It suddenly struck me that that tiny pea, pretty and blue, was the Earth. I put up my thumb and shut one eye, and my thumb blotted out the planet Earth. I didn't feel like a giant. I felt very, very small.
Neil Armstrong, astronaut

CHEMICAL EXPOSURES

An Eye to the Sea

Gardening, choosing contraception, driving to work—we don't typically think of these actions as having a high impact on fisheries, but they can. A session titled "From Kitchen Sinks to Ocean Basins: Emerging Chemical Contaminants and Human Health" at the February 2008 annual meeting of the American Association for the Advancement of Science detailed some recent findings showing that certain day-to-day activities can have big impacts on the oceans.

Think of an oil spill like the 1989 *Exxon Valdez* incident, and you may visualize images of wildlife blanketed in black crude, struggling against acute poisoning and hypothermia. But John Incardona, a scientist with the National Oceanic and Atmospheric Administration (NOAA), was surprised that some spill compounds could cause far less obvious, though equally dramatic, effects. He found that polycyclic aromatic hydrocarbons (PAHs) caused heart defects in fish after the *Exxon Valdez* spill. He also found that PAHs had a similar adverse response in zebrafish, which is in many ways a better model of the human heart than the more commonly used mouse or rat.

PAHs are also released during the combustion of wood, coal, and oil. "The emissions from a tailpipe include the PAHs created by burning but also aerosolized fuel that doesn't get burned," said Incardona. "In essence, the air is just like an aerosolized oil spill. And, if a physician knowingly gave an aerosolized cardiotoxicant to a patient with coronary artery disease or congestive heart failure, they would probably be sued for malpractice. But the air in big cities is doing just that to millions of people every day."

Untested synthetic chemicals emitted into waterways also could put fisheries at risk. Derek Muir, an environmental chemist with Environment Canada, wanted to find out if any of the 22,000 chemicals in medium to high levels of production today are as bioaccumulative or persistent as banned substances such as DDT and polychlorinated biphenyls. He developed a computer model that analyzed compounds' structures and estimated levels of persistence using a database of known bioaccumulation rates. He found 400 chemicals that fit the persistence bill. Of those 400, 75% have never been described in the environmental literature, only 4% are regularly analyzed, and all have been in production for several decades.

Other research focused on 17α-ethinylestradiol (EE_2), a synthetic estrogen used in women's birth control. EE_2 passes through the female body and, later, wastewater treatment plants, often finding its way into fish when treated water is discharged into nearby rivers, streams, and oceans. Several studies in recent years have described the feminization of male fish in response to estrogenic exposures, but Karen Kidd, an ecotoxicologist with the University of New Brunswick, presented some of the first findings on how estrogens could affect an entire population.

She exposed an isolated test lake in northwestern Ontario to 5 ng/L EE_2, about average for streams and rivers receiving wastewater effluent. After one summer, male fish began releasing egg-forming proteins and had delayed sperm development, while females' sexual development was significantly delayed. As a result, the fathead minnow in the lake stopped reproducing, and their population collapsed. That collapse had profound implications for larger predators such as lake trout, whose own population dropped 30% as a result.

"These results are sobering because they show that estrogens can affect fish abundances both through direct toxicity or indirectly through the food chain because of the loss of their food supply," said Kidd. EE_2 can be easily broken down, however, and improvements to wastewater processing could mean less estrogen makes it into waterways. [For more on one possible improvement, see "Fe-TAML Takes On Estrogens in Effluent," p. A159 this issue.]

Finally, although the effects of many chemicals are known, the way they interact with other chemicals is not always clear. "We've got a pretty good handle on how to assess the health effects of single chemicals in toxicity trials," said NOAA zoologist Nathaniel Scholz. "But the real world is more complex, and exposure to multiple chemicals in mixtures is the rule."

Using salmon as a test model, Scholz found that combinations of pesticides that run off into river waters frequently were synergistic, and certain combinations (such as diazinon plus malathion, both common pest control chemicals) can be lethal. This research is critical to the success of the multimillion-dollar effort to restore salmon habitat on the West Coast. As well, it may shed light on human health effects, because the human nervous system is similar to that of the salmon. "Pesticide residue typically occurs in the human food supply at very low levels, but pesticide mixtures are also very common," Scholz said. "This creates the potential for synergistic interactions and enhanced toxicity to people." –Graeme Stemp-Morlock

Rob Broek/iStockphoto

URBAN ISSUES

A Climate for Pollution

Carbon dioxide (CO_2) emissions may be killing people by increasing airborne concentrations of other pollutants including ozone, particulate matter, and carcinogens such as formaldehyde and benzene, a Stanford University scientist reports in the 12 February 2008 issue of *Geophysical Research Letters*. The situation is only likely to get worse, especially in already-polluted areas, according to author Mark Jacobson, a professor of civil and environmental engineering.

CO_2 causes temperatures to rise, which in turn increases evaporation, leading to higher water vapor content in the air. Jacobson has now confirmed the effect of these CO_2-induced changes on ozone production using an algorithm that can quantify the reactions between hundreds of different airborne compounds over time.

He examined different scenarios involving more than 100 gases and nearly 400 inorganic and organic air pollutants. When nitrogen oxides (NO_x; ozone precursors found in car exhaust fumes) were present at greater than 80 ppb by volume (ppbV) in the presence of organic acids, he found the ozone concentration increased by 2.8 ppbV per 1 ppth by volume water vapor. The higher the water vapor content of the air, the more readily further ozone precursors were formed.

Increasing temperature also contributed to increased ozone levels—again, the more ozone there was to start with, the more was made. A 1°C rise was associated with a 0.1-ppbV increase in ozone when the gas was present at 40 ppbV, and with a 6.7-ppbV increase when it was present at 200 ppbV. The reason: higher ozone levels are accompanied by higher levels of unstable peroxyacyl nitrate. When the latter compound breaks down as the temperature rises, it forms more NO_x and volatile organic compounds, thus providing further ozone precursors.

The data mass produced by the algorithm was then used in a three-dimensional climate–air pollution model known as GATOR-GCMOM to determine how CO_2 emissions might affect ozone and other atmospheric variables over different areas of the United States. Two simulations were run, one at present CO_2 concentrations and one at pre–Industrial Era concentrations, leaving all other variables equal.

Top to bottom: Matteo Natale/iStockphoto

For every 1°C rise, these emissions were associated with increases in ozone of 0.12 ppbV for the United States as a whole, but by up to 5 ppbV in heavily polluted areas such as Los Angeles. In some areas, fine particulate matter rose by an average of 0.1 μg/m^3 per 1°C rise, whereas carcinogenic compounds experienced small increases. According to the current epidemiologic literature, says Jacobson, that could mean around 350–1,800 extra noncancer deaths per year per CO_2-associated 1°C rise in the United States alone, and up to 39,000 deaths worldwide, with the worst hikes occurring in polluted cities. U.S. cancer deaths could rise by 20–30 per CO_2-associated 1°C rise.

"This paper makes an interesting contribution to the literature on the less direct effects of climate change," remarks Douglas Crawford-Brown, a professor of environmental sciences and engineering at the University of North Carolina at Chapel Hill. "While the results are even more speculative than estimates of the direct effects [such as storms and increased drought], they do point to . . . a plausible argument that these indirect effects may rival the direct effects in scale of public health concern."

The results may help California and 19 other states in their suit against the U.S. Environmental Protection Agency (EPA) over the recent denial of a waiver for the states to set their own tailpipe emission standards, partly on the grounds that climate change does not affect them in any extraordinary way. Bart Croes, chief of the Research Division at the California Air Resources Board, says this new research shows that California, home of three of the four most polluted U.S. areas, could suffer 300 deaths per 1°C rise for every 700 in the rest of the country—a notable number given its 12% share of the population. According to the 2006 report *Our Changing Climate: Assessing the Risks to California* by the California Climate Change Center, the state can expect at least a 1.7°C rise in average temperatures by the end of this century.

Meanwhile, on 12 March 2008 the EPA signed into law a new 8-hour standard for ground-level ozone of 0.075 ppm. Under the former standard, ozone levels as high as 0.084 ppm were considered to be in compliance. –Adrian Burton

ehpnet | by Erin E. Dooley

WHO Ultraviolet Radiation Website

http://www.who.int/uv/en/

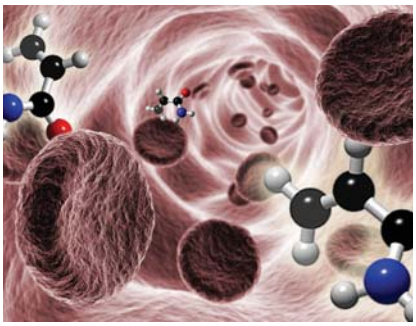
The World Health Organization (WHO) has devoted a section of its website to activities related to the health effects of sunlight. The homepage for this section provides a brief overview of the topic along with links to resources such as the 2006 report *Solar Ultraviolet Radiation: Global Burden of Disease from Solar Ultraviolet Radiation* and a brochure on how to enjoy sunlight safely.

A Frequently Asked Questions section contains information on topics including ultraviolet radiation (UVR), tanning beds, and the UV Index. The site also has subsections on the health effects of UVR and on sun protection. The health effects page discusses the beneficial health effects of UVR, such as how it helps the body produce vitamin D and acts in the treatment of psoriasis, eczema, and jaundice. Other information addresses the relationship between sun exposure and skin cancer, blindness, and cell-mediated immunity. The Sun Protection page lists precautions that can help prevent sun damage and explains how children are more vulnerable to the health threats posed by too much exposure to the sun.

The homepage also provides a link to information on the INTERSUN Programme. INTERSUN was established during the 1992 United Nations Conference on Environment and Development. The program has three primary goals: to serve as a source of practical and scientific information relating to the health impact and environmental effects of UVR exposure; to encourage governmental action to reduce UVR-related health problems; and to provide guidance to governments and agencies about establishing effective sun awareness programs. Two areas of special activity are tourism and occupational health. On the Tourism page, INTERSUN provides guidance to tourists and tour operators to help mitigate the impact of short, intense bursts of sun exposure, which are associated with malignant melanoma. The Occupational Health page provides information for arc welders, lab technicians, outdoor workers, and others who encounter high UVR exposures on the job.

DIET & NUTRITION

Acrylamide Study Suggests Breast Cancer Link



The International Agency for Research on Cancer classifies acrylamide as a probable human carcinogen. It has only been in recent months that an epidemiologic study first found a link between dietary acrylamide and human cancer risk. Now Danish researchers report that acrylamide adduct levels in blood are associated with an increased risk of breast cancer in postmenopausal women.

This is the first epidemiologic study to use blood biomarkers to assess acrylamide exposure. The findings, says first author Pelle Thonning Olesen, emphasize the importance of using biomarkers for exposure assessment. "Biomarkers are a more trustworthy indicator for exposure," he says.

Before 2002, people were known to be exposed to acrylamide in certain industries and through smoking tobacco. That year, the Swedish National Food Administration discovered that acrylamide also forms in fried or baked starchy foods such as french fries, coffee, and baked goods. Diet is now thought to be the major source of exposure among nonsmokers, but the cancer risk posed by acrylamide in food is unknown.

All previous epidemiologic trials estimated acrylamide consumption from food frequency questionnaires. Olesen, a toxicologist at the Technical University of Denmark, Søborg, and colleagues instead measured levels of acrylamide and a key metabolite, glycidamide, bound to hemoglobin. The subjects included 374 postmenopausal women with breast cancer and 374 controls who participated in the Danish Cancer Society's Diet, Cancer, and Health Study.

Adduct levels of acrylamide among smokers reflect both dietary and smoking intake of the compound. After statistical adjustments for smoking behavior, women with the highest acrylamide-hemoglobin levels showed a 2.7 times higher risk of estrogen receptor–positive breast cancer compared with women with the lowest acrylamide-hemoglobin levels. The risk rose with increasing acrylamide exposure.

Acrylamide-hemoglobin levels were not linked to estrogen receptor–negative breast cancer, and glycidamide-hemoglobin levels showed no connection with any breast cancer. The finding that only acrylamide-hemoglobin was associated with breast cancer suggests that the compound may induce cancer by nongenotoxic routes such as alkylation of proteins that could alter estrogen receptor function. The findings were reported in the 1 May 2008 issue of the *International Journal of Cancer*.

"This is an important study because it's the first to measure acrylamide adducts," says epidemiologist Lorelei Mucci, an assistant professor at the Harvard School of Public Health. Nonetheless, the study should be repeated in larger numbers of nonsmoking women, according to Mucci, because more than half the cases and controls were current or former smokers.

"The big public health question here is whether the amount of acrylamide in foods is enough to lead to cancer," Mucci says. It is possible that other chemical compounds formed along with acrylamide may be the culprit in any cancer link. "Acrylamide-hemoglobin may be a biomarker for other carcinogenic chemicals formed during the heating of foods," cautions Olesen. –Carol Potera

The Beat | by Erin E. Dooley

Dust Up in the West

A study published in the 24 February 2008 issue of *Nature Geoscience* shows that the western United States has become 500% dustier over the past two centuries, with dust deposition higher than at any other point in the past 5,000 years. The authors based their findings on sediment records from alpine lakes in Colorado, which show that levels of nutrient and mineral deposition shot up between 1860 and 1990, coinciding with booms in mining, agriculture, ranching, and railroad activity. High dust levels can cause significant human health problems such as lung damage, allergies, and other respiratory problems. The increased levels could also have a pronounced impact on surface-water alkalinity, aquatic productivity, and nutrient cycling.

Stratford, Texas, 1935

Tiny Particles a Great Solution?

University of South Australia researchers have discovered a new approach that could help prevent waterborne disease for millions of people. Their method, described in volume 5, issue 2/3 (2008) of the *International Journal of Nanotechnology*, is supposedly more effective and cheaper than conventional water purification technologies. The method uses silica particles covered with a nanometer-thin hydrocarbon-based coating along with an anchor that contains silicon. Stirring the particles through contaminated water for up to one hour binds pathogens, which are then filtered out along with the particles.

Bright Nights and Breast Cancer

Using NASA satellite data showing the amount of nighttime light reaching space, scientists at the University of Haifa have shown that living in a brightly lit area may contribute to greater risk of breast cancer. The scientists generated a map of nighttime light measurements overlaid with another map showing local breast and lung cancer statistics. The scientists adjusted for such variables as smoking, income, and ethnicity. Residents of neighborhoods with the most nighttime brightness had an average 64% higher rate of breast cancer than those living in areas with the lowest nighttime light. The study appears in the January 2008 issue of *Chronobiology International*.

Pollution's Effects on Intelligence

Unlike links between air pollution and effects on the cardiovascular and respiratory systems,

Top to bottom: Ben Greer/iStockphoto & Joseph Tarr/EHP; AP Photo/Smithsonian; NOAA/George E. Marsh Album

REMEDIATION

Fe-TAML Takes On Estrogens in Effluent

For more than a decade, endocrine-disrupting chemicals (EDCs) have been an environmental and health worry, linked to cancer and reproductive abnormalities in humans and animals. The European Union's new REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) legislation labels them "substances of very high concern," meaning they will need special authorization to be marketed in Europe. According to a report in the 15 February 2008 issue of *Environmental Science & Technology*, a recently developed chemical agent known as Fe-TAML® may help with one aspect of EDC concerns: it can destroy certain EDCs in wastewater in less than 15 minutes.

EDCs, including various chlorinated organics, plastic additives, and estrogenic compounds, can be found in pesticides, in contraceptives, and in growth hormones given to livestock. These compounds are then excreted in human and animal waste. Existing techniques to degrade EDCs include chlorination and ozonation, but chlorination can yield harmful disinfectant by-products, and ozonation requires expensive equipment.

Although wastewater treatment plants may remove 95% of EDCs, residual levels can persist and affect the environment, says study coauthor Nancy Shappell, a research physiologist with the Agricultural Research Service. Of particular concern, says Shappell, is 17α-ethinylestradiol (EE_2), a synthetic estrogen used in women's birth control, which can alter reproduction at very small doses.

In this study, Fe-TAML (short for iron–tetraamidomacrocyclic ligand) was combined with hydrogen peroxide and added to sewage effluent in a laboratory setting. The compound successfully destroyed several estrogenic compounds, including EE_2. Estradiol, the chief endogenous estrogen, was reduced by about 98%. Furthermore, the Fe-TAML "estrogen breakdown products had little to no estrogenic activity," the researchers write. The mechanism by which the catalyst works was described in detail in the Environews article "Fe-TAML: Catalyst for Cleanup" [*EHP* 114:A656–A659 (2006)].

The treatment could be used to remove EDCs from sewage treatment discharges, says principal investigator Terrence Collins, a professor of chemistry at Carnegie Mellon University and lead inventor of the Fe-TAML catalyst. He suggests the catalytic technique be used as a final treatment for effluent after solids are removed.

The research, says Trevor Stuthridge, a scientist with the New Zealand biomedical research institute Scion Research who has collaborated on Fe-TAML studies, shows that the agent may offer performance advantages over current processes: "This enhanced efficacy means that waste treatment operators have a potential new weapon in the fight to ensure that final discharges from these systems are safer for the environment."

Collins says that preliminary results showed that no toxic products resulted from using Fe-TAML/peroxide. And he notes that Fe-TAML catalysts have passed a series of aquatic toxicity assays, as reported in the 12 April 2002 issue of *Science*, among other sources. But he cautions that more toxicity studies need to be done to ensure that Fe-TAML does no harm if used to treat drinking water.

Although 1 kg of the catalyst can treat 20,000 tons of water, a large city plant can process many times that amount of water each day. Consequently, says Collins, any chemical treatment "must be very, very cheap for massive-scale applications." He and his colleagues are currently working to make Fe-TAML competitive on the marketplace. –Harvey Black

which have been well documented, associations between such pollution and neurologic effects remain largely unexamined. In one of the first such studies, published 1 February 2008 in the *American Journal of Epidemiology*, scientists from the Harvard School of Public Health found that children who were heavily exposed to black carbon, a component of vehicle exhaust, scored lower on several intelligence tests, with effects were similar to those seen in children whose mothers smoked 10 cigarettes a day while pregnant or who had been exposed to lead. The authors believe the effects could be the result of inflammation and oxidative damage in the brain caused by exposure to the pollutants.

Top to bottom: AP Photo/George Osodi; Kelton/Creative Commons

Flour Mill Fathers Have Fewer Sons

A body of research has shown that exposures to a number of chemicals can affect men's reproductive health as well the survival of male fetuses. Now a study in the February 2008 issue of the *American Journal of Industrial Medicine* adds to this evidence, with findings that male flour mill workers tend to father a disproportionate number of female offspring. The study also found that male offspring of these men had lower birth weights than their female counterparts. The authors believe the effects may result from the men's occupational exposure to highly toxic pesticides used to kill insects in stored grain and flour. One such pesticide, phosphine, is a known genotoxicant. Another, 1,2-dibromo-3-chloropropane, causes testicular dysfunction and other reproductive effects.

Nigeria Taxes e-Waste Imports

Nigeria's information minister John Odey announced in February 2008 the Nigerian government's plans to impose duties on

"Computer village" in Lagos, Nigeria

imported "e-waste"—used computers, appliances, cell phones, and other electronic goods sent to developing countries for dumping or salvage. Such items are flooding Nigeria alone at rates such as 400,000 computers each month. Toxic components such as lead, cadmium, mercury, hexavalent chromium, and brominated flame retardants in the e-waste pose health threats to the people and environment of the countries where these items are shipped. Until now, imported e-waste has not been subject to duties because it has been classified as educational material.