ILL WIND BLOWING

Authors:
Kirby, David
Source:
Discover; Apr2011, Vol. 32 Issue 3, p56-65, 8p
Abstract:
The article focuses on high levels of air pollution being produced by China's booming industry, which is being carried around the world by prevailing winds. Atmospheric chemist Dan Jaffe has been researching the phenomenon, finding pollution in Washington state that originated in Asia. The U.S. Environmental Protection Agency took note of his research and showed concern over mercury found in air samples, which can have a health impact on fetuses, among other effects.

Made in China: mercury, sulfates, ozone, black carbon, and flu-laced desert dust, liven as America tightens emission standards, the fast-growing economies of Asia are filling the air with toxins that circumnavigate the globe

"THERE IS NO PLACE CALLED AWAY" IT IS A STATEMENT WORTHY OF Gertrude Stein, but University of Washington atmospheric chemist Dan Jaffe says it with conviction: None of the contamination we pump into the air just disappears. It might get diluted, blended, or chemically transformed, but it has to go somewhere. And when it comes to pollutants produced by the booming economies of East Asia, that somewhere often means right here, the mainland of the United States. ¶ Jaffe and a new breed of global air detectives are delivering a sobering message to policy makers everywhere: Carbon dioxide, the predominant driver of global warming, is not the only industrial by-product whose effects can be felt around the world. Prevailing winds across the Pacific are pushing thousands of tons of other contaminants -- including mercury, sulfates, ozone, black carbon, and desert dust -- over the ocean each year. Some of this atmospheric junk settles into the cold waters of the North Pacific, but much of it eventually merges with the global air pollution pool that circumnavigates the planet.

These contaminants are implicated in a long list of health problems, including neurodegenerative disease, cancer, emphysema, and perhaps even pandemics like avian flu. And when wind and weather conditions are right, they reach North America within days. Dust, ozone, and carbon can accumulate in valleys and basins, and mercury can be pulled to earth through atmospheric sinks that deposit it across large swaths of land.

Pollution and production have gone hand in hand at least since the Industrial Revolution, and it is not unusual for a developing nation to value economic growth over environmental regulation. "Pollute first, clean up later" can be the general attitude, says Jennifer Turner, director of the China Environment Forum at the Woodrow Wilson International Center for Scholars. The intensity of the current change is truly new, however. .

China in particular stands out because of its sudden role as the world's factory, its enormous population, and the mass migration of that population to urban centers; 350 million people, equivalent to the entire U.S. population, will be moving to its cities over the next 10 years. China now emits more mercury than the United States, India, and Europe combined. "What's different about China is the scale and speed of pollution and environmental degradation," Turner says. "It's like nothing the world has ever seen."

Development there is racing far ahead of environmental regulation. "Standards in the United States have gotten tighter because we've learned that ever-lower levels of air pollution affect health, especially in babies and the elderly," Jaffe says. As pollutants coming from Asia increase, though, it becomes harder to meet the stricter standards that our new laws impose.

The incoming pollution has sparked a fractious international debate. Officials in the United States and Europe have embraced the warnings of the soft-spoken Jaffe, who, with flecks of red and gray in his trim beard, looks every bit the part of a sober environmental watchdog. In China, where economic expansion has run at 8 to 14 percent a year since 2001, the same facts are seen through a different lens.

China's smog-filled cities are ringed with heavy industry, metal smelters, and coal-fired power plants, all crucial to that fast-growing economy even as they spew tons of carbon, metals, gases, and soot into the air. China's highways are crawling with the newly acquired cars of a burgeoning middle class. Still, "it's unfair to put all the blame on China or Asia," says Xinbin Feng of the Institute of Geochemistry at the Chinese Academy of Sciences, a government-associated research facility. All regions of the world contribute pollutants,' he notes. And much of the emissions are generated from making products consumed by the West.

Our economic link with China makes all the headlines, but Jaffe's work shows that we are environmentally bound to the world's fastest-rising nation as well.

DAN JAFFE HAS BEEN WORRYING about air pollution since childhood. Growing up near Boston, he liked to fish in local wetlands, where he first learned about acid rain. "I had a great science teacher, and we did a project in the Blue Hills area. We found that the acidity of the lake was rising," he recalls. The fledgling environmental investigator began chatting with fishermen around New England. "All these old-timers kept telling me the lakes had been full of fish that were now gone. That mobilized me to think about when we burn fossil fuels or dump garbage, there is no way it just goes somewhere else."

By 1997 Jaffe was living in Seattle, and his interest had taken a slant: Could pollution reaching his city be blowing in from somewhere else? "We had a hunch that pollutants could be carried across the ocean, and we had Satellite imagery to show that," Jaffe says. "And we noticed our upstream neighbors in Asia were developing very rapidly. I asked the question: Could we see those pollutants coming over to the United States?"

Jaffe's colleagues considered it improbable that a concentration of pollutants high enough to significantly, impact American air quality could travel thousands of miles across the Pacific Ocean; they expected he would find just insignificant traces. Despite their skepticism, Jaffe set out to find the proof. First he gathered the necessary equipment. Devices to measure carbon monoxide, aerosols, sulfur dioxide, and hydrocarbons could all be bought off the shelf. He loaded the equipment into some university trucks and set but for the school's weather observatory at Cheeka Peak. The little mountain was an arduous five-hour drive northwest of Seattle, but it was also known for the cleanest air in the Northern Hemisphere. He reckoned that if he tested this reputedly pristine air when a westerly wind was blowing in from the Pacific, the Asian pollutants might show up.

Jaffe's monitors quickly captured evidence of carbon monoxide, nitrogen oxides, ozone, hydrocarbons, radon, and particulates. Since air from North America could not have contaminated Cheeka Peak with winds blowing from the west, the next step was identifying the true source of the pollutants. Jaffe found his answer in atmospheric circulation models, created with the help of data from Earth-imaging satellites, that allowed him to trace the pollutants' path backward in time. A paper he published two years later summarized his conclusions succinctly. The pollutants "were all statistically elevated… when the trajectory originated over Asia."

Officials at the U.S. Environmental Protection Agency took note, and by 1999 they were calling Jaffe to talk. They were not calling about aerosols or hydrocarbons, however, as concerning as those pollutants might be. Instead, they were interested in a pollutant that Jaffe had not looked for in his air samples: mercury.

Mercury is a common heavy metal, ubiquitous in solid material on the earth's surface. While it is trapped it is of little consequence to human health. But whenever metal is smelted or coal is burned, some mercury is released. It gets into the food chain and diffuses deep into the ocean. It eventually finds its way into fish, rice, vegetables, and fruit.

When inorganic mercury (whether from industry or nature) gets into wet soil or a waterway, sulfate-reducing bacteria begin incorporating it into an organic and far more absorbable compound called methylmercury. As microorganisms consume the methyl-mercury, the metal accumulates and migrates up the food chain; that is why the largest predator fish (sharks and swordfish, for example) typically have the highest concentrations. Nine-tenths of the mercury found in Americans' blood is the methyl form, and most comes from fish, especially Pacific fish. About 40 percent of all mercury exposure in the United States comes from Pacific tuna that has been touched by pollution.

In pregnant women, methylmer-cury can cross the placenta and negatively affect fetal brain development. Other pollutants that the fetus is exposed to can also cause toxic effects, "potentially leading to neurological, immunological, and other disorders," says Harvard epidemiologist Philippe Grandjean, a leading authority on the risks associated with chemical exposure during early development. Prenatal exposure to mercury and other pollutants can lead to lower IQ in children -- even at today's lower levels, achieved in the United States after lead paint and leaded gasoline were banned.

Among adults, University of California, Los Angeles, neuroscience researcher Dan Laks has identified an alarming rise in mercury exposure. He analyzed data on 6,000 American women collected by the Centers for Disease Control and Prevention and found that concentrations of mercury in the human population had increased over time. Especially notable, Laks detected inorganic mercury (the kind that doesn't come from seafood) in the blood of 30 percent of the women tested in 2005-2006, up from just 2 percent of women tested six years earlier. "Mercury's neurotoxicity is irrefutable, and there is strong evidence for an association with Alzheimer's and Parkinson's disease and amyotrophic lateral sclerosis," Laks adds.

CIRCUMSTANTIAL EVIDENCE STRONGLY pointed to China as the primary origin of the mercury; the industrial processes that produce the kinds of pollutants Jaffe was seeing on Cheeka Peak should release mercury as well. Still, he could not prove it from his data. To confirm the China connection, and to understand the exact sources of the pollution, researchers had to get snapshots of what was happening inside that country.

One of the first scientists with feet on the ground in China was David Streets, a senior energy and environmental policy scientist at Argonne National Laboratory in Illinois. In the 1980s he was at the forefront of the study of acid rain, and in the 1990s he turned his attention to carbon dioxide and global warming as part of the Intergovernmental Panel on Climate Change. Streets began focusing on emissions from China about 15 years ago and has since become such a noted expert that he helped the Chinese government clean up the smoke-clogged skies over Beijing before the Olympics in 2008.

In 2004, spurred by increased attention to mercury in the atmosphere, Streets decided to create an inventory of Chinas mercury emissions. It was a formidable undertaking. Nobody had ever come up with a precise estimate, and the Chinese government was not exactly known for its transparency.

Nevertheless, Streets considered the endeavor important because China . is full of the two biggest contributors to human-generated mercury, metal smelting and coal combustion. Smelting facilities heat metal ores to eliminate contaminants and extract the desired metal, such as zinc, lead, copper, or gold. Unfortunately, one of the consistent contaminants is mercury, and the heating process allows it to escape into the atmosphere in gaseous form. Similarly, coal contains trace amounts of mercury, which is set free during combustion at power plants.

Streets began by studying reports from China's National Bureau of Statistics. China's provinces provide the central government with detailed data on industrial production: how much coal they burn, how much zinc they produce, and so on. "China is very good at producing statistical data. It's not always 100 percent reliable, but at least it's a start," he says. Those statistics help the Chinese government monitor the economy, but for Streets they also quantified China's mercury-laden raw materials.

The numbers from the statistics bureau told Streets the total amount of mercury that might be emitted, but he also needed to know how much actually made it into the air. To obtain that information, he turned to pollution detectives -- a group of professional contacts he had met at conferences, along with graduate students who spent time in his lab. Most of the time, Chinese factories turned these "spies" away. "Factory owners had nothing to gain and a lot to lose," Streets says. "They were nervous that the results would get leaked to the government."

Yet some of Streets's moles got through by guaranteeing that the data would stay anonymous. Once inside, they took samples of raw materials -- zinc ore in a smelting facility, for example -- and installed chemical detectors in smokestacks. After a few days of data collection, they passed the information to Streets.

The statistics Streets collected were hardly airtight. Factory foremen and provincial officials were not above providing inflated data to make themselves look more productive, and the managers who were willing to let his inspectors take measurements were often the very ones with nothing to hide. "There's still a lot of uncertainty," Streets concedes, "but we know more than we did before."

In 2005 Streets and his team reported their first tally of human-generated mercury emissions in China, for the year 1999. The scientists estimated the amount at 590 tons (the United States emitted 117 tons). Almost half resulted from the smelting of metals -- especially zinc, because its ores contain a high concentration of mercury. Coal-burning power plants accounted for another 38 percent of Chinese mercury emissions, and that percentage may be going up. As recently as 2007, China was building two new power plants a week, according to John Ashton, a climate official in the United Kingdom.

Streets's team published a subsequent inventory estimating that China's mercury emissions had jumped to 767 tons in 2003. "Mercury emissions in China have grown at about 5 to 6 percent a year," he says. "It's pretty much undeniable."

Streets had shown that China was churning out mercury, but he was left with a big uncertainty: What happened to it on its journey aloft? Finding the answer fell to Hans Friedli, a chemist at the National Center for Atmospheric Research (NCAR) who had spent 33 years working for Dow Chemical. Friedli had found his own path into the esoteric world of pollution forensics. Back in the early 1990s, a conversation with his neighbor, an NCAR scientist, sparked an interest in wildfires, a major source of mercury emissions. By 1998 he had a full-time job tracking the toxin for NCAR.

With its copious mercury emissions (not only from industry but also from volcanoes, wildfires, and dust storms), Asia drew Friedli's interest. China would never allow him to do aerial studies in its airspace, but in 2001 he heard about research flights off the coasts of Japan, Korea, and China designed to track dust particles emanating from the mainland. Friedli convinced the research team to take him along to measure mercury concentrations in the atmosphere. Throughout April 2001,19 researchers, professors, and grad students took 16 flights aboard a cavernous retired Navy C-130 plane custom fit with 19 instruments for measuring pollutants like carbon monoxide, sulfur, and ozone.

During each flight, Friedli sat at his station awaiting readouts from his mercury sensor: an intake valve that sucked in air and guided it over a gold cartridge within the plane. Any mercury in the air would be absorbed by the gold. Every five minutes the instrument rapidly heated the gold, releasing any trapped mercury.

Plumes of mercury-laced air near the earth's surface are mixed with other pollutants, but at 20,000 feet Friedli discovered concentrated mercury plumes soaring eastward toward North America. He concluded those plumes must have circled the entire globe at least once, releasing more ephemeral pollutants like carbon monoxide so that the mercury stood out even more.

Eager to follow the trail of Asian mercury plumes, Friedli set his sights across the Pacific, off the West Coast of the United States. In a series of 11 research flights in 2002, he identified a plume that looked very much like the ones he'd found near China the year before. Specifically, the plume had a carbon monoxide-to-mercury ratio that served as a fingerprint for gases from the same source.

What Friedli detected was just one detail of a much larger picture. Mercury plumes can wobble in latitude and altitude or park themselves in one spot for days on end. Emissions from China -- and from the United States, and indeed from every industrial country -- feed a network of air currents that, as equal-opportunity polluters, serve up toxic mercury around the world.

DRAWING INSIGHTS FROM RESEARCH BY Friedli and Streets, Jaffe looked at his data anew. If mercury were arriving from' China, he should be able to detect it, yet his operation on Cheeka Peak showed no such signal. Conducting reconnaissance from a plane, he realized why. The peak, at 1,500 feet, hovered below the mercury plume line. Seeking a higher perch, he chose Mount Bachelor, a ski resort in central Oregon with an altitude of 9,000 feet.

In late winter 2004, Jaffe and his students huddled deep in their down jackets, bracing against a bitter gale that buffeted the chairlift ferrying them and their costly equipment to the summit. Inside the mountaintop lodge they installed a small computer lab and extended tubes outside to vacuum up the air. Later that year they conducted a similar experiment in Okinawa, Japan.

Back in Washington, they plotted their analysis of mercury in the air against satellite data showing wind currents. "My hypothesis was that we would see the same chemicals, including the same ratio of mercury to carbon monoxide, from Mount Bachelor and Japan," Jaffe says. The numbers showed exactly the expected similarity. "This was a real aha moment for us, because the two regions were phenomenally close."

It was the first time anyone had decisively identified Asian mercury in American air, and the quantities were stunning. The levels Jaffe measured suggested that Asia was churning out 1,400 tons a year. The results were a shock to many scientists, Jaffe says, because "they still couldn't wrap their heads around the magnitude of the pollution and how dirty China's industry was." They were only starting to understand the global nature of the mercury problem.

Over the years, Jaffe's Mount Bachelor Observatory has also monitored many other noxious pollutants wafting across the Pacific. One major category is sulfates, associated with lung and heart disease. When sulfur dioxide exits China's coal and oil smokestacks, it converts into sulfates in the air. "Sulfates are water-soluble and get removed from the atmosphere relatively quickly, creating acid rain that falls in China, Korea, and Japan," Jaffe says. Yet some of the sulfates stay aloft, finding their way here and contributing to smog along the West Coast.

Another Chinese import is black carbon, the soot produced by cars, stoves, factories, and crop burning and a major component of Chinese haze. The small diameter of the carbon particles means they can penetrate deep inside the lungs, providing absorption sites for secondary toxins that would otherwise be cleared. This compounds the danger, making black carbon an especially potent risk factor for lung disease and premature death.

The biggest pollutant coming out of Asia, at least in terms of sheer mass, could be dust from the region's swelling deserts. "It's not a new phenomenon," Jaffe says, but it has gotten worse with deforestation and desertification caused by poorly managed agriculture. About every three years, a huge dust storm over China sends enormous clouds across the Pacific. "We can visually see it," Jaffe says. "It usually hangs around for about a week. We've tried to quantify how much it contributes to the particulate loading here, and it's a little under 10 percent of the U.S. standard on average each year. It's a significant amount."

Chinese dust has obscured vistas in U.S. national parks, even on the East Coast. The amount of dust is widely variable and can hit rare extreme peaks. The highest level recorded was from a 2001 dust event. "It reached approximately two-thirds of the U.S. air quality standard at several sites along the West Coast," he reports. One study from Taiwan tracked avian flu outbreaks downwind of Asian dust storms and found that the flu virus might be transported long-distance by air spiked with the dust.

Perhaps the most counterintuitive traveling contaminant is ozone, commonly associated with ground-level pollution in cities. Volatile organic compounds, carbon monoxide, and nitrogen oxides from Asian cars and industry mix in the atmosphere as they cross the Pacific Ocean and convert in sunlight into ozone, a main ingredient in smog, Jaffe explains. When air with high ozone concentrations touches down in North America, it can pose the classic dangers of urban smog: heart disease, lung disease, and death.

Jaffe recently coauthored a paper on Asian ozone coming to America. It found that ozone levels above western North America creep upward every spring. "When air was coming from Asia, the trend was strongest. That was the nail in the coffin," Jaffe says. "The increase was estimated at 0.5 part per billion [ppb] per year. But that's huge. In 10 years that's another 5 ppb. Let's say the EPA orders a 5 ppb reduction and we achieve that, and yet, because of the growing global pool, in 10 years that gets wiped out. We'll have to keep reducing our emissions just to stay even."

THE UNDERLYING MESSAGE OF JAFFE'S detective work should not be all that surprising: All of the world's atmosphere is interconnected. People have accepted this notion when it comes to carbon dioxide or the chemicals that eat away at the ozone layer, but Jaffe is finding that they are still coming to terms with the reality that it applies to industrial pollutants in general.

The fact is, those pollutants are everybody's responsibility, not just China's. The EPA has estimated that just one-quarter of U.S. mercury emissions from coal-burning power plants are deposited within the contiguous U.S. The remainder enters the global cycle. Conversely, current estimates are that less than half of all mercury deposition within the United States comes from American sources.

Then again, the United States has spent considerable effort over the past half-century trying to clean up its act. China is still much more focused on production. To fuel its boom, China has become a pioneer in **wind** power but has also begun buying up huge inventories of coal from markets around the world. Streets recently estimated that China's use of coal for electricity generation will rise nearly 40 percent over the next decade, from 1.29 billion tons last year to 1.77 billion tons in 2020. That is a lot more pollution to come.

"It's a classic example of a tragedy of the commons," Jaffe says, refer-ring to a dilemma in which individuals act in their own self-interest and deplete a shared resource. "If 20 people are fishing in the same pond, with no fishing limit, then you catch as many as you can because it will be empty in weeks. Nobody has an incentive to conserve, and the same goes for pollution."

The discovery of the global mercury cycle underscores the need for an international treaty to address such pollutants. Under the auspices of the United Nations, negotiations have at least begun. Jaffe, Streets, and China's Xinbin Feng are now consultants to the UN. Environment Programme's Global Partnership on Mercury Atmospheric Transport and Fate Research, which helped contribute data that led to a proposed UN. mercury treaty in 2009.

When it comes to some pollutants, China has taken important steps. For instance, recent policies encourage desulfurization and other filtering technology in power plants. But convincing developing nations to move aggressively on mercury may be at least as tough as mobilizing them against carbon emissions. "This is not considered a pollutant that urgently needs to be controlled on the national level," Feng says. "It's not fair that you emitted so much mercury and other pollutants when you had the chance to industrialize. You had 200 years, and now you want to stop other countries from developing too."

"We need to be concerned," Jaffe counters in his low-key way. "There is no Planet B. We all live downwind."

He sent his spies into Chinese factories to determine how much mercury was entering the atmosphere. Usually they were turned away, but every so often a manager let them in with the promise off anonymity.

All the atmosphere is interconnected. People are still coming to terms with the reality that it applies to industrial pollutants.

On the Pollution Trail

This NASA satellite photo of East Asia documents a common path for industrial pollutants once they enter the atmosphere; along the way, South Korea and Japan can receive acid rain resulting from China's sulfate emissions. The inset map is a computer model of Asian mercury emissions across the Pacific Ocean at an altitude of 20,000 feet in April 2004, while atmospheric chemist Dan Jaffe was picking up significant mercury readings on Mount Bachelor (the highest concentrations are in red). The model indicates that Asian mercury can reach western North America in as little as four days. Satellite images and atmospheric models such as these have helped Jaffe demonstrate how mercury and other emissions from China feed into a complex network of air currents that distribute pollutants across the globe.