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Determination of Metal Levels in Thirteen Fish Species from Lakshadweep Sea

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Abstract A bio-monitoring study was performed to investigate the concentration of certain metals (cadmium, cobalt, copper, iron, magnesium, manganese, nickel, lead and zinc) in gill, skin and muscle of thirteen demersal fish species of Agatti Coast of Lakshadweep Sea. All the metal concentrations in gill are higher than skin and muscle. Concentrations of toxic metals such as Cd (0.61 ± 0.67 μg g^{-1} in *Gerres longirostris*), Mn (0.83 ± 1.21 μg g^{-1} in *Lutjanus fulvus*) and Ni (0.56 ± 0.83 μg g^{-1} in *L. bengalensis*) were well above the permissible limits suggested by World Health Organization and Food and Agricultural Organizations.

Keywords Demersal fish · Metals · Tissues · Agatti coast

Metal contamination has been identified as a concern in coastal environment, due to discharges from industrial wastes, agricultural and urban sewage. Metals can be accumulated by marine organisms through a variety of pathways, including respiration, adsorption and ingestion (Zhou et al. 2001). Iron, copper, zinc and manganese are essential metals since they play an important role in biological systems, whereas mercury, lead and cadmium are non-essential metals, as they are toxic, even in traces. The essential metals can also produce toxic effects when the metal intake is excessively elevated. Fish is widely consumed in many parts of the world because it has high protein content, low saturated fat and also contains omega fatty acids known to support good health (Ikem and Egiebor 2005). Fish are constantly exposed to chemicals in polluted and contaminated waters. So they have been found to be good indicators of metal contamination in aquatic systems because they occupy different trophic levels and are of different sizes and ages (Burger et al. 2002).

Trace elements may exert beneficial or harmful effects on plant, animal and human life, depending on their concentration. Some of the pollutants introduced to land and aquatic ecosystems may possess an important toxic potential (Gagnaire et al. 2004). The pollution of the aquatic environment with metals has become a serious health concern during recent years. In many studies, fish are the subject of investigations on metal accumulations and monitoring programs in seas, due to their importance in human nutrition (Keskin et al. 2007). In the sea, pollutants are potentially accumulated in marine organisms and sediments, and subsequently transferred to man through the food chain (Giordano et al. 1991). For these reasons, it is important to determine the chemical quality of the marine organisms, particularly the contents of metals. The studies on the metal accumulation in Agatti island of Lakshadweep (Anu et al. 2010) from fish tissues are limited. So the present study was undertook to determine the metal levels (Cd, Co, Cu, Fe, Mn, Mg, Pb, Ni and Zn) in gill, muscle and skin of thirteen fish species from Agatti coastal waters.

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Materials and Methods

Fish species were collected from random catches in the Agatti Island coast (latitude 10°48′–10°52′N; longitude 72°10′–72°12′E), Lakshadweep (India) during July–August, 2010 (Fig. 1). Thirteen species of fish, namely *Lutjanus bengalensis, L. fulvus*, *L. monostigma, L. gibbus, Gerres longirostris, Epinephelus tauvina, E. merra, Cephalopholis argus, Rhinecanthus aculeatus, Pterocaesio pisang, Upeneus moluccensis, Pinjalo lewisi* and *Lethrinus lentjan* were selected for the study. The samples were washed with distilled water, dissected to gill, muscle and skin using stainless steel knife and dried in Microwave oven (Samsung) at 70°C for 15 min. After complete dry, the samples were finely powered using mortar and pestle and weighed to 1 g (±1 g) using an electronic weighing balance (Denver, USA).

The tissues were digested with 20 mL of concentrated nitric acid over night followed by hot plate method (120°C) after mixing with concentrated nitric acid and perchloric acid (4:1 v/v) (Merck) up to complete dryness. All samples were diluted and made up to 10 mL with Milli-Q water with 20% conc. nitric acid and then this solution is filtered through Whatman filter paper (11 μm) and metal concentrations were determined by using Inductively Coupled Plasma Optical Emission Spectrometer (Perkin Elmer, Optima 2100DV). The precision of the analytical procedure was checked by analysing standard reference materials of commercially available standards (Merck KGCA, 64271 Damstadt, Germany, ICP-Multielement standard solution IV, 23 elements in nitric acid). Milli-Q water was obtained using a Millipore water system. All acids and chemicals were of analytical reagent grade. Metal concentrations were calculated in microgrammes per gramme dry weight (μg metal g^{-1} d.w.). All glass wares were kept overnight in 10% nitric acid solution and rinsed with deionised water and air dried before use.

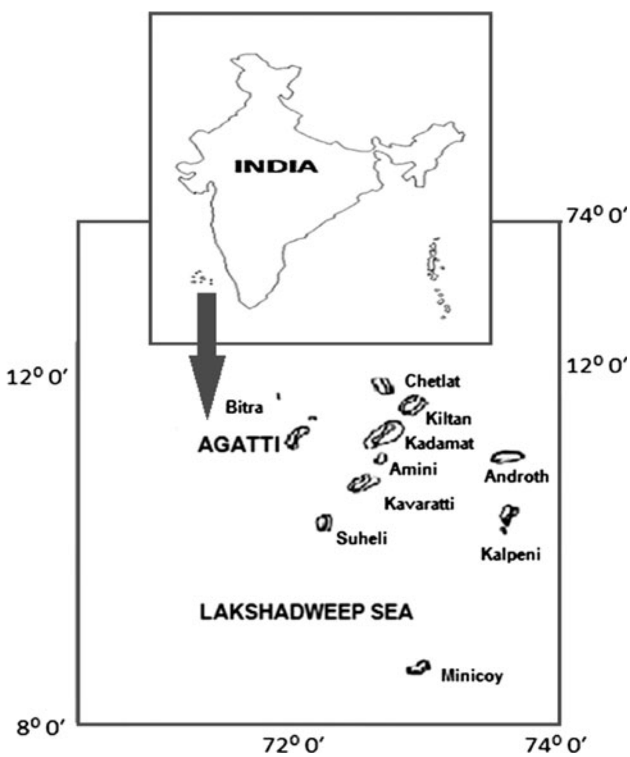

Fig. 1 Map showing the sampling location at Agatti coast of Lakshadweep sea, India

Statistical analysis was performed using the SPSS 16.0 for windows. Data were grouped according to species. One-way analysis of variance was used to test for differences in tissue metal concentrations in different species. Possibilities less than 0.05 were considered statistically significant ($p < 0.05$).

Results and Discussion

Concentrations of nine elements (Cd, Co, Cu, Fe, Mn, Mg, Pb, Ni and Zn) in the gill, muscle and skin of thirteen fish species from Agatti coastal waters of Lakshadweep Sea, are given in Table 1. In the present study, total metals were ranging over following intervals Cd: 0.01–0.61 μg g^{-1}, Co: 0–0.11 μg g^{-1}, Cu: 0.07–0.56 μg g^{-1}, Fe: 1.6–6.64 μg g^{-1}, Mg: 52.63–117.4 μg g^{-1}, Mn: 0.05–0.83 μg g^{-1}, Ni: 0.04–0.56 μg g^{-1}, Pb: 0.08–0.55 μg g^{-1} and Zn: 1.8–9.83 μg g^{-1}.

It is well known that metals accumulate in the tissues of aquatic animals, and therefore metals measured in the tissues of aquatic animals can reflect the past exposure (Dural et al. 2007). Gill, skin and muscle are good indicators of chronic exposure to metals because they are the site of metal metabolism. Gill is often considered a good indicator of water pollution with metals since their concentrations are proportional to those present in the environment. According to Miller et al. (1992), muscle was a poor indicator of metal contamination while gill tissue is highly active in the uptake and storage of metals as in the present study. All the metals were highly accumulated in gill tissues than skin and muscle (Figs. 2 and 3). According to Pearson's correlation, the metal concentrations were positively correlated with each other at 0.01 level. One way ANOVA revealed that the mean metal concentrations were significantly different with different species at 0.05 level ($p < 0.05$). But the metal concentrations in gill, skin and muscle of fishes, were not significantly different except Cu, Fe, Pb and Zn at 0.05.

According to the present study, Mg has the highest concentration (117.4 ± 18.67 μg g^{-1} in *P. pisang*), followed by Zn, Fe, Mn, Pb, Cu, Ni, Cd and Co. The higher concentration of Pb was 0.55 ± 0.74 μg g^{-1} in *L. fulvus*

Table 1 Mean concentrations (±SD) of metals (μg g^{-1} dry wt.) in gill, skin and muscle of thirteen fish species from Agatti coastal waters

Species	Cd (μg g^{-1})	Co (μg g^{-1})	Cu (μg g^{-1})	Fe (μg g^{-1})	Mg (μg g^{-1})	Mn (μg g^{-1})	Ni (μg g^{-1})	Pb (μg g^{-1})	Zn (μg g^{-1})
L. bengalensis	0.03 ± 0.02	0	0.15 ± 0.04	3.3 ± 2.04	99.01 ± 24.02	0.19 ± 0.05	0.56 ± 0.83	0.18 ± 0.15	3.95 ± 1.79
L. fulvus	0.02 ± 0.01	0	0.09 ± 0.05	5.2 ± 3.15	95.82 ± 15.52	0.83 ± 1.21	0.39 ± 0.61	0.55 ± 0.74	9.83 ± 11.32
L. monostigma	0.02 ± 0.03	0	0.09 ± 0.07	2.82 ± 2.51	100.7 ± 31.08	0.19 ± 0.18	0.04 ± 0	0.16 ± 0.16	4.74 ± 2.56
G. longirostris	0.61 ± 0.67	0.07 ± 0.06	0.37 ± 0.40	3.37 ± 1.29	88.43 ± 14.32	0.53 ± 0.44	0.1 ± 0.06	0.47 ± 0.13	5.89 ± 2.49
E. tauvina	0.02 ± 0.03	0	0.12 ± 0.05	3.27 ± 2.07	86.96 ± 12.63	0.2 ± 0.05	0.06 ± 0.06	0.16 ± 0.16	3.72 ± 2.11
C. argus	0.01 ± 0.01	0	0.14 ± 0.05	3.39 ± 1.92	90 ± 34.94	0.18 ± 0.10	0.06 ± 0.06	0.12 ± 0.05	5.85 ± 2.76
R. aculeatus	0.04 ± 0.02	0	0.11 ± 0.06	2.97 ± 2.45	107.86 ± 21.48	0.22 ± 0.15	0.04 ± 0.01	0.18 ± 0.15	5.71 ± 0.93
E. merra	0.01 ± 0.02	0	0.1 ± 0.04	2.84 ± 1.62	71.34 ± 2.53	0.12 ± 0.08	0.06 ± 0.04	0.19 ± 0.18	2.26 ± 1.03
P. pisang	0.04 ± 0.03	0.11 ± 0.17	0.27 ± 0.21	1.98 ± 0.59	117.4 ± 18.67	0.46 ± 0.54	0.23 ± 0.35	0.19 ± 0.09	5.7 ± 3.87
U. moluccensis	0.03 ± 0.02	0.01 ± 0.01	0.56 ± 0.49	6.64 ± 6.73	69.61 ± 44.79	0.19 ± 0.14	0.07 ± 0.05	0.33 ± 0.11	5.94 ± 5.14
P. lewisi	0.03 ± 0.01	0	0.18 ± 0.03	5.8 ± 2.6	81.9 ± 12.3	0.17 ± 0.03	0.1 ± 0	0.2 ± 0.1	3.07 ± 1.58
L. lentjan	0.02 ± 0.01	0.01 ± 0.01	0.19 ± 0.12	1.6 ± 0.4	91.85 ± 6.82	0.12 ± 0.12	0.06 ± 0.06	0.22 ± 0.16	3.24 ± 2.16
L. gibbus	0.01 ± 0.01	0	0.07 ± 0.01	2.28 ± 0.55	52.63 ± 42.45	0.05 ± 0	0.04 ± 0.01	0.08 ± 0.04	1.8 ± 0.06

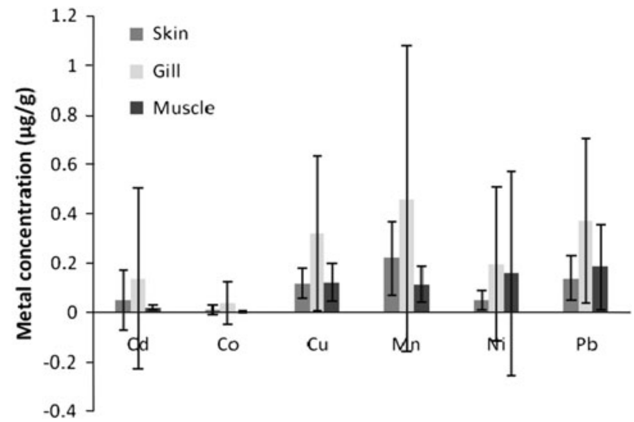

Fig. 2 Levels of Cd, Co, Cu, Mn, Ni and Pd (μg g^{-1} dry wt.) in gill, skin and muscle of demersal fishes of Agatti coast

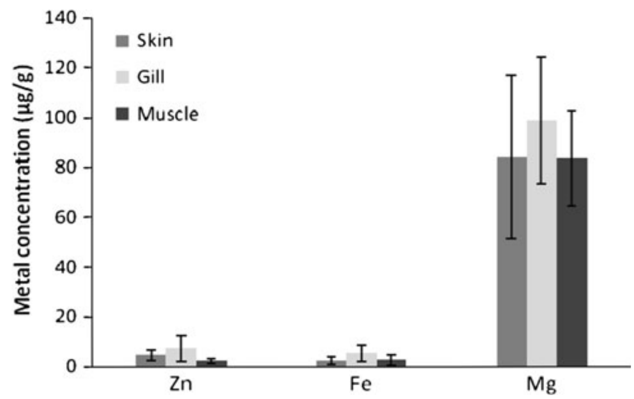

Fig. 3 Levels of Zn, Fe and Mg (μg g^{-1} dry wt.) in gill, skin and muscle of demersal fishes of Agatti coast

and this level is lower than those reported previously from lakes in Tokat, Turkey (Mendil and Uluozlu 2007) and maximum permissible limits suggested by WHO. The literature on lead toxicity indicates that, depending on the dose, lead exposure in children and adults can cause a wide spectrum of health problems, ranging from convulsions, coma, renal failure and death at the high end to subtle effects on metabolism and intelligence at the low end exposures (US Agency for Toxic Substances and Disease Registry 1999). The maximum permissible doses for an adult are 3 mg Pb and 0.5 mg Cd per week, but the recommended doses are only one-fifth of those quantities (FAO/WHO 1976) in rapport, the level of Cd observed in the present study (0.61 ± 0.67 μg g^{-1} in *G. longirostris*) was above the maximum permissible limit (0.2 μg g^{-1}). Miller et al. (2002) reported that exposure to environmental contaminants can lead to immune-suppression and increased susceptibility to disease in salmonids and other fish. The health implications of cadmium exposure are exacerbated by the relative inability of human beings to excrete cadmium. The occupational levels of cadmium exposure prove to be a risk factor for chronic lung disease and testicular degeneration (Benoff et al. 2000). Mean copper concentrations ranged from 0.07 to 0.56 μg g^{-1} and these values are lower than the permissible limits and earlier reported values (Chale 2002).

For an average adult (60 kg body weight), the provisional tolerable daily intake (PTDI) for Pb, Fe, Cu and Zn are 214 μg, 48, 3 and 60 mg, respectively (Joint FAO/WHO 1999). The mean concentration of iron and nickel were ranged from 1.6–6.64 to 0.04–0.56 μg g^{-1}, respectively. Among them, Ni values in *L. bengalensis* (0.56 ± 0.83 μg g^{-1}), *L. fulvus* (0.39 ± 0.61 μg g^{-1}) and *P. pisang* (0.23 ± 0.35 μg g^{-1}) were higher than the maximum permissible limits (0.14 μg g^{-1}) of WHO/EPA. Mn is recognised as essential trace element for humans, and several of their metabolic roles have been determined. The concentration of Mn in all fishes were exceeded the permissible limit (0.005 μg g^{-1}) and the recorded maximum level was 0.83 μg g^{-1} in *L. fulvus*.

Zinc values in fish species varied from 1.8 to 9.83 μg g^{-1} while the maximum zinc level was observed in *L. fulvus* (9.83 ± 11.32 μg g^{-1}), and it is far below the permissible limit and the minimum level in *L. gibbus* (Table 1). Zinc in low to moderate amounts is of very low toxicity in its ordinary compounds and in low concentrations is an essential element in plant and animal life. In humans, prolonged excessive dietary intake of zinc can lead to skin irritation, nausea, vomiting, fever, headache, tiredness, and abdominal pain.

An individual with metals toxicity, even if high dose and acute, typically has very general symptoms, such as weakness or headache. Industrialization of the world has dramatically increased the overall environmental 'load' of metal toxins, to the point that the societies are dependent upon them for proper functioning. Today, metals are abundant in our drinking water, air and soil due to the increased use of these compounds. It is very difficult for anyone to avoid exposure to any of the many harmful metals that are so prevalent in our environment. Metal toxins contribute to a variety of adverse health effects. There exist over 20 different metal toxins that can impact human health and each toxin will produce different behavioural, physiological, and cognitive changes in an exposed individual.

In conclusion, statistically significant differences were observed in mean metal values obtained for fish species from the Agatti Coast of Lakshadweep Sea. The results presented on metal contents in the examined species gave an indication of the environmental conditions along the coast of the Lakshadweep Sea. Accordingly, the concentrations of Cd, Mn and Ni obtained were above the established values by the World Health Organization and Food and Agricultural Organizations. Significant reasons for large proportion of metals in the island are the enormous usage of crude oil in power generators, shipping activity and antifouling coatings of ships. Even though Lakshadweep is considered as a ''no industry zone'', there are certain minor industrial units working under public and private sectors. Anthropogenic introduction of pollution and tourist activities also play a significant role in the pollution load of some of the metals. This study fills a gap by providing base line information on metal concentrations in different fish species from the Agatti coast.

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