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HEAVY METALS UPTAKE BY OREOCHROMIS MOSSAMBICUS OF BUDHASAGAR POND

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ABSTRACT

Food consumption is a major source through which humans as well as other animals are exposed to toxic heavy metals. Many reported studies have confirmed that contamination of heavy metals via the food chain can cause human health risk because of their toxicity, long persistence, bioaccumulation, and biomagnification. Heavy metals disrupt cellular events including growth, proliferation, damage-repairing processes, and apoptosis. Studies have widely used fishes as a bioindicator of metal pollution in the aquatic ecosystem for advantages discussed in the previous sections. Studying heavy metals presence in fishes has another advantage. Since we eat fish, it also tells us about possible health risks it poses for us to consume contaminated fish. We measured the presence of heavy metals, namely, mercury, lead, cadmium, and chromium in gills, livers, and muscles of Oreochromis mossambicus of Budhasagar pond using Target Hazard Quotient (THQ) and Hazard Index (HI). An HI of >1 indicates health risks, that <1 indicates a safe level of exposure. HI was recorded at safe levels in gills, livers, and muscles for both adults and children. Similarly, THQ too was found within the safe limits of 1 for each of the four heavy metals across the study period.

***Keywords**: Oreochromis mossambicus, heavy metals contamination, Budhasagar pond.*

Introduction

Even though two-third of the Earth's surface is covered with water, only 1% of this is freshwater. This freshwater is mainly found in ponds, rivers, lakes, and groundwater. These sources have served and supported evolving needs of the human civilization for millennials. Unfortunately, the latest evolution in the human civilization that took place in the form of industrial revolution in the 18^{th} century has come to threaten the freshwater security for the whole human civilization as well as various animal and plant kingdoms. Researchers have attempted to bring attention to this growing insecurity and have predicted water insecurity to be the biggest crisis of the 21^{st} century.

Water pollution is one of three major pollutions threatening the environment today. It is a broad term defined by the presence of unwanted contaminants in water and includes seawater as well as freshwater contamination. Seawater pollution threatens ocean and sea habitats such as seawater plants and fishes. Disposal of plastic at beaches and oil spills are two major sources of seawater pollution. Freshwater contamination is due to three primary sources: domestic, agriculture, and industrial. Disposal of domestic waste and sewage discharge into rivers and ponds pollute these freshwater sources. Agricultural runoffs containing chemical fertilizers and discharge of untreated industrial waste are major and most lethal sources of freshwater contamination.

The presence of heavy metals such as iron, lead, and cadmium in agriculture runoffs and industrial water make contaminated freshwater unsafe for human use. Heavy metals are elements with an atomic density of more than 4 g/cm^3 (Nriagu, 1988). Some of the major sources of heavy metals pollution of freshwater bodies include sewage discharge, agricultural runoffs, battery industry, metal electroplating, chrome plating, tanning and leather industry, and dyes industries (Farmaki and Thomaidis, 2008).

While the human body needs certain heavy metals such as iron, zinc, chromium, copper and manganese up to a limited extent for proper functioning of organs, other heavy metals such as mercury and lead are non-essential and even the slightest presence of these metals in the human body can prove to be lethal (Unger, 2002). International and national authorities such as the European Union and the United States Environmental Protection Agency have defined permissible limits for the presence of different heavy metals in food products (see Table 1). Above these permissible limits, the food is considered unsafe for human consumption (Nolan, 2003; Young, 2005).

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industry effluent, according to Ajmal et al. (1985). Fertilizer, agricultural ashes, industrial effluents, and rubbish contaminated the Cauvery River, and the researchers found high levels of heavy metal in the fish. To find out how much heavy metal is in freshwater, scientists have done a variety of tests. Fish muscle from home sewage and industrial effluent was investigated by Nayaka et al. (2009).

Heavy metals in tissues of *Mystus vittatus* were studied by Rao and Patnaik (2000). Maiti and Banerjee (2002) and Vinodhini and Narayanan (2008) conducted a similar study in Kolkata's various freshwater bodies in *Cyprinus carpio* fish. Heavy metal build-up in fish tissues were studied by Begum et al. (2009b) in Bangalore's Madivala Lake. As the muscle is the most consumed and most heavily contaminated section of fish, Gupta et al. (2009) examined the contamination of *Aorichthys aor* and *Channa punctatus* to check if they were infected. Other studies investigated the presence of heavy metals in freshwater fish tissues and tested them up to the maximum allowable level (Gupta et al., 2002; Shrivastava and Sohani, 2002; Chandrasekhar et al., 2003; Chakraborty et al., 2003; Raja et al., 2009).

Heavy metals in *Oreochromis mossambicus*

Fishes are great bioindicators of metal contamination of a water body as they appear at higher trophic levels allowing for metals to accumulate (Palanichamy and Baskaran, 1995). Since fishes are also eaten by humans, investigating the contamination in fishes also allows us to measure the health risks posed by contamination simultaneously.

James (1990) examined individual as well as combined effects of the heavy metals' contamination on *Oreochromis mossambicus'* respiratory and behavioural responses, their oxygen consumption, and opercular movements. Chatterjee et al. (2006) found that metal concentrations were lowest in muscle and highest in liver in *Oreochromis mossambicus* sampled from coastal waters of Kolkata. Dye et al. (2007) studied the histological changes in the livers of *Oreochromis mossambicus* following exposure to cadmium and zinc. Dye et al. found that longer exposure affected results. *Oreochromis species* had a higher metal contamination index value in Malaysian aquaculture ponds where they were compared to Penaeus monodon species (Mokhtar, 2009). Hossein et al. (2015) looked at the build-up of heavy metals in fish tissues from Egypt's Nile River and concluded that species like *Oreochromis* are suitable candidates for bio-monitoring pollution since they can tolerate the harsh circumstances of the ecosystem. Noorjahan and Jamuna (2015) used *Azolla Microphylla* as a biodegradation agent in their study of sewage wastewater treatment and repurposed the treated water for aquaculture. To treat sewage water in a sustainable and environmentally friendly manner while also promoting aquaculture, researchers used *Oreochromis mossambicus* farmed fish.

Research Methodology

Samples of *Oreochromis mossambicus* were collected across winter, summer, and post-monsoon seasons in 2016-17 and their gills, livers, and muscles were studied for presence of heavy metals. The concentration of select heavy metals were recorded in different organs of sample and results analysed using SPSS v. 26. The selection of *Oreochromis mossambicus* is based on the following criteria (Widdows, 1985; Adelman and Smith, 1976).

i) Edible status – Whether the fish is widely consumed by people.
ii) Availability – Whether the fish is available in the pond throughout the year.
iii) Omnivores – Sample fishes should be omnivores to allow bioaccumulation.
iv) Environment tolerability – Sample fishes should have greater tolerability to a wide range of environmental conditions.

Oreochromis mossambicus fulfils all the above criteria. They are widely eaten fish specimen across the state of Chhattisgarh. They also have an advantage over other fish species as they are prolific breeder and eat blue-green algae, insects, and weeds, therefore, contaminants found in these insects and organisms could also be observed in *Oreochromis mossambicus* (Jhingran, 1984). *Oreochromis mossambicus* are also found in abundance and throughout the year.

Target Hazard Quotient (THQ)

After computing the heavy metals concentration in fish samples, we compared the findings on two indices, e.g., the Target Hazard Quotient (THQ) and the Hazard Index (HI). THQ was developed by the United States Environmental Protection Agency in 1989 and is used for the assessment of potential non-carcinogenic threat associated with exposure to contaminants such as heavy metals in food. The THQ is a ratio of the determined dose of a pollutant to a reference dose level. It has a binary interpretation. A THQ value of < 1 indicates that the contamination is within safe permissible limits, whereas a THQ value of > 1 is indicative of potential risk (USEPA, 2010). One should take care in interpreting THQ as the values are additive but not multiplicative. That is, a THQ value of 20 does not indicate that the risk is tenfold of those at THQ value of 2. THQ doesn't measure risk but is indicative of the level of concern.

We computed the THQ values based on Chien et al.'s (2002) method as follows.

$$THQ = \frac{\text{EF. ED. FIR. C}}{\text{RFD. WAB. TA}} \times 10^{-3}$$

where,

E_F is the exposure frequency measured per 365 days/year,

E_D refers to the exposure duration,

F_{IR} is the food ingestion rate (g/person/day),

C is the total concentration in food (mg/kg),

R_{FD} is the oral reference dose (Table 2),

W_{AB} refers to the average body weight (55kg for adults and 20kg for children), and

T_A is the averaging exposure time for non-carcinogens.

Table 2 USEPA Oral Reference Dose

Heavy metals	R_{FD} value (mg/kg) (USEPA)
Cadmium	0.001
Lead	0.004
Mercury	5 x 10^{-4}
Chromium	0.003
Iron	0.7

Hazard index (HI)

Hazard Index (HI) is based on EPA's guidelines for health risk assessment of chemical mixtures (USEPA, 1986). It is used to measure the overall risk hazard for non-carcinogenic effects posed by more than one heavy metal. HI is given by the sum of THQ as described in the below equation. An HI value of > 1 indicates potential health risks (USEPA, 1989).

$$HI = \sum_i \text{THQi}$$

Heavy Metals Analysis

Inductively coupled plasma-optical emission spectrometry (ICP-OES) was used to examine fish samples for heavy metal contamination. The study focused on heavy elements like lead, cadmium, chromium, iron, and mercury. Using the methods provided in the American Public Health Association (2005) and the United States Department of Agriculture, samples were crushed and examined inductively with ICP-OES (Perkin Elmer, 2008). Glassware used in the experiment was rinsed with 10% (v/v) nitric acid and deionized water before the samples were digested. Sterilized surgical blades and scissors were used to defrost fish samples and remove tissues. Acid-washed petri dishes were used to oven-dry fish tissues at 80°C to a consistent weight. Desiccators were used to chill the fish samples. The fish tissues were ground into a fine powder and weighed after being homogenised with a mortar and pestle. Microwave digestion was used to breakdown fish tissues processed in Nitric acid (Table 3). 2 mL of 30% hydrogen peroxide were given to digests after digestion to reduce nitric acid vapours and speed up organic component digestion by raising the temperature (Dig-Acids, 2001).

Blanks are used to ensure that the analysis is authentic. Triplicate analyses of fish samples were performed to ensure high analytical quality. Digested fish samples were diluted in acid-washed standard flasks with 50ml of ion free water and filtered through a 0.45-m filter paper. ICP-OES was used to evaluate digested materials after they had been filtered and purified. Table 4 lists the parameters for the Perkin Elmer Optima 4100DV ICP-OES system. Standardization was carried out by diluting 1000 mg/L stock solutions of multi-element standard solutions (Merck) (Mohammed, 2007). Heavy metal concentrations in sample fishes were measured in mg/L of dry weight. All tests were carried out in threes to ensure reproducibility and a detection limit of 0.01 mg/kg was used. The results indicated below detection limit (BDL).

Table 3 Microwave digestion program used for fish (Source: USDA, 2008)

S. no.	Temp. (°C)	Time (min.)	Power (Watt.)
1	25-96	20	1000
2	96	30	1000
3	180	10	1000
4	180	10	1000

Table 4 Summary of the operational parameter setting used for the ICR-OES

Characteristics	Instrument condition
RF Generator	Fully solid-state generator. Operating frequency ~40 MHz
RF Power	Adjustable power between 750 to 1300 Watts
Spray chamber	Scott type
Nebulizer	Cross flow
Plasma gas flow	15 L/min
Auxiliary gas flow	L/min
Nebulizer gas flow	0.60 L/min

Results and Discussion

Table 5, 6 and 7 list the season-wise heavy metals concentrations in gills, livers and muscles of *Oreochromis Mossambicus*, respectively. Figures 1, 3 and 5 indicate the min., max., and other descriptive values of recorded across three seasons for the concentration of mercury, cadmium, chromium, and lead in gills, livers, and muscles, respectively. Figures 2, 4 and 6 respectively indicate the descriptive stats for iron concentration in gills, livers and muscles.

In general, higher concentrations of heavy metals were found in gills except for iron which shows a much greater concentration in livers than gills. On the other hand, muscles had the least concentration for heavy metals across the three seasons for all five metals. Mercury was the only heavy metal (out of the five selected heavy metals) which was not detected at all in summer and post-monsoon samples. A slight amount of mercury from 0.05 to 0.151 mg/Kg was detected in all three organs during the winter season. Cadmium was not detected in gills during the post-monsoon and in muscles in summer as well as post-monsoon seasons.

Table 5 Heavy metals concentration in gills

	Summer	Post Mon	Winter
Mercury	BDL	BDL	0.148
Lead	3.94	2.98	2.88
Cadmium	0.614	BDL	0.04
Chromium	1.08	2.4	3.77
Iron	336	347	286

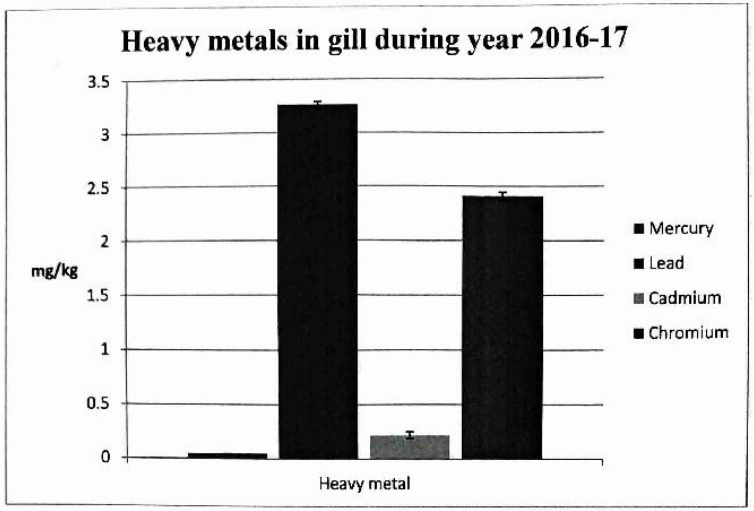

Figure 1

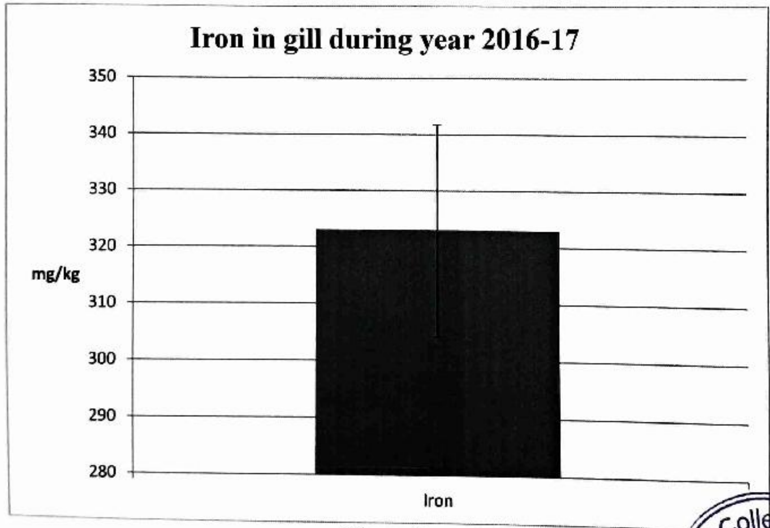

Figure 2

Table 6 Heavy metals concentration in livers

	Summer	Post Mon	Winter	Mean
Mercury	0	0	0.147	0.049
Lead	4.36	3.38	2.85	3.53
Cadmium	0.044	0.85	0.04	0.31
Chromium	5.91	1.72	3.74	3.79
Iron	6649	9351	1784	5928

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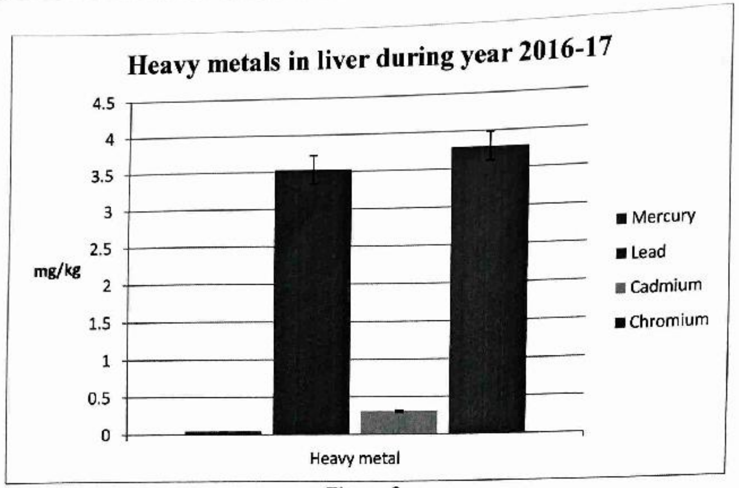

Figure 3

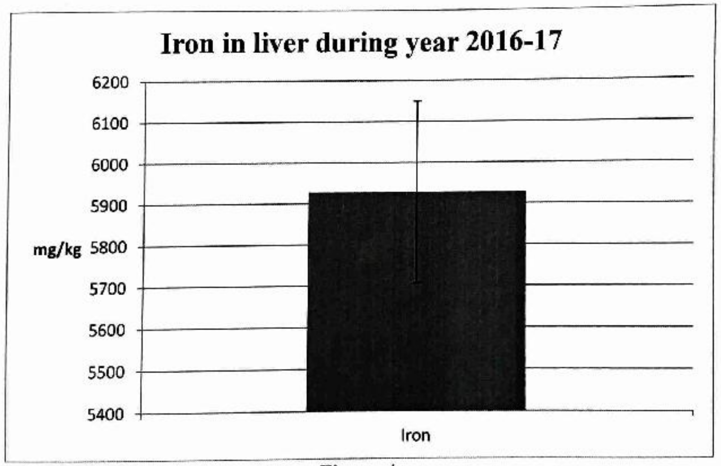

Figure 4

Table 7 Heavy metals concentration in muscles

	Summer	Post Mon	Winter	Mean
Mercury	BDL	BDL	0.418	0.139
Lead	2.83	0.96	0.343	1.377
Cadmium	BDL	BDL	0.015	0.005
Chromium	0.824	2.23	0.762	1.272
Iron	65.5	126	105	98.83

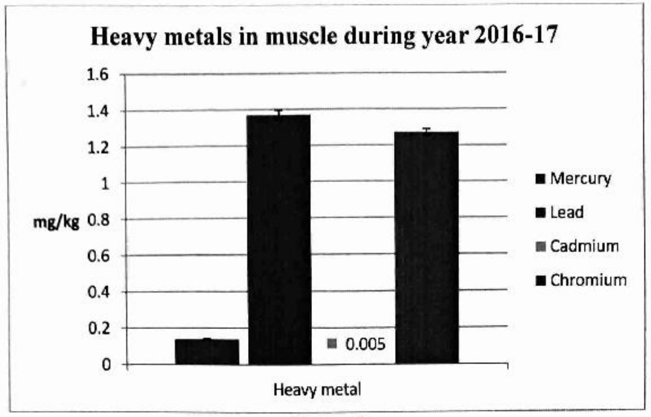

Figure 5

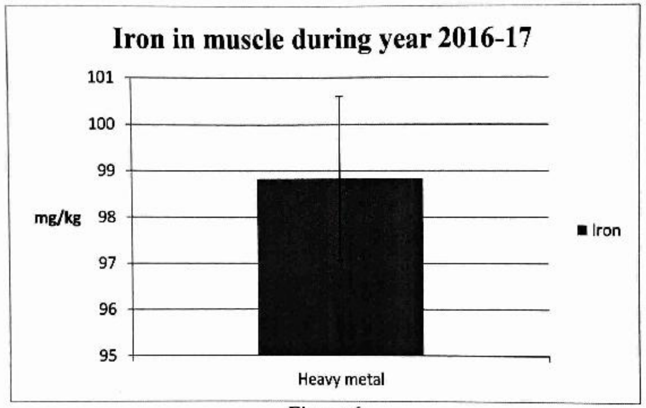

Figure 6

Potential Health Risks

We examined THQ and HI values to determine the health risks posed from the concentration of mercury, lead, cadmium, chromium and iron in *Oreochromis mossambicus* samples collected from Budhasagar pond. The previous section covered these indices. The previous section discussed safe levels of exposure for adults and children, measured in mg/Kg per day for each of the four heavy metals examined. There was 0.001 Cadmium in the air, 0.004 Lead in the soil, 0.0005 Mercury in the water, and 0.003 Chromium in the soil. Hazard index measures the health risk posed by multiple heavy metals exposure. The total hazard presented by all heavy metals, as determined by THQ, is what this represents. A HI value of > 1 should raise alarm as it indicates potential health risks to consumer of contaminated food.

Tables 8 and 9 respectively indicate the THQ and HI values for children. Tables 10 and 11 respectively indicate the THQ and HI values for adult consumers. One could observe from these tables that the THQ and HI values are well within permissible limits. That is, to say, it is safe to eat *Oreochromis mossambicus* of the Budhasagar pond.

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Table 8 THQ (Children)

Metal	Gill			Liver			Muscle		
	Summer	Post Mon.	Winter	Summer	Post Mon.	Winter	Summer	Post Mon.	Winter
Mercury	0	0	0.070	0	0	0.069	0	0	0.197
Lead	0.232	0.176	0.170	0.257	0.199	0.168	0.167	0.056	0.020
Cadmium	0.145	0	0.009	0.010	0.201	0.009	0	0	0.003
Chromium	0.085	0.189	0.297	0.465	0.135	0.294	0.064	0.175	0.060
Iron	0.113	0.117	0.096	2.246	3.159	0.602	0.022	0.042	0.035

Table 9

Metal	Gill			Liver			Muscle		
	Sum.	Post Mon.	Wint.	Sum.	Post Mon.	Wint.	Sum.	Post Mon.	Wint.
HI	0.462	0.365	0.546	0.732	0.535	0.540	0.231	0.231	0.280

Table 10

Metal	Gill			Liver			Muscle		
	Summer	Post Mon.	Winter	Summer	Post Mon.	Winter	Summer	Post Mon.	Winter
Mercury	0	0	0.025	0	0	0.025	0	0	0.0718
Lead	0.084	0.064	0.061	0.093	0.072	0.061	0.060	0.020	0.007
Cadmium	0.052	0	0.003	0.003	0.073	0.003	0	0	0.001
Chromium	0.030	0.068	0.108	0.169	0.049	0.107	0.023	0.063	0.021
Iron	0.041	0.042	0.035	0.816	1.148	0.219	0.008	0.015	0.012

Table 11

Metal	Gill			Liver			Muscle		
	Sum.	Post Mon.	Wint.	Sum.	Post Mon.	Wint.	Sum.	Post Mon.	Wint.
HI	0.166	0.132	0.197	0.265	0.194	0.196	0.083	0.083	0.100

Conclusion

Food consumption is a major source through which humans as well as other animals are exposed to toxic heavy metals. Many reported studies have confirmed that contamination of heavy metals via the food chain can cause human health risk because of their toxicity, long persistence, bioaccumulation, and biomagnification. Heavy metals disrupt cellular events including growth, proliferation, damage-repairing processes, and apoptosis. Comparison of the mechanisms of action reveals similar pathways for these metals to toxicity including ROS generation, immunity weakening, enzyme inactivation, and oxidative stress.

On the other hand, some heavy metals have selective binding to certain macromolecules. The interaction of lead with aminolaevulinic acid dehydratase and ferro chelatase is within this context. Some toxic metals like chromium and cadmium cause genomic instability. Defects in DNA repair following the induction of oxidative stress and DNA damage by cadmium and chromium have been considered as the cause of their carcinogenicity. Mercury and lead, on the other hand, disrupts the functioning of human body in other ways. Mercury could cause thiol binding, inhibit glutathione peroxidase and enzymes, reduce aquaporins mRNA, and affect ROS production. Lead causes increased serum and inflammatory cytokines and a reduction in GSH, SOD, CAT, and GPx levels. The incidence of heavy metals poisoning remains considerable and requires preventive and effective treatment.

Studies have widely used fishes as a bioindicator of metal pollution in the aquatic ecosystem for advantages discussed in the previous sections. Studying heavy metals presence in fishes has another advantage. Since we eat fish, it also tells us about possible health risks it poses for us to consume contaminated fish. The present research was carried out at Budhasagar pond to investigate the presence of heavy metals in *Oreochromis mossambicus* and the health risks for humans upon the consumption of *Oreochromis mossambicus*. We investigated the health risks due to the consumption of contaminated *Oreochromis mossambicus* of the pond.

We measured the presence of heavy metals, namely, mercury, lead, cadmium, and chromium in gills, livers, and muscles of *Oreochromis mossambicus* of Budhasagar pond using THQ and HI. These indices were discussed in the previous section. In brief, a THQ of <1 is considered safe whereas a THQ of >1 poses health risks. Healthy limits of exposure, in mg/kg/day, for adults and children for all five studied heavy metals were mentioned in the previous section. These were 0.001 for Cadmium, 0.004 for Lead, 0.0005 for Mercury, and 0.003 for Chromium. Hazard index assesses the health risk posed from the combined exposure to multiple heavy metals. It is basically the sum of risk posed by all heavy metals measured in THQ. An HI of greater 1 is a cause of concern for it poses health risks for humans.

Between gills, livers, and muscles, it poses the most danger to human health of have a greater level of heavy metals presence in the muscles as this is the edible part in the fish. The presence of heavy metals in sample *Oreochromis mossambicus* of Budhasagar pond was found to be in controlled levels. That is, the consumption of *Oreochromis mossambicus* of Budhasagar pond does not pose health risks for adults or children and are safe to eat.

HIs were measured to assess health risks associated with exposure to the four heavy metals for adults and children. An HI of greater than 1 indicates potential health risks, that below 1 indicates a safe level of exposure. Across all three seasons, HI remained below the safe level of 1 in gills, livers, and muscles for both adults and children. Similarly, THQ too was found within the safe limits of 1 for each of the four heavy metals across the study period.

References

1. Adelman, I.R. and Smith, L.L. (Jr.). 1976. Fathead minnows (Pimephales promelas) and goldfish (Carassius auratus) at standard fish in bioassays and their reaction to potential reference toxicants. J. Fish. Res. Bd. Can. 33: 209-214.
2. Adeniyi, A. A. and Yusuf, K. A. 2007. Determination of Heavy metal in fish tissues, water and bottom sediments from Epe and Badagry lagoons, Logas, Nigeria.Environ. Monitor. Assess. 37: 451-458.
3. Ajmal, M., Khan, M. A. and Nomani, A. A. 1985. Distribution of Heavy metal in plants and fish of the Yamuna River India. Environ. Monitor. Assess. 5: 361-367.
4. Anderson, R. A. 1989. Essentiality of chromium in humans. The Science of the Total Environment. 86: 75-81.
5. APHA (American Public Health Association). 2005. Standard Methods for the Examination of Water and Wastewater, 21st edn. American Wastewater Association and Water Environment Federation, Washington, D.C.
6. Balasubramanian, S., Pappathi, R., Bose, A. J. and Raj, S. P. 1997. Bioconcentration of copper, nickel and cadmium in multicell sewage-fed fish ponds. J. Environ. Biol. 18(2): 173-179.
7. Begum, A., Harikrishna, S. and Khan, I. 2009b. Analysis of Heavy metal in water, sediment and fish samples of Madivala lakes of Bangalore Karnataka. Int. J. Chemtech Res. 1(2): 245-249.
8. Bernard A, Lauwerys R.1986. Effects of cadmium exposure in humans. In: Handbook of experimental pharmacology. E.C. Foulkes, editors Berlin Springer-Verlag. pp. 135-77.
9. Braver, E. R., Infante, P. 1985. An analysis of lung cancer risk from exposure to hexavalent chromium. Teratogenesis, Carcinogenesis, & Mutagenesis. 5(5): 365-78.
10. Chakraborty, R., Dey, S., Dkhar, P. S., Ghosh, D., Singh, S., Sharma, D. K. and Myrboh, B. 2003. Accumulation of Heavy metal in some freshwater fishes from Eastern India and its possible impact on human health. Poll. Res. 22(3): 353-358.
11. Chandrasekhar, K., Chary, N. S., Kamala, C. T., Suman Raj, D. S. and Rao, A. S. 2003. Fractionation studies and bioaccumulation of sediment-bound Heavy metal in Kolleru Lake by edible fish. Environment International. 29: 1001- 1008.
12. Chatterjee S., Chattopadhyay B., Mukhopadhyay S.K. 2006. Trace metal distribution in tissues of cichlids (Oreochromis niloticus and Oreochromis mossambicus) collected from wastewater-fed fishpond. Acta Ichthy. Et Pisca. 36 (2): 119-125.
13. Chen, Y., Chen, C., Hwang, H., Chang, W., Yeh, W. and Chen, M. 2004. Comparison of the metal concentrations in muscle and liver tissues of fishes from the Erren River, southwestern Taiwan, after the restoration in 2000, J. of Food and Drug analysis. 12(4): 358-366.
14. Cohen, M. D., B. Kargacin B. 1993. Mechanisms of chromium carcinogenicity and toxicity. Critical Reviews in Toxicology. 23(3): 255-81.
15. Crichton, R. R., Wilmet, S., Legsyer, R. and Ward, R. J. 2002. Molecular and cellular mechanisms of iron homeostasis and toxicity in mammalian cells. J. Inorg. Biochem. 91: 9-18.
16. Decker C, Menendez R. 1974. Acute toxicity of iron and aluminum to brook trout. Proc. W. Virg. Acad. Sci. 46: 159-167.
17. Dig-Acids. 2001. Guidelines for Microwave Acid Digestion. In: ED (ed) http:// www.scribd.com/doc/6789831/DigAcids.
18. Duruibe, J. O., Ogwuegbu, M. O. C. and Egwurugwu, J. N. 2007. Heavy metals

pollution and human bio toxic effects. Int. J. Phy. Sci.. 2(5): 112-118.
19. Dyk J.C., G.M. Pieterse, Vuren J.H.J. 2007. Histological changes in the liver of Oreochromis mossambicus (Cichlidae) after exposure to cadmium and zinc, Ecotoxicology and Environmental Safety. 66(3): 432-440.
20. Forstner, U. & Wittmann, G.T.W.1979. Metal pollution in the aquatic environment. Springer Verlag, Berlin.
21. Geller, R. 2001. Chromium In: Clinical Environmental Health and Toxic Exposures. Sullivan, JB, Jr. and Krieger, GR, editors. 2nd Ed. Lippincott Williams & Wilkins, Philadelphia, PA.
22. Gupta, A., Rai, D. K., Pandey, R. S. and Sharma, B. 2009. Analysis of some Heavy metal in the riverine water, sediments and fish from Ganges at Allahabad.Environ. Monitor. Assess. 157: 449-458.
23. Gupta, N. and Dua, A. 2002. Mercury induced architectural alterations in the gill surface of a freshwater fish, Channa punctatus. J. Environ. Biol. 23(4): 383-386.
24. Hagino N, Yoshioka Y. 1961. A study of the etiology of Itai-Itai disease, J Jpn Orthop Assoc. 35: 812-5.
25. Hantson, P., O. Van Caenegem. 2005. "Hexavalent chromium ingestion: biological markers of nephrotoxicity and genotoxicity." Clinical Toxicology, The Official Journal of the American Academy of Clinical Toxicology & European Association of Poisons Centres & Clinical Toxicologists. 43(2): 111-2.
26. Hosnia S. Abdel-Mohsien, Manal, Mahmoud A.M. 2015. Accumulation of Some Heavy metal in Oreochromis niloticus from the Nile in Egypt: Potential Hazards to Fish and Consumers, Journal of Environmental Protection. 6: 1003-1013.
27. James, R. 1990. Individual and combined effects of Heavy metal on behaviour and respiratory response of Oreochromis mossambicus. Indian J. Fish, 37 (2): 139 - 143.
28. Jarup, L. 2003. Hazards of Heavy metals contamination. British Medical Bulletin. 68:167-182.
29. Khangarot, B. S. and Ray, P. K. 1987. Correlation between Heavy metals acute toxicity values in Daphnia manga and fish. Bull. Environ. Contam. Toxicol. 38: 722-726.
30. Kureishy, T. W. and D'Silva, C. 1993. Uptake and loss of mercury, cadmium and lead in marine organisms. Ind. J. Exp. Biol. 31(4): 373-379.
31. Livingstone, D.A. 1963. Chemical composition of rivers and lakes - In. Fleischer, M. (Ed.) Data of Geochemistry. 6ed. U.S. Geol. Surv. Prof. Paper 440-G 489 pp.
32. Maiti, P. and Banerjee, S. 2002. Bioaccumulation of metals in different food fishes in wastewater fed wetlands In Ecology of Polluted water Vol.-1Ed. Arvind Kumar, Daya Publishing House New Delhi. pp 217-230.
33. Mokhtar M.B. 2009. Assessment Level of Heavy metal in Penaeus monodon and Oreochromis spp in Selected Aquaculture Ponds of High Densities Development Area, European Journal of Scientific Research. 30(3): 348-360.
34. Nayaka, B. M. S., Ramakrishna, S., Jayaprakash and Delvi, M. R. 2009. Impact of Heavy metal on water, fish (Cyprinus carpio) and sediment from a water tank at Tumkur, India. Int. J. Ocen. Hydrobiol., 38(2): 17-28.
35. Noorjahan C. M and. S. Jamuna S. 2015. Biodegradation of Sewage Waste Water Using Azolla Microphylla and Its Reuse for Aquaculture of Fish Tilapia Mossambica, IOSR J. of Envir. Science, Toxi. and Food Tech. 9(3): 75-80
36. Nordberg G, Nogawa K, Nordberg M, Friberg L. 2007. Cadmium. In: Handbook on toxicology of metals. Nordberg G, Fowler B, Nordberg M, Friberg, L editors New York: Academic Press. pp. 65-78.
37. Nriagu, J. O. and Pacyna, J. 1988. Quantitative assessment of worldwide contamination of air, water and soil by trace metals, Nature. 333: 134-139.
38. Palanichamy, S., Baskaran, P. and Balasubramanian, M.P. 1986. Sublethal effects of malathion, thiodon and ekalux on protein, carbohydrate and lipid contents of muscle and liver of Orechromis mossambicus. Proc. Sym. Pest. Resid. Env. Poll. 97: 102.

39. Pandey, B. K., Sarkar, U. K., Bhowmik, M. L. and Tripathi, S. D. 1995. Accumulation of Heavy metal in soil, water, aquatic weed and fish samples of sewage-fed ponds. J. Environ. Biol. 16(2): 97-103.
40. Raja, H. A., Schmit, J. P. and Schearer, C. A. 2009. Latitudinal, habitat and substrate distribution patterns of freshwater escomycetes in the Florida peninsula. Biodiversity and Conservation, 18(2): 419-455.
41. Rao, L. M. and Patnaik, R. M. S. 2000. Heavy metals accumulation in the catfishMystus vittatus (Bloch) from Mehadrigedda stream of Visakhapatnam, India.Poll. Res. 19(3): 325-329.
42. Raphael, E. C., Augustina, O. C. and Frank, O. 2011. Trace metals distribution in fish tissues, bottom sediments and water from Okumeshi river in Delta State, Nigeria, Environmental Research Journal. 5(1): 6-10.
43. Sethi PK, Khandelwal DJ. 2006. Cadmium exposure: health hazards of silver cottage industry in developing countries. Med Toxicol. 2: 14-5.
44. Sharma, M. and Jain, K. L. 2004. Toxic effects of mercury and cobalt on the biochemical composition of freshwater fish Cirrhinus mrigala (Ham.). In: Proceeding of the National workshop on Rational Use of Water Resources for Aquaculture (Hisar, March 18-19), Ed. S. K. Garg and K. L. Jain.
45. Shrivastava, V. S. and Sohani, D. 2002. Bioaccumulation of Heavy metal. In: Ecology of Polluted water Vol.-1Ed. Arvind Kumar, Daya Publishing House, New Delhi. Pp 435-442.
46. Shukla V, Dhankhar M, Prakash J, Sastry KV. 2007. Bioaccumulation of Zn, Cu and Cd in Channa punctatus, J Environ Biol. 28: 395-7.
47. Smith, E. J., J. L. Sykora and M. A. Shapiro. 1973. Effect of lime neutralized iron hydroxide suspensions on survival, growth, and reproduction of the fathead minnow (Pimephales promelas). J. Fish. Res. Board Can. 30: 1147-1153.
48. Sullivan, R.J. Preliminary Air Pollution Survey of Chromium and Its Compounds. EPA/APTD 69-34. October 1969. pp. 33-45.
49. Takeuchi, T. 1968. pathology of minimata disease. (Ed.) Kutsuma M. Japan, pp.141.
50. Theis, T.L. and Singer, P.C. The stabilization of ferrous iron by organic compounds in natural water. - In: Singer, P.C. (ed.), Trace metal and metal-organic interaction in natural water: 3030 -320.
51. Towill, L.E., et al. Reviews of the Environmental Effects of Pollutants: III. Chromium. ORNL/EIS-80 and EPA-600/1-78-023. May 1978. pp. 28-55.
52. USEPA, Guidelines for the health risk assessment of chemical mixtures. 1986 Fed. Reg. 51 34014–34025.
53. USEPA. Risk-based Concentration Table. United State Environmental Protection Agency, Washington, DC, 2010.
54. Vandecasteele C., Block, C. B. 1991. Modern methods for trace element determination, John Wiley & Sons Inc, New York: 259.
55. Vinodhini, R. and Narayanan, M. 2008. Bioaccumulation of Heavy metal in organs of freshwater fish Cyprinus carpio (common carp). Int. J. Environ. Sci. Tech. 5(2): 179-182.
56. Widdows, J. 1985. Physiological responses to pollution. Mar. Poll. Bull. 16: 129-134.
57. Young, R. A. 2005. Toxicity Profiles toxicity summary for cadmium, risk assessment information system, RAIS, University of Tennessee (rais.ornl.gov/tox/profiles/cadmium.shtml).

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