Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
e-ISSN: 2395-3454

Vol. 18 | No. 3 | pp. 975-979 | 2019

Original Research Paper | Open Access

Heavy Metal Accumulation in Some Fishes Preferred for Consumption by Egrets in Odisha, India

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 22-02-2019
Accepted: 29-03-2019

Key Words:
Fish
Heavy metal accumulation
Wetland

ABSTRACT

The reduction of wetlands due to the increase of urbanization and industrialization has been an emerging global concern and is a threat to the fish population. Fishes have been proved as excellent indicators of heavy metal contamination of the aquatic ecosystems. The present research aims to determine the metal accumulation in fishes of different wetlands. Fish samples were collected for analysis of different metals like lead (Pb), chromium (Cr), copper (Cu) and zinc (Zn) by atomic absorption spectrophotometer. Pb concentration varies from 0.41-44.33 µg/g and found to be highest at Hirakud, whereas Cr, Cu and Zn were highest at Koraput which vary from 1.3-10.36 µg/g, 1.29-4.17 µg/g and 20.97-54.99 µg/g, respectively.

INTRODUCTION

Wetland is a transition zone between terrestrial and aquatic ecosystems where water covers the soil at least for a period of three years (Ayas et al. 2007). It is a complex ecosystem which contains many critical environmental processes like sediment deposition, delta accretion, water interaction and pollutant retention. Wetland is a suitable habitat for a diverse array of flora and fauna. It has been an emerging global concern on the diminishing freshwater supply and reduction in the size of wetlands due to immense anthropogenic activities causing a discharge of pollutants (Jayakumar & Muralidharan 2011). Wetlands are the most important ecosystems for covering a wide range of biodiversity (Mogalekar & Canciyal 2018), which are now contaminated with toxic materials. The increasing pace of urbanization and industrialization is the major source of heavy metal contamination (Rai 2008). Although metals such as copper, iron and zinc are required in trace quantities for both plant and animal life, an excessive amount may produce hazardous effects (Pipe et al. 1995, Oliveira et al. 2004). Heavy metals are generally studied in aquatic plants and animals due to their bioaccumulation and cumulative effect on the food chains (Edward et al. 2013).

Among various aquatic organisms, fishes have been proved as an excellent indicator of heavy metal contamination, because they clearly illustrate a relationship with the heavy metal contamination and to its assessment endpoint (Bervoets & Blust 2003). Fishes occupy the top trophic level in the aquatic food chains, which are ultimately consumed by human beings affecting human health (Burger et al. 2002). Fish acquire substantial quantities of trace elements from water, suspended particles and sediments (Chen et al. 2002). Passive diffusion or active uptake through the semi-permeable membrane of gill and gut epithelia are the two main routes for chemicals into the fish body (Ozturk et al. 2009). Several factors such as ecological need, metabolism of the animal, temperature and amount of pollutants in water affect the rate of uptake of the contaminant from its source (Bervoets & Blust 2003). Environmental exposure and the biochemical availability of metals to the organism, physiological need and life cycle are the key factors for bioaccumulation. It has been observed that increased uptake of metals such as cadmium and chromium occurs in kidney and liver in fishes, which may be attributed to the increased synthesis of metallothioneins and their storage as a constituent of liver and kidney cytoplasm. Metals such as copper and zinc are known to have an effect and also to be accumulated by aquatic biota such as fish and crustaceans. Most metals are furthermore known to become more bioavailable and have increased toxicity with decreasing pH (Chen et al. 2002). The present paper tries to address the assessment and impact of heavy metal pollution on fishes, which are the selected biomarker species of wetland ecosystems.

MATERIALS AND METHODS

Study area: Eight different heronries were sampled from various sampling sites of Odisha for their exposure to contamination, presence of breeding egret colonies and sampling suitability (Fig. 1). The 1st sampling site was Mangalajodi area (19°53'16.78"N, 85°26'19.55"E) of Chilika, which is a large bird congregation site all over the year for migratory as well as resident birds situated in Khurda district. The 2nd sampling site Hirakud reservoir is one of the largest water reservoirs of India. Sampling was done near the south western part of the reservoir near Debrigarh Wildlife Sanctuary (21°28'56.03"N, 83°48'53.73"E) of Bargarh district. Tihidi in Bhadrak district of Odisha (20°59'30.4"N, 86°38'11.24"E) was the 3rd sampling site which is surrounded by a large cultivation area. The 4th sampling site Chandaneswar of Balasore district is the northeast border of Odisha with West Bengal. Those heronries (21°38'1.03"N, 87°28'7.29"E) are in the coastal region around 3-4 kilometres from the main tourist area. Talcher, the 5th sampling site (20°57'43.74"N, 85°13'20.03"E), is situated in Angul district which is a highly urbanizing city with various industrial and mining activities. The 6th sampling site (19°53'34.36"N, 84°6'47.91"E) is Daringbadi. It is a hill station in Kandhamal district with 914 m altitude. Sampling was done inside the forest patches near the outskirts of the town. Titlagarh city of Bolangir district was the 7th sampling site (20°16'18.96"N, 83°9'10.26"E). It is a semi urban place which is known for its high temperature (avg. 27.3°C and max. 48.5°C) in Odisha. The heronries are present at periphery of the city and surrounded by many abandoned water bodies. The 8th sampling site is in Koraput district (18°48'16.2"N, 82°42'41.17"E). The sampled heronries are near the town of Koraput with high anthropogenic pressure like cattle and human interference.

Sampling design: Sampling was carried out for a period of two years covering the three seasons, i.e. pre-monsoon, monsoon and post-monsoon. A set of experimental gill nets (measuring 5 m length, 0.5 m height and mesh size of 0.5 to 1 inch) were set up and left from morning to afternoon. *Puntius* sp. was collected for analysis purpose because they are commonly eaten by egrets. Fish samples were properly labelled and placed in an ice box and transported to the laboratory for further study.

Chemical analysis and statistics: The whole body tissue of fish was used for analysis in this study. All the samples were oven dried at 110°C and then wet digestion method was followed for acid digestion with nitric acid (HNO_3) and hydrochloric acid (HCl) in 1:3 ratio. Each acid digestion is compared by digestion blank. Concentrations of heavy metals were measured by Atomic Absorption Spectrophotometer of model Shimadzu, AA 6300 with wavelength 217.0 nm, lamp current 5.0 mA and expressed as µg/g. For a better interpretation of the results, statistical tools like mean, standard deviation and ANOVA were applied using RStudio 3.4.4 software.

RESULTS

Table 1 gives the concentration of different metals found in different sampling stations. Concentration of Pb was found to be highest at Hirakud (44.3±5.76 µg/g) followed by Talcher (24.9±2.43 µg/g). The amount found at Chandaneswar, Bhadrak and Koraput were 14.19±2.07 µg/g, 13.47±3.4 µg/g and 6.89±2.14 µg/g respectively. Lowest amount of Pb was found at Chilika followed by Daringbadi

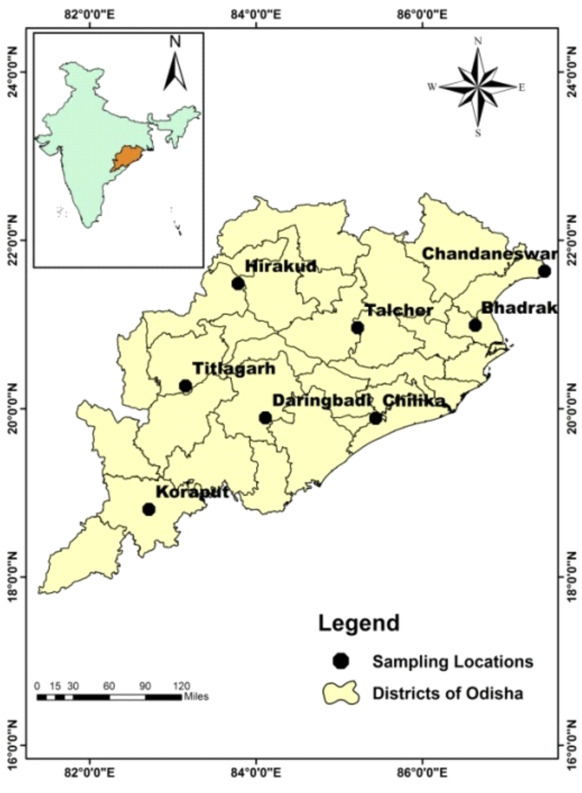

Fig. 1: Map of the study area showing location of sampling sites.

Table 1: Descriptive statistics (Mean±SD) of Pb, Cr, Cu and Zn (µg/g) in fishes.

Sampling point	Pb	Cr	Cu	Zn
Chilika	0.41±0.14	1.33±0.27	2.88±1.17	24.67±1.64
Hirakud	44.3±5.76	3.92±1.15	1.61±0.62	23.78±2.49
Bhadrak	13.47±3.4	1.61±0.38	1.64±1.04	20.97±3.86
Chandaneswar	14.19±2.07	1.94±0.93	1.29±0.64	23.69±2.41
Talcher	24.9±2.43	3.73±1.11	1.78±1.07	36.56±4.53
Daringbadi	0.99±0.68	1.36±0.65	1.81±0.75	25.03±3.6
Titlagarh	1.48±0.6	1.3±0.61	2.76±1.11	27.28±2.89
Koraput	6.89±2.14	10.36±2.64	4.17±1.49	54.99±5.22
Permissible Limit	2.0	0.6	3.0	30.0

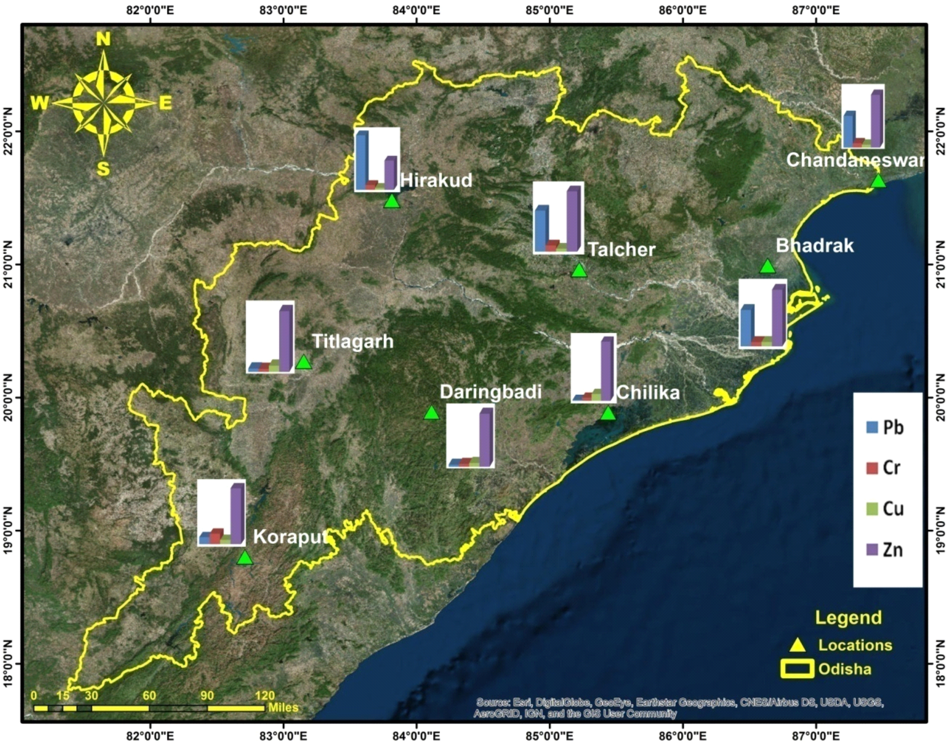

Fig. 2: Comparision of heavy metals in fishes from different locations of the study area.

and Titlagarh with 0.41±0.14 µg/g, 0.99±0.68 µg/g and 1.48±0.6 µg/g respectively. The higher amount of Pb at Hirakud and Talcher may be due to the presence of different industries. Amount of Cr was found to be highest at Koraput with 10.36±2.64 µg/g followed by Hirakud and Talcher with 3.92±1.15 µg/g and 3.73±1.11 µg/g respectively. In other sampling stations, it varied from 1-2 µg/g. Koraput is a place of high mineral deposition. This may be the reason for getting higher amount of Cr from that region. The amount of Cu was found highest at Koraput followed by Chilika and Titlagarh with 4.17±1.49 µg/g, 2.88±1.17 µg/g and 2.76±1.11 µg/g respectively. All other sites were found 1-2 µg/g of Cu. The amount of Zn was found to be highest at Koraput followed by Talcher with 54.99±5.22 µg/g and 36.56±4.53 µg/g respectively. In all other sites, Zn concentration varies from 20-30 µg/g. Koraput and Talcher are the mineral rich areas with high mining effect. This can be a reason for getting higher amount of Zn here as compared to other sites (Table 1). Concentration of Pb and Cr in the *Puntius* sp. shows less significant variation among the sampling sites (F=2.666, P=0.124 and F=0.879, P=0.364) respectively. While concentration of Cu and Zn is signifi-

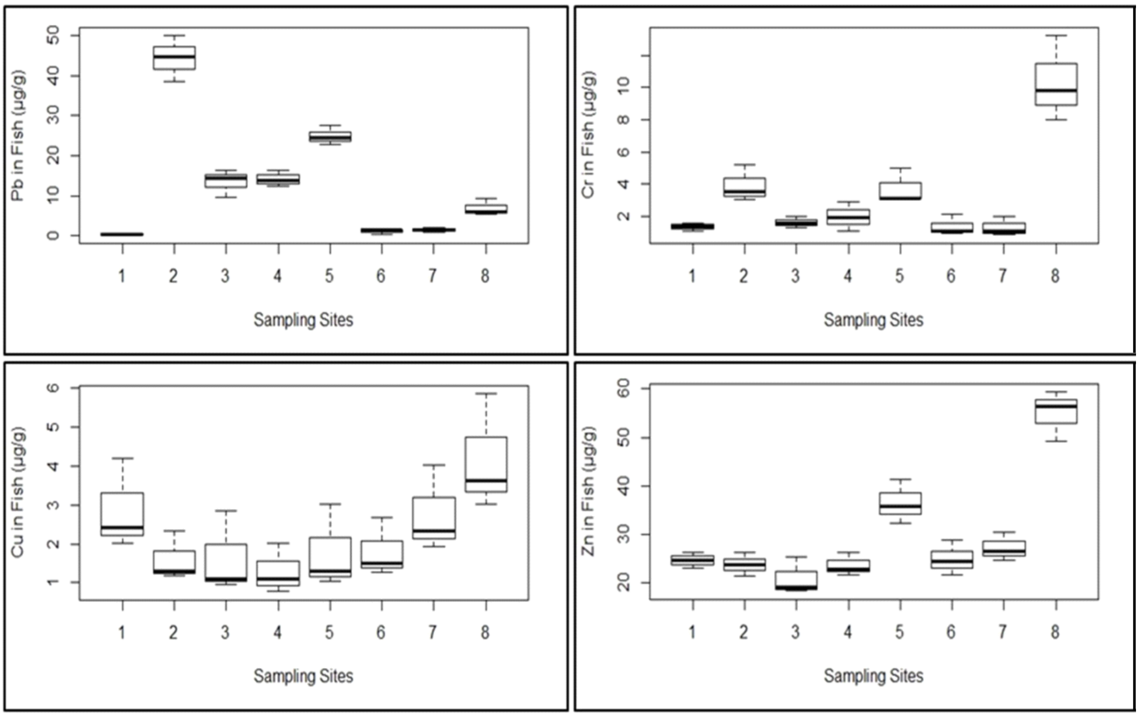

Fig. 3: Box plot of heavy metals found from fishes.

cantly varied among sampling sites (F=5.889, P=0.029 and F=38.043, P=2.44) respectively.

According to the World Health Organization (WHO 1985, 1989), the permissible limit for Pb is 2.0 µg/g in fishes, but in the present study, it was observed that, Hirakud, Bhadrak, Chandaneswar, Talcher and Koraput have higher concentration than the permissible limit (Table 1, Fig. 2). Permissible limit for Cr is 0.6 µg/g in fishes, but the present study shows higher amount of Cr from all the sampling stations. The permissible limit of Cu is 3 µg/g in fishes, but in the present study, near Koraput it is higher than the limit. Permissible limit of Zn is 30 µg/g in fishes, but in the present study, Talcher and Koraput are the two sites where the amount of the metal found is much higher than the limit (Fig. 3).

At Chilika the amount of Zn (24.67±1.64 µg/g) was found to be highest followed by Cu (2.88±1.17 µg/g) in the order of Zn>Cu>Cr>Pb. At Hirakud, Pb is highest with 44.3 µg/g and order of the metals was Pb>Zn>Cr>Cu. At Bhadrak the order of metals was Zn>Pb>Cu>Cr, and at Chandaneswar, the order was Zn>Pb>Cr>Cu. Pb concentration near Talcher was found to be much higher (24.9±2.43 µg/g) than other sites and follow the order Zn>Pb>Cr>Cu. At Daringbadi the order of the metals was Zn>Cu>Cr>Pb. Titlagarh followed the order Zn>Cu>Pb>Cr. At Koraput the order of metals was Zn>Cr>Pb>Cu.

DISCUSSION

Fishes are vulnerable to different metal contaminants in the water. The contaminants may significantly alter the physiological and biochemical processes of the organisms upon their entry to the target organs. Prolonged exposure of fish to sublethal trace metal levels cause alteration in ion regulation, reduced growth and swimming efficiency (Pandey & Madhuri 2014). Haematological changes, biochemical alterations and affecting locomotion, negative modulation of biochemical processes and immune responses, inhibition effect on activity of enzyme Na/K ATPase and oxygen consumption are some of the well-known effects of metals in fishes (Velmurugan et al. 2016). Copper induces oxidative stress in various fish models. In grey mullet *Mugli cephalus*, the oral exposure of copper resulted in the decrease of hepatic α-tocopherol concentration by 63% (Hosseini et al. 2014). Chromium has been known to damage DNA. It has been reported that formation of DNA-protein crosslink in the erythrocytes occurs in the fathead minnow *Pimephales promelas* and largemouth bass *Micropterus salmoides* on exposure to hexavalent chromium in water and in the diet (Kuykendall et al. 2006). It has been well known that exposure to various metals in water alters the biochemical status of the fish tissue. Cadmium and chromium are well known heavy metals having effects on lipid peroxidation, GSH depletion and inhibition of antioxidant enzymes (Basha &

Rani 2003). It has also been seen that, environmental toxicants reduce the breeding capacity of *Heteropneustes fossilis* (Dutta et al. 2017). These toxicants moving to the next trophic level are affecting the higher organisms who use fish as food (Aboushiba et al. 2013, Abdullah et al. 2015, Dalio 2018).

CONCLUSION

Fish has become a key component to be investigated as they are found to be the major victims of heavy metals contamination in an aquatic ecosystem. This study describes more amounts of heavy metals than the limit value from many sites of the study area. Thus, fish tissue contamination monitoring is an important function of sediment and water quality contamination. It shows a major effect on the next trophic level like different birds and animals who use fish as their food. It especially comes to the evaluation of human health risk because fish is a good source of food for human beings.

ACKNOWLEDGEMENTS

The authors are highly thankful to the Institute of Technical Education and Research, Siksha 'O' Anusandhan Deemed to be University.

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