Fishing for Identity: Mercury Contamination and Fish Consumption Among Indigenous Groups in the United States

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Mercury contamination of local fish stocks has become an escalating problem in the United States. Federal and state governments increasingly have issued fish consumption advisories to warn individuals of the risks of eating specific species of fish in particular quantities from individual bodies of water. Some indigenous groups in the United States who rely on these fisheries for subsistence and ritual cultural reasons have become disproportionately impacted by the risks of mercury contamination of their food source. Some of these groups are forced to make a decision whether to continue their cultural life ways and become exposed to mercury or to stop eating fish and witness the degradation of their identity. This article explores the unique conditions of cultural fishing practices among Native American groups in the United States and their disproportionate risk to mercury contamination. Spatial analysis using the geographical information systems software is accompanied by two case studies to explore the risks faced by indigenous communities.

Keywords: *fish consumption; fish contamination; indigenous people; ethnic identity; mercury*

Fish consumption from local waters is not equally distributed among Americans. Due to their fishing and consumption practices, Asian Americans, African Americans, and Hispanic Americans are all considered so-called sensitive populations. This study focuses on the unique conditions of fishing among some Native American groups, for which fishing is an important social practice that can place them at disproportionate risk to environmental pollutants that concentrate in fish tissue. One such pollutant, mercury, has been shown to be a cause for great concern among indigenous groups in the United States.

Mercury Pollution

Mercury exists in the environment in several forms and readily changes from one form to another because of environmental and biological processes. Of the three most common forms that occur in the natural environment, elemental mercury (HG^0), inorganic mercury (HG^{2+}), and methyl mercury (MeHg), methyl mercury poses the greatest threat to human and ecosystem health. Through organic processes known as methylation, elemental and inorganic mercury are transformed into methyl mercury. It is the more dangerous form of methyl mercury that appears in aquatic environments (Cook, 1997, p. 173; Ganguli, Mason, Abu-Saba, Anderson, & Flegal, 2000, p. 4773; Marvin-Dipasquale et al., 2000, p. 908).

Mercury is used widely in industrial processes and is a byproduct of the burning of fossil fuels and solid waste. Mercury has been used in more than 3,000 industries, from the medical industry to pesticides to chlor-alkali production and battery manufacture. Of all the mercury used in industry, 80% returns to the environment. Today, fossil fuel combustion by electrical utilities and solid waste incineration are responsible for 87% of anthropogenic emissions of mercury in the United States. During 1999, total mercury emissions from power plant emissions exceeded 95,000 pounds (Cook, 1997, p. 174; U.S. Environmental Protection Agency, 1999, 2001, p. 1).

In comparison with other heavy metals that are associated with particulate matter, mercury vapor has

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an extremely long "atmospheric residence time," from 6 months to 2 years (Schroeder & Munthe, 1998, p. 810). As a consequence, mercury can travel great distances. Elemental mercury is able to travel up to tens of thousands of kilometers, whereas inorganic mercury is able to travel from a few tens to a few hundred kilometers. The shortest range mercury, particulate mercury, is still able to travel "intermediate" distances, "depending on aerosol diameter/mass" (p. 813).

Riverine environments become contaminated with ambient mercury through processes of atmospheric deposition, including wet scavenging by means of precipitation. The extent of mercury contamination in some watersheds has been directly related to the size of the drainage basin, illustrating the importance of nondiscriminate atmospheric inputs into a watershed environment (Hoff et al., 1996, p. 3507; Hurley, Cowell, Schafer, & Hughes, 1998, p. 129, 130; Louchouarn & Lucotte, 1998, p. 140; Schroeder & Munthe, 1998, p. 813).

Unlike other contaminants that fix to soils, mercury not absorbed by various forms of aquatic biota is available to recycle back into the atmosphere. Because of the cumulative problems of substantial anthropogenic mercury releases, its ability to reenter the atmosphere, and its long residence time in aquatic and atmospheric environments, the problem of pollution is likely to continue to worsen (U.S. Environmental Protection Agency, 1997, pp. 2-4).

The aquatic food chain plays a critical role in how methyl mercury enters fish tissue. Fish naturally absorb methyl mercury into their tissue both directly from water as it passes over their gills and by eating other contaminated fish. Of the mercury that has been absorbed by fish, greater than 95% is methyl mercury. Methyl mercury bioaccumulates in fish and biomagnifies through the food chain. As a result, the level of mercury in individual fish depends on their age, size, tropic level, diet, metabolic rate, growth rate, excretory pathways, and habitat preferences. Methyl mercury can concentrate to much higher levels in fish tissue than in the surrounding waters, "by a factor of $10^{6.5}$" (Cook, 1997, pp. 174, 178; Hudson, Gherini, Watras, & Porcella, 1994, p. 501; Kehrig, Malm, & Akagi, 1997, p. 17; Neumann, Kauffman, & Gilroy, 1997, p. 211; Raloff, 2001).

Threats of Mercury to Human Health

Methyl mercury exposure from consumption of contaminated fish is much more dangerous than other forms of mercury exposure. When exposed to elemental mercury in various forms, either in water, air, or food, the human body absorbs only .01%. This contrasts with an absorption rate of 90% to 100% for methyl mercury through the gastrointestinal tract. Mercury has an extended duration period in the human body, from a minimum of 50 days to more than 120 days (Cook, 1997, pp. 175, 181; Mahaffey & Mergler, 1998, p. 104; U.S. Environmental Protection Agency, 2001, p. 5).

Acute mercury poisoning, such as that seen in two incidents in postwar Japan (Minamata Bay and Nigata), can lead to paralysis and death. Chronic exposure to lower levels of mercury also results in debilitating health effects, including nervous system and kidney damage and genetic effects. The toxicological effects of mercury are now also being considered as a contributing factor for some cases of autism (Bernhard, Enayati, Redwood, Roger, & Binstock, 2001, pp. 462-471; Cook, 1997, pp. 175, 179, 181; Simonin & Meyer, 1998; U.S. Environmental Protection Agency, 2001, p. 5).

Children are impacted disproportionately when exposure occurs during in the fetal stage. Mercury readily passes the placental barrier and concentrates to levels 30% higher in the red blood cells of the fetus than in the mother. A pregnant woman could be exposed to high levels of mercury and not demonstrate any symptoms. Yet, her child, when born, could suffer debilitating effects from the bioaccumulated mercury exposure. Pregnant women who consume contaminated fish can compromise normal child development. After birth, infants are also susceptible to exposure to mercury from their mother through breast milk. Because of the extended residence period of mercury within the human body, and its negative health effects on the fetus, both pregnant women and women of childbearing age are additionally considered sensitive populations for possible mercury exposure (Cook, 1997, pp. 175, 177, 181; Raloff, 2001; U.S. Environmental Protection Agency, 2001, p. 5).

Fish Consumption Advisories

There are several government agencies that regulate fish consumption advisories in the United States. On the federal level, the Food and Drug Administration (FDA) regulates commercial fish. Primarily, this involves ocean fish, including swordfish and tuna. The Environmental Protection Agency (EPA) oversees fish consumption advisories for locally caught noncommercial fish within the United States on a federal level. State-level agencies also administer fish consumption advisories.

In 2000, approximately 79% of all U.S. fish consumption advisories were issued, at least in part, as a result of mercury contamination. Between 1993 and 2000, the total number of fish consumption advisories for mercury increased by 149%, from 899 in 1993 to 2,242 in 2000. Statewide fish consumption advisories have been issued by 13 states (U.S. Environmental Protection Agency, 2001, p. 4).

Unlike other environmental contaminants that bind to the fat layer, methyl mercury binds to fish protein, rendering it impossible to remove contaminated portions of tissue from the meat. Mercury levels are also not reduced by cooking. Instead, the cooking process reduces moisture in the fish, rendering mercury levels in cooked fish more concentrated than in their raw counterparts (Cook, 1997, p. 178; U.S. Environmental Protection Agency, 2001, pp. 1, 2).

Although virtually all fish contain some level of methyl mercury in their flesh, ranging from .01 to .05 parts per million (ppm), certain fish are at risk for higher levels of methyl mercury contamination. Fish that live in waters directly in the scavenging zone of industrial pollution and predatory fish are at greatest risk. For commercial fish, the FDA asserts that methyl mercury which exceeds 1 ppm should not be consumed. For domestic freshwater fish, the EPA has adopted a more aggressive advisory benchmark and has established a reference dose (RfD) of 6×10^5 mg/kg/day (Neumann et al., 1997, p. 213). The consumers body weight (BW) and the weight of the consumed flesh sample are important factors in determining safe levels for fish consumption. Ones daily allowable fish intake can be derived from the following formula:

$$\frac{\text{RfD (mg/kg/day)} \times \text{BW (kg)}}{\text{Mercury content (mg/kg)} \times \text{Portion Size}}$$

Although most federal and state governments fish consumption advisories establish whether there are dangerous or nondangerous levels of mercury in fish, such an approach is inadequate for determining risk. Specifically, it neglects the fish consumption habits of consumers, which can be important, particularly in view of bioaccumulation. A four-tiered scale of risk enables the consumer to weigh mercury levels in the fish against their own consumption patterns. The risk assessment is based on EPA assessments of recommended maximum number of meals per month according to mercury level and state fish consumption advisory standards: low risk is considered levels of mercury at which it is safe to consume 8 or more fish meals per month; moderate risk is 2 to 6 fish meals per month; high risk is 1 fish meal per month; and severe risk is less than 1 fish meal per month to no consumption (U.S. Environmental Protection Agency, 2001, p. 5). Unlike the binary scale, the four-tiered scale of risk takes bioaccumulation and cultural patterns of consumption into consideration.

Importance of Fishing Among Native American Groups

Because of the cultural relationship to the land and an ethos of subsistence, Native American fishing practices increase the possibility of exposure to environmental hazards. Some indigenous subpopulations eat 4 to 5 times the amount of fish assumed in EPA models that determine fish consumption advisories. As a result, some Native Americans are disproportionately exposed to higher levels of mercury than other populations. Subsistence anglers, including aboriginal fishing peoples, often have elevated mercury levels in their blood. This is primarily because these groups depend on fish as a frequent food source (Neumann et al., 1997, p. 212; Ringquist, 2000, p. 241).

In addition to the cultural underpinnings of subsistence that dominate some native groups, other groups of indigenous people fish as part of annual cultural rituals. Annual fishing events, such as those that correspond with spawning, are of critical importance to maintaining ethnic identity. When confronted by pollution and a decision of whether to eat the fish and maintain the cultural practices essential to sustaining their ethnic identity, individuals are making a cultural assessment of risk and must decide between culture and health. Giving up fish could mean giving up culture. Risks from environmental hazards may be considered differently between native peoples and Western cultures. Perceptions of the invisible risks of mercury pollution may be less influenced by scientific study than cultural understandings of health and their relationships with the environment among some aboriginal cultures. Concepts of the environment and risks of pollution are connected to culture. Within this cultural context, environmental resources can be seen as essential for cultural survival. The relationship that one has with the environment, as in fish consumption, may be critical for cultural conceptions of good health (Wheatley, 1997, pp. 85, 86).

Methodology

Spatial analysis of the environmental risks of exposure to mercury in fish among Native American communities in the contiguous United States was conducted in Arc View 3.2. The methodology for spatial analysis involves a three-stage process. The first step included an analysis of the physical characteristics of mercury contamination at the watershed level. The second phase entailed a comparison of the mercury contamination analysis to demographic data considering the location of Native American populations. In the third stage, demographic analysis, in combination with documented fish consumption habits, is used to characterize the risk experienced by two communities.

Spatial analysis of the physical features of mercury contamination involves examination of the National Listing of Fish and Wildlife Advisories (NLFWA) database and comparisons to Cataloging Hydrological Unit Boundaries (watershed coverage).[1] Methodology for this analysis is adapted from *Mercury Maps: A Quantitative Spatial Link Between Air Deposition and Fish Tissue, Peer Reviewed Final Report* (Cocca, 2001). *Mercury Maps* was developed to evaluate the impact of national mercury emission reductions on fish tissue concentrations and to propose total maximum daily load (TMDL) reductions for mercury through a comparison of air deposition rates to fish contamination levels (Cocca, 2001, p. 1).

The NLFWA fish samples are compared with consumption levels to determine the degree of risk for individuals who consume fish from particular watersheds. There were 16,384 NLFWA samples with latitude and longitude coordinates that were accompanied by mercury data in ppm. Fish in the eastern United States received the heaviest sampling, with comparatively fewer samples extracted from west of the Mississippi River. Fish data were plotted into the Geographic Information Systems (GIS) software *ArcView* and aggregated to the watershed level. The watershed data employed partitions the contiguous United States into 3,202 individual watershed units.

Also aggregated to the watershed level was 2000 Census tract demographic information, and GIS analysis was used to identify watersheds with indigenous communities. Communities were established according to populations greater than 10% at the census tract level. These findings were compared to the fish contamination within those watersheds. In the United States, 625 of a total of 20,407 census tracts have native populations higher than 10%, indicating the existence of a community. Of the census tracts identified, 135 had a native population more than 50%, and 85 tracts had a population more than 75%. Within the United States, there is a total native population of 3,051,067 individuals. Among these, 1,080,759 live on reservations (35.4%).

Mercury Risk Among Native American Communities

By selecting watersheds with native populations by census tract, 655 watersheds were identified that contain native communities. Within the watersheds with native communities, 572 fish samples are in the NLFWA database. The mean level of contamination is 0.3184 ppm, and the maximum level tested is 2.182.

By selecting watersheds with the presence of a reservation, 327 watersheds had mean mercury levels above 0.16 ppm, 128 watersheds had levels above 0.5 ppm, and 25 watersheds had levels above 1.0 ppm. As a result, 59 reservations are at moderate risk for mercury contamination, 70 are at high risk, and 19 are at severe risk.

Two locations for in-depth case study were chosen according to a number of factors. These include: sufficient number of mercury samples to aggregate mean levels, the prevalence of an existing study of the fish consumption habits and mercury concentrations of the cultural groups, and the existence of a local environmental justice movement initiated from within the community to remediate the problems associated with mercury contamination and cultural fish consumption practices. The two communities selected are the Seminole in South Florida and the Chippewa of Wisconsin and Minnesota. These sample Native American cases also cover two contrasting regions within the continental United States.

Mercury contamination from atmospheric deposition has severely compromised the aquatic habitat in the Florida Everglades. The deaths of several Florida panthers, an endangered specie, have been attributed to mercury poisoning, as have declines in wading bird populations. State and federal agencies, in part through the Florida Atmospheric Mercury Study, have been investigating the sources of mercury in the

Everglades as a result of these ecosystem impacts (Dvonch, Graney, Marsik, Keeler, & Stevens, 1998, p. 96).

The Florida Atmospheric Mercury Study concluded that mercury enters the Everglades through atmospheric deposition. Such deposition largely results from the emissions of coal and oil-fired electrical power plants, municipal solid waste incinerators, medical waste incinerators, and coal-fired cement kilns. Mercury originates from a nearby urban expanse (8 km to 35 km) with a population of 7 million people. In the case of the Florida Everglades, local sources of mercury released as vapor are deposited via atmospheric deposition, resulting in high mercury levels within the water and the fish (Dvonch et al., 1998, p. 96).

The Florida Everglades is a unique ecosystem with a relatively small drainage. Consistent and localized sources of mercury directly contaminate the waters of the Everglades on a very concentrated level. The fumes of South Floridas sprawling industrial region wafts over the Everglades at highly concentrated levels. The proximity of the Everglades to atmospheric mercury sources, rather than the size of its drainage basin, contributes to its high mercury concentrations.

Spatial analysis of 2000 Census data, land cover, NLFWA watershed data, and the extent of river systems was analyzed to establish the level of risk for indigenous people within the state. In Florida, very few of the states indigenous population live on the reservation. Florida has an indigenous population of 46,835, out of a total population of 18,843,709. Of these, 2,711 live on a reservation (5.7%). This small amount is quite different from the national average of 35.4%.

For most of the region, degree of risk for mercury contamination is in the high and severe categories. Of Florida's 326 watersheds, 6 are low risk, 15 are moderate, 136 are high risk, and 106 are severe. The remaining 63 watersheds do not have mercury samples to determine the level of risk.

The Florida Seminole have the following four federally recognized reservations in the South Florida Everglades: Big Cypress Preserve, Immokalee Reservation, Brighton Reservation, and the Hollywood Reservation. These groups rely on the Everglades for their cultural, religious, economic, and recreational livelihoods. Just as important, the Everglades is also the foundation for their ethnic identity (Shore, 2000, p. 2).

Ecosystem health in the Everglades is not only important to Seminole health, it is important to their identity and culture. The Seminole suffer from environmental hazards in greater proportion than other South Florida residents. This is principally due to their relationship with the land and water. Many Seminoles depend on their contaminated ecosystem to supply their basic needs. The Seminole survive by eating fish from the contaminated waters and growing vegetables on contaminated land (Tamargo, 1994, p. 5).

A sister tribe to the Seminole, the Muccosukees also live in the Everglades and speak a similar dialect. In 1993, the Centers for Disease Control (CDC) surveyed 100 adult Muccosukee tribal representatives for blood mercury levels. Mercury levels tested between 0.2 and 13.8 μg/L. Their blood mercury levels compare to a baseline of 0.5 μg/L in unexposed individuals. Blood mercury levels were compared to the consumption habits of the individuals. The CDC study confirmed a correlation between fish consumption from local waters and high levels of mercury in the blood of those tested (Mahaffey & Mergler, 1998, p. 110).

Water flow patterns, atmospheric proximity to sources, and seasonal variation are different in the Midwest when compared to the Everglades. An examination of mercury levels in Minnesota has concluded that a combination of atmospheric deposition and seasonal variation impact mercury levels in rivers and streams (Balogh, Meyer, & Johnson, 1998, pp. 109, 110).

There are 22 reservations in Wisconsin and Minnesota and a substantial indigenous population. Unlike other areas of the country in which the majority of the indigenous population does not reside on a reservation, in Wisconsin and Minnesota, there is a different residential trend. The states of Wisconsin and Minnesota have an indigenous population 101,626, of a total population of 11,136,865. Of these 48,138 live on the reservation (47%).

For most of the region, the degree of risk for mercury contamination is in the low to moderate range. There are some watersheds with high levels of risk in the eastern region, but there are no watersheds where the risk is in the severe category.

Fishing among the Chippewa has remained an important part of life and an avenue for tribal members to preserve their culture (Chippewa Ottawa Resource Authority, 2002). Because they regularly consume fish as part of their diets and they take fish from contaminated waters, Chippewa communities are at risk for mercury contamination (Mahaffey & Mergler, 1998, p. 110).

The Chippewa conduct an annual ritual each spring during the 2-week period that follows the ice breakup, usually in April. During this period, walleye, an apical aquatic predator, spawn in shallow waters. During the spearfishing event, spearfishers are highly efficient at catching fish. Spearers are able to take a walleye for every 5 minutes of fishing, whereas experienced anglers are only able to catch a walleye each 9.5 hours, and an average angler is only able to catch a single walleye during a 24-hour period (Peterson et al., 1994), a contrast that has drawn protests from restricted non-Chippewa fishermen.

Among the Chippewa, most of the fish consumption in the tribe is associated with this spring fishing event. Only a few men of the tribe actually participate in spearfishing. Yet, because of a pervasive cultural ethos for sharing, the fish is widely distributed throughout the tribe and is consumed in traditional feasts where it is featured as the main food item. Those fish that are not eaten fresh are frozen for consumption later in the spring. Most of the walleye caught during the spearfishing event is consumed by the end of May (Peterson et al., 1994).

The average Chippewa consumes 62.4 fish meals per year. This compares to the estimated national consumption rate of 36 fish meals per year for Americans generally, and a rate of 42 fish meals per year for sport fishermen. Although subsistence fishing among the Chippewa is rare, there is a seasonal cycle to fish consumption that results from the spring spearfishing event (Peterson et al., 1994). Such a peak in consumption compounds the mercury ingestion problems in a way that a more spaced pattern of consumption would alleviate, especially among women of childbearing age that may become pregnant during the ensuing months.

There have been several studies conducted on Chippewa fishing and consumption habits and the levels of mercury in their blood. One study in which mercury levels tested in the blood of 175 Chippewa Indians showed 36% had levels above 5 μg/L. The elevated levels of mercury in their blood were associated with the recent consumption of walleye (Mahaffey & Mergler, 1998, p. 110). Another study showed mercury levels as high as 33 μg/L. Twenty percent of the 465 Chippewa males tested in this study had blood mercury levels that exceeded 5 μg/L (Peterson et al., 1994).

For the Chippewa, fishing is also critically linked to cultural identity. An indication of this is their yearly observation of the spearfishing event and their efforts to have their fishing rights reinstated in the federal courts. Like other cases of treaty rights in the United States, the history of Chippewa Treaty Rights is a story about identity, sovereignty, and political resistance (Loew, 1997). An example of this is the Mille Lacs Band of Chippewa. President Taylor, by executive order in 1850, terminated the Mille Lacs spearfishing rights granted by treaty in 1837. Using the profits from two casinos that they opened in 1991 and 1992, the Mille Lacs took their case to the Supreme Court in 1999. The Supreme Court ruled in their favor, restoring their spearfishing rights (Krogseng, 2000). This is a classic case of why subsistence fishing is not just a question of simple economics for Native Americans. Given the costs of lawyers and courts, these ritually caught and consumed fish are certainly extremely costly per gram of fish.

Other Chippewa bands have also fought to have their fishing rights reinstated. Members of the Lac Courte Oreilles Chippewa Reservation, when caught spearfishing, were treated as poachers by the State of Wisconsin. To the spearfishers, their practices were a complex expression of sovereignty under the series of treaties the Chippewa had signed with the federal government (Loew, 1997).

As Chippewa communities have gathered in solidarity to fight for their fishing rights, they also are placing themselves at increased risk of mercury poisoning. This decision must be weighted within the minds of these individuals as one between preserving ones culture and gaining their rights or becoming contaminated by a tasteless, odorless metal. The Chippewa and other indigenous communities within the Midwest have formulated strategies for dealing with this issue. They are working in cooperation with state and federal governments, and on their own initiative, to protect their populations from the negative impacts of mercury contamination.

The purpose of fish consumption advisories is to warn the public of the dangers of environmental contaminants in fish. By avoiding eating fish from contaminated waters, the public can be spared the negative health effects of consumptive exposure to environmental pollutants. Thus, contaminated fish do not affect individuals who do not eat them. However, such a linear logic does not protect those who eat contaminated fish for reasons of poverty, cultural values are ignorance. For some, locally caught fish is an important contribution to a familys diet. For others, it is an important venue for exercising cultural practices.

Conclusion

The threat of mercury is real and growing as each year, the amount of mercury we emit accumulates on top of the emissions of centuries past. Emissions from the largest contributors of atmospheric mercury, fossil-fuel electricity production and solid waste incineration, can be reduced through the use of more sustainable forms of energy and solid waste management. The effects of energy production and waste combustion emissions are bioaccumulating in our natural resources. When fish consumption patterns are considered, this risk is particularly threatening to indigenous communities.

Indigenous groups who fish in contaminated waters are paying for their culture with their health. The risks embodied in this practice attest to their resolution to preserve their ethnic identity. Their efforts to improve the situation, through studies and sampling, litigation, cooperation with state and federal governments, and management of their natural resources are all mechanisms whereby they steadfastly strive to maintain their traditional life ways.

Note

1. Mercury advisories and data from the National Listing of Fish and Wildlife Advisories were provided by Elizabeth Sullivan, environmental scientist, at the Center for Environmental Analysis, RTI International; e-mail: esullivan@rti.org.

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