Superfund Scoop

THE NEWSLETTER OF THE UNC-CH SUPERFUND BASIC RESEARCH PROGRAM

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'Cross-Training' Builds Essential Skills for Superfund Scientists

UNC SBRP researcher trains young scientists in an integrated approach to solving hazardous waste problems while leading his own multidisciplinary team in researching the interaction between microorganisms and hazardous chemicals.

As director of the Training Core for the UNC-Chapel Hill Superfund Basic Research Program, Dr. Fred Pfaender implements the program's mission to cross-train scientists in the many disciplines vital to basic research aimed at improving our ability to manage and clean up hazardous waste at Superfund sites.

Each year, five first-year Ph.D. students are chosen to participate in a highly selective one-year training program. Working as a group, the students delve into all aspects of a particular chemical or issue — examining toxicology, environmental distribution, metabolism, regulations and other topics. They then present their findings at an annual research symposium. The project gives students experience in multidisciplinary research, working as a team and making presentations — all skills necessary for a successful career as a scientist. Trainees also rotate through SBRP scientists' laboratories and travel to remediation projects, governmental agencies and consulting firms to learn firsthand from scientists on the job. At the end of the training program, these doctoral candidates join the laboratories of SBRP faculty members to begin several years of focused research.

Dr. Fred Pfaender with students.

Pfaender enjoys helping prepare the next generation of scientists who will guide our country's hazardous waste cleanup efforts. "Part of the overall mission of the SBRP is to look at integrated aspects of how we treat

see **cover story**, next page

The Superfund Basic Research Program (SBRP) at the University of North Carolina at Chapel Hill is one of 19 basic science research programs funded by the National Institute of Environmental Health Sciences (NIEHS).

The program's goal is to advance society's understanding of the human health and environmental risks associated with hazardous waste and to develop new environmental strategies and technologies for the cleanup of Superfund sites thereby minimizing human and environmental risk.

For more information on the UNC-Chapel Hill SBRP and our research projects, and for links to other Superfund Web sites, visit our Web site at www.sph.unc.edu/sfcoep.

Superfund sites — not just research on toxicology or on fate and transport for a specific chemical, but all of the things that are part of how a chemical behaves in the environment, its effect and what we do about it. Because it gives students the opportunity to see all of these pieces, the training program supports our goal of integration."

It is just this type of integrated approach that Pfaender advances through his own research at the SBRP. The UNC professor of environmental microbiology leads one of the SBRP's main research projects, a complex, multidisciplinary effort that combines issues — and team members — in chemistry, microbiology, organic chemistry and soil physics to understand the isolation of hydrophobic organic contaminants in soil.

"At many Superfund sites, there will be very high concentrations of a chemical, yet for some reason the chemical isn't having any toxic effect," Pfaender explains. "An industry representative might say, 'if it's not toxic and it's not hurting anyone, you shouldn't regulate us,' while the government might respond, 'but we don't know how long the chemical will just sit there before it has an effect.'"

Those chemicals are in the soil, but for some reason, the microorganisms that live in the soil and normally eat these chemicals — thus breaking down the chemicals until they are no longer harmful — are instead leaving the chemicals alone. Why is this happening?

Pfaender provides an example. "For the last ten years, we've done a lot of work at a Superfund site in St. Louis Park, a suburb of Minneapolis, Minnesota. This is a site that was used to treat wood with creosote for about 70 years. Then they closed the site, put four feet of topsoil on it and made a park out of it. They don't believe there is any toxicity, although there is a very strong smell of creosote during the summer.

"If we can come up with a process that works, then ten years from now you may be able to walk through that park in Minnesota in the summertime and not smell creosote."

"We've taken soil from the park over the years, and we are trying to understand how the soil particles, the microorganisms and the pollutant chemicals all interact. First, we are extracting DNA and using molecular techniques to determine what types of bacteria and other microorganisms are in there, and what each is doing. Second, we are trying to understand *how* the chemicals bind to the soil – whether by sticking to the soil surface, by getting trapped in between particles, or though a chemical reaction where the microorganisms actually change the chemical until it becomes part of the organic material of the soil — and why this process makes these chemicals unavailable to be consumed and degraded by microorganisms. We also want to know, if a chemical is bound to the soil and isn't doing anything, how long will that last — and will it then break off in one chunk, or will it dribble off bit by bit over time?"

In addition to the soil from Minnesota and other sites, Pfaender's team has created a synthetic soil that allows them to control many variables as they add chemicals and microorganisms and see how they interact with the soil and with each other.

Left alone, Pfaender notes, all pollution problems will eventually be solved naturally. Microorganisms will eventually degrade these chemicals — if we don't mind waiting hundreds or thousands of years.

"But humans don't deal very well with things that take more than one human lifetime. The Superfund program is about cleaning up the mess quickly, and the Superfund Basic Research Program is here to find ways to reduce exposure. One of these ways is to get the chemical degraded to something that doesn't have a harmful effect. We're trying to figure out how to get those chemicals that are stuck in the soil to degrade and go away.

"If we can come up with a process that works, then ten years from now you may be able to walk through that park in Minnesota in the summertime and not smell creosote." ●

Research Highlights

Three UNC-Chapel Hill graduate students who are working toward their doctoral degrees in the Department of Environmental Sciences and Engineering presented posters describing their research at the national Superfund Basic Research Program meeting in New Hampshire last fall. They also took a few moments between exams to share the highlights of these projects.

Measuring the effects of skin exposure to jet fuel

WHEN AN AIR FORCE mechanic gets jet fuel on his hands or it spills on his clothing, how much of it penetrates his skin and enters his body? How quickly does this happen? And what kind of health risks does this present?

That's what Carolina graduate student David Kim is trying to determine.

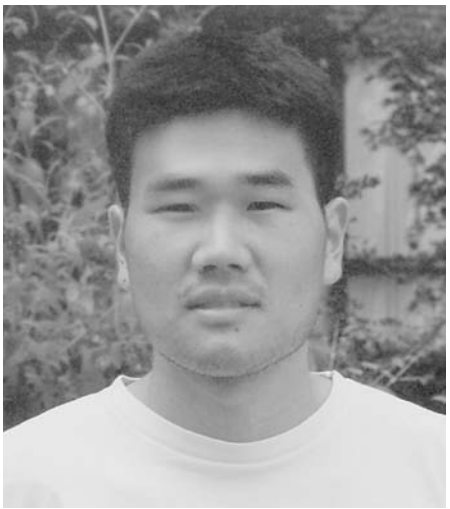
"Several things could happen," Kim explains. "Some jet fuel might evaporate off the skin and not go into the body at all. It could enter the body and be circulated through your liver and other organs. Or, it could enter your body, then come back out through breathing or urination. And some of it may just stay in your body and cause adverse health effects like skin irritations or even cancer."

To determine the likelihood of all of these possibilities, Kim has created a mathematical model to measure skin exposure to jet fuel that takes into account factors like skin thickness and fat content, rate of blood flow, immunity built into the layers of the skin and enzymes that can break down jet fuel before it enters the body.

Kim, who works under the supervision of SBRP faculty member Dr. Leena Nylander-French, says his work is really about risk assessment.

"What we ultimately want to do is to understand how much of this compound goes through the skin, and use that information to regulate or to prevent future exposures. We want to determine how much fuel these workers can be exposed to without causing harm."

The skin model, he notes, "is part of a bigger picture, which is looking at the total body. With jet fuel, there's a lot of evaporation, so we can breathe some of it in, and that's another important route of exposure that may cause damage within our bodies. I'm working on taking the skin model and adding that to a model of the total human body."



David Kim, PhD candidate

"We want to determine how much fuel these workers can be exposed to without causing harm."

Research Highlights

Finding ways to clean up hard-to-corral contaminants

DNAPLS ARE A PARTICULARLY challenging breed of contaminant found at many Superfund sites. Formally known as "dense non-aqueous phase liquids," but more commonly referred to by their acronym and pronounced "dee-napples," these contaminants have physical and chemical properties that make them very difficult to clean up, or "remediate."

Unfortunately, even at small concentrations, DNAPLs can be hazardous to human health. In fact, many are known to cause cancer. When DNAPLs seep into the ground due to a spill, they sink down, and keep sinking until they hit a very dense layer, such as clay. Then, because they don't dissolve easily in water, they stick around for a long time, and even low concentrations of DNAPLs make water undrinkable for decades or even centuries.

How can we clean up these DNAPLs and make the groundwater drinkable again? That's the question that PhD candidate Deona Johnson is working on, under the supervision of the SBRP's Dr. Cass Miller, himself an expert in the study and remediation of DNAPLs.

Johnson is concentrating on DNAPL remediation using a brine (very dense salt solution) technology.

"Hopefully, this technology will ... apply to clean up a variety of sites, so it will be a meaningful timeframe — not hundreds of years — before you can use these groundwater supplies again."

Deona Johnson, PhD candidate

"Using a specially designed tank, we inject a brine solution that seeps to the bottom and forms a barrier. Since the brine is denser than the DNAPL, the DNAPL pools on top of the brine and the brine limits further sinking," she explains. "Then we use another surfactant solution to gather any of the scattered DNAPL residual and pool them on top of the brine. Once we've done that, we can get out most of the DNAPL pool through pumping, and the remainder by other means."

Currently, she and Miller are refining the technique in the laboratory; they plan to apply it in the field within the year.

"Right now there is no silver bullet for cleaning up these contaminated sites," says Johnson, who can see herself continuing in Superfund research after she earns her PhD. "Hopefully, this technology will prove to be something that we can apply to clean up a variety of sites, so it will be a meaningful timeframe — not hundreds of years — before you can use these groundwater supplies again."

Estimating arsenic levels in New England's groundwater

MEASURING THE AMOUNT OF arsenic or other chemicals in groundwater would be easy if instruments could always get clear data. But the reality is, instruments are often unable to get perfectly accurate readings, particularly when very low levels of the chemical are present.

UNC doctoral student Seung-Jae Lee, under the guidance of faculty advisor Dr. Marc Serre, is working on a model to estimate the level of arsenic in New England's groundwater when not all the collected data are perfect. Using data provided by the U.S. EPA, the U.S. Geological Survey and the New Hampshire Department of Environmental Services, Lee is evaluating a powerful statistical model against several other estimation methods.

The favored model, Lee explains, uses data on both arsenic and PH levels, and looks at the relationship between the two compounds. Created by SBRP researchers Drs. George Christakos and Serre, this powerful model can use uncertain, or "soft," information to make a solid estimate of the amount of arsenic present — a feat not possible using other models.

In the future, Lee plans to apply this model to air quality issues such as estimating ozone levels in North Carolina or other regions of the country. "This model gives us a statistical way to consider a lot of things that are not considered in other models, with an error variance so we can see the certainty in estimating. This is important because even though the instruments cannot detect the presence of some things, they are still out there." ●

Seung-Jae Lee, PhD candidate

"Even though the instruments cannot detect the presence of some things, they are still out there."

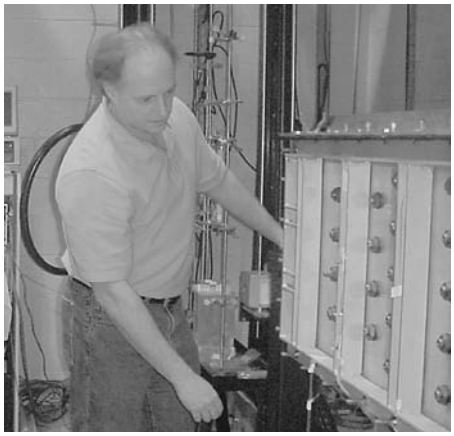
Community Outreach

SBRP researchers share their work with state agency

TO INITIATE A PRODUCTIVE dialogue among SBRP scientists and officials charged with protecting and maintaining North Carolina's environment, SBRP scientists are making regular trips to the North Carolina Department of Environment and Natural Resources (DENR) to share their work and its potential implications for hazardous waste cleanup in our state.

Already, two SBRP scientists have discussed their research with about 30 staff members in the Superfund Section of NC DENR. Dr. Michael Aitken presented on "Biodegradation of Polycyclic Aromatic Hydrocarbons" in July, and Dr. Cass Miller spoke about "Removal of Dense Non-Aqueous Phase Liquids" in September.

Megan Hazelman, Research Associate for the SBRP Outreach Core, coordinates this program. She says it has been well-received by state officials and scientists alike. "In an evaluation of one of the sessions, more than 90 percent of the participants found that the information they heard was relevant to the work they are doing. It is exciting for our staff to have the opportunity to facilitate discussions between the SBRP scientists and the men and women who will be using the practical application of their experimental research."



Dr. Cass Miller examines the experimental results from a porous medium flow cell.

Jack Butler, chief of the Superfund Section, helped coordinate these sessions. "The staff of the NC Superfund Section uses a number of tools to stay current with ever-changing cleanup technologies. We appreciate the opportunity the SBRP seminars have given us to meet and talk with individuals working on new and innovative cleanup technologies and share our field experience with them."

In addition to ongoing presentations by SBRP faculty and graduate student researchers at NC DENR, the SBRP Outreach Core is also looking for opportunities to take these seminars to other state and federal agencies in the area. ●

Online teacher training workshop makes a splash

SINCE ITS INCEPTION, *What's in the Water?* has become a valuable tool for North Carolina's middle and high school teachers. This innovative workshop, developed and piloted as part of the outreach efforts of the UNC-Chapel Hill SBRP, explores water quality issues and the role of Superfund in cleaning up hazardous waste sites in North Carolina. It also shows teachers how they can relate this information back to the NC science curriculum for their classrooms.

To open up opportunities for *all* interested North Carolina teachers to participate in *What's in the Water?* — especially those rural or coastal areas — SBRP Science Educator Michele Kloda worked with UNC-Chapel Hill's Learn NC to develop an online version of the workshop.

This fall marked the maiden voyage of the online workshop. Ten middle and high school teachers and environmental science educators from museums and nature centers across North Carolina enrolled in the free, seven-week course. Each week participants went online at their convenience to read a new lesson, then performed experiments at home and reported their findings back to the group. Small group projects and online discussions were also integrated into the course. Upon completion of the 20 hours of coursework, teachers received two CEUs.

Michele Kloda assists a participant in the What's in the Water? *workshop.*

Kloda, who led the workshop, was pleased that seven counties were represented among the inaugural group. "With the support and partnership of Learn NC, we have been able to extend our reach to all corners of our state. Three students were in northeastern North Carolina and, without the online access, would have been unable to participate in our workshops."

What's in the Water? is the only hands-on science course currently being offered through Learn NC. The workshop is supported through a grant from the National Institute of Environmental Health Sciences.

A new course will be offered in the fall. If you are interested in participating, or for more information, contact Michele Kloda at **919.843.5735** or **mkloda@email.unc.edu**. ●

SUPERFUND SCOOP
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http://www.sph.unc.edu/sfcoep

Community Outreach

SBRP offers assistance to NC communities

IN RESPONSE TO CITIZENS' requests, the UNC-Chapel Hill SBRP Outreach Core has offered assistance to several community groups around North Carolina.

In Barber Orchard, a Superfund site near Waynesville, the Outreach Core staff researched two key soil contaminants, lead and arsenic, to determine their potential health effects as well as precautions and remedies that individuals who may be exposed to these contaminants can take. Fact sheets were compiled and shared with interested citizens. At Camp Butner, where unexploded ordnance and potentially explosive waste has been found on several properties, Outreach Core staff members have been helping concerned citizens find resources in state agencies and in the nonprofit sector that can help them address their concerns.

For more information on SBRP outreach activities, contact Kathleen Gray at **919.966.9799** or **kgray@unc.edu**. ●

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