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Levels of Cadmium and Lead in Tissues of Freshwater Fish (*Clarias batrachus* L.) and Chicken in Western UP (India)

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Toxic heavy metals are increasingly being released into the environment with the advent of agricultural and industrial revolution in India (Khare and Singh 2002; Jayakumar and Paul 2006). A number of geological and anthropogenic activities such as mining, smelting of metals ores, industrial and automobile emission, battery recycling units, painting industries, and application of insecticides and fertilizers contribute to the elevated levels of toxic and hazardous pollutants including toxic metals in the environment (Woodling et al. 2001; Patra et al. 2005; Swarup et al. 2005). Industrial units frequently discharge toxic wastes into different water bodies, which adversely affect the aquatic ecosystem, and heavy metals get accumulated into the tissues of aquatic species including fish intended for human consumption (Jayakumar and Paul 2006). Heavy metals have been detected in low to alarming concentrations in water of many pisciculture water bodies from different parts of India (Das and Kaviraj 2000).

Among the toxic heavy metals, lead (Pb) and cadmium (Cd) that are most abundant toxic metals in the environment are emerging global concern due to their potential deleterious hazards on public health. Satyanarayanan et al. (1985) reported that the substantial levels of heavy metals on the East coast of India require special attention because they come with the industrial effluents and city sewages. Besides producing toxic impact on aquatic ecosystem, Cd can also be bio-accumulated and biomagnified via the food web and finally reach to human fish consumers posing public health risks (Viana et al. 2005). Epidemiological and experimental evidences indicate a range of toxic effects of Cd including carcinogenicity, mutagenicity and teratogenic effects in human and animals (Bellinger et al. 2004). Chronic environmental exposures to low levels of Pb are also frequently reported in many developing and industrializing countries, particularly in urban areas (Tong et al. 2000). At low levels, haeme synthesis and other biochemical processes are affected, psychological and neurobehavioural functions are impaired and there is a series of other adverse effects (Goldstein 1992). Although in unleaded petrol phase, Pb concentration declined gradually, still it is environmental concern in India. Pb concentration ranged from 0.04 to 3.91 $\mu g/m^3$ in the ambient air (Kaul et al. 2003) and 2.1–12.3 $\mu g/m^3$ in tree leaves in 2004 (Singh et al. 2005) at urban sites of Lucknow, India. Recently, Balagangatharathilagar et al. (2006) reported greater blood Pb levels in dog collected from Bareilly city than in unpolluted rural areas (0.25 vs. 0.1 mg/L). Therefore, concerning potential health risk of Pb and Cd, and their existence in environment as well as aquatic ecosystems in India, a survey was conducted in Western UP (Bareilly city), India to investigate the levels of Pb and Cd in the different tissues of fresh water fish (*Clarias batrachus*) and chicken.

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Materials and Methods

This survey was carried out in the district city of Bareilly, Western Uttar Pradesh (UP), India (altitude 172 m; 28°22′N and 79°24′E) in the Northern Gangetic Plain and Tarai region of Himalaya, located 250 km away from Lucknow, capital of UP (Fig. 1). The site has a warm continental weather with an annual average rainfall of 900–1,200 mm, and average temperature in summer and winter of 25 and 7°C, respectively. The city and its suburb area have many small and large-scale chemical and engineering industries.

Thirty samples each of fresh water Indian catfish (*Clarias batrachus*) and broiler chickens were randomly procured from five different markets of the Bareilly city between September and December 2006. They were sold for human consumption in this area. Indian catfish *Clarias batrachus* is a robust, bottom dweller, omnivorous fish. It can thrive well even in shallow dirty muddy water bodies where other cultivable fishes may not even survive. It was selected for the present study because it is extensively cultured as a food fish throughout Indian subcontinent.

Fishes and chickens were killed by decapitation and tissue samples of kidney, liver and muscles were collected, and stored in plastic bags at –20°C until analysis. Fresh tissue samples (approximately 2.0, 1.0 and 1.0 g wet weight of muscle, kidney and liver, respectively) were defrosted and wet digested with nitric and perchloric acids (Excelar grade from Emerk, India) mixture (Kolmer et al. 1951). Two analytical blanks were run simultaneously with each batch of digestion with de-ionized triple distilled water as biosample. Equal amount of acid mixture was added in duplicate test samples, blanks and standard reference materials during digestion. Cd and Pb levels in digested tissue samples were analyzed by atomic absorption spectrophotometer (AAS 4141, ECIL, Hyderabad, India) at wavelength of 229.5 nm (detection limit 0.005 μg/mL) and 217 nm (detection limit 0.025 μg/mL), respectively with 6 mA current. The measurements of detection limit were obtained by taking twice the standard deviation of measurement of blank samples. Recovery experiment was carried out by adding measured volumes of standard solutions (Merck Pvt. Ltd., Mumbai, India) of each metal to measured volumes of a solution containing the samples dissolved in the acid mixtures. The spiked concentration for Cd and Pb were 1 and 5 ppm. Average recoveries of metals added were 91 ± 0.35% for Cd and 94 ± 0.40% for Pb. The presented data have not been corrected for this recovery. The average reading of blanks was subtracted from standards and test samples and then final concentrations (μg/g) were calculated.

The data were analyzed using one-way analysis of variance to find out significant of difference in accumulation

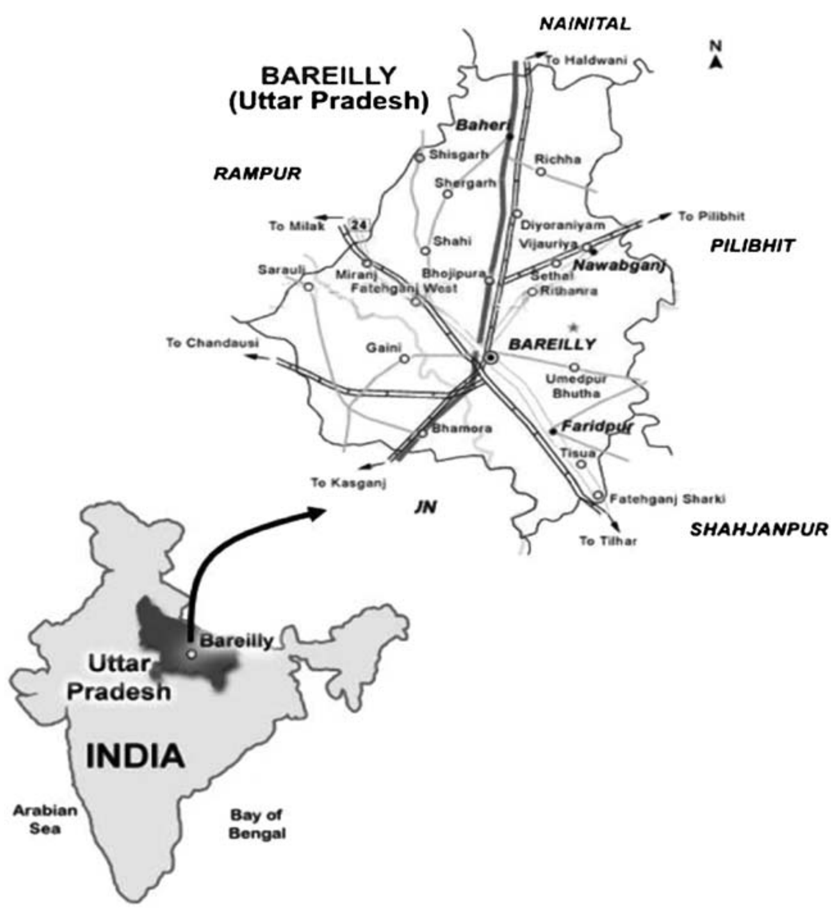

Fig. 1 Map of India/Uttar Pradesh with sampling location marked

Table 1 Concentrations (μg/g fresh weight) of lead (Pb) and cadmium (Cd) in tissues of catfish (*Clarias batrachus*)

Items	Kidney	Liver	Muscle
Pb	n = 30	n = 30	n = 30
Mean	1.60 ± 0.208[a]	0.80 ± 0.125[b]	0.40 ± 0.084[b]
Median	1.59	0.93	0.28
Range	0.00–5.06	0.00–2.17	0.00–1.31
Positive samples (%)	80.0	73.3	46.7
Cd	n = 30	n = 30	n = 30
Mean	0.34 ± 0.048[a]	0.22 ± 0.041[b]	0.17 ± 0.027[b]
Median	0.30	0.15	0.12
Range	0.04–0.95	0.04–0.95	0.00–0.57
Positive samples (%)	100.0	93.3	76.7

[a, b] Mean (±SE) values with different superscripts in a row differ significantly ($p < 0.05$)

Table 2 Concentrations (μg/g fresh weight) of lead (Pb) and cadmium (Cd) in tissues of chicken

Items	Kidney	Liver	Muscle
Pb	n = 30	n = 30	n = 30
Mean	1.18 ± 0.216[a]	0.95 ± 0.167[a]	0.41 ± 0.089[b]
Median	0.87	0.63	0.31
Range	0.00–4.47	0.00–3.29	0.00–1.53
Positive samples (%)	93.3	70.0	53.3
Cd	n = 30	n = 30	n = 30
Mean	0.39 ± 0.044[a]	0.17 ± 0.023[b]	0.18 ± 0.028[b]
Median	0.34	0.16	0.18
Range	0.06–1.05	0.00–0.54	0.00–0.64
Positive samples (%)	100.0	100.0	83.3

[a, b] Mean (±SE) values with different superscripts in a row differ significantly ($p < 0.05$)

patterns among tissues within fish and chicken, and between fish and chicken within tissues (Snedecor and Cocharan 1989). However, no significant difference ($p > 0.05$) was observed between fish and chicken within tissues. When *F*-test was significant, Duncan's multiple range test was applied to compare among means.

Results and Discussion

In fish, levels of Pb were significantly ($p < 0.05$) greater in kidney (1.60 ppm) and liver (0.80 ppm) than in muscle (0.40 ppm); however, Cd levels were greater ($p < 0.05$) in kidney (0.34 ppm) compared with liver (0.22 ppm) and muscle (0.17 ppm) where Cd levels were similar ($p > 0.05$) (Table 1). In chicken, accumulations of Pb were also greater ($p < 0.07$) in kidney (1.18 ppm) than in liver (0.95 ppm) followed by in muscle (0.41 ppm) (Table 2). Cd concentrations were also greater ($p < 0.05$) in kidney (0.39 ppm) than liver (0.17 ppm) and muscle (0.18 ppm). The present finding confirm to those of Jayakumar and Paul (2006) who reported the patterns of Cd accumulations in the order of gills > kidney > liver > skin > muscle. The ability of kidneys to accumulate high concentration of Cd is a feature common to fishes and many animals (Hogstrand and Haux 1991). Cd is reabsorbed by active transport mechanism in the cells of proximal convoluted tubules (Dorian and Gattone 1992). These cells are rich in a metal binding protein called metallothionein. Once Cd enters inside cells of the proximal convoluted tubule, they bind to metallothionein resulting in their accumulation in the kidney. Moreover, liver and kidneys are major organs of metabolic activities including detoxification. Mobilization of Cd from other organs of the body for the purpose of elimination might have contributed for the accumulation in these two organs (Jayakumar and Paul 2006). A range of studies revealed that fish accumulates comparatively little Cd in muscles (Allen 1995). Muscle tissues do not come in direct contact with the toxicants. It is also not an active site of detoxification and hence Cd is not transported from other tissues to muscles.

Cd and Pb accumulations in the tissues were found to be within the range. Reported concentrations of Cd in foodstuffs vary widely. Bellinger et al. (2004) reported that Cd concentrations ranged from 0.01 to 1.36 in fish and fish products, and 0.002–0.025 μg/g in poultry meat. The Pb and Cd values in fish species were found to be in range of 0.07–0.92 and 0.01–0.08 μg/g fresh tissues, respectively (Yilmaz et al. 2007). Concentrations of Cd in beef livers, kidneys, and brown crabmeat reached up to 0.2, 1.6, and 21.0 μg/g, respectively (Chau et al. 1970). However, other fresh meats generally contain less than 0.05 mg/kg Cd. Dural et al. (2007) reported that levels of Pd in liver and muscle were 1.41–3.92 and 0.47–2.44 μg/g fresh weight, respectively; and for Cd, the levels were 0.02–0.35 and 0.03–0.12 μg/g in liver and kidney, respectively.

According to the recommendations of European Union (2005), Pd and Cd concentration in fish or fish products intended for human consumption should not exceed 0.40 and 0.10 μg/g fresh weight, respectively. Certain values of muscular Pb (40%) and Cd (60%) in fish were above thresholds for human consumption. The corresponding values in chicken were 67 and 43%. Pd was present in 93 and 53% samples of kidney and liver of fish, while all samples of kidney and liver contained Cd. The corresponding values in chicken were 80 and 73% for Pb, and 100 and 93% for Cd. This primarily indicates the extent of pollution of heavy metals in ambient air and water bodies. Cd and Pb levels in fish tissues usually reflect concentration in sediment levels, indicating sediment and/or dietary metal uptake (Alquezar et al. 2006). Total Pb concentration in the Ganga river near at Ganga sagar ranged from 2.3 to

3.9 μg/L (Sarkar et al. 2003). Food and water are important sources of baseline exposure to Pb, in addition to atmospheric Pb that is inhaled, which has likely contributed to higher concentration of Pb in tissues of chicken. Blood Pb level is the mostly accepted and commonly used measure of Pb exposure (WHO 2001). Ahmed et al. (2005) observed blood Pb levels ranging from 2.8 to 15.0 $\mu g/m^3$ in Lucknow, capital city of Uttar Pradesh. The higher Pb levels in animals reared around industrial activities are mainly due to intake of foods contaminated with Pb as well as inhalation of Pb particles (Okada et al. 1997). Abraham et al. (1999) reported higher concentration of Pb in different tissues of goats slaughtered in Chennai in India, and the same was attributed to air pollution. Shaposhikov and Prisnyi (2001) recorded mean concentration of 0.11 mg/kg in blood from pigs reared around polluted localities. Higher Pb levels in animals and human beings have been reported from various parts of India particularly in urban areas (Swarup et al. 2005). Swarup et al. (2006) reported higher level of Pb around Pb-zinc smelter than in unpolluted area in goats, which is attributed to intake through contaminated food. Pb concentration in fodder and soil around Pb–Zn smelter were 29.1 and 233 ppm, respectively as compared to control area (2.1 and 28.7). Most of the Pb emitting from different emissions enters into air and is deposited on near by vegetation thus human and animals are exposed to excess Pb by inhalation of contaminated air and/or ingestion of contaminated food in an urban and industrial area as assumed by Balagangatharathilagar et al. (2006). In India, vehicular pollution still accounts for more than 2/3 of total air pollution (Lal 1996). This study indicates that high levels of Cd and Pb in fish and meat are potential concern on consumers' health in urban areas in India. A selective removal of tissues that accumulate highest levels of Cd and Pb might reduce the severity of toxicity through food chain in human consumers, and in animals fed with fish and meat meals.

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