Researcher Profile: Linda Campbell’s Quicksilver Quest

Linda Campbell at Kenya’s Lake Nakuru. (Photo courtesy of Linda Campbell)

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Linda Campbell’s blue camp cooler has many miles on it. She’s taken it all through East Africa’s Rift Valleys, hauling lake fish samples to analyze for the presence of mercury. Her mercurial quest began when she was a PhD student at the University of Waterloo and continues now that she’s an assistant professor at Queen’s University in the Department of Biology and the School of Environmental Studies. Her journey may not finish soon.

“Even though I finished my PhD thesis a while ago, I still don’t think that is the end of the story,” Campbell says. “We uncovered many important questions that still need to be answered.”

Testing the waters

Six years ago, spurred by concerns over crude refining methods used by small-scale African gold miners, Campbell began testing for mercury in Lake Victoria’s fish and water. She was supported by a Doctoral Research Award from the International Development Research Centre (IDRC). She also had support from Uganda’s Fisheries Research Institute, the Kenya Marine and Fisheries Research Institute, and the Tanzania Fisheries Research Institute.

Campbell’s thesis project grew as she took samples from fish sold at markets near Lake Victoria and from research fishing expeditions on the lake itself and tucked them into her cooler.

“Wherever my colleagues and I went, we always attracted crowds who were curious about what we were doing with the fish, and why,” she says. “When I worked and traveled in Africa, and discussed my work with fisherfolk, local people, and scientists living there, the questions most frequently asked of me were: How much mercury is there in the fish? What are the risks to humans dependent on relatively cheap fish protein?”

Those questions led her to widen her scope, comparing different lakes’ mercury concentrations, and seeing if fishes’ places in the food web hierarchy affected the mercury they accumulated. She did this so she could tell people which fish, from which lakes, were safe to eat or sell.

Pinpointing sources of mercury

Lake Victoria is an economic engine and protein source for millions who live around it. Kenya, Tanzania, and Uganda for a time sold Nile perch and tilapia in the European Union (EU). In the early 1990s, however, the EU banned fish from Lake Victoria over concerns about the way fish was being processed. This caused financial crunches in all three countries. As world fish stocks decline, the EU is now interested in importing another small, sardine-like fish (*Rastrineobola argentea*) from Lake Victoria.

Whether mercury is present in lakes and fish, and where it comes from, are becoming questions throughout East Africa. Many of the region's important lakes — Lake Kyoga, Lake Albert, Lake Saka, Lake Nkuruba, Lake Tanganyika, Lake Turkana, Lake Baringo, Lake Nakuru, Lake Naivasha, and Lake Malawi — fall along or between the Eastern and Western Rift Valleys, straddled by the Democratic Republic of Congo, Ethiopia, Kenya, Malawi, Mozambique, Sudan, Tanzania, and Uganda.

Researchers now see fish consumption and soil geography as the main sources of mercury exposure for people around the lakes, Campbell says. Mercury bio-accumulation in East African lakes poses little risk to people, but she believes lakes with longer food webs require more research. A food web is formed of several interrelated food chains, all connected in the same environment.

The original concern at Lake Victoria was the refining process used by small-scale East African miners. They would crush raw gold ore, mix it with liquid mercury in cloth bags, and then set the bags on fire to fuse mercury and gold. Gold is easier to extract from the resulting amalgam. However, if enough methylmercury from mine sites leaches into nearby lakes and enters their food webs, it could lead to neurological damage, especially for at-risk groups such as newborn babies, young children, expectant mothers, and the elderly.

With a second research award from IDRC, Campbell set off to investigate these issues, her cooler in tow.

Where there's smoke….

Indeed, people near gold mines tended to have greater exposure to mercury. But, Campbell says mercury levels from various exposure routes — including fish consumption, bathing, and drinking — still fell within safe limits. Health Canada has defined the tolerable daily intake (TDI) guideline as 710 ng/kg/day, (nanograms of consumption, per kilogram of body weight, per day). Mines' mercury footprints were localized around amalgam burn sites, and the metal didn't seem to be spreading into the lakes.

Moreover, Campbell says, core samples from Victoria's lakebed suggest mercury in East African lakes comes from atmospheric sources. Rising mercury levels match increases in human populations nearby. More cores are needed to add to the data, but the common African practice of burning vast tracts of farmland to renew soil fertility appears to be the likeliest source.
"Plants can take up mercury from the soil, and when burned, the mercury is released into the atmosphere," Campbell says. Photos from space show huge visible plumes of smoke from burning biomass stretching across Africa's lakes. "So, what seems like an insignificant source to us could be a major source in Africa," she adds.

Campbell tested popular food fish varieties — plant-eating tilapia and fish-eating Nile perch and black bass — for mercury. Most fish she took samples from were safe to eat.

Only the largest predators — big Nile perch — were likely to hold risky mercury levels. Campbell says that overfishing has greatly reduced the number of really large Nile perch with mercury levels that exceed World Health Organisation (WHO) limits for people considered to be at risk from mercury toxicity, including pregnant women, young children, and those who frequently consume fish.

In fact, Campbell says, “There is a significant correlation between mercury concentrations in top predators and the food web length.”

Campbell found that mercury levels in virtually all plant-eating tilapia samples from other Rift Valley lakes, as in Lake Victoria, fell below WHO guidelines and less stringent international marketing guidelines. Most Nile perch fell below the limits, too. However, Nile perch and tigerfish from Lake Albert held higher concentrations of mercury than fish from any other lake — many above WHO limits. Curiously though, Lake Albert’s tilapia had among the lowest mercury levels of all her samples. This could mean, says Campbell, that where fish varieties sit in the food web is a more important variable than the quality of the lake environment in which they live.

Comparisons with the Canadian Great Lakes

Comparing water and lakebed sediment samples, Campbell was also intrigued by the differences between tropical and temperate lakes. The Rift Valley lakes she looked at and Canada’s Great Lakes are almost reversed in a couple of important mercury characteristics.

Both kinds of lakes have about the same mercury levels in their sediments. Although most fall within international safe limits for drinking water, African lakes have higher levels of waterborne mercury. Yet their top predator fish varieties don’t accumulate nearly as much mercury as similar ones in Canada’s Great Lakes, which have rather lower levels of waterborne mercury.
“This is one question that I won’t be able to answer now, but am going to study: why is mercury so high in African lake water but so low in African fish?” Campbell asks.

Campbell is considering new, related ventures. One immediate research project will focus on human and ecosystem health by measuring risks of elevated mercury to people around Lake Albert, finding out how mercury affects economically important fisheries, and determining ways to try to deal with the situation. Uganda’s Makerere University and Fisheries Research Institute are concerned about the problem, as is the Ugandan government.

A second research project would compare pristine lakes in Argentina’s protected Nahuel Huapi National Park to North American and African lakes, to understand the way in which mercury cycles through small lake ecosystems in different climates and settings.

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