Contamination status and health risk assessment of heavy metals in *Oreochromis mossambicus* of Budha Sagar pond, Rajnandgaon, Chhattisgarh, India

*1 Yaser Qureshi, 2 Dr. Kanti Choubey

1 Assistant Professor, Department of Zoology, Govt. College Khertha Distt. Balod, Chhattisgarh, India

2 Professor & Head, Department of Zoology, Govt. V.Y.T. Auto. College, Durg, Chhattisgarh, India

Abstract
Heavy metals are known pollutants due to their ability of bioaccumulation in organisms. Sewage may be contaminated by presence of heavy metals in it. Sewage fed fishery is of common occurrence in urban settlements, especially in under developed municipal areas. Effects of heavy metals on fishes are still thoroughly unexplored area in state of Chhattisgarh and Rajnandgaon town in particular. Present study is conducted to throw some light on this issue. Large number of population feeds on fishes so any negative deviation in any health related parameter may cause public health threat. This study was conducted on *Oreochromis mossambicus* fish in year long duration for three season namely winter, Summer and Post monsoon season to know concentration of heavy metals Fe, Cd, Cr, Pd and Hg in fish tissues (Gill, Liver and Muscle).

For determination of quality of water and intensity of heavy metal contamination, indices like OWQI, THQ and MPI are employed. OWQI shows that budha sagar pond is in good and fair condition. THQ is used for determination of contamination due to non-carcinogen. Overall THQ is in the safe limit for all the metals investigated. Mean MPI is recorded highest in gills and lowest in muscles, so we can say gills are mostly and directly affected by heavy metals. All the investigated parameters in present study are within the safe limit but heavy metals like Cd and Hg are reported here so measures should be applied to curb the menace of heavy metals in this urban wetland.

Keywords: heavy metals, overall water quality index, target hazard quotient, metal pollution index

1. Introduction
Over exploitation of natural resources, unsustainable development, Rapid population explosion, as well as increasing urbanization and food demand on the globe combined with the use of contaminated water and food make up a potential food safety hazard. The information of nutritional intake of essential and non-essential heavy metals in India especially Chhattisgarh is inadequate. In Living systems, heavy metals are responsible to affect cellular organelles and mechanism such as cell membrane, mitochondria, lysosome, endoplasmic reticulum, nuclei, and some enzymes concerned in metabolism, detoxification, and damage repair [1].

Some metals are essential for human health. Metals are naturally occurring elements that become contaminants when their level increases above optimum level [2]. Heavy metals are classified in two main categories, essential and non-essential. Some of the essential heavy metals are Cu, Co, Zn, Fe and Mn. they required in very trace amount for the appropriate working and vital activities of organs, RBC formation and vitamin synthesis in body but metabolic disturbances are encountered in case of disturbance of optimum level [2].

Heavy metal pollution is a grave and extensive environmental concern due to their toxicity. Heavy metals enter the environment through different natural channels and human activities, They can bio accumulate in fishes and other living beings.[3] There is a growing concern that metals accumulated in different fish tissues and pose health risk, especially for populations with high fish dependence [4, 5, 6].

Heavy metals are considered harmful because of their toxicity, long persistence, bioaccumulation and bio-magnification in the food chain [8]. The extent of contamination depends on the pollutant type, fish species, sampling location, trophic level, and their mode of feeding [9]. Monitoring heavy metal contamination in freshwater systems by using fish tissues helps to assess the quality of aquatic ecosystems [10].

Fishes are used as bio-indictors and may play an important role in monitoring heavy metals pollution [11].

Heavy metals enter fish through five main routes (food, non-food particles, gills, water, and skin), then flows into the blood, and carried to either a storage point or to the hepatic cells for its transformation or storage [12].

The liver is the main site of accumulation, biotransformation, and excretion of pollutants in fish [13].

2. Material and Methods
Study area
This study was carried out in the Budhasagar pond of Rajnandgaon town it is basically sewage fed urban pond. Municipal sewage line is directly connected to this pond. Fish samples were taken in morning hours. *Oreochromis mossambicus* fish of around 100 gm weight was taken for the study. Freshly captured fishes were taken to the laboratory for analysis. Fish samples dissected to separate organs (gills, liver and muscles). The separated organs were put in oven to dry at 110ºC until reaching a constant weight. The separated organs

were placed into digestion flasks and ultrapure Conc. HNO_3 and H_2O_2 (1:1 v/v) was added. The digestion flasks were heated to 130ºC until dissolution, diluted with water and analyzed for heavy metal concentration using atomic absorption Spectrometer [14, 15, 16].

Health Risk assessment of Pond Water
Overall Water Quality Index (OWQI)

Singh *et al*. (2015) developed OWQI Overall to classify the surface water into five categories, viz. excellent, good, fair, poor and polluted. For this purpose, the concentration ranges have been defined on the basis of the Indian Standards (IS) and Central Pollution Control Board (CPCB) standards, also taking into account other International standards of World Health Organization (WHO) and European Commission (EC). Sixteen parameters are selected based on social and environmental impact and weights are assigned on their relative importance to impact the quality of water. The proposed index improves understanding of water quality issues by integrating complex data and generates a score which describes the status of water quality [17].

$$OWQI = \sum_{i=1}^{n} w_i . Y_i$$

Where
w_i = weight of the ith water quality parameter, Y_i = sub-index value of the ith parameter
Based on the status of water quality, the index value range from 0 to 100 and is classified into five categories: heavily polluted (0-24), poor (25-49), fair (50-74), good (75-94) and excellent (95-100). The status of water corresponding to different OWQI

Health Risk Assessment for Fish Consumption
Target Hazard Quotient (THQ)

The target hazardous quotient (THQ) represents a multifaceted parameter which is developed by the US Environmental Protection Agency (EPA 1989). It is used for the assessment of the potential of non-carcinogenic threat associated with exposure to contaminants, such as heavy metals from food for instance fish. As published by USEPA (2010), if the THQ value is < 1.00 that means the exposed population is supposed to be safe; however, when THQ > 1.00 there is a potential risk related to the studied metal in the exposed population [18].

$$THQ = EF\, E_D F_{IR} C/ R_{FD} W_{AB} T_A\, X\, 10^{-3}$$

where E_F is exposure frequency (365 days/year), E_D is the exposure duration (65 years), equivalent to the average lifetime, F_{IR} is the food ingestion rate (g/person/day) 4.73 gm/day [19], C is the metal concentration in food (mg/kg); R_{FD} is the oral reference dose (mg/kg/day) obtained from USEPA, W_{AB} is the average body weight (55kg for adults and 20 kg for children), and T_A is the averaging exposure time for non-carcinogens (365 days/year X number of exposure years, assuming 65 years in this study).

Metal Pollution Index (MPI)

Metal Pollution Index (MPI) [20] MPI shows cumulative effect of all the heavy metals investigated.

$$MPI = (Cf_1 x Cf_2 ... Cf_n)^{1/n}$$

where Cf_n = concentration of the metal n in the sample.

3. Results and Discussion
OWQI

Water quality parameters contribute information about health of water bodies. To evaluate this we have taken five water quality parameters Tem, pH, DO, TH and TA. Singh classified water bodies in to the five classes according to contamination status of water. He gave heavily polluted, Poor, Fair, Good and Excellent. After analyzing for that we got score 71.6 for winter season it comes under the fair class, In summer season score was 65.83 and it was also of fair class and post monsoon season score was highest as 84.66 It is in good class. So we can conclude that this water body as far as above water parameters are concerned is fair and Good, Quality of water increases in post monsoon season. (Table 1, 2 and 3).

THQ

Target hazard quotient is observed both for adults and children. In adults its highest value is found 0.16 for Iron in post monsoon Liver sample and lowest value is 0.006 recorded again for same metal in winter muscle sample.
In children highest value found is 0.236 for Iron. It is found in sample of Liver in summer season and lowest as 0.006 for mercury in gill sample of post monsoon season. Although few studied metals are not found in some samples but as far as THQ is concerned for present metals we are observing that there is a tendency towards gradual increase. THQ is hazardous when its value is above 1. Its higher values are found for Iron but iron is not considered as carcinogenic element. Its increased level may cause some other abnormalities in fish itself and also on animals feeds on them. (Table 4, 5).

MPI

Metal pollution index shows cumulative effect of all the heavy metal investigated. Highest value of MPI (4.29) is found in sample of Liver in summer season. Lowest value (2.20) is also found in sample of liver of winter season. Mean MPI is found in order of Gill>Liver>Muscle. (Table 6)

Table 1: Parameters for OWQI (Figures in mg/l)

Season Parameters	Winter	Summer	Post Monsoon
Temperature	19	27.6	23.6
pH	6.8	7.1	6.9
Dissolved Oxygen	4.6	3.9	6.2
Total Hardness	141	172	124
Total Alkalinity	221	276	179

Table 2: OWQI and corresponding class and status of water quality

Class	OWQI Value	Status of Water
Heavily Polluted	0 - 24	Unsuitable for all Purpose
Poor	25 – 49	Special Treatment Needed
Fair	50 - 74	Needs Treatment (Filtration & Disinfection)
Good	75 – 94	Acceptable
Excellent	95 - 100	Pristine Quality

Table 3: OWQI result of Budhasagar pond

Season	Score	Status Of Water
Winter	71.6	Fair
Summer	65.83	Fair
Post Monsoon	84.66	Good

Table 4: Target hazard Quotient (THQ) (Adult)

Metal	Gill			Liver			Muscle		
	Summer	Post Monsoon	Winter	Summer	Post Monsoon	Winter	Summer	Post Monsoon	Winter
Mercury (Hg)	BDL	0.021	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Lead (Pb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Iron (Fe)	0.048	0.038	0.044	0.086	0.16	0.006	0.007	0.016	0.006
Cadmium (Cd)	BDL	BDL	BDL	BDL	0.009	BDL	BDL	BDL	BDL
Chromium (Cr)	0.072	0.075	BDL	0.059	0.065	BDL	0.030	0.075	BDL

Table 5: Target hazard Quotient (THQ) (Children)

Metal	Gill			Liver			Muscle		
	Summer	Post Monsoon	Winter	Summer	Post Monsoon	Winter	Summer	Post Monsoon	Winter
Mercury (Hg)	BDL	0.006	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Lead (Pb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Iron (Fe)	0.132	0.105	0.121	0.236	0.441	0.017	0.020	0.045	0.018
Cadmium (Cd)	BDL	BDL	BDL	BDL	0.025	BDL	BDL	BDL	BDL
Chromium (Cr)	0.199	0.207	BDL	0.163	0.181	BDL	0.084	0.208	BDL

Table 6: Metal Pollution Index

Tissue / Season	Gill	Liver	Muscle
Summer	3.97	4.29	2.30
Post Monsoon	2.52	3.16	3.23
Winter	3.24	2.20	2.21
Mean MPI	3.24	3.21	2.58

4. Conclusion

We are living in age of pollution and contamination. We can see ill effects of pollution everywhere from new born babies to old age persons in form of diseases and deformities. Food items are badly effected by pollution, Fishes are major source of food. Fishes lives in constant contact of water and accumulate different contaminant in their life time especially heavy metals.

The present study was carried out to measure contamination of heavy metals in sewage fed pond of urban Budha Sagar pond, This pond is used for fishery purpose, regular fishing activities are carried out in this pond. *Oreochromis mossambicus* commonly known as Tilapia is a major fish procured from this pond.

So present study is the first study to measure the magnitude of heavy metals found in fishes. In this study indexing approach is employed to quantify the effects of heavy metals on consumers, Two indices Target Hazard Quotient (THQ) and Metal pollution Index (MPI) for heavy metal and another Overall Water Quality Index (OWQI) for surface water quality.

THQ for studied fish is under safe limit (THQ<1.00) both for adults and children. When we see comparative chart of THQ both for adults and children, It is observed that THQ is somewhat higher for children. MPI shows cumulative effect of heavy metals on different organs. In this study gills are the organ which shows highest metal pollution index and muscles are least affected.

OWQI gives status of water quality, it is observed for three seasons and according to it water is fair and Good.

At the end we can say that there is no immediate threat to consumers who depends on fishes procured from this pond. But we observed presence of Fe, Cr, Cd, and Hg except Pb, which was not found in any sample. Surprisingly Cr, Cd, and even Hg showed their presence although they are in very trace amount but in future their amount may increase. So it is responsibility of concerned authorities and local civil society to protect this pond from sewage and other contamination. So we can save this pond for future generation.

5. References

1. Wang S, Shi X. Molecular mechanisms of metal toxicity and carcinogenesis, Mol Cell Biochem. 2001; 222:3-9.
2. Unger. Fundamentals of Ecotoxicology, CRC Press, Second Edition. 2002, 27.
3. Kalay M, Canli M. Elimination of Essential (Cu, Zn) and

Non- Essential (Cd, Pb) Metals from Tissues of a Freshwater Fish Tilapia Zilli, Turk. J. Zool. 2000; 24:429-436.

4. Liao CM, Ling MP. Assessment of human health risks for arsenic bioaccumulation in tilapia (*Oreochromis mossambicus*) and large-scale mullet (*Liza macrolepis*) from black foot disease area in Taiwan. Arch. Environ. Toxicol. 2003; 45:264-272.

5. Burger J, Gochfeld M. Perceptions of the risks and benefits of fish consumption: individual choices to reduce risk and increase health benefit, Environ. Res. 2009; 109:343-349.

6. Diez S. Human health effects of methylmercury exposure. Rev. Environ. Contam. Toxicol. 2008; 198. doi:10.1007/978-0-387-09646-9,

7. Diez S, Delgado S, Aguilera I, Astray J, Perez GB, Torrent M, *et al*. Prenatal and early childhood exposure to mercury and methylmercury in Spain, a high-fish-consumer country. Arch. Environ. Contam. Toxicol. 2009; 56:615-622.

8. Yousafzai AM, Chivers DP, Khan AR, Ahmad I, Siraj M. Comparison of heavy metals burden in two freshwater fishes *Wallago attu* and *Labeo dyocheilus* with regard to their feeding habits in natural ecosystem, Pak. J Zool. 2010; 42(5):537-544.

9. Asuquo FE, Ewa-Oboho IA, Asuquo EF, Udoh PJ. Fish species used as biomarkers for heavy metals and hydrocarbon contaminations for the cross river, Nigeria, Environmentalist. 2004; 24:29-37.

10. Adam SM. Biological indicators of aquatic ecosystem stress, American Fisheries Society, Bethesda, MD. 200, 2656.

11. Authman MMN, Zaki MS, Khallaf EA, Abbas HH, Use of Fish as Bio-indicator of the Effects of Heavy Metals Pollution. J Aquac Res Development 2015; 6:328. doi:10.4172/2155-9546.1000328.

12. Jabeen F, Chaudhry AS. Environmental impacts of anthropogenic activities on the mineral uptake in *Oreochromis mossambicus* from Indus River in Pakistan, Environ. Monit. Assess. 2010; 166:641-651.

13. Shinn CA, Dauba F, Grenouillet G, Guenard G, Lek S. Temporal variation of heavy metal contamination in fish of the river lot in southern France, Ecotoxicol. Environ. Saf. 2009; 72:1957-1965.

14. Abida Begum, Harikrishna S, Irfanulla Khan. A study of Fertilizer application and irrigation effects on paddy crop fields near Cauvery River Basin, Nature Environment and pollution technology jour. 2009; 8(1).

15. Abida Begum, Harikrishna S, Irfanulla Khan, Veena K. Flouride removal studies using natural materials, Environmental pollution control Journal. 2008; 11(3):64-67. 972-1541.

16. Clesceri LS. Standard methods for the examination of water and waste water. In Collection and Preservation of Samples and Metals (eds Arnold, E. Greenbergy and Eaton, A. D.), APHA, AWWA, WEF, Washington, DC, 1998.

17. Singh S, Ghosh NC, Krishan G, Galkate R, Thomas T, Jaiswal RK. Development of an Overall Water Quality Index (OWQI) for Surface Water in Indian Context. Curr. World Environ. 2015, 10(3).

18. USEPA. Risk based Concentration Table. United State Environmental Protection Agency, Washington, DC, 2010.

19. Handbook on fisheries statistics, ministry of agriculture & farmers welfare, Govt. of India Table J, 2014.

20. Usero J, Morillo J, Gracia I. Heavy metal concentrations in molluscs from the Atlantic coast of southern Spain, Chemosphere. 2005; 59:1175-1181.