

Man's violence toward his surroundings is just as sinful as his violence toward his fellows.

Donald E. Engel

Zygon (September 1970)

INNOVATIVE TECHNOLOGIES

Environmental Forensic Files

If the spate of recent television shows focused on investigating crimes is any indication, forensic science has taken hold of the public consciousness. A standing-room-only crowd at environmental forensics sessions at the 17th Annual International Conference on Soils, Sediments, and Water held in October 2003 in Amherst, Massachusetts, proved the forensics bug has infected scientists, too. In this case, proponents say environmental forensics, which combines approaches from several disciplines to analyze cases of environmental contamination, brings a new level of sophistication to environmental science and the assessment of health risks.

Environmental forensics uses investigative tools from fields as varied as analytical chemistry, isotopic analysis, epidemiology, toxicology, geology, history, and statistics, with technologies ranging from aerial photography to gas chromatography/mass spectrometry and other chemical fingerprinting methods. The aim, often, is to characterize environmental problems and resolve litigation regarding how they occurred.

"Forensics is rekindling the curiosity in environmental science," says Eric Cherry, environmental forensics practice leader with the Ohio-based consulting firm of Hull & Associates. In recent decades, while the legislation of environmental standards has established needed benchmarks, it has also "commodified" the general environmental assessment field, he says; environmental consultants are often asked merely to measure samples against government standards rather than interpret actual risks, pathways, or long-term fate. For Cherry, forensics marks an attempt to strengthen the remediation process by building techniques for identifying appropriate solutions into the diagnosis of a problem.

Experts in environmental forensics have applied its techniques in court cases to establish the source of a pollutant and thus determine who is responsible for paying for remediation. This can require unraveling complex time sequences of when pollutants entered the environment and untangling multiple plumes of contaminants. For instance, chemical fingerprinting can be used to distinguish among

acquire the appropriate data in order to make a more informed risk management decision."

Cherry illustrated this with a recent study of historic chemical releases at Cleveland-Hopkins International Airport. The city of Cleveland had asked Hull & Associates to determine the health risks to airport workers and nearby residents of past runoff of jet fuel and de-icing fluid.

Former airport employees reported smelling odors that could signal contamination, but conventional analyses could not isolate the source. However, using broad-spectrum analyses of multiple media and a chemical use history of the site, Cherry and colleagues identified 164 chemical compounds, 65% of which would not have appeared either using conventional analysis or on an Environmental Protection Agency checklist of target breakdown compounds to screen for. The study found, however, that only a few chemicals exceeded regulatory standards at certain spots on the site. Further analysis showed that the site did not pose a toxicologic health risk.

The forensic approach has drawn the most attention where it has been used in lawsuits to make polluters pay for damages and remediation, but

it is also used to help assess potential liabilities—for example, before purchasing land with an industrial history. Increasingly, companies are commissioning forensic assessments of sites before they buy, to see what legal and health risks may exist.

Robert Morrison, editor-in-chief of the journal *Environmental Forensics*, expects that, with increasing environmental regulation and costlier litigation, the demand for these skills will grow internationally. One school, at least, is stepping up to meet that demand. In September 2003, the University of Wales, Bangor, announced the world's first degree program in environmental forensics, which was organized by Mudge. Students will study statistics, chemistry, biology, and geology as well as legal strategies for arguing their case in court. —David A. Taylor



A new view of environmental science. Interpretation of aerial photographs is among the sophisticated investigative tools used in environmental forensics to solve health risk puzzles.

different petroleum products in a water sample and determine the contribution of each chemical (and possibly—for example, through the identification of specific additives and other components—different corporations) in a spill.

In one case, Stephen Mudge, a professor of ocean sciences at the University of Wales, Bangor, is studying the effects of the 1989 *Exxon Valdez* oil spill to assess whether Exxon is liable for ongoing effects on the ocean environment. As part of his assessment, he's testing water samples with chemical fingerprinting to see to what extent the *Valdez* petroleum is still affecting marine life.

"Environmental forensics is a toolbox of techniques that lets you 'think outside the box,'" Cherry said in a presentation at the Amherst conference. "Forensics helps you select the appropriate tests to

TRADE/COMMERCE

Stopping Traffic

Illegal trafficking of hazardous waste, endangered natural resources including animals and plants, and toxic chemicals including ozone-depleting substances has become big business. To stop that traffic, the United Nations Environment Programme (UNEP) and other organizations in June 2003 launched a coordinated international effort that emphasizes more efficient training for customs officials on the front line.

The "GreenCustoms" initiative aims to build capacity among border police and customs authorities. Among its resources are a new website, <http://www.unepie.org/ozonaction/customs/>, where visitors can find online and print training manuals and videos, as well as lists of upcoming training events. Besides UNEP, other organizations involved in the initiative are Interpol, the World Customs Organization, and the secretariats of the three multilateral environmental agreements (MEAs) that have trade provisions: the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Montréal Protocol on Substances that Deplete the Ozone Layer, and the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal.

According to estimates in a December 2000 U.S. government report, *International Crime Threat Assessment*, criminal organizations around the world earn \$10–12 billion a year from illegally dumping trash and hazardous waste. The same report estimates that criminals make as much as \$8 billion from stealing and illegally trading natural resources such as forest timber and fish. Trade in ozone-depleting substances such as chlorofluorocarbons also is huge—the United Nations estimates that criminals worldwide traffic as much as 30,000 metric tons per year.

As the three MEAs have been implemented, customs officers seasoned mostly in stopping drug trade have had to learn to track down environmental crime, says Rajendra Shende, head of the Energy and OzonAction Branch in UNEP's Division of Technology, Industry, and Economics.

Training to control and monitor environmental crime is a challenge because the MEAs are so complex. CITES, for example, provides various protections to more than 30,000 species of animals and plants that are traded illegally in many forms, including live animals, wooden musical instruments, and medicines. The Montréal Protocol bans production of more than 97 ozone-depleting substances, while the Basel Convention regulates the import and export of more than 40 categories of hazardous waste. The challenge to customs officers is to keep track of what—and how—resources are protected, as well as recognizing standardized names for all the species, chemicals, and categories addressed by the MEAs.

GreenCustoms does not require the training, only offers and promotes it. Under the new initiative, the World Customs Organization and the secretariats of the three MEAs are coordinating and integrating their training so that officers receive training on all the agreements at the same time, rather than having to attend a separate training session for each MEA.

Training sessions provide identical guidelines to customs officers from the countries that have ratified the three MEAs so that all use the same methods for identifying illegal substances and sharing information. The initiative is also promoting a "train the trainer" approach—officers who attend the joint training sessions can go back and train their colleagues. The secretariats plan to seek grant funding for additional projects such as monitoring and review of the initiative and the compilation of a manual that will include overviews of customs rules and regulations, trading methods used by criminals, and how to recognize illegal substances.

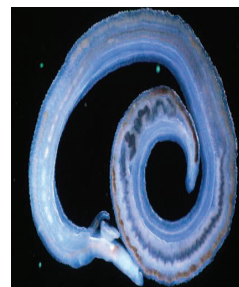
Training sessions also allow officers to share information and intelligence about suspected crimes. In addition, the initiative is introducing other networking methods, for example by setting up electronic forums. "We need to get customs officers in neighboring countries into discussion," Shende says. "Ignorance of customs officers is the friend of smugglers." For more on environmental crime, see "Environmental Crime: Profiting at the Earth's Expense," p. A96 this issue. —Angela Spivey



Customs aid. A new UNEP initiative will train customs officers to identify environmental contraband.

Stopping Schistosomiasis in Africa

The Schistosomiasis Control Initiative, a project funded by the Bill & Melinda Gates Foundation and based at Imperial College London, has announced it will deliver treatment to some 15 million people, mainly children, in Burkina Faso, Mali, Niger, Tanzania, Uganda, and Zambia, in addition to the half million already being treated in Uganda, where the initiative was launched in March 2003. Schistosomiasis, a chronic parasite-borne disease, currently affects 200 million people worldwide, mostly in sub-Saharan Africa. Along with an intensive program of surveillance and monitoring, patients will receive annual treatment for up to four years of the intestinal worms that often accompany schistosomiasis.



NAFTA Side Accord Under Review

The North American Agreement on Environmental Cooperation was signed in 1993 as a side accord of the North American Free Trade Agreement, in part to address environmental concerns expected to arise in conjunction with the boost to intracontinental trade. Now a six-member independent committee is reviewing the accord's effectiveness, with a report expected by spring 2004. The review will focus on the programs of the Commission for Environmental Cooperation, which was created by the accord, and will make recommendations on that group's agenda for the next decade. Experts say the review may call for more funding and jurisdiction for the commission, possibly granting it greater input into the trade policies of the countries involved.

FDA Issues Animal Drug Guidance

The U.S. FDA has issued first-ever guidelines for assessing the safety of antimicrobial drugs used in food-producing animals with regards to microbial resistance in the humans who eat them. The guidance centers on a three-part, evidence-based scientific risk assessment process for integrating relevant information into an overall estimate of the likelihood that any given antimicrobial used for veterinary purposes will cause resistance in human consumers. The assessment is not mandatory, but instead offers drug manufacturers one alternative for demonstrating to the FDA during the drug approval process that their products do not contribute to microbial resistance in humans.



RESEARCH ISSUES

The Stress Factor: Temperature and Toxicity

For toxicologists, defining the toxicity of a substance focuses on determining the lethal dose for 50% of rodents under well-defined conditions, even though life itself is rarely carried out under anything like the ideal. Environmental physiology, on the other hand, focuses on understanding how organisms deal with the demands placed on them by stressors in the world around them. At the point where these two fields intersect, important biological insights may be found, as described in a report in the May 2003 issue of *Environmental Research*.

"Life and exposure to toxic chemicals do not occur under ideal environmental conditions," says author Christopher J. Gordon, a research physiologist at the National Health and Environmental Effects Research Laboratory (NHEERL) of the Environmental Protection Agency. "We have to consider that life goes on at many temperatures, humidities, and wind speeds." Organisms constantly adjust to changes in temperature, humidity, workload, and other factors that can cause stress using a variety of physiological and behavioral responses. Gordon says temperature is one of the best-studied and biggest factors in how a rodent responds to a toxic insult.

NHEERL research physiologist Penn Watkinson was testing software he had developed for analyzing electrocardiograms when he noticed how dramatic the effect of temperature can be. "Someone gave me a pesticide that they'd been working with, and it gave me everything I



Maxed out. Stressors such as temperature can exacerbate the response to toxic exposures.

wanted: heart rate changes, blood pressure changes, acute and chronic effects, lethality, and arrhythmia," he says. "But I was getting effects at five milligrams per kilogram, and when I looked at the literature, it showed seventy-five milligrams per kilogram as a no-effect level."

Yet, testers had never held rodents' temperatures constant. As a physiologist, Watkinson knew that rodents actively control their body temperature as a survival mechanism. By holding his animals' temperature constant, it turns out he was "just knocking their socks off" with the pesticide, he says. "What really happens in the toxicology world is the animals' body temperature is allowed to go down, so they're somewhat protected," he explains.

The hypothermic response will buy time for the rodent's body to detoxify harmful agents, but it may also slow the clearance of some chemicals. "If the rodent's temperature and metabolism decrease, then the retention of the toxicant may be longer in the animal, and it may cause a larger effect," says Matthew Campen, an associate research scientist at the Lovelace Respiratory Research Institute of Albuquerque, New Mexico, who has studied this phenomenon. "It can be a warning about using the rodent as the toxicological workhorse."

Epidemiologists, too, have noted an important temperature effect that bears watching. "Human mortality is clearly associated with ambient temperature effects," Gordon says. Despite broad use of heating and cooling to maintain comfortable indoor temperatures, population studies have shown strong ties between average *outdoor* temperature and mortality. Whether the connection is physiological or reflects seasonal changes in the persistence of toxicants (for example, in air pollution), learning to

understand these temperature effects will stretch scientists beyond their traditional boundaries. —Victoria McGovern

GENETICS

Arsenic, Variability, and Risk

Millions of people across the world consume arsenic daily in their drinking water. In some regions, such as parts of Bangladesh and Taiwan, the drinking water levels of this toxic metal have been associated with diseases such as anemia, vascular lesions, peripheral neuropathy, and cancers of the skin, bladder, kidney, prostate, liver, and lung. But these risks may vary considerably, even among populations that seem to have similar levels of arsenic exposure. According to Ellen Silbergeld, a professor of environmental health sciences at The Johns Hopkins University, such variations could reflect polymorphisms in genes such as those that code for methylase enzymes (which mediate the metabolism of arsenic), and these polymorphisms may determine both the incidence and severity of disease among individuals.

Silbergeld and her colleagues, reporting in the June 2003 issue of *Environmental Research*, analyzed data on the urinary distribution of arsenic and arsenic metabolites in three populations from Mexico, Chile, and Inner Mongolia. Earlier analysis by other researchers had revealed a substantial variability in levels of urinary arsenic and methylated metabolites. Silbergeld's reassessment of the data set revealed that the distribution of arsenic metabolites was consistent with the possibility of genetic differences in arsenic metabolism.

Christopher Loffredo, the Georgetown University cancer epidemiologist who spearheaded the reassessment, says the reported differences in arsenic-associated health risks among the populations his team surveyed may reflect, at least in part, the ethnic variation across the three groups. "This research eventually might help us identify subsets of the population that are at higher risk for developing arsenic-related cancers," he says.

But whether these population-based differences reflect genetic polymorphisms in arsenic-metabolizing enzymes remains an open question. The frequency of polymor-

phisms in several methylase genes is known to vary by ethnicity, and such polymorphisms could exert differential effects on arsenic metabolism. However, this study was not designed to demonstrate that relationship. Moreover, because the Chilean and Mongolian population samples were relatively small, the researchers acknowledge that larger studies are needed to verify the results. Finally, the analysis did not control for covariates such as water intake and diet, both of which may influence the distributions of urinary arsenic metabolites.

According to the National Research Council, it has been difficult to establish the magnitude of arsenic-related risks in human population studies when data are drawn from different countries. Improvements in cancer risk estimation may require an improved understanding of such factors as metabolism, as well as the role of metabolites in carcinogenicity and other toxic effects.

Silbergeld agrees. For a complete picture, she says, genotypic studies should be coupled with studies of phenotypic variation, such as those that measure biomarkers of arsenic metabolism. —M. Nathaniel Mead

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The Center for International Environmental Law

Founded in 1989, the nonprofit Washington, D.C.– and Geneva, Switzerland–based Center for International Environmental Law (CIEL) is a public-interest law firm focused on building awareness of international and comparative environmental law and policy. Its website, located at <http://www.ciel.org/>, provides an in-depth look at this organization's mission and its ongoing work to promote law-based solutions to the myriad environmental concerns facing countries around the world.

CIEL has a four-part mission: to solve environmental problems and promote sustainable societies through the use of law; to incorporate fundamental principles of ecology and justice into international law; to strengthen national environmental law systems and support public interest movements around the world; and to educate and train public-interest-minded environmental lawyers. To this end, CIEL provides a range of environmental legal services in both international and comparative national law, including policy research and publication, advice and advocacy, education and training, and institution building.



The CIEL homepage features links to 8 program areas (biodiversity, biotechnology, climate change, human rights, international financial institutions, law and communities, persistent organic pollutants,

and trade and sustainable development). For each program area, visitors will find a brief rundown of the latest-breaking related news items of relevance to policy makers and practitioners of environmental law (archives of CIEL news dating back to 1999 can be accessed through the Announcements link on the homepage).

Each program area further contains in-depth descriptions of the work CIEL is doing in that area, including research, advocacy, litigation, and investigations. Visitors can also find links to CIEL-produced and other publications of interest (many of which are available online for free), as well as related websites. The program area pages also include updates on relevant domestic and international initiatives.

On the Human Rights and Environment page, for example, visitors can learn about how CIEL is working on behalf of indigenous groups to protect their community-based property rights to local natural resources. In one research initiative under this program area, CIEL is gathering data to persuade the World Bank to consider the human rights implications of its lending operations, despite the bank's traditional argument that this would contradict its mandate to not consider political issues when making lending decisions.

Among the general resources offered in the CIEL site's topic areas are press releases; updates on domestic and international initiatives in such fields as law, accounting, education, and research; and glossaries on topics such as climate change and forestry. Listings of upcoming workshops, courses, partner programs, and publications relevant to topic areas are also furnished. —Erin E. Dooley

Europe Boosts Battery Recycling

The removal of potentially toxic batteries from the world's waste stream got a boost in November 2003 when the

European Commission adopted a directive that will require the collection of, and new recycling targets for, all types of batteries in the European market. The directive also

mandates the recovery of the heavy metals in batteries to keep the potentially toxic waste from being landfilled or incinerated. Under the new directive, battery producers are responsible for all costs related to collection, treatment, and recycling. Earlier regulations applied only to batteries containing specific quantities of cadmium, lead, or mercury, and proved to be inefficient deterrents for keeping batteries out of final disposal facilities.



EU Gets Graphic

Fourteen graphic health warnings featuring color photographs and illustrations of the damage that smoking can inflict on the human body are being developed as part of a European Union (EU) effort to stem the use of tobacco products in member states. "We have to find new and innovative ways to illustrate the shocking truth that half of all smokers will be killed by their habit," said EU commissioner David Byrne. Similar graphic warnings are already used in Canada and Brazil. The colorful graphics will be available in October 2004. Use of the new graphics will be voluntary. However, tobacco companies must provide written warnings that cover at least 30% of the front of cigarette packs and 40% of the back. EU member states also are prohibited from restricting the importation of cigarettes using the new warnings.

Pesticides Prevalent in Hospitals

A new study released by the advocacy groups Health Care Without Harm and Beyond Pesticides, has found that a large percentage of major U.S. hospitals use hazardous conventional pesticides to rid their facilities of pests. But conventional pesticides may adversely affect the health of patients and staff in the hospitals while killing their intended targets. The November 2003 report, *Healthy Hospitals: Controlling Pests Without Harmful Pesticides*, is available at <http://www.noharm.org/> and

provides an overview of the prevalence of pesticide use by health care facilities. It also describes nonchemical methods that some hospitals have used successfully to control pests.

