All science as it grows toward perfection becomes mathematical in its ideas.
Alfred North Whitehead, mathematician/philosopher (1861–1947)

WATER POLLUTION

Up a Chemical Creek

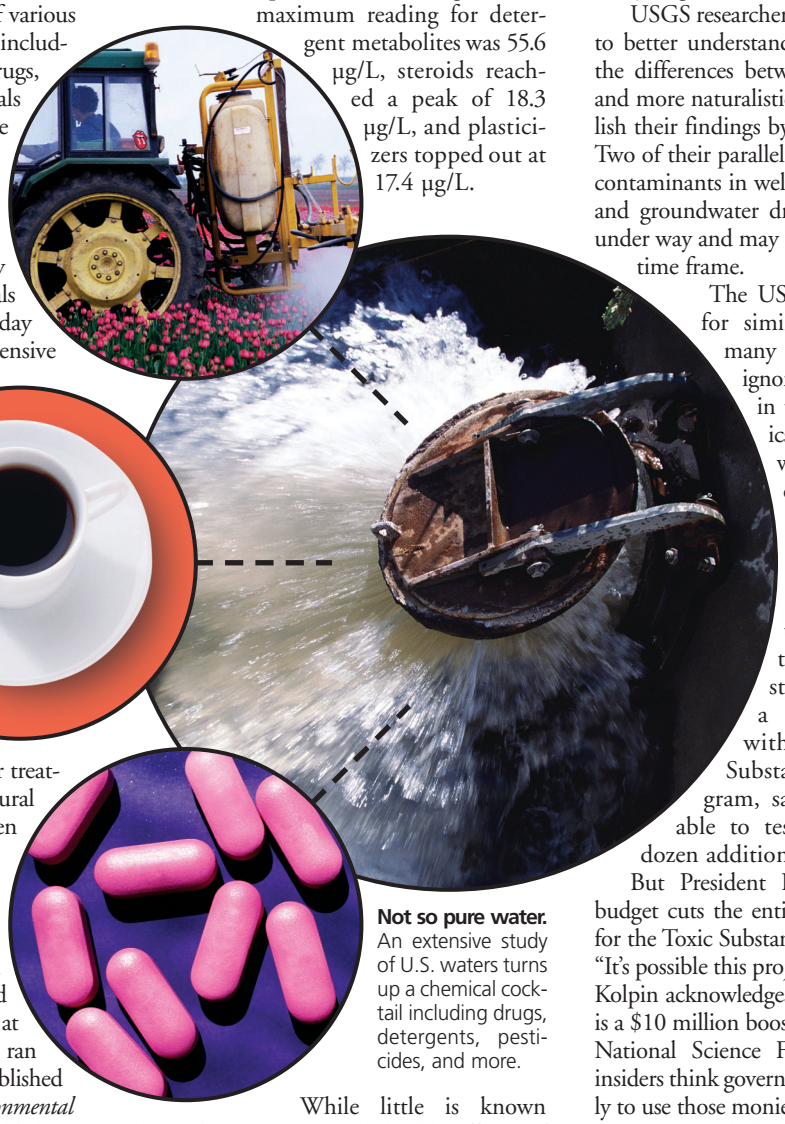
A federal agency's survey of 95 chemicals in U.S. rivers and streams has unveiled what the survey's leader calls "a real cocktail of various compounds." The chemicals studied included antibiotics, other prescription drugs, pesticides, and household chemicals such as detergents and fragrances. The U.S. Geological Survey (USGS) found median concentrations that usually were relatively low, but some maximum concentrations were high and occasionally exceeded regulatory guidelines for the few such chemicals that have them. This study of everyday products in U.S. waters, the most extensive conducted so far, adds to the growing body of information on the topic, which includes work published in *EHP Supplements* in December 1999.

The sample sites aren't necessarily representative of the country's waterways. Most samples were taken immediately downstream from suspected pollution sources, such as wastewater treatment plants, urban areas, or agricultural operations. However, eight were taken in less-polluted settings.

The chemicals chosen for the USGS study were known to be used in significant quantities, were suspected of being in the environment and affecting environmental health, and could be cost-effectively evaluated at low concentrations. The study, which ran through 1999 and 2000 and was published in the 15 March 2002 issue of *Environmental Science & Technology*, focused on establishing the first snapshot of concentrations of the selected chemicals; it made no attempt to assess the implications of the findings regarding human health or ecologic systems.

At each of 139 sites in 30 states, one composite sample was drawn from 4–6 strata within a cross-section of the waterway. Of the 95 chemicals evaluated, 82 showed up in at least one sample. A mixture of 7 or more showed up in 50% of the streams, and 34% of the streams revealed a mixture of 10 or more.

The chemicals found most frequently were steroids (from plant and animal sources), caffeine, and components of insect repellent, disinfectants, and fire retardants. The median concentration detected for each group of chemicals was always less than 1.0 µg/L, but some individual samples were much higher. The maximum reading for detergent metabolites was 55.6 µg/L, steroids reached a peak of 18.3 µg/L, and plasticizers topped out at 17.4 µg/L.



Not so pure water. An extensive study of U.S. waters turns up a chemical cocktail including drugs, detergents, pesticides, and more.

While little is known about the environmental health effects of many of the chemicals, 46 are known to be pharmacologically active, and 33 are known to be hormonally active. That's a particular concern to Rebecca Goldburg, a senior scientist with the advocacy organization Environmental Defense, because she says such substances can have a biologic impact at very low doses. But Mark Grayson, senior director of public affairs for the Washington, D.C.–based Pharmaceutical Research and Manufacturers of America, says his organization maintains its position that no adverse environmental effects have ever been proven at these concentrations. U.S. Food and Drug Administration spokesman Brad Stone says the study causes his agency no immediate concern, but that the agency is reviewing the findings to determine if any targeted follow-up studies are needed.

USGS researchers are analyzing their data to better understand their nuances, such as the differences between urban, agricultural, and more naturalistic sites, and hope to publish their findings by the beginning of 2003. Two of their parallel studies, one of chemical contaminants in wells and another of surface and groundwater drinking sources, also are under way and may be published in the same time frame.

The USGS has a five-year plan for similar studies, looking at many of the issues that were ignored or only touched upon in this study. Potential topics include specific pathways of contamination, daily and seasonal variations in concentrations, degradation products of chemicals, and concentrations in sediment and the atmosphere. In addition, Dana Kolpin, the study's project chief and a research hydrologist with the USGS Toxic Substances Hydrology Program, says his team already is able to test for more than two dozen additional chemicals.

But President Bush's fiscal year 2003 budget cuts the entire $13.9 million budget for the Toxic Substances Hydrology Program. "It's possible this project may get terminated," Kolpin acknowledges. The potential trade-off is a $10 million boost in research through the National Science Foundation. But USGS insiders think government agencies are unlikely to use those monies, because federal salaries aren't covered by such funds. However, Congress may reinstate the USGS funding, as it did last year.

Other organizations are picking up the ball on some of the angles covered in this study. Researchers at The Johns Hopkins University announced in April 2002 that with a three-year $525,000 grant from the U.S. Environmental Protection Agency they are beginning to look at the environmental fate of 200 of the most commonly used drugs.

–Bob Weinhold

PhotoDisc, Matt Ray/EHP

WASTE DISPOSAL

Big Chill in Fridge Recycling

A new regulation requiring the recovery of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) from refrigerators has caused the United Kingdom to adopt new control procedures and build new recycling facilities on very short notice. The United Kingdom disposes of about 2.5 million consumer fridges and half a million larger commercial fridges each year. From a handling process that saw 40% of discarded fridges still in working order exported to developing countries and the rest degassed and recycled as scrap metal, the nation is moving quickly toward recycling all fridges domestically and controlling all related forms of ozone-depleting substances for proper disposal.

The stage for change was set by the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, which identified CFCs and HCFCs as ozone-depleting substances. In response, the European Commission adopted Regulation 2037/2000, which requires members of the European Union to remove all such substances from refrigeration equipment before it is scrapped.

CFCs and HCFCs are found in two components of fridges. About 20–25% is gaseous, mixed with oils and used in piping as a coolant. The rest is used as a propellant in the foam insulation inside the fridge body and door. Most manufacturers stopped using CFCs as refrigerants in the mid-1990s, but HCFCs continued to be used as a propellant for several years after. The coolant form has always been removed before recycling the metal, but until recently there were no U.K. scrap facilities capable of capturing the CFCs and HCFCs in the foam.

Out in the cold. A new U.K. rule requires recycling of fridges, but a lack of recyclers has led some people to just dump outdated chillers.

Regulation 2037/2000 was issued in June 2000, with a compliance date for domestic fridges of 1 January 2002. But questions over the extent and means of compliance dragged on for a year before the commission clarified that all forms of CFCs and HCFCs must be removed and treated as hazardous waste, usually by incineration. With initial confusion over who would recycle the fridges and where they could be stored, news stories surfaced of farmers finding old fridges dumped on their property.

At the same time, to clarify fridge handling procedures, the U.K. Department for Environment, Food, and Rural Affairs (DEFRA) and the U.K. Environment Agency issued guidelines for temporary storage and processing to local authorities and recycling companies. They also encouraged several scrap metal companies to set up properly equipped facilities, and facilitated the export of some fridges to Germany, which has the recycling capacity to handle them.

Getting new fridge recycling plants capable both of capturing the CFCs and HCFCs to a suitable standard and of scrapping the metal and other components has been the most pressing issue. The German company SEG is now operating two mobile plants in the United Kingdom, and fixed plants will be running by summer in North London, South Wales, and the Liverpool area. DEFRA estimates that about 10–12 such plants will be needed to work through the fridge backlog and make the country self-sufficient.

European Metal Recycling runs the North London facility, which can store large numbers of units and process about 300,000 per year. As a major European recycling corporation, they see grounds for more expansion as the market for scrap metal and for CFC/HCFC processing evolves.

Ozone Friends, a London community service group, is feeling other impacts of the regulation. Executive director Mike Jenn says the group once made money by extracting and reselling refrigerant gases from discarded fridges. They also refurbished the units for sale at discount in low-income communities. Jenn says 10% of all fridges could be reused, but the new system makes this business no longer economical. However, Ozone Friends has developed a new business hauling fridges to storage areas or recyclers (retailers no longer pick up old fridges in exchange for new, and local authorities generally do not accept commercial waste). The group may expand into offering to remove the refrigerant and cut the fridges into easily transportable pieces. **–W. Conard Holton**

Clockwise from left: PhotoDisc; Arnold Greenwell/EHP; Eyewire

The Beat

edited by **Erin E. Dooley**

Rice Code Cracked

Reports of the completion of the genome sequences of one of the world's most important food sources—rice—were published in the 5 April 2002 issue of *Science*. The two most widely grown varieties were sequenced. A group of U.S. and Chinese scientists, including scholars from the Beijing Genomics Institute (a new major genome sequencing center in China whose work was partially funded by the NIEHS), sequenced the *indica* variety, while researchers from Sygenta, a biotechnology/agribusiness company, sequenced the *japonica* variety. In an editorial accompanying the reports, *Science* editor-in-chief Donald Kennedy notes that this work may not only help improve the crop yields and nutritional value of rice for the millions who depend on it as a food source, but will also serve as a stepping stone to decoding the similar but larger genome sequences of other important cereal grains.

Canada Restricts Cars

In 2002 the Canadian government announced new stricter emissions standards for on-road vehicles targeted at reducing levels of smog-forming pollutants (such as particulate matter, volatile organic compounds, and carbon monoxide) and toxic substances (such as benzene and acrolein). Cars and trucks are the largest source of greenhouse gases in Canada, contributing 25% of such emissions, a level that is only expected to increase in the future.

Included in the proposed measures are technical standards for exhaust, evaporative, and crankcase emissions, onboard diagnostic systems, and other vehicle emission control systems. The measures have been developed to mirror U.S. EPA regulations for the same systems in line with efforts of create an integrated vehicle manufacturing market in North America.

The Origin of Rain

A new NASA computer model can trace precipitation back to the place on Earth from which it originally evaporated, possibly helping scientists improve rainfall and drought forecasts. Project leader Mike Bosilovich says the model provides a much clearer picture than ever before of how water vapor travels through the atmosphere, and is the only tool available that can determine individual regional atmospheric moisture sources and account for all the variables required for source analysis. This can help scientists gain a clearer picture of climate change by helping them understand annual fluctuations in geographic sources of atmospheric moisture. The next step is to plug more observational data into the model; currently all variables are simulated except sea surface temperature.

URBAN ISSUES

If a Tree Falls in the City

Trees in urban settings have often been thought of as little more than decorative objects ripe for sacrifice in the name of development. But in addition to making city life more pleasant, trees also offer significant health and environmental benefits, trapping and converting air pollutants as well as catching and controlling stormwater runoff. To provide city planners and officials with solid evidence of the value of city foliage, the Washington, D.C.–based nonprofit organization American Forests has quantified the economic worth of trees to cities and towns.

Using satellite and aerial imagery and other data, researchers at American Forests have determined the amount of tree canopy cover for almost 20 cities and towns so far. Using the organization's own geographic information system–based software, they then calculated the amount of air pollution removed by urban forests and the lost benefits urban forests would have provided had they been left standing. They also calculated the effect of trees on stormwater runoff.

Overall, urban tree canopy cover has declined by 30% over the past three decades, says Cheryl Kollin, director of the Urban Forest Center at American Forests, and canopy tree cover has decreased in most of the surveyed areas. In Washington, D.C., for example, densely forested areas—those with at least 50% tree cover—decreased from 37.4% of the city's land to 13.4% over the period 1973–1997, while sparsely forested areas—those with less than 20% tree cover—increased from 51% to 71.8%. The result, according to American Forests, is a 34% increase in stormwater runoff. The lost trees also would have removed an estimated 354,000 pounds of air pollutants, including sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, and particulate matter of 10 microns or less.

Pollutant gases diffuse into leaves through the stomata and react in a variety of ways, converting into other compounds that sometimes actually benefit the tree. The effectiveness of trees at removing air pollution varies with the type of pollutant and the type of tree, says David Nowak, project leader of the U.S. Forest Service's urban forest ecosystem research unit in Syracuse, New York.

Trees mitigate solids pollution by filtering particles from the air, Nowak explains. "Trees that have sticky and hairy leaves or smaller leaf surfaces or smaller leaves tend to be better filters," he says. But unlike gaseous pollutants, particulates aren't converted or absorbed. An average of 50% of particles blow off the tree and back into the atmosphere. Most of the rest either fall to the ground when the tree sheds its leaves or are washed off by rain. "The soil is the ultimate resting place for a lot of these particles," Nowak says. The Forest Service is currently investigating whether these particles actually do less harm in the soil than in the air.

The increased costs to taxpayers as a result of the shrinking tree canopy are significant. In Washington, D.C., alone, processing the additional stormwater runoff costs about $226 million per year, and the additional air pollution abatement expenses add another $1 million annually, according to American Forests. "The economic value placed on air pollutants is established by state public service commissions from costs to society not reflected in the marketplace, such as rising health care costs from respiratory illnesses," Kollin says. And trees provide still other concrete benefits to urban dwellers, such as providing shade that can reduce residential cooling costs.

Everybody likes trees, but many city dwellers and city managers don't realize just how valuable they are. But according to Kollin, the average urban area still has about a 30% tree canopy cover. She says, "American Forests believes that cities could increase their tree canopy cover by at least ten percent and reap increased environmental benefits." **–Scott Fields**

RADIATION

Save Your Hide from UV Damage

Despite the increasing number of sunscreen products on store shelves, the incidence of skin cancer continues to climb. The American Cancer Society says the rate of melanoma, the deadliest type of skin cancer, more than tripled in Caucasians between 1980 and 2002. However, two recent studies have found that properly treating clothing and adding stable antioxidants to sunscreen can reduce skin damage from ultraviolet (UV) exposure.

Although experts recommend covering up in sleeves and pants to block UV rays, just how protective is clothing? In a study published in the May 2001 issue of the *Journal of the American Academy of Dermatology*, researchers at the New York University School of Medicine measured the UV rays that pass through different T-shirt fabrics. White T-shirt fabric was washed and dried five times under home laundry conditions. Some samples were then dyed yellow or blue with liquid fabric dye or treated with Tinosorb, a commercial UV absorber added to the wash cycle. The researchers then calculated UV protection factors (UPFs), analogous to sun protection factors, or SPFs.

Before any treatment, white T-shirts had a UPF of about 5. After five launderings, UV protection improved by 50% due to fabric shrinkage. Tinosorb boosted UV protection by 407% (to a UPF of 23.4), yellow dye by 212% (UPF 16.5), and blue dye by 544% (UPF 33.25). This shows that clothing can be treated inexpensively to block UV rays. Tinosorb is the active ingredient in the laundry additive Sun Guard™, says research team member David Polsky. One box of Sun Guard costs $2–3, and protection lasts several months.

But no sunscreen totally blocks UV light. The small amount of UV light that leaks through penetrates skin, creating free radicals that damage DNA and depress the immune system. To investigate where free radical damage occurs, biophysicist Kerry Hanson of the Laboratory for Fluorescence Dynamics at the University of Illinois at Urbana-Champaign peered into different depths of skin with a two-photon laser fluorescence imaging microscope. This type of microscopy shows cellular details down to the submicron level without damage to living cells. She and her colleagues are the first to use two-photon microscopy to measure UV-induced free radical generation in living skin.

Center for Science in the Public Interest Antibiotic Resistance Project

Sixteen years after discovering penicillin, Alexander Fleming predicted in a 1945 *New York Times* interview that the misuse of antibiotics could lead to the evolution of drug-resistant bacteria. As early as the late 1940s, when antibiotics were available to the public without prescription, hospitals began reporting evidence of drug-resistant strains. Agricultural use of antibiotics surged forward in the United States when, in 1951, the U.S. Food and Drug Administration (FDA) approved their use as feed additives for farm animals to control disease and promote growth. Antibiotics are also used to control crop diseases.

As the antibiotic market grows—by some estimates to over $24.5 billion by 2006—so do concerns over the evolution of drug-resistant bacteria. As part of its health and food safety advocacy efforts, the Washington, DC–based Center for Science in the Public Interest (CSPI) has developed a website, located at http://www.cspinet.org/ar/, highlighting the work of its Antibiotic Resistance Project. The project serves as a way to educate public and private institutions, as well as the general public, on why policies and practices should be changed to prevent further increases in antibiotic resistance.

Browsing through the site, consumers can find guidelines for using antibiotics responsibly through the Consumer Tips for Using Antibiotics link. Links to information on proposed antibiotic-related federal legislation and the CSPI's regulatory activities, such as their petitions to the FDA on banning the use of human antibiotics for livestock growth promotion, are available under the Legislative and Regulatory Update header. The homepage also includes a request for stories from people who have become sick from antibiotic-resistant bacteria. Still another link on the homepage takes visitors to the site of the Keep Antibiotics Working campaign, a project of the CSPI and several other environmental, agricultural, and advocacy groups.

The Antibiotics in Jeopardy page features an in-depth interview with project director Tamar Barlam that discusses in lay terms topics including the hows and whys of antibiotic-resistant bacteria and how food can spread such bacteria. These topics are further addressed in the 1998 CSPI report *Protecting the Crown Jewels of Medicine*. The report outlines the CSPI's proposals for government and health care provider actions that the group believes could reduce the spread of antibiotic resistance and lead to better overall management of antibiotics. The report also includes a section on the economic effects of antibiotic resistance and a listing of 10 common antibiotic-resistant bacteria, along with the diseases they cause and the drugs they are resistant to. –Erin E. Dooley

Hanson exposed skin to UV rays equivalent to two hours of North American midday sun in July. She measured free radical formation before and after UV exposure with a fluorescent probe that glows when it reacts with free radicals. Hanson found that UV light generates tremendous numbers of free radicals in skin in all layers of the epidermis. But compared to bare skin, an SPF-15 sunscreen reduces free radical formation in the lower epidermis, where DNA resides, by 90%. Adding the antioxidants vitamin E acetate and a stable form of vitamin C called sodium ascorbyl phosphate to sunscreen reduces free radical formation by 95.5%. This research will appear in an upcoming issue of *Photochemistry and Photobiology*.

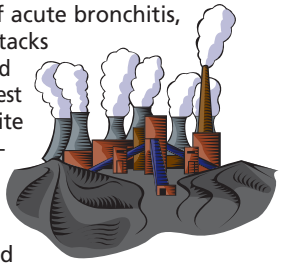
Ascorbic acid, the common form of vitamin C found in vitamin supplements and orange juice, degrades rapidly when light hits it, says Hanson. In contrast, sodium ascorbyl phosphate remains completely stable in sun and heat, she says, as does vitamin E acetate. Enzymes in the skin convert the vitamins to active forms that accumulate in skin and change free radicals into nondestructive molecules. Hanson advises checking a sunscreen's ingredient list to make sure these stable forms of vitamins C and E are there.

Hanson's research "involves some interesting new techniques," says Wayne Wamer, a research chemist at the U.S. Food and Drug Administration Center for Food Safety and Applied Nutrition in College Park, Maryland. However, the connection between UV-induced free radicals and skin cancer remains controversial. Wamer says future studies need to evaluate whether the observed reduction of free radicals by antioxidants has biological significance, such as a reduction in cell toxicity, carcinogenesis, or aging effects.
–Carol Potera

Clockwise from left: Center for Science in the Public Interest; Eyewire; European Environmental Bureau

The Power to Harm

A report presented in April 2002 by former EPA regulatory affairs director Eric Schaeffer implicates air pollution produced by coal-burning power plants in an estimated 5,900 deaths, 14,000 cases of acute bronchitis, and 140,000 asthma attacks yearly. Schaeffer resigned his post in March in protest of what he calls "a White House that seems determined to weaken the rules [the EPA is] trying to enforce."



Eight utilities named in the report were all charged in 1999 with violations of an EPA regulation under the Clean Air Act that establishes the extent to which aging coal-fired power plants can be enlarged or upgraded before investments are made for pollution control devices. The utility industry has countered that no generally accepted models exist that can produce the kind of causation implied in the study.

Zero-Sulfur Future

Penn State University researchers have developed a new fuel desulfurization process that uses lower temperatures than current methods and does not require reactive gases. The process yields the ultraclean, zero-sulfur compounds needed for fuel cells as well as fuels that will meet the new stricter U.S. fuel sulfur standards slated to take effect in 2006.

The process uses metals or metal alloys to "grab" only the sulfur, leaving behind the desirable fuel components. The metals can clean 10 times their volume of fuel before becoming saturated with sulfur, whereupon they are regenerated with solvents. The researchers envision the process being used in special clean fuel pumps and in fuel cell vehicles themselves.

A Financial Plan for the Environment

The European Environmental Bureau (EEB), a federation of 133 environmental organizations, has launched a campaign for environmental fiscal reform consisting of environmental taxation reform, the removal of subsidies that negatively affect the environment, and the development of fiscal incentives for environmental protection. The EEB plan will also address any societal impacts resulting from the higher energy prices they propose. German researchers estimate that implementing environmental fiscal reform could create up to 250,000 new jobs in Germany alone over the next eight years.