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Mercury and Lead Content in Fish Species From the River Gomti, Lucknow, India, as Biomarkers of Contamination

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The release of heavy metals into the environment has alarmingly increased because of emissions from automobiles, coal burning, mining, industrial activities, and trash incineration. Most heavy metals are released into the environment, then find their way into the aquatic phase as a result of direct input, atmospheric deposition, and erosion caused by rains. Therefore, aquatic animals may be exposed to elevated levels of heavy metals. Contamination of the aquatic ecosystem by heavy metals can be monitored in water, sediment, and organisms.

The high accumulation of heavy metals in the aforementioned components can result in serious ecologic changes. Mercury and lead are globally well-distributed environmental heavy metal pollutants released from natural and anthropogenic sources. Once they are released into the environment, they circulate between air, water, soil, and biota in various forms. When deposited in the biota, mercury undergoes biotransformation, in which inorganic mercury may convert to organic mercury (methyl mercury). Speciation involves microbes, which subsequently concentrate mercury through the food chain in the tissue of fish and marine animals (Altindag and Yigit, 2005). Episodes such as Minamata have been linked to mercury poisoning in man with the consumption of fish. Lead has been used since ancient times, and some of its toxic effects have been recognized for several centuries.

Fish serve as a valuable and nutritious component of the human diet. Mercury and lead through this important food source are major threats to health. Humans who consume significant amounts of contaminated fish may be at risk. Fish are important indicators of surface and groundwater pollution through municipal waste and industrial effluents.

The river Gomti serves as a major source of drinking water for Lucknow City, the state capital of Uttar Pradesh in India with the population of about 3.5 million. Throughout its stretch, several small tributaries join within a short distance carrying wastewater and industrial effluents from different towns and industrial units to the river. Industrial units are present in the catchment areas of the river, and the Gomti receives the untreated wastewater and effluents (Gaur et al. 2005).

Aquatic life in the Gomti in Lucknow region was destroyed in June, 2003, when untreated sewage was dumped into the river water, causing a drastic drop in oxygen level. Sugar mills and distilleries located upstream from Lucknow together with more than 20 sewage outlets in Lucknow were thought to be responsible for this pollution load leading to the critical situation. Such episodes occur from time to time in this river as reported in the newspapers. Because heavy metals constitute an important segment of chemical pollutants, it was considered worthwhile to investigate two major toxic metals (i.e., mercury and lead) in edible fish species available in the Gomti that might cause adverse health effects for the consumer.

Materials and Methods

The river Gomti originates from a natural reservoir, Gomat tal, in the swampy and densely forested area situated approximately 20 miles east of district Pilibhit in Uttar Pradesh. The river flows through the districts of Pilibhit, Sitapur, Lucknow, Barabanki, Sultanpur, Jaunpur, and Ghazipur in Uttar Pradesh and finally merges with the river

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Ganga in Ghazipur district about 22 miles north of Varanasi (Figure 1).

The river Gomti is the natural water source together with underground water for the citizens of Lucknow City, and the river also has been supporting fishermen for decades. Fresh fish from the Gomti were procured for the current experiment. Edible muscular tissue was taken for analysis from the middle region of the fish body. The selected eight fish species were those considered important in the diet of the regional nonvegetarian population including *Clarius batrachus* (Mangur), *Mysteus cavasius* (Tengan), *Channa punctatus* (Girai), *Rita rita* (Belgegra), *Heteropneustes fossilis* (Singhi), *Mastocembelus armatus* (Bam), *Notopterus notopterus* (Patra), and *Labeo rohita* (Rohu). Five samples from each variety of these freshwater fish species were analyzed.

Hydrogen peroxide, sulphuric acid, nitric acid, hydrochloric acid, and sodium borohydride were procured from Merck (Mumbai, India). Vanadium pentaoxide from Sisco Research Laboratory (Mumbai, India), and perchloric acid

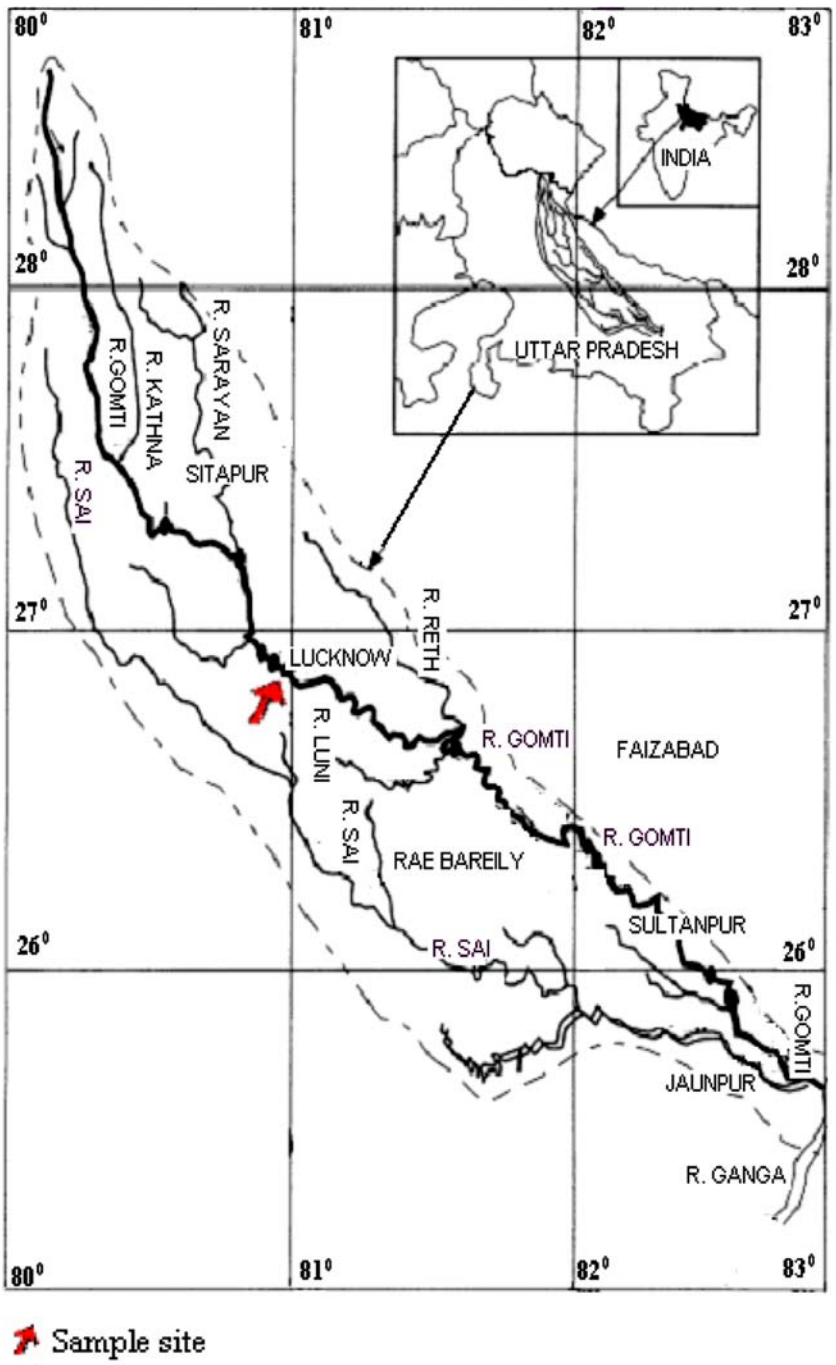

Fig. 1 Map showing the river Gomti and the sample site, Lucknow, India

from Qualigens (Mumbai, India), were used. All reagents used were of analytical grade. Certified reference material of mercury and lead procured from the National Physical Laboratory, New Delhi, were used for calibration in the Atomic Absorption Spectrophotometer (AAS) analysis.

The Association of Official Analytical Chemists (AOAC) method (Horwitz 2000) was used for digestion of tissue for total mercury analysis. Approximately 5 g (wet weight) of tissue was digested with 20 mL of a sulfuric acid:nitric acid (1:1) mixture containing 10 mg of vanadium pentaoxide in a round-bottom flask fitted with a water condenser on a heating mantel. The mixture was heated for 1 h, then washed with 15 mL of water. A few drops of hydrogen peroxide (30%) were added, and the mixture was allowed to cool at room temperature. The volume finally was increased to 100 mL with distilled water and further diluted three times with diluting solution (5.8 mL of nitric acid and 6.7 mL of sulfuric acid in 87.5 mL of distilled water). The digested samples were analyzed by the Atomic Absorption Spectrophotometer equipped with a vapor generation assembly [Varian AAS 250+ coupled with VGA 77, Varian Australia Pty Ltd (manufacturing site), Mulgave, Australia] for total mercury estimation.

For determination of lead concentration, muscle tissue samples (2–3 g, wet weight) of fish were digested in a K'jeldhal flask with 5 mL of nitric acid (HNO_3) by being heated in a sand bath for 8 h. After cooling, they were again digested with 5 mL of HNO_3 for 8 h followed by addition of 5 mL digestion mixture (nitric acid:perchloric acid in 5:1 ratio) and heating for 4 to 5 h. The digested solutions were evaporated to 1 mL, then transferred to a 10-mL volumetric flask, with the volume raised to the mark using 1% HNO_3. Analysis was performed using AAS in flame mode.

All the samples were analyzed in triplicate, and the mean of each value was taken. During the analysis, blank determinations in triplicates also were run in the same manner. Recovery studies were performed by spiking the 2 g of tissue samples with suitable aliquots of mercury (1 μg) and lead (2 μg) standards in triplicate. Recoveries were 115% to 120% for mercury and 99% to 105% for lead. The detection limits with the method used were found to be 0.04 μg/g (parts per million [ppm]) for mercury and 0.1 μg/g (ppm) for lead.

Results and Discussion

The results of the analysis for mercury and lead in fish muscle tissues are summarized in Table 1. Fish consumption can be a major factor in the mercury intake of humans. The current study showed that the accumulation pattern of total mercury in the fish species examined was, in order, *M. armatus* (Bam) > *C. batrachus* (Mangur) > *M. cavasius* (Tengan) > *N. notopterus* (Patra) > *R. rita* (Belgegra) ≃ *H. fossilis* (Singhi) > *C. punctatus* (Girai) > *L. rohita* (Rohu). The maximum accumulation of mercury was found in *M. armatus* (0.277 μg/g), whereas in *L. rohita*, it was below the detection limit of the method. Five samples of each species were examined, which showed almost similar mercury levels within the same species. *Mastocembelus armatus* showed a mercury concentration near the reference dose set by the U.S. Environmental Protection Agency in fish tissue (0.30 μg/g) (US EPA CR 2001). *Labeo rohita*, the most commonly used fish of the region, was found to accumulate a very low mercury concentration. It might be possible that some mechanism in this fish variety does not allow mercury to accumulate in tissues compared with other species available in the same aquatic environment. This needs further investigation.

All the fish species examined had a mercury content below the regulatory limit/permissible level of 0.50 μg/g (wet weight of fish) for human consumption recommended by World Health Organization (WHO 1990), the United Kingdom, and the United States (Gammons et al. 2006) as well as the maximum residue limit as per PFA Act 1954 India (amended 2002) (Figure 2a). Comparing the results with those of the other studies, Ayyadurai and Krishnasamy (1989) reported a total mercury level of 0.05 to 0.27 μg/g in fish from the swamp contaminated with sewage and hospital wastewater at Madras, India, whereas Paul (1987) reported a mercury level of 0.135 to 0.200 μg/g mercury in 10

Table 1 Concentration of mercury and lead (μg/g, wet weight) in muscle tissues of fish species from the river Gomti[a]

Species	Common name	Mercury	Lead
Clarius batrachus	Mangur	0.203 ± 0.086	1.133 ± 0.391
Mysteus cavasius	Tengan	0.160 ± 0.008	0.341 ± 0.194
Channa punctatus	Girai	0.067 ± 0.005	0.631 ± 0.537
Rita rita	Belgagra	0.119 ± 0.029	0.129 ± 0.088
Heteropneustes fossilis	Singhi	0.119 ± 0.033	0.400 ± 0.224
Mastocembelus armatus	Bam	0.277 ± 0.036	1.065 ± 0.227
Notopterus notopterus	Patra	0.122 ± 0.035	0.200 ± 0.092
Labeo rohita	Rohu	BDL	0.608 ± 0.223

BDL, below the detection limit

[a] Values are given as mean ± standard deviation (n = 5)

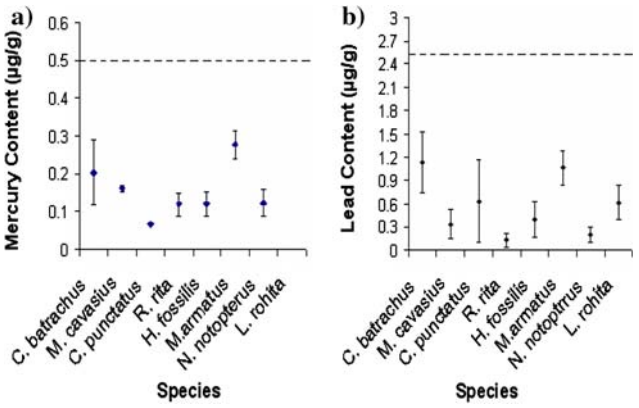

Fig. 2 Mercury and lead concentrations in muscle tissues of eight fish species from the river Gomti at Lucknow compared with the maximum residue limit allowed for human consumption (dotted line) according to The Prevention of Food Adulteration (PFA Act 1954), India (amended 2002)

common edible fish species from the Stanley reservoir at Tamil Nadu, India. These data are similar to the range of mercury found in our study.

When the results were compared with the findings of studies conducted abroad in the area of an uncontaminated environment, Mirlean et al. (2005) and Viana et al. (2005) reported similar patterns of mercury content (0.041–0.117 µg/g and 0.054–0.183 µg/g, respectively) in fish. Although the fish species examined were different, they were common edible fish species of the region. However, Altindag and Yigit (2005) reported the low mercury level (0.012–0.028 µg/g) from lake Beysehir, Turkey, whereas Gammons et al. (2006) and Carvalho et al. (2005) reported the high mercury level in fish species (0.06–1.18 µg/g and 0.49–2.74 µg/g, respectively) compared with the current results.

The current study shows that the concentration of lead in the different species of fish examined was in the following order of accumulation: *C. batrachus* (Mangur) > *M. armatus* (Bam) > *C. punctatus* (Girai) > *L. rohita* (Rohu) > *H. fossilis* (Singhi) > *M. cavasius* (Tengan) > *N. notopterus* (Patra) > *R. rita* (Belgegra). The highest level of lead was found in *C. batrachus* (i.e., 1.133 µg/g), whereas *R. rita* showed the lowest lead concentration (0.129 µg/g). The lead level in fish was quite low as per the maximum residue limit value recommended for lead (2.5 µg/g) by PFA Act 1954, India (amended 2002) (Figure 2b). These values are, however, higher than the value set by international regulating agencies (e.g., 0.2 µg/g set by EU (2002).

The current data are comparable with the almost similar level of lead in common fish species reported by the other investigator (i.e., 0.07–1.27 ppm from Mumbai Coast, India (Tungare and Sawant 2002). However, the lead levels in sea fish are reported to be much lower than represented by our data. Carvalho et al. (2005) reported 0.02 to 0.06 µg/g for the Portuguese Coast, Portugal, whereas the report for the Mediterranean Sea, Turkey (Canli et al. 2001) was on the higher side of the lead content in the common fish species of the region (1.58–2.30 ppm).

In Lucknow City, heavy metal pollution likely results from the pollutants that enter through drains. Untreated urban effluents, including industrial and municipal wastes, are thus discharged into the river. These industrial and domestic wastes, besides other pollutants, also contain toxic heavy metals (Gaur et al. 2005). They can be bioaccumulated and biomagnified via the food web, finally reaching humans and posing as a health risk (Viana et al. 2005). The current study may provide baseline data for fish available from the river Gomti at Lucknow. The consumption of these fish varieties may not cause any toxic effects to the fish consumer from the mercury and lead, as indicated by the results from the analysis of the two metals.

The current data also indicate that the Gomti river water is not contaminated with mercury or lead so as to cause any current health risk. The data of the study may be helpful in the follow-up investigation on the monitoring of river water pollution as a biomarker.

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