# Health

AN ECOSYSTEM APPROACH



## Mercury Contamination in the Amazon

### Reducing soil erosion may provide a lasting solution

*Brazilian and Canadian researchers seeking to find the source of mercury contamination in the Amazon came to a startling conclusion: agricultural practices rather than gold mining were most to blame. Supported by Canada's International Development Research Centre (IDRC), the research team is now working with communities to find short- and long-term solutions to the serious health and environmental problem.*

IDRC: Jean Lebel

On the Tapajós river and other Amazonian waterways, mercury contamination is mainly caused by deforestation upstream.

Every year for almost a decade, Canadian and Brazilian researchers armed with hammocks and lab equipment have chugged their way up a tributary of the Amazon River. There are few roads in the Amazon Basin, and the waterway is the main transportation route. The boats are the researchers' laboratories and temporary home.

In the researchers' jargon, the aim of this joint Canadian-Brazilian project is to merge scientific findings with the traditional knowledge of communities to find sustainable and lasting solutions to the problem of human mercury poisoning in the Amazon.

From various specialties — neurotoxicology, ethnobotany, cytogenetics, sociology, biogeochemistry, environmental sciences, agriculture, and forestry — the researchers spend weeks, sometimes months, each year testing the soils and river systems for mercury levels and making an inventory of fish species and contamination levels. But the most important work is with the villagers living along the river, discussing the problems and hazards with them; checking their manual dexterity, coordination, and vision as well as blood, urine, and hair samples; and then working together on solutions.

### Mercury in the Amazon

For some years, the focus of the research has been Brasilia Legal, a village of 500 people on the banks of the Tapajós River. Accessible only by water, and a 12- to 18-hour boat trip from the nearest large city, it is some 250 km downstream from Brazil's most extensive gold-mining fields.



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Brasilia Legal's proximity to the gold mines is the crucial factor in the research that started in 1994. The Tapajós flows through the heart of northern Brazil's rain forest and a major gold rush occurred along its banks in the 1970s. Since then, a million miners have panned there for ore, using mercury to extract the precious metal. Much of the mercury is recycled, but every year many tonnes are lost from dumping or evaporation, and this finds its way into the surrounding area.

Concerned about the health risks, scientists at the Federal University of Pará in Belém teamed up with the Université du Québec à Montréal (UQAM) in the early 1990s to find the contamination's source and measure the impact on local inhabitants' health. Funded by Canada's International Development Research Centre (IDRC), the researchers set out to live like the people along the river, eating fish twice a day. Within one three-week period, recalls Dr Jean Lebel, team leader with IDRC's Ecosystem Approaches to Human Health (Ecohealth) program, the level of methylmercury in researchers' hair doubled or tripled.

The team expected to find that the mercury levels in the water, sediment, and soil decreased as they got further from the goldfields. To their surprise, it remained constant up to 400 km from the site. It was obvious that although mining was contributing to mercury contamination within 50 km of the goldfields, it was not the major cause of mercury pollution further downriver.

## A poisonous chain

Studies revealed widespread contamination in river sediments, in many of the fish, and in people living beside the river. The researchers had reason to be alarmed. Mercury in the food chain is a universally recognized health hazard. Once mercury is released into rivers and lakes, bacteria can transform it into its organic form — highly toxic methylmercury — that can be absorbed by microscopic aquatic organisms and insects eaten by fish. These fish are eaten by larger fish and, in turn, the larger fish are eaten by humans, who receive the highest concentration.

Methylmercury poisoning — known as Minamata Disease after the Japanese community where thousands of people were affected in the 1950s — attacks the nervous system and brain, causing tingling sensations, muscle weakness, unsteady walk, tunnel vision, slurred speech, and hearing loss. It can lead to paralysis, convulsions, and death, and can affect neural development in fetuses, crippling the child's development.

After checking soils and sediment samples, the researchers came to the conclusion that the mercury was occurring naturally in the soil and was being released into the river system — and eventually the food chain — by slash-and-burn farming (see box: "How did mercury get into Amazonian soils?"). Analysis of riverbed sediments, sampled in half-centimetre increments, showed that the most recent layers contained 1.5 to 3 times more mercury than layers deposited 40 years ago.

### How did mercury get into Amazonian soils?

Mercury is one of the most poisonous natural substances known. That's why many countries are phasing it out in household, commercial, medical, and industrial applications.

Mercury occurs naturally. It spews from volcanoes, evaporates off bodies of water, and rises as gas from the Earth's crust. Eventually it falls to Earth in rainwater to settle in soils and sediments, oceans and lakes.

"Mercury is emitted by any volcano around the world and travels very long distances on the wind," says Dr Marc Lucotte, a biogeochemist at the Université du Québec à Montréal who worked on IDRC's Brazil project for years. "The soils in the Amazon are very old — 500 000 to a million years old. They have been receiving mercury from the atmosphere for a very long time. This is why there is so much mercury in the soil. In Canada, the last glaciation occurred 10 000 years ago. When the ice receded, there were just bare rocks. The soils have been building up for only 10 000 years and so there is only 10 000 years' worth of accumulating mercury. Our soils are very young, but the Amazon soils are very old and have immense reservoirs of mercury."

The area has undergone massive colonization in the last 40 years and most of the colonists farm for a living. This involves clearing large tracts of forest, typically by slash-and-burn methods. Similarly, when cleared soils lose their fertility after a few years, the farmers clear adjoining areas of forest by cutting down the trees and burning them. It's estimated that in the late 1990s more than 2.5 million hectares of the Amazon region were deforested.

As there are few roads in the region and waterways are the major means of access, slash-and-burn and the resulting deforestation occur mainly along the riverbanks. As the mercury-contaminated soil is exposed, heavy rains wash contaminants into the water systems. There, microorganisms and water plants absorb the mercury and convert it into methylmercury, which is potentially harmful to humans. Fish eat the waterplants, then bigger fish eat the smaller fish. The mercury passes up the food chain to the top predators — humans.

"This is happening all over the world where thick tropical rain forests are being removed," says Dr Lucotte. "Other researchers are starting to find some problems in Indonesia and Africa, for example. If humans eat fish, they are exposed to the mercury. If they eat birds that eat fish, the level of mercury can be even higher."

A year after the initial research began, the team led by Dr Donna Mergler, a university professor, neurotoxicologist, and director of UQAM's Institute of Environmental Studies, met with the villagers of Brasilia Legal to enlist their cooperation.

None of the villagers tested displayed severe symptoms of mercury poisoning but they were experiencing declines in coordination, manual dexterity, and vision. The study also revealed a direct relationship between declining coordination and increasing levels of methylmercury in their hair. This was another surprise for the researchers — the mercury levels in hair samples were below that considered "safe" by the World Health Organization. It was obvious that mercury could damage human health even at levels well below accepted international safety standards.

The researchers also discovered a link between the seasons and the amount of methylmercury in villagers. Testing of the 40 local fish species showed that herbivorous or plant-eating fish contained very little mercury, while predatory fish contained the most. People who ate mostly herbivorous fish were found to have

less mercury than those who ate mostly predatory species — and mercury exposure varied by season, depending upon fish availability.

## The search for solutions

Having found the source and extent of the contamination, the researchers moved into the project's second phase — working with the villagers to find solutions. The researchers worked closely with the village women — teachers, health workers, and fisher women who not only chose fish for their family's consumption but also marketed salted fish in exchange for vegetables. The community suggested using a poster showing the different kinds of fish and how each rated for mercury contamination. Those most contaminated were shown in red on the poster, orange was used for the less contaminated, and green for those with least contamination. All families received the poster, and the commercial fishermen started to spread the knowledge to surrounding communities. "Eat fish that don't eat other fish" became the slogan.

When hair samples provided by 45 villagers from the original 1995 group were again analyzed in 2002, the results were highly encouraging: hair mercury levels had decreased by 40 percent. Dr Mergler says: "This is truly incredible. People are sensible. It shows that when people are part of a research project, they can appreciate the findings."

Thirty women subsequently offered to participate in a food-consumption study. With the village midwife acting as coordinator, the women kept track of what they ate daily for 14 months. Dr Mergler's research team then took a long strand of each woman's hair, cut it into one-centimetre segments representing one month's growth, and measured the mercury levels. By checking the corresponding month's growth against the diet sheet, they could tell how the food eaten was affecting mercury absorption. "For a similar amount of fish consumption, those who ate more fruit had lower mercury levels," Dr Mergler points out.

IDRC: Jean Lebel

Researchers concluded that mercury occurred naturally in the soil and was being released into the river system.

IDRC: Jean Lebel

Teams of young Brazilian and Canadian researchers have gained valuable field experience through the project.

"This important discovery has important repercussions not only for health but also for future agricultural practices."

The researchers, in collaboration with local farmers, are now identifying crops that can augment food sources and improve the diet while decreasing the leaching of mercury from the soil. One tree in particular is raising hopes: it grows locally, improves the soil, and produces a fruit that, when eaten, may reduce mercury levels in the human body.

Researchers have also worked with the fishermen to identify hot spots — areas in the river with conditions that favour the transformation of mercury into toxic methyl-mercury. Research by Dr Jean-Rémy Davy Guimaraes of the Federal University of Rio de Janeiro, who heads the project in Brazil, showed that mats of floating water plants and the fauna living on them are key in the conversion. Now proliferation of the mats is being limited by shoreline conservation and restoration.

## Participation is key

Central to the ecosystem approach is empowering the community to act on research results. "Every time we go back to the village we have workshops and meetings with the local people," says Dr Robert Davidson, scientific advisor at the Montréal Biodome and adjunct professor at UQAM's Institute of Environmental Sciences. "We tell them what we have found. It's a matter of building a relationship of confidence."

Brazilian social researcher Elizete Gaspar, a doctoral student, says that the women's role was crucial in changing the dietary habits of the villagers and attributes the project's success to "intensive and participatory work with the community, based on a trusting and committed relationship between villagers and researchers."

Results of the project's first two phases have been published and presented at a number of scientific events. The project is regularly showcased as a successful example of the ecosystem approach to human health. It is considered a breakthrough because it led to counter-intuitive results: mining had been assumed to be the

main cause of mercury contamination but, in fact, research showed it to be soil erosion. And the contact with and inclusion of the local community in the project has produced short-term solutions — changes in types of fish eaten and the diet.

## Lasting contributions

The project's recently approved third phase will "regionalize" research to the whole Low-Tapajós River basin, involving more communities and a network of key village personnel in finding both short- and long-term solutions. Short-term measures will encourage dietary changes to include more tropical fruit, for example, and the types of fish that contain less mercury. This will mean a change of fishing habits. Long-term solutions will include reforestation and changes in agriculture to reduce soil erosion throughout the area. Once again, as in the first and second phases, community involvement will be key to success.

"Agroforestry programs can contribute to reducing soil erosion and therefore the source of pollution," says Dr Renaud De Plaen, senior program specialist with IDRC's Ecohealth program. "Using specific tree species that bear fruit which slow the absorption of mercury can affect local people's exposure to mercury. Reinforcing or supporting agroforestry projects may therefore represent a key natural resource management strategy for rural communities in the Tapajós valley."

IDRC: Jean Lebel

Community participation is key to success, all the more as the research is now being extended to the entire river basin.

The project has had another benefit for both Brazil and Canada: it has allowed a group of young researchers at the master's and doctorate levels to build up skills and knowledge. The team in the first and second phases has included not only UQAM and the Federal University of Para students, but also students from the Federal University of Rio de Janeiro. The project's third phase will also involve Brazilian students. When the project is finally completed, IDRC's legacy will be this new crop of researchers, both Brazilian and Canadian.

This *Case Study* was written by Maureen Johnson on behalf of IDRC's Communications Division.

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## Ecosystem Approaches to Human Health

Human health and well-being are intimately tied to the health of the ecosystems that sustain life. Yet the potential for improving health by better managing the local environment is an avenue rarely explored in mainstream health programing. Through its Ecosystem Approaches to Human Health (Ecohealth) Program Initiative, IDRC aims to identify the web of economic, social, and environmental factors that influence human health. Communities can then use this knowledge to better manage ecosystems and improve the health of both people and the ecosystem.


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