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USGS Toxic Substances Hydrology Program, 2010

Contamination of surface water, groundwater, soil, sediment, and the atmosphere by toxic substances is among the most significant issues facing the Nation. Nutrients, organic chemicals, metals, and pathogens enter the environment, often inadvertently, by way of industrial, agricultural, mining, domestic, municipal, and other waste sources. Contaminant migration and persistence in the environment, and the potential human and ecological health impact are difficult to ascertain. The USGS Toxic Substances Hydrology Program conducts research to provide reliable and objective scientific information and tools that explain the occurrence, behavior, and effects of toxic substances in the natural environment. These products are used by resource managers, regulators, industry, and the public to help avoid exposure, to mitigate environmental deterioration, to enable cost-effective cleanup, and to establish efficient waste-disposal strategies.

The U.S. Geological Survey (USGS) Toxic Substances Hydrology Program adapts research priorities to address the most important contamination issues facing the Nation and to identify new threats to environmental health. The Program investigates two major types of contamination problems:

- **Subsurface Point-Source Contamination,** and
- **Watershed and Regional Contamination.**

Research objectives include developing remediation methods that use natural processes, characterizing and remediating contaminant plumes in fractured-rock aquifers, identifying new environmental contaminants, characterizing new and understudied pesticides in common pesticide-use settings, explaining mercury methylation and bioaccumulation, and developing approaches for remediating watersheds affected by active and historic mining.

Subsurface Point-Source Contamination

The goal of these investigations is to improve capabilities to describe, manage, and remediate subsurface contamination from local releases that affect aquifers and local receiving waters. The contamination sources studied include chemical spills, leaking storage tanks, industrial discharges, and leakage from landfills and other waste facilities.

Research is conducted at sites representative of common contamination problems and geohydrologic settings. The investigations are long-term, field-based studies conducted by interdisciplinary research teams. Results from these field laboratories are generalized to similar sites across the Nation to improve the cost effectiveness of characterizing and remediating other contaminated sites.

A unifying research theme is defining the response of the natural environment to contamination, making these studies ideally suited for assessing potential long-term impacts, evaluating natural remediation alternatives, and designing remediation-performance monitoring.

A multi-point sampling array installed at the Cape Cod Research Site, Mass., helps evaluate subsurface physical and geochemical heterogeneities in a contaminant plume.

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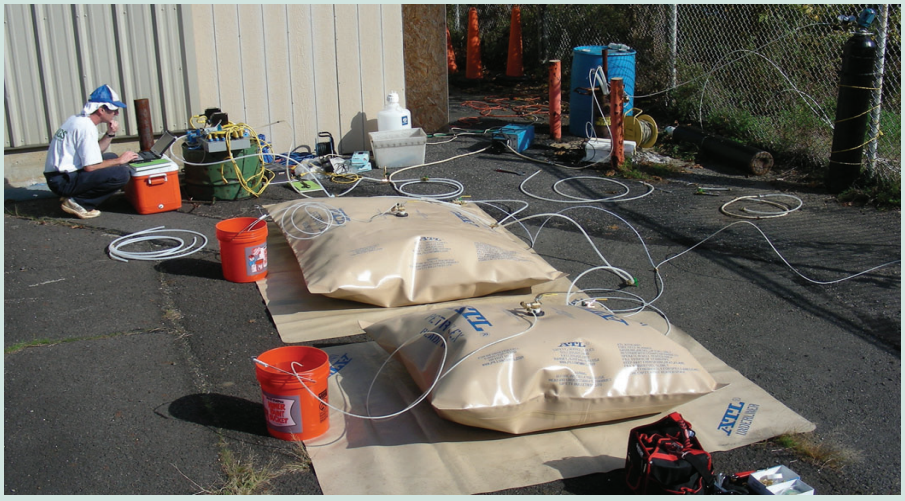
Current Subsurface Point-Source Investigations

- **Solvents in Fractured Rock—Naval Air Warfare Center, New Jersey.** The research focuses on the movement of water and dissolved and separate-phase solvents in fractured rock aquifers, including the role of fractures, contaminant residual in pore spaces, and remediation performance.
- **Waste Disposal in the Arid Southwest—Amargosa Desert Research Site, Nevada.** Research on the movement of moisture and chemicals, including radioactive and organic contaminants in the thick unsaturated zone between the land surface and the water table, is improving knowledge of the extent and mechanisms of contaminant migration in environments often used for waste disposal and isolation.
- **Landfill Leachate—Norman Municipal Landfill, Norman, Oklahoma.** Biogeochemical controls on the migration and fate of complex chemical mixtures found in landfill leachate are studied with special emphasis on the processes at geochemical and hydrologic interfaces, such as the fringe of the contaminant plume and where the plume discharges to surface water.

A vertical shaft at the Amargosa Desert Research Site, Nev., provides access for measuring soil moisture and vapor in the unsaturated zone.

- **Sewage-Contaminated Ground Water—Cape Cod, Massachusetts.** Research at a treated sewage effluent plume is characterizing the fundamental processes that affect contaminant transport and fate in sand and gravel aquifers. Tracer studies and other field experiments are improving models of the subsurface movement and attenuation of contaminant mixtures.
- **Crude Oil Contamination—Bemidji, Minnesota.** Studies are characterizing the long-term geochemical evolution of a plume of petroleum hydrocarbons and the performance of natural cleanup processes. One emphasis is the potential for residual product in the unsaturated zone to prolong cleanup, promote down-gradient expansion of the plume, and threaten the efficacy of natural cleanup strategies.



USGS scientist prepares a slurry containing contaminant-degrading bacteria for an injection experiment at the former Naval Air Warfare Center, New Jersey. Test results help design engineered bioremediation treatments in fractured-rock aquifers.

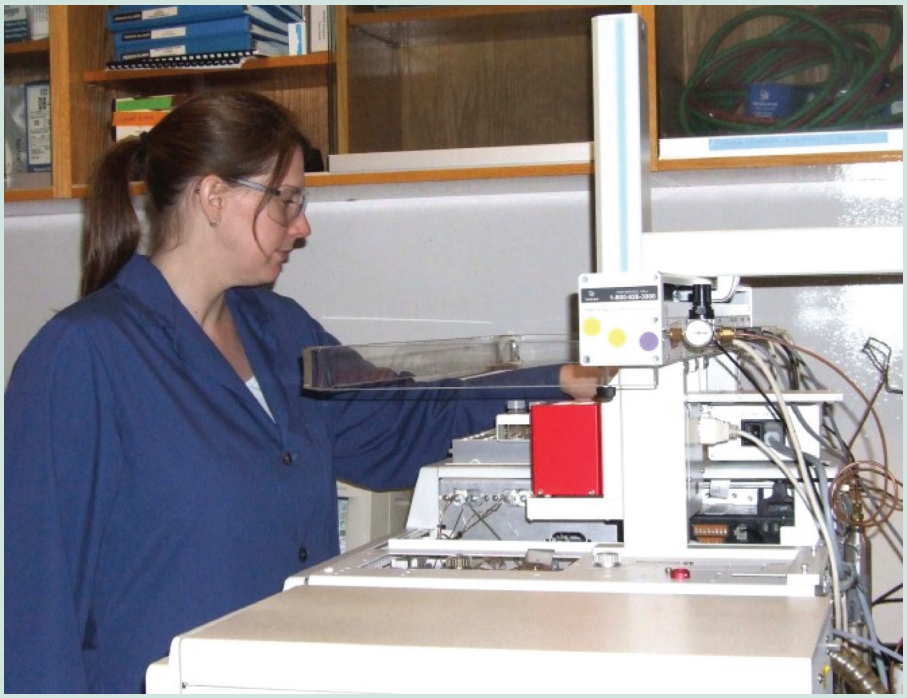
Watershed and Regional Contamination

The goal of these investigations is to improve knowledge of the factors that affect the environmental fate and effects of contaminants that enter the environment from nonpoint and distributed point sources.

Watershed and regional contamination problems are typical of widespread land uses or human activities that may pose a threat to environmental health throughout large areas of the Nation. These investigations help (1) determine the extent, levels, and mixtures of widely used chemicals in the environment; (2) characterize the relative contributions from different contaminant sources; (3) identify the processes that control contaminant dispersal within the hydrologic cycle (including transformation of contaminants into less toxic or potentially more toxic chemicals); (4) define the effects on aquatic ecosystems; and (5) develop approaches and modeling tools that aid management decision making.

Current Watershed and Regional-Scale Investigations

- **Watershed Contamination from Hard Rock Mining**—Our western landscapes are dotted with thousands of hard-rock (gold, copper, and zinc) mines. This research focuses on the processes controlling migration of contaminants from mine



USGS scientists have developed sensitive methods to measure the pyrethroid insecticides in stream water and sediments, and are applying them in the field.

dumps, tailing piles (ore processing residuum), and unmined mineral deposits to local ground and surface waters. A watershed approach enables realistic restoration goals and resource investments where they will do the most good.

- **Mercury in Aquatic Ecosystems—** Mercury in its most toxic form, methylmercury, is a neurotoxin that can be concentrated in simple organisms and accumulate in the food chain. Our studies provide an improved understanding of the relation between atmospheric mercury loading (including changes from emission reduction) and accumulation in aquatic plants and animals, and assessments of the relative sensitivity of aquatic ecosystems across the Nation to accumulation of methylmercury.
- **Environmental Pesticide Contamination—**This research advances understanding of the environmental occurrence, fate, and effects of new and understudied pesticides, the accompanying chemical additives, and their degradation byproducts. This knowledge is essential to product registration and responsible use. Studies focus on ecosystems adjacent to common pesticide-use settings across the Nation.
- **Chemicals of Emerging Environmental Concern (Emerging Contaminants)—**More and more chemicals used daily in our homes and businesses, such as pharmaceuticals, household and personal care products, and industrial chemicals, are entering the environment. Studies develop methods to measure new contaminants, define important sources and the associated contaminant mixtures, identify environmental settings that are susceptible to contamination, characterize ecological effects, and provide data essential to defining human exposure.
- **Human Stresses on Sensitive Aquatic Ecosystems—**This research evaluates the broad range of chemical stressors associated with human development on the landscape. Studies focus on sensitive ecosystems, such as water quality and ecosystem health in San Francisco Bay and the Chesapeake Bay drainages.

Recent Program Contributions

Framework for Assessing the Sustainability of Natural Attenuation—Natural attenuation employs natural processes

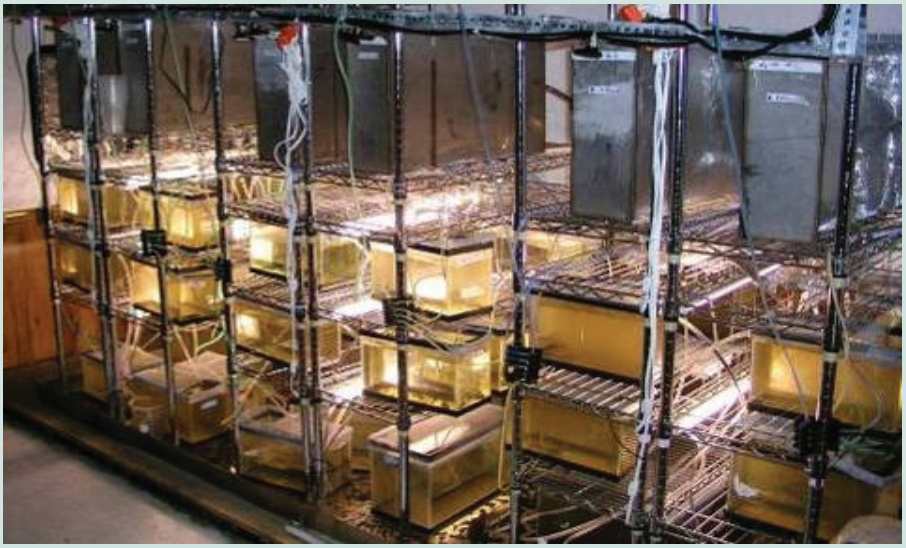
Emerging contaminants were measured in biosolids (the solid byproduct of wastewater treatment), soil amended with biosolids, and earthworms living in the soil.

to clean up contamination and offers significant cost advantages over engineered approaches. USGS Circular 1303 provides environmental managers with a blueprint for monitored natural attenuation at toxic waste sites (*http://pubs.usgs.gov/circ/circ1303/*).

Antidepressants in Fish Brains—Pharmaceutical antidepressants were detected in stream water, stream sediment, and fish neural tissue downstream of two wastewater treatment plants (Boulder, Colo., and Ankeny, Iowa). The results indicate that specific antidepressants are selectively taken up by brain tissues and occurrence in water or sediment does not necessarily indicate the presence in fish brain tissue.

Tracer Test Quantifies Active Microbial Processes at Contamination Sites—Comparing the levels of injected dissolved hydrogen gas and a conservative tracer in groundwater enables scientists to identify the active microbial processes (iron-reducing, sulfate-reducing, or methane-producing bacteria) and to estimate the rate of microbial degradation. The test enables performance assessment of active or passive bioremediation.

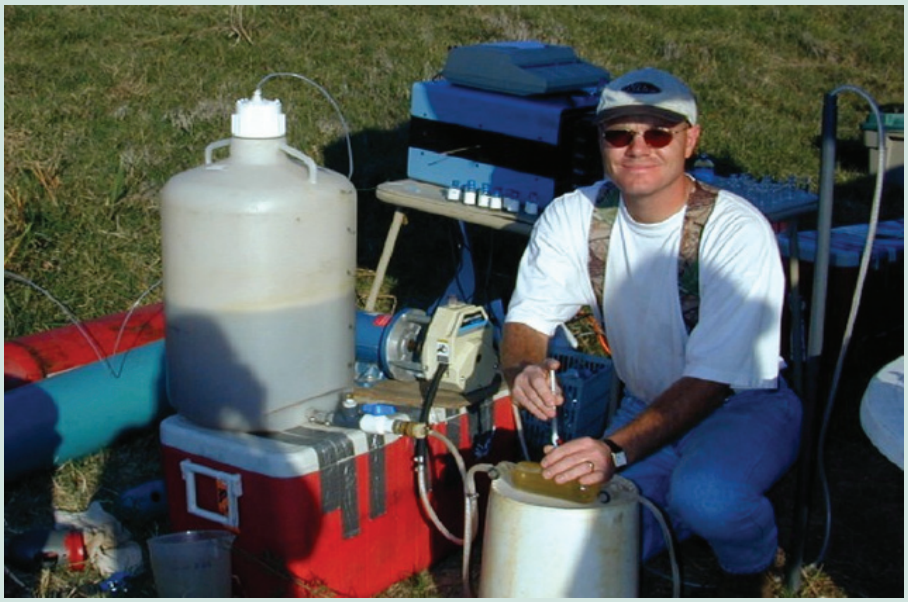
New Source of Mercury in the North Pacific Ocean—Mercury in the open ocean was believed to be of geologic origin, associated with deep-sea vents. We now know that mercury deposited from the atmosphere settles to ocean depths of 200 to 700 meters where decomposition of organic matter also results in unintentional conversion of mercury to methylmercury, which is bioavailable to ocean fish. This knowledge is useful to public health managers seeking ways to minimize human mercury exposure.



Male fathead minnows exposed to municipal wastewater effluent in an onsite field laboratory at Boulder Creek, Colo., exhibited intersex—internal and external female characteristics.

Evaluating Pre-mining Conditions in Historically Mined Watersheds—A field- and modeling-based approach to estimate pre-mining conditions was developed. It enables resource managers to evaluate whether historical water-quality conditions in highly mineralized watersheds supported healthy fish populations. This information is essential for making effective resource investments in restoration and establishing realistic restoration targets.

By Herbert T. Buxton



A subsurface tracer test at the Norman Landfill Research Site, Okla., measures dissolved hydrogen gas to define how microbial processes affect contaminant transport.

Additional program contributions are available at *http://toxics.usgs.gov/highlights/*.

A searchable bibliography of over 5,000 program publications is available at *http://toxics.usgs.gov/bib/*.

For more information on the activities of the USGS Toxic Substances Hydrology Program

Visit the Web site:
http://toxics.usgs.gov/

Or call: 609-771-3944