Massachusetts Military Reservation.
- Establish a link between prenatal PCE exposure and adverse birth outcomes, including cleft lip and neural tube defects.
- Determine that women living in northern latitudes may be at greater risk for rheumatoid arthritis.



The BU project, led by Jennifer Schlezinger, Ph.D., looks at how environmental contaminants impact bone quality.
(Photo credit: Michael Saunders, BUSPH)

Ongoing Community Engagement and Research Translation

The BU SRP interacts with local boards of health in Massachusetts, residents living in proximity to hazardous waste sites, and residents of environmental justice areas to provide scientific expertise in response to community questions, develop materials, and implement training on hazardous materials regulations and solid waste reduction resources.

For example, BU SRP offered free soil lead testing to community gardeners at events open to the public in the metro Boston area and developed research-based educational materials for gardeners to guide interpretation of soil results and provide tips for risk management. The soil testing station was the latest outreach effort rooted in ongoing work led by Wendy Heiger-Bernays, Ph.D., to educate gardeners about soil quality and best practices for safe urban agriculture.

They also work with the Boston Museum of Science and the Collaborative on Health and the Environment (CHE) to inform more people about their research. CHE, founded in 2002, is an international partnership committed to strengthening scientific and public dialogue about environmental health.

For more information on the
National Institute of Environmental Health Sciences, visit
http://www.niehs.nih.gov

For more information on SRP, visit
http://www.niehs.nih.gov/srp

For more information on the
Boston University Center, visit
http://www.busrp.org

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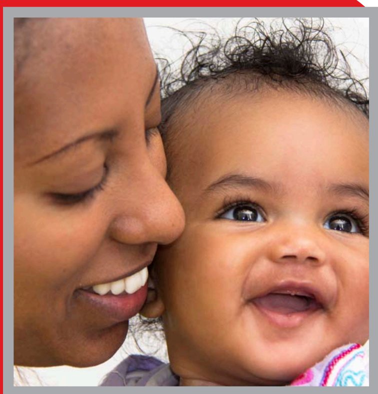

Brown University

Reuse in Rhode Island: A State-Based Approach to Complex Exposures

Researchers focus on mixed exposures, taking a state-based approach to environmental health research, technology development, and contaminated land re-use with Rhode Island as their laboratory.

Led by Kim Boekelheide, M.D., Ph.D., researchers at the Brown University SRP Center are investigating:

- The role of polychlorinated biphenyls (PCBs) in endocrine disruption, inflammation during pregnancy, and postnatal effects.
- How exposure to one chemical alters the susceptibility of the male reproductive system to exposure by a second chemical.
- The health hazards of emerging contaminants, such as nanoparticles.
- Pathological alterations ranging from cells to organ systems.
- Ways to develop biological markers to measure exposure to hexavalent chromium, a potent human carcinogen.
- How to create new engineering-based technologies to assess and cleanup hazardous waste and to remove trace heavy metals, such as arsenic, chromium, and lead from contaminated water.
- How vapors from contaminated soil and groundwater flow into homes, schools, and workplaces.

Brown SRP provides Rhode Islanders with a responsive center of technical research excellence for resolving complex issues that arise when considering the reuse of hazardous waste sites. It is a model for how academics, government leaders, and community members can work together to address multifaceted issues.

Recent Noteable Findings:

- In a national sample, most women of childbearing age exceeded the median blood level for two or more of these environmental pollutants: lead, mercury, and PCBs.
- A novel, scalable system, called Cyclic Electrowinning/Precipitation, removes low concentrations of copper, nickel, and cadmium simultaneously from water, returning it to federally accepted standards of cleanliness.
- Analysis of soil samples from 31 properties around southern Rhode Island revealed lead concentration in surface soil may not be a reliable indicator of contamination that is deeper.

BROWN

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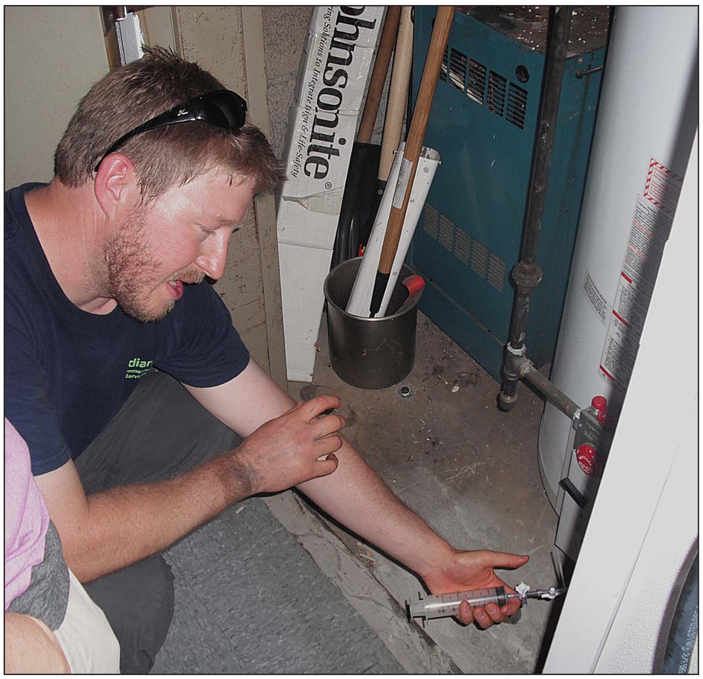
Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Evaluating Vapor Intrusion Exposures and Risks

Eric Suuberg, Sc.D., and Kelly Pennell, Ph.D., led an effort to measure vapor intrusion in Somerville, Mass., just north of Boston. Certain vapors can intrude and contaminate the indoor air of structures built atop polluted sites. The neighborhood had already known about vapor intrusion issues related to releases of chlorinated solvents from an adjacent industrial site. Analyzed field study data is now being incorporated into models so that exposure and risk may be more thoroughly evaluated.

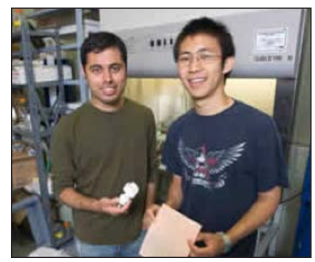


Flint Kinkade of Viridian Energy, a project collaborator, demonstrates vapor sampling technique with a syringe. *(Photo courtesy of Jim Rice)*

Creating Nanomaterial Designed for Safety

Robert Hurt, Ph.D., and Agnes Kane, Ph.D., research both the applications and implications of nanotechnology for environmental health. They are working to understand the material and molecular basis for nanotoxicity by creating nanomaterials and testing their biological properties. This work will add to the knowledge base for developing general rules for safe nanomaterial design.

An example of nanomaterial design work stemmed from the switch from incandescent light bulbs to energy-efficient compact fluorescent lamps (CFLs), each of which contains 3-5 milligrams of mercury. Hurt discovered that a variant of a substance called nanoselenium can absorb most mercury emitted from broken and spent CFLs. This substance can be used in a container lining to help reduce potential mercury exposure.



Engineering students Love Sarin, Ph.D., and Brian Lee display a nanoselenium-enriched cloth that can capture vapor from broken CFLs. *(Photo courtesy of Brown University SRP)*

Facilitating Environmental Justice

The Brown SRP Community Engagement Core promotes environmental health and education across Rhode Island, a small, densely populated state with a proud history of industrial activity. The program's state-based approach works on multiple levels with a variety of partners, including community-based organizations, tribal governments, secondary education, public health, and state and federal government agencies.

The Environmental Justice League of Rhode Island (EJLRI) was created in 2007 by an informal coalition of community members, environmental health advocates, and members of the Brown SRP. The EJLRI is a community-based organization that addresses issues related to Superfund and Brownfield sites and other environmental health issues encountered by low-income and minority communities throughout Rhode Island.

For more information on the National Institute of Environmental Health Sciences, visit **http://www.niehs.nih.gov**

For more information on SRP, visit **http://www.niehs.nih.gov/srp**

For more information on the Brown University Center, visit **http://brown.edu/Research/SRP**

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Columbia University

Health Effects and Geochemistry of Arsenic and Manganese

Interdisciplinary teams of biomedical and geoscience researchers seek to better understand the exposure routes, functional changes, and population dynamics contributing to arsenic and manganese exposure risks.

Led by Joseph Graziano, Ph.D., researchers at the Columbia University SRP Center want to discover:

- The chronic health effects of low-level arsenic exposure over time.
- How children's health is affected by exposure to arsenic and manganese in drinking water.
- How nutrition can change the effects of arsenic in the body.
- The processes that threaten the quality of groundwater in aquifers and ways to lower exposure to arsenic from aquifers.
- How arsenic, manganese, iron, and sulfur move through groundwater and sediment.
- Ways to increase the speed and efficiency of treatments to remove arsenic from groundwater.

Columbia develops tools for innovative community participation to better understand behaviors and improve health for people at risk of arsenic exposure from drinking water in heavily contaminated areas of New Hampshire, Maine, New Jersey, and abroad in Bangladesh.

More About Arsenic and Manganese Contamination and Related Health Problems:

- Arsenic and manganese contamination in groundwater and soil leads to major public health, remediation, and environmental policy problems in the U.S. and abroad.
- Nearly 200 million people in the world are chronically exposed to inorganic arsenic, a human carcinogen, increasing their risk of cancers, as well as cardiovascular, pulmonary, and other diseases.
- Forty-three million people in the U.S. rely on private well water. The EPA arsenic standard of 10 micrograms per liter for drinking water does not apply to private wells. Columbia promotes arsenic testing and treatment to reduce health risks in people that rely on wells for drinking water.

COLUMBIA UNIVERSITY

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Understanding Arsenic Toxicity

Columbia's multidisciplinary Health Effects of Arsenic Longitudinal Study (HEALS) in Bangladesh, led by Habibul Ahsan, M.D., investigates health issues related to chronic exposure to arsenic in drinking water. HEALS, one of the first large-scale genomic studies conducted in a developing county, is providing important evidence for arsenic toxicity and potential effects at low exposure levels.

A child pumps low-arsenic water at a newly installed deep well in Bangladesh. *(Photo courtesy of Joseph Graziano)*

The researchers found that chronic exposure to relatively low levels of arsenic is associated with increased mortality. These findings are highly relevant in nearly 70 countries, including the United States, where communities are faced with chronic low-level arsenic exposure. In Bangladesh alone, about 57 million people depend on well water contaminated with arsenic.

Learning how to reduce the toxic effects of arsenic exposure is another priority. Mary Gamble, Ph.D., demonstrated that folic acid supplementation may help lower blood arsenic concentrations, potentially leading to ways to prevent arsenic toxicity and improve public health.

Providing Safe Drinking Water to Families

The researchers are also helping families gain access to safer drinking water through better wells. Relying on the observation that deeper wells in Bangladesh generally had lower arsenic concentrations, Alexander van Geen, Ph.D., and the SRP team raised money to install about 100 new deep wells in communities.

The researchers later measured adult urinary arsenic and found decreased levels over time, indicating that the deep-well installations were effective. There are now more than 20,000 deep wells in Bangladesh serving millions of people. SRP research seeks to establish the vulnerability of these wells to arsenic contamination due to groundwater pumping.

Enhanced Mitigation Methods for Groundwater Arsenic at U.S. Superfund Sites

Ben Bostick and Steven Chillrud work on ways to improve the removal of arsenic from contaminated groundwater at Superfund sites. One potential approach is to trap dissolved arsenic onto aquifer solids, but such attempts in the past have often failed due to the instability of these solids when aquifer conditions change. The Columbia SRP team hypothesized that magnetite would be a better target mineral for immobilizing arsenic due to its stability under the wide range of conditions found in aquifers.

The Columbia University strategy is to use lab and field experiments to learn how to form magnetite within aquifer sediments through injection of inexpensive and innocuous compounds. The new mineral formation appears to create a reactive barrier that immobilizes arsenic and continues to remove incoming dissolved arsenic under the wide range of conditions found in aquifers. So far, the research has been limited to the laboratory; however, the lab results suggest that at contaminated sites, a single injection of the compounds could form a diffuse reactive barrier that could trap dissolved arsenic for 10-20 years. Work is now focusing on improving upon these promising preliminary results.

Columbia SRP hypothesizes that magnetite (the black mineral) formed in aquifer sediments could immobilize dissolved arsenic in contaminated aquifers. *(Photo courtesy of Jing Sun)*

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http://www.niehs.nih.gov

For more information on SRP, visit
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For more information on the Columbia University Center, visit
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Dartmouth

Dartmouth College

Toxic Metals in the Northeast: From Biological to Environmental Implications

Dartmouth researchers seek to understand the ways in which arsenic and mercury in the environment affect human health and ecosystems, including pinpointing factors contributing to higher levels of mercury in seafood.

Led by Bruce Stanton, Ph.D., researchers at the Dartmouth College SRP Center want to know:

- Whether arsenic at levels found in drinking water and food in the U.S. raises the risk of human disease, including lung disease, respiratory infections, and premature births.
- Precisely how arsenic affects the cellular processes that are known to contribute to cardiovascular, lung and heart disease, and cancer.
- What factors control arsenic uptake in plants, with the eventual goal of protecting plant foods from arsenic contamination.
- How mercury and other metals move through ecosystems.
- How mercury ends up in fish that are most commonly consumed by humans.
- The levels and distribution of metals in water, foods, and other environmental and biological samples, using low-level trace metal analysis and speciation with state-of-the-art ICP-MS and synchrotron analysis.
- What types of information will lead to higher rates of well testing and remediation efforts by private well owners.

Dartmouth scientists also communicate their results to communities, grassroots organizations, and state and federal agencies. They train students to conduct research from both a clinical and community-based perspective.

Toxic Metals and Health Effects:

- Arsenic and mercury are numbers one and three on the Agency for Toxic Substances and Disease Registry 2011 Substance Priority List of hazardous substances commonly found in Superfund sites in the U.S.
- The EPA arsenic standard of 10 micrograms per liter in public drinking water does not apply to private wells or to other sources of arsenic, like food. Some plants, like rice, have a natural ability to uptake and retain arsenic from soil. Determining the health effects of ingesting arsenic at levels below the drinking water standard will help guide public policy for safe levels of exposure.
- Fish and shellfish are an important part of a healthy diet, but certain fish contain unsafe mercury levels that may harm the developing nervous system of an unborn baby or young child.

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Studying Arsenic as an Endocrine Disruptor

Dartmouth researchers, led by Joshua Hamilton, Ph.D., were the first to report that arsenic is a potent endocrine disruptor that can broadly alter the behavior of a wide range of hormone receptors.

Because hormone receptors were disrupted at levels far below the current EPA standard of 10 micrograms per liter, Hamilton's results suggest that low levels of arsenic in drinking water may lead to adverse effects on human health. Up to one-quarter of the 2.3 million people who routinely consume water from wells in New England may be exposed to potentially harmful levels of arsenic.

Informing Mercury Policy

Celia Chen, Ph.D. and the Research Translation Core brought together an international group of scientists and policy stakeholders to establish the Coastal and Marine Mercury Ecosystem Research Collaborative (C-MERC). The goal was to review current knowledge – and knowledge gaps – relating to a global environmental health problem: mercury contamination of the world's marine fish. C-MERC authors published a series of peer-reviewed papers in the journals Environmental Health Perspectives and Environmental Research that elucidated key processes related to the inputs, cycling, and uptake of mercury in marine ecosystems, effects on human health, and policy implications. Their findings provide policymakers and public health and environmental protection officials with information they can use to inform mercury policy from a local to global scale.

Chen (far right), collects samples near the Callahan Mine Superfund site in Brooksville, Maine. *(Photo courtesy of Dartmouth SRP)*

Producing Videos to Spread the Word

To inform the public about arsenic and mercury exposures, two 10-minute videos were produced that explain research findings on arsenic in well water and mercury in seafood. The film, "In Small Doses: Arsenic," targets residents relying on wells for their drinking water and explains how naturally occurring arsenic moves into groundwater, how it is detected, what can be done to remove it, and the current science surrounding the question of "How much is too much?" The take-home message is: Test Your Well!

The film, "Mercury: From Source to Seafood," explains how mercury accumulates in seafood, and raises awareness of the health effects from consumption. It also describes the health benefits of eating low-mercury fish, and the need to keep mercury from entering the environment.

Dartmouth also reaches out to the community through science festivals. Michael Paul (left) explains to fourth grade students at a New Hampshire water festival how arsenic can get into drinking water.

For more information on the National Institute of Environmental Health Sciences, visit **http://www.niehs.nih.gov**

For more information on SRP, visit **http://www.niehs.nih.gov/srp**

For more information on the Dartmouth College Center, visit **http://www.dartmouth.edu/~toxmetal**

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Duke University

Developmental Toxicants: Mechanisms, Consequences, and Remediation

Collaborative researchers seek to better understand how early-life exposures to environmental chemicals may alter development and lead to later-life health issues.

Led by Richard Di Giulio, Ph.D., researchers at the Duke University SRP Center want to know how:

- Fetal exposures to certain organophosphate pesticides interfere with normal brain development and metabolism, potentially contributing to later-life obesity and diabetes.
- Fish exposed to PAHs (polycyclic aromatic hydrocarbons) are able to inherit resistance to certain health effects of PAHs, which provides insight into PAH mechanisms of toxicity.
- Nanomaterials could treat sediment and water contaminated by developmental toxicants, such as organophosphates, PAHs, and polybrominated flame retardants.
- Early-life exposure to halogenated phenolic compounds, such as hydroxylated polybrominated diphenyl ethers (OH-BDEs) and triclosan, affect early-life development and behavior.

Duke connects with government agencies, industry professionals, community organizations, K-12 teachers, and other partners to bring information and research results about environmental health and toxic exposures to the public. Underserved communities are a particular focus.

More About Duke Research and Public Health Effects:

- Organophosphates are in nearly 50% of insecticides used worldwide, indicating that exposure to these pesticides may be widespread. Early-life exposure may cause metabolic disruption, increasing the incidence of obesity and diabetes.
- Early exposure to PBDEs, widely used in flame retardants, has been linked to low birth weight, lower IQ in children, and impaired motor and behavioral development.
- Flame retardant chemicals present in the foam of residential furniture may be released and found in household dust. Exposure to these chemicals may alter thyroid hormone levels.

Duke UNIVERSITY

NIEHS Grant Number: P42ES010356

Grant Period: 2000-2016

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research Highlights

Identifying Toxic Chemicals in Residential Furniture

More than half of all couches tested in a study led by Duke University contained potentially toxic or untested chemical flame retardants that may pose risks to human health.

Heather Stapleton, Ph.D., and her colleagues analyzed 102 polyurethane foam samples from couches purchased for home use in the U.S. between 1985 and 2010. "Overall, we detected flame-retardant chemicals in 85 percent of the couches we tested and in 94 percent of those purchased after 2005," said Stapleton. "More than half of all samples, regardless of the age of the couch, contained flame retardants that are potentially toxic or have undergone little or no independent testing for human health risks."

Flame retardants do not stay in cushions. Young children who crawl on the floor are highly exposed through dust.

The flame retardant pentaBDE, which is banned in 172 countries and was voluntarily phased out by U.S. manufacturers in 2005, was found in 17 percent of couches. PentaBDEs are long-lasting chemicals that, over time, migrate into the environment and accumulate in living organisms. Studies show they can disrupt endocrine activity, and affect thyroid regulation and brain development. Early exposure to them has been linked to low birth weight, lowered IQ, and impaired motor and behavioral development in children. Although some of the chemicals found are no longer used, Stapleton said that because many new proprietary chemical flame retardants have been introduced in recent years, it has become very difficult for scientists to identify them all or determine their presence in consumer products.

Using Nanomaterials to Clean up Contaminated Water

One method of remediating, or cleaning up, contaminated sites is the use of nanoparticles, which are extremely small particles about one-tenth the width of a fine human hair. When certain nanoparticles are mixed with contaminants, a specific reaction, called a redox reaction, takes place and changes chemicals, so they aren't as dangerous or toxic. Duke is exploring how two different nanoparticles, zero-valent iron (NVI) and titanium dioxide (TiO2) can be used to clean up sites in a way that complements the remediation carried out by natural bacteria found in soils and lake and river bottom sediments. In addition to understanding how nanoparticles may clean up contaminants, Duke is also investigating whether NVI and TiO2 may be possible contaminants themselves.

Studying Health Problems in Fish Caused by Pollution

Graduate students Daniel Brown and Audrey Bone collect killifish in Virginia. *(Photo courtesy of Duke SRP)*

A former wood treatment facility in Portsmouth, Va. heavily contaminated soils and sediments with PAHs, resulting in a Superfund site. Studies show an association between PAH exposure and human health consequences, such as cancer and impaired child development.

A killifish from the Elizabeth River. *(Photo courtesy of Duke SRP)*

For more information on the National Institute of Environmental Health Sciences, visit **http://www.niehs.nih.gov**

For more information on SRP, visit **http://www.niehs.nih.gov/srp**

For more information on the Duke University Center, visit **http://sites.nicholas.duke.edu/superfund**

The NIEHS Superfund Research Program (SRP)

SRP enables university-based scientists, engineers, and public health workers, along with community members, to lessen the environmental health effects of hazardous waste sites across the nation.

Harvard School of Public Health

Metal Mixtures and Child Development

People are rarely exposed to one environmental chemical at a time, and a mixture of contaminants can sometimes produce greater health effects than each contaminant would alone. Researchers are studying how exposure to metal mixtures in the environment might affect child development.

Led by David Bellinger, Ph.D., researchers at the Harvard School of Public Health SRP Center want to know:

- The ways in which exposure to a mixture of heavy metals, such as lead, arsenic, and manganese, might enhance the adverse health effects of each metal.
- How the timing of exposure can affect neurodevelopment.
- The influence of genetic variations on a person's susceptibility to the metals.
- The human genes that influence the effects of heavy metals on the central nervous system.
- How heavy metals are mobilized and cycled through the environment to enter groundwater and soil.
- Ways to improve statistical design and analysis tools to increase the accuracy and reliability of site and exposure assessment for Superfund hazardous waste sites.

Harvard SRP members engage the community through updates on research and by providing information about health risks associated with heavy metals.

Child Development and Heavy Metals:

- About one in six children in the United States have one or more developmental disabilities or other developmental delays.
- Studies suggest association of prenatal exposures to heavy metals, including mercury, lead, and arsenic, with increased risk for brain damage, neurodevelopment problems, and congenital malformations.
- Because children crawl on the ground and put objects in their mouths, they are at a greater risk of being exposed to heavy metals and other contaminants found in the soil and indoors.

HARVARD
SCHOOL OF PUBLIC HEALTH

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Understanding Neurodevelopmental Metal Toxicity

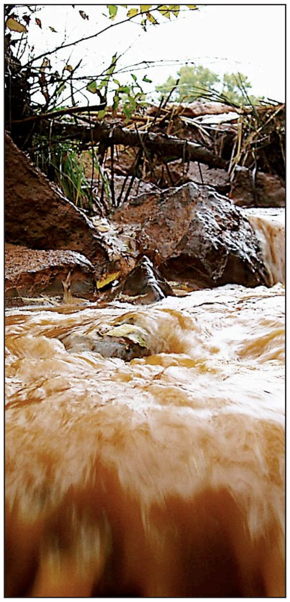
Metals such as manganese and arsenic are of increasing public health concern since recent data demonstrates their neurotoxicity to the developing brain. However, the role of genetic susceptibility to these toxic metals is unknown. David Christiani, M.D., and his team are looking at a population in Bangladesh, where metal exposures are unusually high; one in Mexico, a middle income country where metal exposures are moderately high; and one in the United States, near a Superfund site in Tar Creek, Okla., where exposure is representative of a community near a U.S. toxic waste site. Christiani is studying interactions between genes and environmental exposures to better understand how metals induce toxicity and to provide biological insight that may be useful for potential treatment and prevention measures.

Calcium Lowers Lead Levels of Nursing Mothers

Exposure to lead remains an international public health problem. Scientific evidence suggests several nutrients may positively interact with lead absorption, deposition, and excretion from the body. A study led by Howard Hu, M.D., Sc.D., found that supplementing pregnant and breastfeeding women with calcium lowers their blood lead levels. The supplement was particularly helpful for women with high lead levels, who experienced a 16 percent decline in blood lead levels after taking calcium. Dietary supplementation with calcium may constitute an important prevention effort aimed not only at reducing circulating levels of lead in the mother but also at reducing lead exposure to the developing fetus and nursing infant.

Harvard SRP Community Engagement

James Shine, Ph.D., began working in 2004 at the Tar Creek Superfund Site in Oklahoma, a 40 square-mile area contaminated with remains from what was once one of the largest lead and zinc mining operations in the world. He studies the environmental pathways that determine how metal mining wastes move through the environment and ultimately end up in people. He and other Harvard SRP staff provide updates on research and health risk information to people living around this site. They also cultivate interest in science and environmental health in young community members. For example, they organized a Science Exhibition for the 14th National Tar Creek Conference in rural Miami, Okla., where students presented environmental science projects to a team of judges, including the local Grand Riverkeeper.



Shine and the Tar Creek Superfund site. *(Photo courtesy of Jim Shine)*

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For more information on SRP, visit **http://www.niehs.nih.gov/srp**

For more information on the Harvard School of Public Health Center, visit **http://www.srphsph.harvard.edu**

National Institute of Environmental Health Sciences
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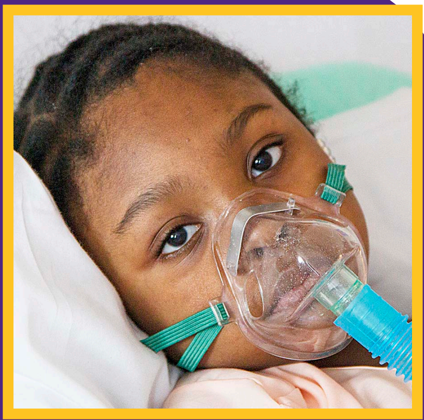

Photo courtesy of Le Bonheur Children's Hospital and the University of Tennessee Health Science Center.

Louisiana State University (LSU)

Environmentally Persistent Free Radicals

Particles from the thermal remediation of hazardous wastes, called environmentally persistent free radicals (EPFRs), are all around, and the LSU Superfund Research Center is studying how they may affect our health.

Led by Barry Dellinger, Ph.D., researchers at the Louisiana State University (LSU) SRP Center are investigating how:

- EPFRs that formed during remediation processes at Superfund sites are released into the air and impact the environment and human health.
- Exposure to EPFRs affects lung function and blood flow, leading to asthma and worsening recovery after ischemic events, such as heart attacks.
- EPFRs can also be formed in soils that have been contaminated with pentachlorophenol, a chemical used to preserve wood.
- The structure and chemical properties of particles affect EPFR formation and reactivity.
- To prevent the formation of EPFRs and how to destroy existing EPFRs in an efficient and inexpensive manner.
- The biological mechanisms behind EPFR toxicity may lead to pulmonary and cardiovascular harm in people.

LSU researchers engage people in communities close to Superfund sites to learn about their concerns and communicate their research findings. They also work with the Louisiana Environmental Action Network, a community organization with more than 100 affiliated groups.

More About EPFRs:

- Recently discovered, their radical and regenerative nature and persistence in the environment suggests the potential for significant health consequences.
- Thermal remediation of hazardous wastes and other incomplete combustion processes produce EPFRs. Therefore, EPFRs are a global health concern, with children being especially vulnerable to such exposures.
- Reducing air pollution levels to just 7 percent below the current standard would save the U.S. about $15 million annually in healthcare costs, due to fewer hospitalizations of children with bronchiolitis.

LOUISIANA STATE UNIVERSITY

NIEHS Grant Number: P42ES013648

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Health Effects of a New Class of Airborne Pollutant

Clarifying the pulmonary and cardiac health effects associated with inhalation exposure to EPFRs is the focus of the LSU SRP. EPFRs are a novel class of pollutant, generated by the adsorption of halogenated hydrocarbons onto particulate matter (PM) formed during thermal remediation processes occurring at Superfund sites across the United States. Because the LSU SRP team only recently identified EPFRs, there are no air quality standards for EPFR-containing PM, and a better understanding of the health effects of EPFR exposure is needed.

LSU SRP trainee Phillip Potter works with Dellinger, the center director, to investigate the formation and reaction of EPFRs in thermal processing of Superfund waste. *(Photo courtesy of Maud Walsh)*

According to research led by Stephania Cormier, Ph.D., EPFR-containing PM is capable of inducing severe asthma. Asthma exacerbations in individuals with severe asthma are not responsive to steroid treatment and are more fatal. Kurt Varner, Ph.D., and his group have demonstrated that EFPR exposure diminishes baseline cardiac function and increases cardiac vulnerability to ischemia, a restriction in blood supply to tissues.

Identifying the mechanism by which EPFRs alter pulmonary and cardiac function and distinguishing EPFR-specific damage caused by PM will be critical for properly characterizing the health hazards they pose. This information will help develop air quality standards based on the presence and relative levels of EFPRs versus inactive PM.

LSU SRP trainees Cholena Ren and Elisabeth Feld serve as LSU "Environmentors" for a student at Scotlandville Magnet High School in north Baton Rouge. *(Photo courtesy of Maud Walsh)*

Connecting With the Community

Residents of south Louisiana face potential exposures to hazardous substances in air, soil, groundwater, and food. Work at the LSU SRP led by Margaret Reams, Ph.D., is building capacity for resilience among partner communities by encouraging self-organization among residents, providing scientific information concerning risks, and sharing information about specific adaptive strategies to reduce exposure to risks.

To improve knowledge of community resilience, the LSU SRP co-hosted with the Oregon State University Superfund Center a symposium and workshop, "Response, Recovery, and Resilience to Oil Spills and Environmental Disasters: Engaging Experts and Communities," for community stakeholders, researchers, and environmental professionals. Maud Walsh, Ph.D., coordinates workshops and visits with professional organizations, educators, and K-12 students to relate Center research to their interests and concerns. LSU trainees are active in local partner communities, presenting at teacher conferences and mentoring high school students.

For more information on the
National Institute of Environmental Health Sciences, visit
http://www.niehs.nih.gov

For more information on SRP, visit
http://www.niehs.nih.gov/srp

For more information on the
Louisiana State University Center, visit
http://www.srp.lsu.edu

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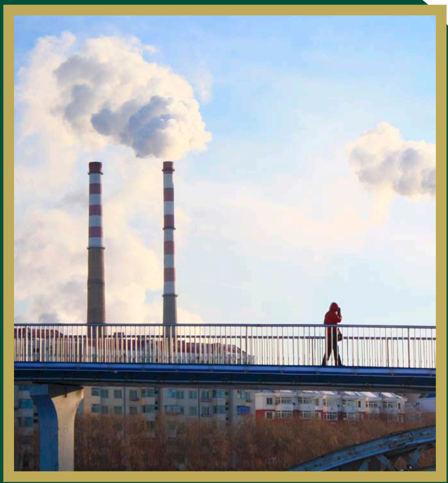

Michigan State University (MSU)

Biological Responses to Contaminants

Research focuses on human health risks from halogenated aromatic hydrocarbons, such as dioxins and dioxin-like compounds, that bind and activate a protein in cells and interfere with normal immune and inflammatory responses.

Led by Norbert Kaminski, Ph.D., researchers at the Michigan State University (MSU) SRP Center are investigating:

- How proteins and genes associated with the aryl hydrocarbon receptor (AhR) may affect toxicity.
- The ways that contaminants, such as 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and dioxin-like compounds, alter immune response and contribute to an individual's susceptibility to disease.
- How dioxins and related contaminants attach to mineral surfaces, and how microbes influence the bioavailability and biodegradation of these contaminants.
- The effects that exposure to complex pollutant mixtures have on interactions at the molecular and physiological levels.

The MSU SRP research team includes the Hamner Institutes for Health Sciences; Rutgers, The State University of New Jersey; Purdue University; Texas A&M University; and the U.S. Environmental Protection Agency (EPA). They disseminate their research findings to health professionals, regulatory agencies, industry, and other stakeholders. They also coordinate educational activities on dioxin and dioxin-like compounds.

More About the Chemicals Under Investigation:

- As some of the most toxic chemicals known, halogenated aromatic hydrocarbons hold four of the top 10 positions on the EPA-ATSDR registry of priority substances that contaminate Superfund sites.
- These chemicals, including dioxins, are industrial byproducts that work their way up the food chain to humans, potentially raising the risk of certain cancers and other diseases. Many people are exposed from dietary sources.

MICHIGAN STATE UNIVERSITY

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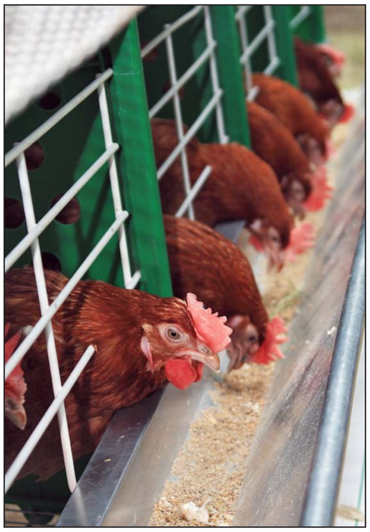
Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Dioxin Contamination in Clay

Clay minerals may be a major, but largely unrecognized, sink for chemicals like dioxins, according to Stephen Boyd, Ph.D. Naturally occurring clay deposits, commonly called ball clays, contain dioxins and have led to human contamination in potters and to livestock poisoning when used as feed additives. Boyd is working to better understand the bioavailability of dioxin-contaminated soils and sediments.



Naturally occurring clays containing dioxins have led to livestock poisoning when used as feed additives.

Boyd and colleagues showed that certain classes of organic contaminants have equal or greater affinities for clays. Their studies revealed that some dioxins in clays are likely to be easily taken up by mammals. This knowledge should be considered in risk assessment and in the development of remediation goals, especially for sites where clays are heavily contaminated.

New Models Help Determine Toxicity Levels for Contaminants

System-level biochemical modeling is a necessary and powerful tool for health researchers analyzing biochemical pathways of toxicological relevance. These models are valuable in demonstrating both the normal functioning of cellular systems and the nature and magnitude of problems due to contaminants.

MSU SRP developed a computational model to test the biochemical effects of TCDD in B cells, which are crucial to immune response. When stimulated, B-cells in the spleen rapidly turn into plasma cells, which can secrete antibodies that attack pathogens. TCDD is formed during waste incineration and metal production. The chemical raises the stimulation level needed to flip a biological switch that initiates differentiation of B-cells into helpful plasma cells. The researchers' model represents an alternative to traditional dose-response evaluation techniques and can aid the understanding of how low doses of contaminants affect human health.

TCDD is often released in stack emissions from the incineration of municipal refuse and certain chemical wastes.

Community Engagement

SRP members facilitate dialogue with stakeholders by partnering with local government as well as EPA Region 5, Michigan Department of Agriculture and Rural Development, Michigan Department of Environmental Quality, and industry groups. MSU SRP organizes conferences and workshops about the state of the science related to their research and about their findings. They also seek input on future directions for research.

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For more information on SRP, visit **http://www.niehs.nih.gov/srp**

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Northeastern University

Contamination and Preterm Birth

The Northeastern University SRP Center, Puerto Rico Testsite for Exploring Contamination Threats (PROTECT), is studying exposure to environmental contamination and its contribution to preterm birth (less than 37 weeks of gestation) in Puerto Rico and the U.S.

Led by Akram Alshawabkeh, Ph.D., researchers at the Northeastern University SRP Center are working to:

- Define the relationship between preterm birth and exposure to environmental contaminants, including phthalates and chlorinated solvents, such as trichloroethylene (TCE), a known carcinogen.
- Provide much-needed information on the potential biological mechanisms involved in preterm birth related to environmental factors.
- Better understand fate and transport of contaminants in karst aquifers and how they affect patterns of exposure.
- Create a green process that uses solar energy to remediate Superfund chemicals in aquifers.

The local community, non-governmental organizations like March of Dimes, and government agencies have been engaged and play major roles in Center activities. Findings will be used to develop environmental health "geographic information systems," which investigators plan to demonstrate in northern Puerto Rico, home of 10 Superfund sites.

More About Preterm Birth and Superfund Contaminants:

- In Puerto Rico, the preterm birth rate has increased to nearly 20 percent of live births, and there is sufficient evidence that exposures to Superfund and related contaminants are a contributing factor.
- The racial/ethnic and socioeconomic status of the community and the high exposure to extensive contamination highlight the relevance of PROTECT to environmental justice.
- PROTECT is studying a potentially highly exposed and susceptible population, and it is able to determine sources of exposure and identify potential strategies to reduce exposure or remediate.

Northeastern University

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

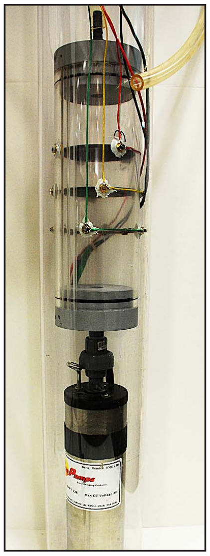
Research and Public Engagement Highlights

Phthalate Activation of Oxidative Stress in Gestational Tissues

Rita Loch-Caruso, Ph.D., from the University of Michigan, leads a team of Northeastern SRP researchers investigating the possible ways by which environmental contaminants may promote the onset of early labor and increase risks for preterm birth. Her studies are focused on measuring oxidative stress in gestational tissues, which is associated with early labor. The team's findings are providing a biological explanation for associations between exposure to environmental pollutants and preterm birth.

Postdoctoral fellow Iman Hassan, Ph.D., is analyzing human placental cells exposed to phthalates. *(Photo courtesy of Northeastern SRP)*

Increasing the Efficiency of TCE Remediation



TCE, which is used as an industrial solvent and degreaser, is also one of the most common soil and groundwater contaminants in the U.S. Alshawabkeh's team developed a new, low-cost strategy for remediating this contaminant. This work is the first to develop and examine an in-well solar-powered electrolytic system for remediating TCE and other contaminants.

Pilot-scale setup of solar-powered reactor for in-situ transformation of contaminants in groundwater. *(Photo courtesy of Akram Alshawabkeh)*

Transport and Exposure Pathways in Groundwater Systems

Two chemicals, di(2-ethylhexyl)phthalate (DEHP) and TCE, are believed to contribute to Puerto Rico's high rate of preterm birth, the highest of any jurisdiction in the U.S. Ingrid Padilla, Ph.D., leads a project aimed at determining the fate and transport of mixtures of DEHP and TCE in acquifers within geologic formations known as karst.

Padilla's lab uses models to simulate flow behavior in karst aquifers, and these models can be used to assess fundamental transport processes. Field sampling of groundwater wells and springs during dry and wet seasons, as well as tap water, is also ongoing. Their data supports the hypothesis that the aquifers have a large capacity to store and slowly release contaminants. This work is providing crucial information about contaminants in the aquifers with the ultimate goal of reducing human exposures.

Hydrogeologist Padilla, left, and students examine well equipment installed through the Monte Encantado aquifer cave in Puerto Rico. *(Photo courtesy of Northeastern SRP)*

Developing Detection and Exposure Assessment Tools

Roger Giese, Ph.D., and his team invented a Porous Extraction Paddle (PEP) device that is a porous nylon bag, attached to a stirring motor and filled with particles that can extract chemicals. This provides a convenient way to extract a large volume of liquid (urine or water) at a remote location, while minimizing contamination.

Giese's team calls the PEP tool a "tea bag" because it can contain adsorbents in a fashion that resembles a tea bag in hot water. *(Photo courtesy of Northeastern SRP)*

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For more information on the Northeastern University Center, visit **http://www.northeastern.edu/protect**

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Oregon State University (OSU)

PAHs: New Technologies and Emerging Health Risks

A multidisciplinary team uses state-of-the-art techniques to better understand a pollutant of concern, polycyclic aromatic hydrocarbons (PAHs), found in air, soil, and water, as well as the associated human and ecological health issues.

Led by David Williams, Ph.D., researchers at the Oregon State University (OSU) SRP Center are:

- Predicting and identifying novel nitro and oxygenated PAHs in food and the environment.
- Developing devices that can sample bioavailable concentrations of PAH mixtures as well as other contaminants in air, water, and sediments. The bioavailable extracts are integrated with high-throughput bioassays to further assess toxicity.
- Applying a new physiologically-based pharmacokinetic modeling technique to better understand human response to different levels of individual environmental contaminants and mixtures, providing critical data for predicting health risk.
- Characterizing absorption and elimination of Bezo(a)pyrene, a hazardous PAH, in humans at levels commonly found in the environment and identifying susceptible groups of people.

OSU also builds scientific capacity in Tribal communities and cultural capacity within the research community. They are improving risk assessment models and translating scientific findings into effective and appropriate risk reduction strategies to reduce environmental disparities and improve the health of Pacific Northwest Tribes.

More About PAHs and Related Problems:

- PAHs come from petrogenic and pyrogenic sources, such as spills or burning of carbon-containing materials. Vehicle exhaust, industrial emissions, and smoke from burning wood, charcoal, and tobacco contain high levels of PAHs.
- In the U.S., PAH exposure occurs on a regular basis for most people, primarily through inhalation and oral exposure.
- PAHs are associated with increased incidence of lung, skin, and urinary cancers. Other health effects from chronic or long-term exposure may include decreased immune function, cataracts, kidney and liver damage, breathing problems, asthma-like symptoms, and lung function abnormalities. In addition, repeated contact with skin may cause redness and inflammation.

Oregon State UNIVERSITY

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Assessing Toxicity of Contaminant Mixtures

Biological response indicator devices for gauging environmental stressors (BRIDGES) are passive sampling devices that bridge environmental exposure and biological response/effect. A research team led by Kim Anderson, Ph.D., is using the devices to collect PAH samples at the Portland Harbor Superfund site in Oregon and in the Gulf of Mexico before, during, and after the Deepwater Horizon oil spill of 2010. This work addresses the gap between environmental exposures from an oil spill and biological responses, using a system to selectively measure the environmental exposure that elicits a toxic response. Adding passive sampler data to cumulative exposure and health risk models increases precision, improves risk estimates, reduces animal collection, and lowers costs.

Graduate students, led by Anderson, take samples in the Portland Harbor. *(Photo courtesy of OSU SRP)*

Defining the Toxicity of Complex PAH Mixtures

Tanguay assesses the health of adult zebrafish. *(Photo courtesy Robert Tanguay)*

Robert Tanguay, Ph.D., is defining the mechanisms of PAH activity using a high-throughput embryonic zebrafish research platform. Researchers seek to understand the ways in which certain PAH exposures produce biological responses, with an emphasis on developmental toxicity. Tanguay's work is resulting in the identification of developmental responses to PAHs at the molecular and cellular level and determining the role of responsive genes in toxicity. The identification of cellular targets has the potential to unravel gene-environment interactions that will help explain individual susceptibility to PAHs and are important to understanding long-term health effects.

Measuring PAH Levels During Tribal Salmon Smoking

Anna Harding, Ph.D., assessed PAH exposure specific to a cultural tradition by engaging the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) in the research process. The study found that exposure to PAHs from traditional Native American salmon smoking may pose elevated cancer risks, if consumed at high levels over many years.

Inside a tipi used for smoking salmon by the CTUIR. *(Photo courtesy of OSU SRP)*

Responding to tribal requests to assess exposure and cancer risk, the researchers investigated PAH exposure from wood burning stoves, measured PAH exposure from eating traditionally smoked salmon, and distributed passive-sampler wristbands to CTUIR tribe members to measure overall exposures. The community-based research project also included capacity-building exercises with tribal partners and risk assessment and communication assistance.

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http://www.niehs.nih.gov/srp

For more information on the Oregon State University Center, visit
http://superfund.oregonstate.edu

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University of California, Berkeley (UC Berkeley)

Toxic Substances in the Environment

Researchers work to improve understanding of the relationship between exposure and disease; provide better risk assessments; reduce cleanup costs; and develop a range of prevention strategies to improve and protect public health, ecosystems, and the environment.

Led by Martyn Smith, Ph.D.,researchers at the University of California, Berkeley (UC Berkeley) SRP Center are:

- Developing advanced techniques for detecting, assessing, and evaluating the effect of hazardous substances on human health, including exposure to benzene, arsenic, trichloroethene, and other contaminants.
- Determining the role of exposure to benzene and polycyclic aromatic hydrocarbons in the development of childhood leukemia.
- Developing new cost-effective methods to remediate waste sites and reduce hazardous substances in the environment.
- Identifying the genetic basis for the variation in human susceptibility to pollutants.
- Improving ways to detect and quantify hazardous chemicals found at existing or potential Superfund sites.

UC Berkeley SRP translates research findings and scientific knowledge for government agencies, relevant business interests, and others involved in the remediation of Superfund sites and efforts to protect public health. This work may lead to a better understanding of the research's significance and applicability to public policy discussions and practical remediation projects.

More About Biomarkers of Chemical Exposure:

- Leukemia, the most common type of childhood cancer, is associated with benzene exposure. There is probably no safe level of exposure to benzene.
- Researchers are using genomic, proteomic, and nanotechnology approaches to discover biomarkers (indicators of a biological state). Biomarkers can link a specific environmental exposure to a health outcome, revealing information about the development of chronic diseases, as well as higher susceptibilities of certain subpopulations of people.

Berkeley
UNIVERSITY OF CALIFORNIA

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Legislative Authority:

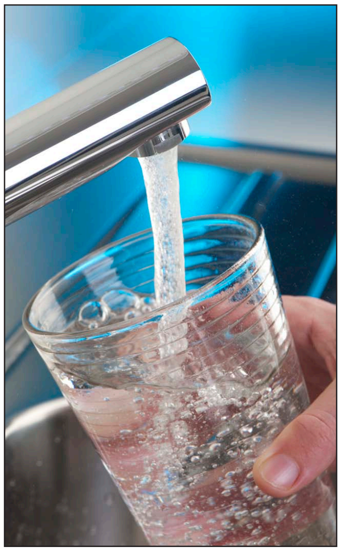
Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research Highlights

Linking Arsenic to Cancer

Millions of people are exposed to arsenic-contaminated water in the U.S. and worldwide, and arsenic is ranked first on the most recent priority list of Superfund site hazardous substances. Arsenic contaminates groundwater in many countries, including parts of the U.S. Investigators from UC Berkeley SRP have contributed greatly to knowledge about the many diseases and disorders caused by arsenic. Current evidence suggests that lung cancer is the leading arsenic-associated mortality. At UC Berkeley SRP, arsenic research activities, focusing mainly on cancer, began in the early 1990s. This work, conducted under program director Martyn Smith, Ph.D., identified a strong link between early-life arsenic exposure and adult mortality.

Research conducted by a group led by epidemiologist Allan Smith, M.D., provided definitive evidence that arsenic in drinking water causes lung, bladder, and other internal cancers. They were also the first to discover that exposure to arsenic in childhood, even at relatively low levels, causes disease later in life. Smith and colleagues have worked tirelessly to acquaint public health and government officials with the importance of taking actions to control arsenic in drinking water around the world.



UC Berkeley SRP research provided the first definitive link between arsenic in drinking water and cancer.

Maximizing Cleanup While Keeping Costs Down

Kent Udell, Ph.D., and James Hunt, Ph.D., developed a steam-enhanced extraction (SEE) method that removes trapped contaminants from soil more effectively and efficiently than previous technologies. Replacing traditional pump-and-treat methods at the Visalia Pole Yard Superfund site in California, the SEE method put the project approximately 190 years ahead of schedule. The project, which began in 1997, represents the first complete cleanup of an EPA Superfund site and saved $85 million in estimated costs. This remediation technology is now used at other Superfund sites, as well as the space shuttle launch complex in Cape Canaveral, Fla. Internationally, SEE is used routinely in the Czech Republic, including the first successful remediation of a fractured bedrock site, and has been successfully demonstrated at the Pancevo site in Serbia.

The Cape Canaveral complex, shown above, is one of many locations where the SEE method is being used.

For more information on the National Institute of Environmental Health Sciences, visit
http://www.niehs.nih.gov

For more information on SRP, visit
http://www.niehs.nih.gov/srp

For more information on the University of California, Berkeley Center, visit
http://superfund.berkeley.edu

The NIEHS Superfund Research Program (SRP)

SRP enables university-based scientists, engineers, and public health workers, along with community members, to lessen the environmental health effects of hazardous waste sites across the nation.

UC DAVIS
UNIVERSITY OF CALIFORNIA

University of California, Davis (UC Davis)

Biomarkers of Exposure to Hazardous Substances

Biomarkers, or biological signs, link a specific environmental exposure to a health outcome. Researchers investigate many hazardous substances to find biomarkers in living organisms. They also seek to understand adverse health effects from exposures, particularly related to pulmonary and reproductive functions.

Led by Bruce D. Hammock, Ph.D., researchers at the University of California, Davis (UC Davis) SRP Center are working to:

- Develop systems to detect markers of exposure and toxicological effect in the body to better predict the effect of hazardous materials on humans and their environment.
- Develop rapid, accurate methods to measure Superfund priority chemicals in the environment.
- Explore new technologies for thermal and bioremediation of toxic waste, and address possible health risks associated with these technologies.
- Understand how hazardous materials are transported in groundwater, surface water, and air, as they move from toxic waste sites.
- Assess the effects of environmental exposures on reproductive and pulmonary health.

In partnership with government agencies, UC Davis SRP translates research and delivers information and technology products to federal and state agencies that are measuring contaminants and removing them from the environment. Drawing on interdisciplinary expertise, researchers identify and facilitate opportunities for research dissemination and collaboration in California and beyond.

Addressing Big Issues Related to Hazardous Exposures and Effects:

- Hazardous waste sites contain complex chemical mixtures. Therefore, the UC Davis SRP is developing rapid and inexpensive ways to detect those mixtures, using specific standardized systems.
- Tracing the movement of hazardous materials from Superfund sites through the environment and predicting the exposure or effect of these materials on the public and environment is difficult. UC Davis SRP is working to address these issues, as well as others.

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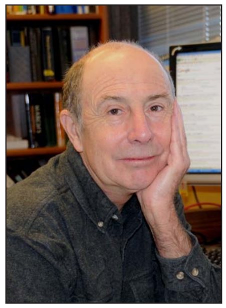
Legislative Authority:

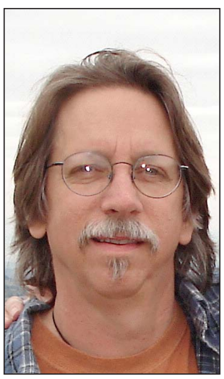
Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Hammock's Immunoassay Technologies Greatly Improve Detection of Hazardous Chemicals



Immunoassays can measure contaminants in a variety of media, such as water, air, and blood. Hammock opened new possibilities when he developed an immunoassay to test for the presence of pyrethroids, a class of pesticides. He saw great possibilities in antibodies being used to detect proteins and other large molecules and developed a way to use immunoassays to detect chemical compounds. These assays can be used on numerous samples for quick results, often on site and at low cost. His team is also developing immunoassays for other insecticides and emerging environmental contaminants.



Luciferase Assay Reveals Toxins

Michael Denison, Ph.D., tackled the difficult problem of tracking halogenated aromatic hydrocarbon (HAH) contamination by developing the Chemical-Activated Luciferase Gene Expression (CALUX®) bioassay. HAHs are global environmental contaminants present in food, water, and soil. The CALUX® bioassay is a sensitive and low-cost method for detecting and quantifying HAHs using cultured cells. Accepted by the international community, it is being used as a rapid and cost-effective tool for screening food and feed ingredients for dioxin and dioxin-like compounds in Europe. Additionally, a similar system developed by Denison, the BG1Luc estrogen receptor transactivation assay, was accepted by the U.S. Environmental Protection Agency's Tier 1 screening program for estrogenic chemicals.

Bioremediation Provides Powerful Solution to MTBE Groundwater Contamination

Methyl tertiary-butyl ether (MTBE) reduced air pollution when added to gasoline and was used for several years in California, before further studies revealed it also contaminated groundwater and is a probable carcinogen. Although California discontinued MTBE in 2002, many underground tanks at abandoned gas stations leaked the chemical into groundwater. When MTBE threatened to limit already strained water resources in California, Kate Scow, Ph.D., found a solution, based on her detailed understanding of bacterial metabolism and biodegradation of toxic compounds. Scow and her team worked with Tesoro Petroleum and Haley & Aldrich Engineers to develop a bioremediation platform based on a microbe that can degrade MTBE. Their water treatment process decreased peak levels of MTBE 10-fold in just two months and eventually brought the aquifers into compliance and back online.

Entrepreneurship Academy Teaches the Business of Environmentalism

Each year, UC Davis SRP sponsors the UC Entrepreneurship Academy. The three-day intensive program acts as a springboard to move research out of the lab, by educating researchers about potential business opportunities. Venture capitalists, entrepreneurs, university faculty, industry executives, and angel investors serve as mentors and guest speakers, providing participants with the knowledge and networks to commercialize their research.

Students learn about bringing research to market by participating in an activity at the entrepreneurship academy. *(Photo courtesy of the UC Davis SRP)*

For more information on the National Institute of Environmental Health Sciences, visit **http://www.niehs.nih.gov**

For more information on SRP, visit **http://www.niehs.nih.gov/srp**

For more information on the University of California, Davis Center, visit **http://www-sf.ucdavis.edu**

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University of California, San Diego (UCSD)

Detection and Models of Toxicant Exposure

An interdisciplinary team seeks to better understand molecular processes that cause health issues for people exposed to environmental contaminants, and works to improve detection, monitoring, and bioremediation.

Led by Robert Tukey, Ph.D., researchers at the University of California, San Diego (UCSD) SRP Center are:

- Examining the mechanisms that lead to toxicant-induced liver diseases, such as fibrosis and cancer.
- Uncovering the genes and pathways that determine resistance or sensitivity to heavy metals, such as arsenic and cadmium, and investigating molecular mechanisms and models for exposure to those chemicals.
- Developing field-portable technologies to detect harmful chemicals with carcinogenic or endocrine-disrupting properties.
- Investigating the molecular processes and genes that govern heavy metal uptake, transport, distribution, and detoxification in plants to discover their bioremediation potential.
- Working with the City of San Diego's EPA-funded Area-wide Brownfields Redevelopment Project to transform vacant lots into sites for urban agriculture and stormwater management.

UCSD SRP works with the community to help reduce exposures to the cross-border flow of hazardous wastes and to improve environmental public health in the San Diego-Tijuana region.

More About Industrial Chemicals and Heavy Metals:

- Chemicals in personal care products (e.g., antimicrobials) are contaminating the environment. This class of chemicals is an increasing source of concern, as some of them are now known to induce liver disease.
- Arsenic, a naturally occurring heavy metal, is an ever-present global environmental hazard. People are exposed through air, food, and water, with drinking water being the major source of exposure.

UC San Diego

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

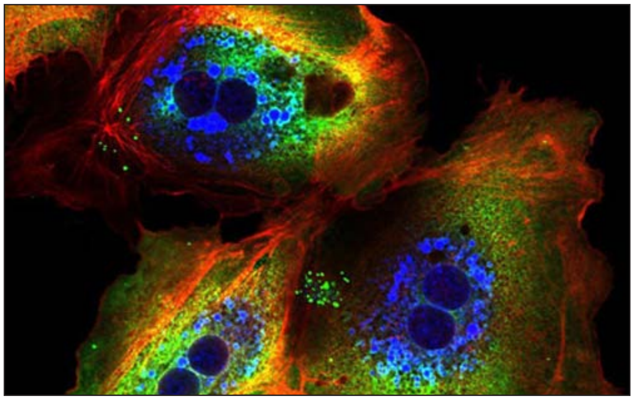
Improving Environmental Health Through Plants

Julian Schroeder, Ph.D., has conducted extensive research to improve understanding of phytoremediation, a process in which plants are used to contain, degrade, or eliminate contaminants from soils and water. His research and applications indicate that uptake of heavy metals into plants, through the roots, and accumulation in plant shoots could provide a cost-effective approach for toxic metal removal and remediation of soils and waters.

Schroder's team has identified numerous genes and enzymes that transport metals within plants. This information may help scientists modify plants so they increase metal absorption for phytoremediation. Conversely, his research may also be used to reduce metal accumulation in food plants, such as rice, to minimize exposures to metals that would naturally occur through eating certain foods.

Learning How Cells Respond to Chemical Carcinogens

Michael Karin, Ph.D., investigates various signaling pathways that activate cellular processes in the body. His extensive work has increased understanding of molecular links between inflammation, obesity, and cancer.



Karin's work shows how liver cells become cancerous after exposure to carcinogenic chemicals. *(Photo courtesy of UCSD)*

Karin's lab is using a variety of genetic, cell biological, and biochemical approaches to search for new molecules, including protein kinases and transcription factors, which are involved in the oxidative stress response to carcinogens. Recent studies have identified key signaling pathways in tobacco smoke-induced lung tumorigenesis and diethylnitrosamine-induced liver cancer. Using this information, Karin and colleagues are creating gene arrays, cell lines, and transgenic mice that can be used as biosensors for monitoring exposure to toxicants that cause oxidative stress.

Surveying Environmental Health Conditions

UCSD's SRP Center worked with Alter Terra, a community partner, to conduct a 388 household survey of environmental health conditions in a rapidly urbanizing canyon of Tijuana. Residents in the canyon are living in poverty conditions with serious concerns about health risks posed by many illegal hazardous waste dump sites.

Survey Team, Los Laureles Canyon, Tijuana. *(Photo courtesy of UCSD)*

Health conditions in the study area's neighborhoods, as reported by the residents in the survey, differed significantly with respect to exposure to dust, possibly contaminated by hazardous substances from the illegal dump sites. The results of this study are informing a pilot project that aims to improve the detection and remediation of toxicants using SRP knowledge and technology.

For more information on the
National Institute of Environmental Health Sciences, visit
http://www.niehs.nih.gov

For more information on SRP, visit
http://www.niehs.nih.gov/srp

For more information on the
University of California, San Diego Center, visit
http://superfund.ucsd.edu

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The University of Iowa

University of Iowa (UI)

Semi-volatile PCBs: Sources, Exposures, Toxicities

This multidisciplinary program brings a broad range of expertise to bear on problems associated with Superfund chemicals that are critical to the Midwest and the nation. In particular, researchers seek to better understand semi-volatile polychlorinated biphenyls (PCBs) — focusing on those associated with contaminated waters, former industrial sites — and other atmospheric sources, and the health consequences of exposure to them.

Led by Larry Robertson, Ph.D., researchers at the University of Iowa (UI) SRP Center are:

- Identifying, characterizing, and predicting the sources and fate of airborne PCBs in urban environments.
- Assessing the exposure to airborne PCBs for mothers and their children living in urban or rural environments.
- Investigating the mechanisms by which PCBs damage human cells and how to suppress these toxic effects.
- Studying how PCB metabolites in humans can affect PCB toxicity.
- Determining the mechanism of PCB carcinogenesis and how the route of exposure can affect health outcomes.
- Investigating how plants can be used to break down PCBs in soil and groundwater at contaminated sites.

The UI SRP brings together scientists and community advisory boards from Iowa, Illinois, and Indiana to address environmental concerns about PCBs, integrate activities with educational programs in local schools, and disseminate findings to affected communities.

More About The PCB Problem:

- Although U.S. industrial production of PCBs was banned in 1979, their continued use in closed applications, their occurrence as byproducts in dyes and paints, and their structural stability allows them to remain in the environment. These sources of PCBs and their environmental persistence, along with continued dispersal and redistribution through air, has led to widespread contamination of water and soil and accumulation in the food chain.
- The 209 different forms of PCBs, or PCB congeners, and closely related chemicals that contain chlorine vary greatly in physical and chemical properties.
- Despite the variety, PCBs are contaminants that threaten human health, even at low levels. People are exposed to PCBs from eating or drinking contaminated food, direct inhalation, or skin contact. The EPA states that PCBs can have several different health endpoints, including cancer, depending on the particular congener.

NIEHS Grant Number: P42ES013661

Grant Period: 2006-2015

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Assessing Airborne Exposure to PCBs

In 2012, a dredging operation in the Indiana Harbor and Ship Canal in Lake Michigan began placing several million cubic meters of PCB-contaminated sediment into a disposal facility adjacent to two schools in East Chicago, Ind. The dredging is underway to make the canal deeper for ships, but environmental health concerns arose because PCBs from the sediment can enter the air during the process of removal and above-ground storage.

The Airborne Exposures to Semi-volatile Organic Pollutants project, led by Peter Thorne, Ph.D., is investigating exposures to atmospheric PCBs in East Chicago and a low-exposure comparison group in Columbus Junction, Iowa, where there are no known local sources of PCBs. In anticipation of the dredging project, exposures were assessed through repeated air sampling, inside and outside of community homes and schools, and also through blood samples of community members.

Through repeated sampling, researchers will be able to compare air and blood concentrations of specific PCBs before and during dredging operations. Investigators also coordinate with local schools and community advisory boards, which is essential to the continued success of this community-based participatory research study.

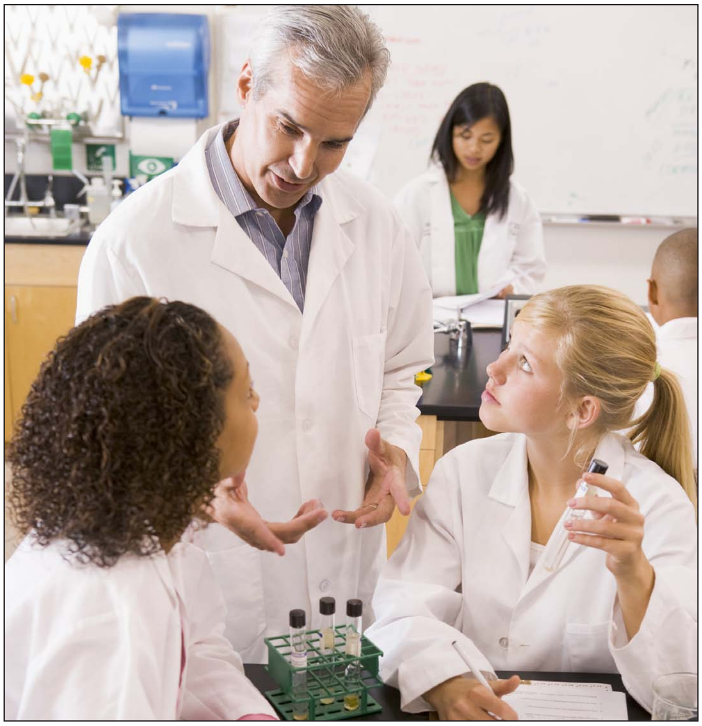
Phytoremediation to Degrade Airborne PCB Congeners from Soil and Groundwater Sources

Jerald Schnoor, Ph.D., focuses on the remediation of sites containing airborne PCBs. Schnoor's work is providing information on the role played by higher plants in the environmental fate of PCBs and how they can be used in land management strategies for the rehabilitation of contaminated waste sites. Schnoor and his team are identifying metabolites and proteins involved in PCB remediation by plants to provide a scientific basis for the development and application of land management strategies at contaminated waste sites.

Bringing Superfund Science to Local Schools and Communities

School science teachers invited the UI researchers to their classrooms to deliver several presentations on PCBs and environmental health research. Additionally, school students have visited the UI SRP labs. Students were encouraged to consider the presence of PCB hazards in their own community and learn how scientists approach environmental health research. In addition, students have been urged to consider careers in science. Parents see materials students take home, including PCB models that were built by students during class periods.

Researchers also enjoy the cooperation of citizen groups in East Chicago, where many residents live below the poverty level near old industrial sites. Community members and their advisory boards are kept aware of research activities, and these contacts are used to relay any significant findings identified in the course of the studies.



For more information on the National Institute of Environmental Health Sciences, visit **http://www.niehs.nih.gov**

For more information on SRP, visit **http://www.niehs.nih.gov/srp**

For more information on the University of Iowa Center, visit **http://iowasuperfund.uiowa.edu**

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University of Kentucky (UK)

Nutrition and Superfund Chemical Toxicity

Research efforts focus on the idea that certain nutrition components can mitigate the negative health effects in people related to chemical exposures near Superfund sites.

Led by Bernhard Hennig, Ph.D., researchers at the University of Kentucky (UK) SRP Center want to discover:

- Better ways to remediate groundwater contaminated with harmful chlorinated organics, such as polychlorinated biphenyls (PCBs), through improved membrane or hydrogel systems, using nanosized iron particles.
- How to develop molecular biosensors employing genetic engineering tools that are selective, sensitive, portable, and inexpensive, which will become new tools for monitoring PCBs in the environment.
- How certain plant-based bioactive food components, with antioxidant and anti-inflammatory properties, can lessen the toxicity of PCBs to the layer of cells that line blood vessels.
- If PCB exposure affects fat cell functioning in a way that contributes to obesity and cardiovascular disease.
- Molecular mechanisms of brain metastasis, the spread of cancer to other parts of the body, caused by particular PCBs and how dietary factors, such as polyunsaturated fatty acids, can affect cancer tumor metastases.

UK SRP presents nutrition research findings to the general public, including Superfund communities in eastern Kentucky as well as officials and regulators associated with the Kentucky Energy and Environment Cabinet.

More About Obesity and Superfund Contaminants:

- Despite a production ban in 1979 and decades of remediation efforts, the structural stability of PCBs allows them to remain a persistent environmental contaminant and accumulate in the food chain.
- Obesity is common, serious, and costly. More than one-third of U.S. adults (35.7%) are obese. From 1988-2008, obesity prevalence increased in adults at all income and education levels.
- Although medical costs from adult obesity are difficult to calculate, current estimates range from $147 billion to nearly $210 billion per year in the U.S.

UNIVERSITY OF KENTUCKY®

NIEHS Grant Number: P42ES007380

Grant Period: 1997-2013

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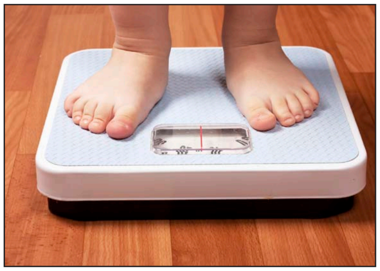
Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

PCB Exposure May Contribute to Obesity



Even low-level exposure to PCBs may contribute to the development of obesity and obesity-associated diseases, according to research led by Lisa Cassis, Ph.D. Her team looked at how PCBs affect the function of adipocytes, or fat cells, and the subsequent influence on cardiovascular disease. They found that exposure to PCBs can result in an increase in the accumulation of fat and can promote inflammation in adipocytes, increasing risk for diabetes and cardiovascular disease. This discovery of the interrelationships of PCBs, obesity, and obesity-related diseases may inform public health policy and practice.

Nutrition Modulates PCB Toxicity

Even with the best remediation efforts, it's nearly impossible to remove all harmful chemicals at a given site. Other ways to mitigate harmful effects are needed. To this end, Hennig leads a research program examining how diet affects the toxicity of environmental contaminants. His team discovered that some food components can increase cellular dysfunction, while others can protect against cell damage caused by PCBs.

They found that the type of fat in the diet, not just the amount, can make a difference in cell damage triggered by environmental chemicals. In a study in mice, diets high in corn oil showed significant changes in serum fatty acids and increased vascular inflammation after PCB exposure. But, there was little negative effect on fatty acid profiles with diets rich in olive oil. Hennig also found that a diet with a high ratio of omega-3 to omega-6 fatty acids, and other components such as vitamin E, can reduce cell damage caused by PCBs and other pollutants.

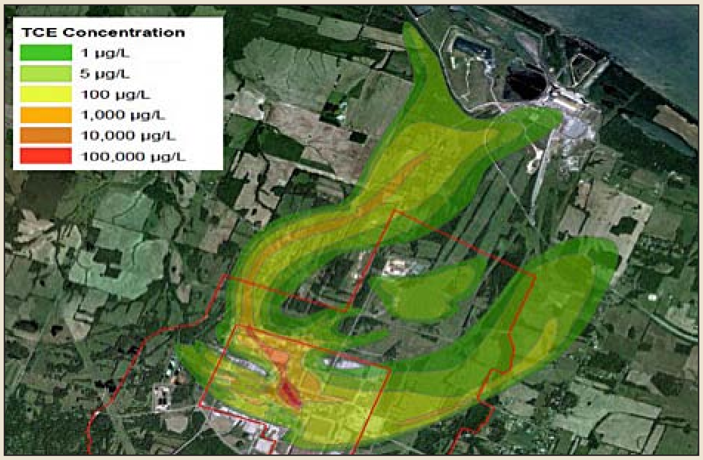
Salmon is a good source of omega-3 fatty acid.

To convey their nutritional and scientific expertise, UK SRP has developed easy-to-understand materials to educate people about the complex relationships between chemicals and health.

Water Purifier Harnesses Nanotechnology

Dibakar Bhattacharyya, Ph.D., and other scientists developed a double membrane remediation system that removes chlorinated organic contaminants, such as trichloroethylene (TCE), from groundwater. The device may offer an inexpensive way to provide clean drinking water in areas of the world where chemical contamination is prevalent.

Although developed for environmental applications, the researchers believe this device could have other uses, including disinfection and virus inactivation. Lindell Ormsbee, Ph.D., worked closely with Bhattacharyya to employ the technology at the Gaseous Diffusion Plant in Paducah, Ky., which is the state's largest Superfund site.



TCE plumes at the Paducah Gaseous Diffusion Plant. *(Photo courtesy of UK SRP)*

For more information on the National Institute of Environmental Health Sciences, visit **http://www.niehs.nih.gov**
For more information on SRP, visit **http://www.niehs.nih.gov/srp**
For more information on the University of Kentucky Center, visit **http://www.uky.edu/Research/Superfund**

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University of North Carolina at Chapel Hill (UNC)

Elucidating Risks: From Exposure and Mechanism to Outcome

Researchers seek to understand the human health and environmental risks associated with hazardous waste sites, with the goal of more accurately assessing risks and more efficiently remediating waste sites.

Led by James Swenberg, D.V.M., Ph.D., researchers at the University of North Carolina at Chapel Hill (UNC) SRP Center are:

- Identifying and characterizing the biological signals that reveal exposure to a specific chemical to enhance knowledge about how it affects the body.
- Understanding genetic differences in cancer susceptibility and risk assessment using trichloroethylene (TCE), an industrial chemical, as a model environmental contaminant.
- Applying new molecular and analytical tools, within a systems biology framework, to understand critical pathways for environmental disease, particularly related to metals, such as cadmium and arsenic.
- Examining the role of oxidative stress and associated genetic damage for highly persistent polyhalogenated hydrocarbons.
- Evaluating complex microbial communities in bioremediation systems, particularly related to removal of polycyclic aromatic hydrocarbons (PAHs).
- Quantifying the chronic exposure and bioavailability of toxic compounds in environmental systems.

UNC SRP also focuses on communicating how Superfund chemicals harm health, enabling government officials and the public to make informed decisions about reducing risk.

More About UNC's Research:

- Scientists will be able to improve how risks are calculated and communicated by better understanding the human health and environmental effects associated with hazardous waste sites.
- The UNC SRP has defined the Endogenous Exposome, identifying and quantifying the types and amounts of DNA damage formed in all living cells. Researchers can now determine what comes from environmental exposure and compare this with what is formed in the absence of exposure.
- They have measured the relatively constant amounts of DNA damage per cell. This baseline finding, accomplished with ultrasensitive mass spectrometry and the use of stable isotope exposures, is of great importance when assessing risk from chemicals.

THE UNIVERSITY *of* NORTH CAROLINA *at* CHAPEL HILL

NIEHS Grant Number: P42ES005948

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Preventing Metal-induced Birth Defects

An estimated 120,000 infants are born with birth defects each year in the U.S., and of these, 60-70 percent are caused by unknown environmental or genetic causes. Seeking to learn about mechanisms, Rebecca Fry, Ph.D., led a study to investigate contaminants as potential causes.

Fry, second from right, with scientists in her laboratory at UNC.
(Photo courtesy of UNC SRP)

Fry found that blocking the glucocorticoid receptor (GR) pathway in a chick embryo model prevented structural birth defects induced by arsenic. The laboratory study was performed after computationally predicting the association between the GR pathway and metal-induced birth defects, with a novel approach to identify a targeted biological pathway.

The researchers anticipate that the systems biology-based computational strategy can be employed to predict other biological pathways that mediate environmentally induced birth defects. The method is cost-effective and can be used on a wide range of contaminants, generating information that may be useful in the prevention and treatment of metal-induced birth defects.

Understanding Genetic Susceptibility to Environmental Chemicals

Researchers led by Ivan Rusyn, M.D., Ph.D., are exploring how genetic differences can influence an individual's susceptibility and risk, while working to improve the ability to evaluate risk from exposures at low doses. Rusyn uses Trichloroethylene (TCE), an industrial chemical that has become one of the nation's most prevalent groundwater pollutants, as a model environmental contaminant that individuals may respond to differently after exposure. Currently genetic factors related to TCE are not being fully considered in risk assessment.

Previous research from Rusyn's lab established that genes play a key role in metabolizing TCE in mice. Rusyn and his team are working to understand genetic controls underlying species- and organ-specific metabolism and toxicity of TCE. These data will be used to investigate the genetic causes of variation in the metabolism of TCE, a step crucial for understanding the potential for TCE-induced adverse health effects in a human population.

Informing Private Well Owners

Through a partnership with the North Carolina Division of Public Health (NC DPH), UNC SRP is working to identify North Carolina populations at greatest risk from well water contamination and to inform owners of private wells about potential environmental exposures and their impact on health.

As part of this effort, SRP researchers (Fry, Gray, Serre) mapped average concentrations of 31 contaminants in North Carolina groundwater. Each map displays the average concentration of the contaminant detected in private wells at the county level; locations of National Priorities List sites and permitted toxic releases; and information about how certain contaminants can enter the environment. They also created a website that includes information about groundwater and the construction of private wells in North Carolina, as well as resources for testing water, safe drinking water standards, and interpreting well testing results.

For more information on the National Institute of Environmental Health Sciences, visit **http://www.niehs.nih.gov**
For more information on SRP, visit **http://www.niehs.nih.gov/srp**
For more information on the University of North Carolina at Chapel Hill Center, visit **http://sph.unc.edu/srp**

The NIEHS Superfund Research Program (SRP)

SRP enables university-based scientists, engineers, and public health workers, along with community members, to lessen the environmental health effects of hazardous waste sites across the nation.

University of Washington (UW)

Understanding Susceptibility to Environmental Contaminants

Biological signs, known as biomarkers, may help predict who is more susceptible to metals and organophosphate pesticide contaminants, both of which can damage the nervous system. Researchers investigate these biomarkers to reveal more about the relationships between exposure to chemicals and the development of human diseases. They also study the effects of toxicants on salmon and how trees can clean contaminated soils.

Led by Evan Gallagher, Ph.D., researchers at the University of Washington (UW) SRP Center want to know:

- The susceptibility of pesticide-exposed farmworkers to environmentally induced neurotoxicity and neurodegenerative diseases.
- The role of metals, such as manganese, in determining the risk, severity, and progression of Parkinsonism among professional welders.
- Biomarkers unique to metal-induced Parkinsonism that can be measured in blood plasma.
- Gene-environment interactions in the olfactory system, the system that produces the sense of smell of salmon, to learn how neurotoxicants cause neurobehavioral impairment.
- How plants can be used in the bioremediation of organic solvents and pesticides.

UW SRP also works directly with community groups associated with hazardous waste sites and supports the Northwest Toxic Communities Coalition, which is active in the U.S. Environmental Protection Agency (EPA) Region 10.

More About Pesticide and Metal Contaminants:

- Organophosphate compounds were developed as nerve agents in wartime and were later used in pesticides. Today, these compounds can also be found in plastics, flame retardants, and jet engine lubricants.
- Nearly 200 million people in the world are chronically exposed to inorganic arsenic, a human carcinogen, increasing their risk of cancers, as well as cardiovascular, pulmonary, and other diseases.
- The metal manganese is commonly found in welding fumes, and welders are routinely exposed to it at levels much higher than most people. UW SRP researchers found that welders have a high prevalence of Parkinsonism, a condition characterized by movement abnormalities.

UNIVERSITY of WASHINGTON

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Legislative Authority:

Section 311(a) of the Superfund Amendments and Reauthorization Act (SARA) of 1986

Research and Public Engagement Highlights

Determining Susceptibility to Environmentally Induced Toxicity

Clement Furlong, Ph.D., and his research group have greatly contributed to our understanding of the role of the paraoxonase 1 (PON1) gene in the metabolism of organophosphate pesticides. His group developed the concept of PON1 status, which can determine how rapidly an individual will metabolize a contaminant. Laboratories around the world use PON1 status to investigate risk factors for disease or exposures. Furlong is now working to identify biomarkers of exposure and susceptibility to organophosphates and related compounds.

Furlong's work was considered in decisions to restrict use of chlorpyrifos and diazinon pesticides. *(Photo courtesy of Clement Furlong)*

Effects of Cadmium and Copper on the Fish Olfactory System

(Photo courtesy of University of Washington SRP)

A series of studies from a research group led by UW grantee Evan Gallagher, Ph.D., provides insight into the mechanisms underlying injury to the olfactory system of fish exposed to cadmium and copper including those concentrations seen in the environment. In fish, the peripheral olfactory organs are in direct contact with the surrounding aquatic environment and are particularly vulnerable to waterborne exposures to trace metals and pesticides. These exposures can disrupt key olfactory-mediated behaviors such as foraging, predator avoidance, prey selection, and natal homing, the process where salmon return to their birthplace to reproduce.

By understanding the metal-induced neurotoxicity in the fish olfactory system, the researchers have also identified novel biomarkers of metal exposures that may be used to assess olfactory injury in fish, such as salmon, at Superfund sites.

Informing Communities About River Cleanup

The UW SRP has a long history of working with tribal nations, community groups, health professionals, and individual stakeholders to address environmental health concerns. For example, through community forums and other outreach activities with the Duwamish River Cleanup Coalition, the UW SRP helped educate the Seattle community about the proposed EPA cleanup of the Duwamish River. The EPA plan would reduce the risk associated with eating contaminated fish and shellfish in the Duwamish by 90 percent.

The river holds more than 40 different contaminants, including carcinogenic polycyclic aromatic hydrocarbons and arsenic, which are mostly in river-bottom sediment. In 2001, a 5.5-mile stretch of the lower Duwamish River was declared a federal Superfund site. The Muckleshoot and Suquamish Tribes use the waters in and around the site for fishing.

For more information on the National Institute of Environmental Health Sciences, visit **http://www.niehs.nih.gov**

For more information on SRP, visit **http://www.niehs.nih.gov/srp**

For more information on the University of Washington Center, visit **http://depts.washington.edu/sfund**