# Soils and Acid Lakes: Finding Common Ground

After years of debate, scientists now agree that acid rain can acidify lakes and have identified the key factors that decide whether a particular lake or stream is sensitive to acid rain. Sulfur deposition, in the form of sulfur dioxide in air or sulfate ions in rain and snow, is largely responsible for the acidification of lakes and streams in areas like the northeastern United States, says a National Academy of Sciences panel of leading acid-rain researchers. They also say that even when sulfur deposition remains constant or begins to decline, water quality can continue to deteriorate with corresponding changes in plant and animal life.

I. Peterson

*Mountain streams are particularly sensitive to acid rain.*

This consensus reflects a recent shift among many acid rain researchers from the question of whether acid rain can acidify lakes to how quickly the process happens and how many lakes are vulnerable. "I had no idea that the nine of us would come out with that kind of joint understanding of what we think reality is," James N. Galloway of the University of Virginia in Charlottesville says. "That really is new." The nine panel members presented this new information to William D. Ruckelshaus, Environmental Protection Agency administrator, at a roundtable discussion last week.

"The soil is the key we're looking for," says Galloway. Soil particles are negatively charged and attract positive ions (cations), including aluminum and hydrogen ions and the base cations calcium, potassium and magnesium. Researchers have found that the more acid a soil is the higher the proportion of aluminum and hydrogen ions surrounding soil particles. When acid deposition introduces negatively charged sulfate ions into soil waters, these ions pull away cations from the soil particles. If the soils are very acidic to start with, then hydrogen and aluminum ions are more likely to be leached and travel with the sulfate into lakes and streams, increasing the water's acidity (hydrogen ion concentration) and adding toxic aluminum. Thus, watersheds surrounded by highly acidic soils become acidified, not because of the leaching of natural acids into the water, as some researchers had believed, but because of the role of sulfate, deposited from the atmosphere, in stripping aluminum and hydrogen ions from the soil.

Two processes affect the rate at which acidification occurs. One involves how quickly base cations are replaced by the weathering of minerals like limestone in the soil. The other is the ability of the soil to absorb sulfate, thus preventing it from leaking into streams and lakes. Soil scientist Dale Johnson of Oak Ridge National Laboratory in Tennessee says, "What we need to know very badly, and don't have a very good handle on right now, is the rate at which those exchangeable base cations [those ions surrounding soil particles] are replenished from the nonexchangeable reserves."

The vulnerability of a body of water to acidification due to sulfate deposition depends on how much sulfate falls into a watershed, the paths that water follows through the soil (SN: 5/21/83, p. 332), the natural acidity of a soil, the soil's ability to absorb sulfate and the rate at which base cations are released by the weathering of minerals (which depends on the type of bedrock). These factors vary widely for individual lakes and streams. Galloway likens the two extreme cases to water sitting in a marble bathtub, which has a limitless supply of base cations and never becomes acidified, and water sitting in a quartz bathtub, which responds immediately to any acid sulfate input. Natural lakes and streams can fall anywhere along the continuum between these two cases.

Years of sulfate deposition can gradually deplete a soil's ability to absorb sulfate or replace base cations. Thus, it is possible for certain types of lakes at first to show little response to acid rain for years or decades and then to suffer a sudden, rapid decline. Geologist Stephen A. Norton of the University of Maine in Orono demonstrated this effect using chemical analyses of lake-bottom sediments from lakes in the Adirondacks in New York. He also showed that the chemistry of the sediments was still changing although the level of deposition has remained virtually constant for the last few decades.

Also at last week's meeting, Richard F. Wright of the Norwegian Institute for Water Research described a similar time-lag effect for aquatic life. Although acid deposition may level off, major, long-term biological changes continue to occur. Fish and other aquatic life that manage to live in acidified waters are also much more vulnerable, for instance, to sudden rainstorms, which carry a lot of sulfate and aluminum into the water within a short time. "In Norway, there has been no significant trend in acid deposition over the last 13 years," Wright says, "but salmon kills are still occurring."

One unresolved question involves how long lakes and soils will take to recover if, for example, sulfur deposition is reduced or eliminated. Equally important is the question of how many lakes are on the verge of becoming acidified if nothing is done to reduce sulfate deposition levels. Galloway says these were questions on which the panel could not yet reach a consensus. However, he adds, "Using information we have now, we can tell what the acidification state of a lake or stream is and give a general idea of what will happen in the future. But once we get more information on this rate of base cation supply to the ion exchange pool, then we'll...also be able to predict what will happen in the future given different scenarios for sulfur deposition."

Johnson says, "I think we're finally, after all these years, in a position that most soil people agree on the important mechanisms. Now, we've just got to quantify them, to sort out what's important at each site." —*I. Peterson*

# Harp seal pups are hunted again

The immensely controversial Canadian harp-seal hunt kicked off March 11 amidst a spate of violence and contradictory allegations. About the only thing that remains crystal clear is that despite press accounts to the contrary, pups are among the animals being "harvested." The latter came as some surprise both to Canadian officials and to environmentalists who had stationed themselves in the Gulf of St. Lawrence to photograph the herd; only three days earlier the Canadian Sealers Association had vowed publicly to discontinue the slaughter of "white coats" — newborn pups two weeks of age and younger.

Until recently, white coats frequently accounted for 80 percent or more of the



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total annual slaughter, well in excess of 100,000 animals. Because the young lose their prized, downy white fur within the third week after birth, the hunt focused on nursing animals. But a ban on the importation of white-coat pelts by the European Economic Community (EEC) last year (SN: 3/5/83, p. 150) dried up the commercial market for trade involving these newborns. As a result, last year's slaughter fell 143,000 animals short of the federally imposed ceiling for the kill of 186,000.

Only this week, Mark Small, president of the Canadian Sealers Association, told SCIENCE NEWS, "We [the association] have called for a moratorium on white coats." Reached in Wild Cove, Newfoundland, he said, "The pups are out there now and the season is open for taking pups, but there's nobody out there. There are no sealers taking any pups." He added emphatically, "I know for sure that there won't be any pups taken." Asked for clarification, he said he could speak for the 5,000 "landsmen" — land-based sealers from Newfoundland, Labrador and the Magdalen Islands — that there would be no slaughter of animals under one year of age during this year's hunt.

But on Tuesday, Jim Winter of the Canadian Department of Fisheries and Oceans in Ottawa contradicted that, saying the hunt had officially begun Sunday and that the first day's kill totaled 43 animals — "mostly young ones," on the ice. He emphasizes that these were not white coats, but "just after the white-coat stage."

That's impossible, counters Vivia Boe, international projects coordinator for Greenpeace. Reached in Canada, where she and colleagues are now monitoring the hunt, she notes that when escorted into the main herd of harp seals on Feb. 28 by fisheries officials, the only pups she saw were a day old. Clearly, whelping didn't begin until Feb. 27, she says, "which means that today [March 12] the oldest animals are two weeks old." That also means, she says, that the young being killed are white coats.

Kirk Smith, executive director of the Canadian Sealers Association, said he could not confirm that the clubbing of white coats had occurred. However, he did say that in the Magdalen Islands — where the hunt is now being conducted — landsmen occasionally take white coats for their own family's meat consumption. Moreover, he said, in striking contradiction to what his group's president had said, "Our position is very clear: There's no difference in the taking of seals at any age."

"There's a *de facto* moratorium at the moment" on the commercial sale of white-coat pelts, Smith says, so pups would only be killed for individual consumption. Suggesting that earlier media accounts may have distorted his organization's stance, he explained: "We said to the Canadian government that if you need a fallback position, if you need to change policy, then this [white-coat ban] is what we would do. However, we are very pleased to see that the government has not seen fit to change its policy." Hence, there has been no need to curb the killing of the youngest seals.

Both the International Fund for Animal Welfare (IFAW) and Greenpeace are outraged, but not only because of the killing of pups. On March 9, a Canadian airport refused to refuel an IFAW helicopter that had been observing the herd. And while the craft was still grounded, a mob stormed the airport on Sunday and destroyed the vehicle. IFAW's Donna Hart says this just confirms her group's intention to campaign for a U.S. boycott of Canadian fish. Initially, IFAW will focus on "encouraging" the McDonald's, Burger King, Gorton, Mrs. Paul's and Taste o'Sea companies to boycott Canadian fish until the seal hunts end.

"We did a dress rehearsal of this boycott in the United Kingdom starting about six months ago," Hart says, "and feel it's a success. We got two of the major supermarket chains in England to take a moral stand against the seal hunt: Their 600 stores no longer stock Canadian fish products."

*— J. Raloff*

# EPA to limit only smallest particles

A major revision of the national clean-air standards affecting particulate matter — pollution consisting largely of dust, soot, dirt and smoke — was proposed by the Environmental Protection Agency (EPA) last week. More than 100 million tons of particulates enter the atmosphere annually. Rather than trying to regulate all of these suspended particles, EPA is now proposing to focus only on those most likely to cause lung damage, those 10 micrometers or smaller in diameter.

EPA's current ceiling on particulates, designed to protect human health, is 260 micrograms ($\mu$g) per cubic meter ($m^3$) of air, averaged over 24 hours, or an annual geometric mean (AGM) concentration of 75 $\mu g/m^3$. The new proposal suggests replacing these standards with a 24-hour limit of somewhere between 150 and 250 $\mu g/m^3$ and an AGM concentration of between 50 and 60 $\mu g/m^3$. Precise limits within the ranges announced probably won't be proposed for a year.

Condemning this proposal, David Doniger of the National Clean Air Coalition (a consortium of nine environmental groups) cited several studies that he said indicated health could be jeopardized at even the lower end of the proposed ranges. The coalition also worries whether particulates might go unregulated altogether for the three or more years it will take to get data and technology to enforce limits on the respirable (10 micron and under) fraction.

*— J. Raloff*

# Chipping away at silicon processing

An integrated-circuit chip is built up in layers to create a microscopic, silicon sandwich. It consists of a sequence of metallic films and insulating layers, etched with intricate patterns and doped with traces of elements that alter a layer's properties. The production of such electronic chips requires a complicated, expensive manufacturing process that limits the number of companies and laboratories that can make them. However, current research on the use of lasers and a technique called "chemical vapor deposition" may within a few years bring chip manufacture to, for instance, a university laboratory.

A recent, surprise discovery at the Sandia National Laboratories in Albuquerque, N.M., illustrates the potential value of laser processing. The Sandia researchers use a newly developed technique, called "plasma-initiated laser deposition," for depositing thin layers of silicon on surfaces. The method depends on the interaction between light from an ultraviolet laser and a gas that has passed through a high-voltage, electrical discharge to create a "chemical soup" or plasma of charged, excited molecular fragments. The gas, in this case silane ($SiH_4$), enters the reaction chamber at a low pressure and passes through a 10,000-volt discharge. Ultraviolet light from a krypton-fluoride laser shines through a window onto the surface of a quartz-glass or silicon wafer. Only when both the plasma is present and the laser is shining does silicon deposit on the area outlined by the laser beam on the wafer's surface. In other words, the discharge activates the gas, and the laser defines where deposition should occur.

The researchers found that at low laser energies, silicon films made up of many randomly oriented crystals form on the surface of a single-crystal silicon wafer. However, when the laser energy reaching a given area is increased beyond a threshold value, the deposited silicon atoms line up in a very orderly arrangement so that the surface-film crystals take on a single orientation.

The results for deposition on quartz plates were even more surprising and puzzling. In this case, Philip J. Hargis Jr. and his colleagues discovered that while low-energy, 10-millijoule laser pulses cause silicon deposition, higher-energy, 30-millijoule pulses cause etching to occur. Simply altering the laser energy changes deposition to etching or etching to deposition. When the experiment was tried on a single-crystal silicon wafer coated with a thin film of silicon dioxide (quartz), the high-energy laser pulses etched the coating until they reached the silicon base. At that point, silicon began to deposit within the etched groove.

Sandia's A. Wayne Johnson, head of the