Bioaccumulation Of Heavy Metals In Freshwater Fish Thynnichthyes sandkhol From Aurangabad (MS).

Pramod M. Davne
Department of Zoology, S.B.E.S. College of Science, Aurangabad-431001.

ABSTRACT

The concentration of heavy metals like copper, chromium and nickel in the tissues of Thynnichthyes sandkhol were determined by using Atomic Absorption Spectrophotometer (Thermo fisher - model AA-303). The concentration of heavy metals accumulated in freshwater fish Tilapia might be due to the increase in agricultural influx and some anthropogenic activities.

KEYWORDS: Heavy metals, River, Dam, Thynnichthyes sandkhol.

1. INTRODUCTION

Fishes are one of the important groups of vertebrates which influence the life of humans in various ways. Fishes have a rich source of food and provide a meat to tide over the nutritional difficulties of man. The pollution of the aquatic environment with heavy metals has become a worldwide problem during recent years, because they are indestructible and have toxic effects on organisms. On entering, it may precipitate or adsorb in solid surface, remain soluble or suspended in water and taken up by fauna and flora. These heavy metals may accumulate in aquatic organisms which consumed by human later on. Knowledge about the fate of chemicals in aquatic environments is essential for the understanding possible ecotoxicological effects. Bio concentration of chemicals in aquatic biota is an important factor in the assessment of the potential hazard of chemicals to the environment.[23] Among the environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to getting accumulates in aquatic ecosystems.

The accumulation of heavy metals in freshwater ecosystem has been a major concern. Fish being one of the main aquatic organisms in the food chain, may often accumulate large amounts of certain metal above the levels in the aquatic environment. Essentially fishes have been reported to assimilate these heavy metals through ingestion of suspended particulates, food materials and by constants ion exchange process of dissolved metals across the lipophilic membranes such as the gills, absorption of dissolved metals on tissue and membrane surfaces.[10, 19] Heavy metals are defined as metallic elements that have a relatively high density compared to water.[3]

In recent years, there has been an increasing ecological and global public health concern associated with environmental contamination by these metals. Reported sources of heavy metals in the environment include geogenic, industrial, agricultural, pharmaceutical, domestic effluents, and atmospheric sources.[12] Environmental pollution is very prominent in point source areas such as mining, foundries and smelters, and other metal-based industrial operations.[3,12,15] Environmental contamination can also occur through metal corrosion, atmospheric deposition, soil erosion of metal ions and leaching of heavy metals, sediment resuspension and metal evaporation from water resources to soil and ground water.[2] Industrial sources include metal processing in refineries, coal burning in power plants, petroleum combustion, nuclear power stations and high tension lines, plastics, textiles, microelectronics, wood preservation and paper processing plants.[24,20,31] It has been reported that metals such as cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se) and zinc (Zn) are essential nutrients that are required for various biochemical and physiological functions. Inadequate supply of these micro-nutrients results in a variety of deficiency diseases or syndromes.[14] Heavy metals are also considered as trace elements because of their presence in trace concentrations (ppb range to less than 10 ppm) in various environmental matrices.[6]

The essential heavy metals exert biochemical and physiological functions in plants and animals. They are important constituents of several key enzymes and play important roles in various oxidation-reduction reactions.In biological systems, heavy metals have been reported to affect cellular organelles and components such as cell membrane, mitochondrial, lysosome, endoplasmic reticulum, nuclei, and some enzymes involved in metabolism, detoxification, and damage repair.[32] Metal ions have been found to interact with cell components such as DNA and nuclear proteins, causing DNA damage and conformational changes that may lead to cell cycle modulation, carcinogenesis or apoptosis.[4,32,33] Several studies from our laboratory have demonstrated that reactive oxygen species (ROS) production and oxidative stress play a key role in the toxicity and carcinogenicity of metals such as arsenic[28,29,34]cadmium[21], chromium [22,35], lead [25,30], and mercury.[16, 26] Because of their high degree of toxicity, these five elements rank among the priority metals that are of great public health significance. They are all systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure.

According to the United States Environmental Protection Agency (U.S. EPA), and the International Agency for Research on Cancer (IARC), these metals are also classified as either “known” or “probable” human carcinogens based on epidemiological and experimental studies showing an association between exposure and cancer incidence in humans and animals. As a result metal bioaccumulation is a major route, thought which increased levels of the pollutants are transferred across food chain web creating public health problems wherever man is involved in the food chain therefore, it is important to always determine the bioaccumulation capacity for heavy metals by organisms especially the edible ones, in order to assess potential risk to human health.[1] The present work has been carried out to study the bioaccumulation of heavy metals [Cu, Cd, Pb, Cr and Zn] in the selected organs viz. Gills, intestine, liver, kidney and muscle of the freshwater edible fish Thynnichthyes sandkhol, collected from different water bodies of Aurangabad during period of January 2018to April 2018.

2. MATERIALS AND METHODS

Collection of fish samples: Freshwater fish, like Thynnichthyes sandkhol were collected from different water bodies of Aurangabad mentioned in table-1 by the local fishermen’s. Fish were ice-packed and transported to the laboratory and identified with the help of fishes of India.

Table No.1 Surface Water Bodies from Aurangabad.

Name of sampling sites	**Status of Water Body**	**Area of sample collection**
Godavari river (S1)	Large river	Aurangabad District
Salim Ali Lake (S2)	Percolation tank	Aurangabad at Delhi gate
Harsul Dam (S3)	Percolation tank	Aurangabad at Harsul
Jayakwadi Dam (S4)	Irrigation dam	Aurangabad District

Analysis of metal accumulation: The selected fish tissues were removed and take weight then put it in Petri dishes to dry at 102° until reaching a constant weight. We select organs viz Gill, skin, Liver and Muscle. The dried tissue was placed into digestion flask and ultra pure concentrated nitric acid and hydrochloric acid [1:3] [SD fine chemicals] were added. The digestion flask was heated to 130°C until all the material was dissolved. Digest was diluted with double distilled water appropriately. The elements like Copper, Nickel and Chromium were assayed by using Thermo fisher (model AA-303) Atomic Absorption Spectrophotometer.

3. RESULTS AND DISCUSSION

Heavy metals have tendency to accumulate in various organs of aquatic organisms, especially fish, which in turn may enter into the human metabolism through consumption causing serious health hazards. The mean concentration (ppm) of Copper (Cu), Nickel (Ni) and Chromium (Cr) were calculated and the levels of these heavy metals concentration were measured in the fish Tilapia mossambica organs, Gills, Skin, Liver and Muscle using Atomic Absorption Spectrophotometer (Thermo fisher - model AA-303) and compared with international standards given by WHO (World Health Organization).[31] The results of the analysis are presented in Table 1, 2 and 3 and further illustrated in Figures 1, 2 and 3, as follow,

Table 1: Mean concentration (ppm) of Copper in different organs of the Thynnichthyes sandkhol fish from four different water bodies

Organs	S1	S2	S3	S4	WHO permissible limit (ppm)
Gill	0.45 ± 0.07	0.37 ± 0.03	0.36 ± 0.01	0.33 ± 0.01	3
Skin	0.23 ± 0.03	0.25 ± 0.05	0.18 ± 0.05	0.21 ± 0.04	3
Liver	0.34 ± 0.04	0.35 ± 0.02	0.36 ± 0.02	0.28 ± 0.07	3
Muscle	0.27 ± 0.04	0.33 ± 0.04	0.31 ± 0.08	0.26 ± 0.05	3

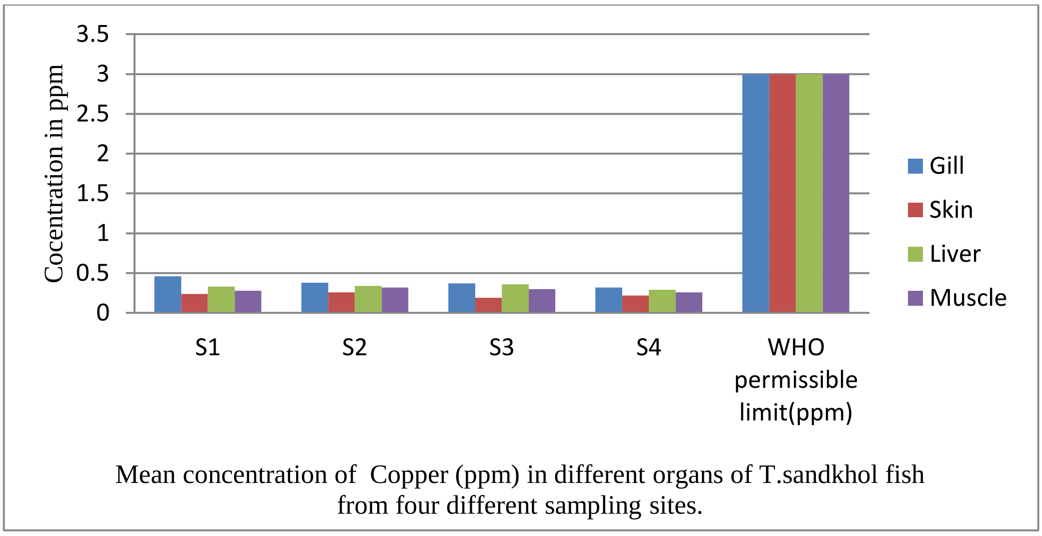

Figure 1: Distribution of Copper (Cu) (ppm) in the Gills, Skin, Liver and Muscle, from four different water bodies of Aurangabad.

From the above analyzed data, the level of Copper metal in selected fish organs does not excide the permissible limit given by WHO (World Health Organization) for fish food i.e. 3 ppm.[31] The highest mean concentration of Copper is 0. 45 ppm in Gill from S1 sampling site and the lowest mean concentration is 0.18 ppm in skin from S3 sampling site. The distribution of mean concentration for Cu in organs of the fish from above figure-1 shows the trend like Gill > Liver > Muscle > Skin.

Table 2: Mean concentration (ppm) of Nickel (Ni) in different organs of the Thynnichthyes sandkhol fish from four different water bodies.

Organs	S1	S2	S3	S4	WHO permissible limit (ppm)
Gill	0.72 ± 0.04	0.66 ± 0.04	0.57 ± 0.03	0.53 ± 0.01	0.5
Skin	0.51 ± 0.04	0.44 ± 0.05	0.46 ± 0.03	0.45 ± 0.06	0.5
Liver	0.36 ± 0.02	0.43 ± 0.03	0.41 ± 0.07	0.41 ± 0.03	0.5
Muscle	0.17 ± 0.04	0.16 ± 0.04	0.14 ± 0.01	0.15 ± 0.05	0.5

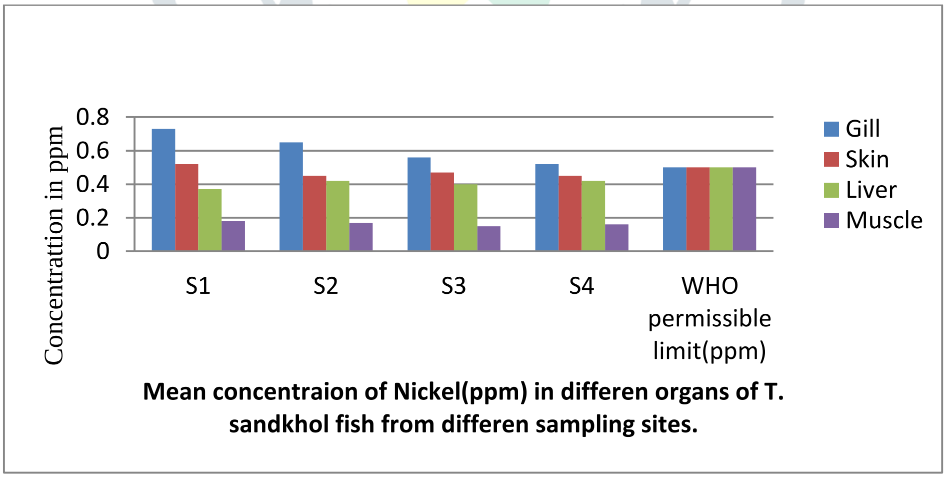

Figure 2: Distribution of Nickel (Ni) (ppm) in the Gills, Skin, Liver and Muscle, from four different water bodies of Aurangabad.

From above analyzed data for Nickel metal, the mean concentration in Gills (0.72-0.53 ppm) from S1 to S4, Skin (0.51 ppm) from S1 sampling site is excide permissible limit given by WHO (World Health Organization) for fish food i.e. 0.5 ppm.[31] But in Liver and Muscle from all sampling sites concentration of Nickel does not crossed permissible limit given by WHO for fish food.

Table 3: Mean concentration (ppm) of Chromium in different organs of the Thynnichthyes sandkhol fish from four different water bodies.

Organs	S1	S2	S3	S4	WHO permissible limit (ppm)
Gill	4.85 ± 0.89	3.89 ± 0.49	4.59 ± 0.63	3.67 ± 0.59	0.15
Skin	2.19 ± 0.90	1.88 ± 0.65	2.75 ± 0.76	2.41 ± 0.19	0.15
Liver	1.98 ± 0.13	1.57 ± 0.59	2.15 ± 0.55	1.85 ± 0.16	0.15
Muscle	4.22 ± 0.41	2.97 ± 0.51	3.42 ± 0.24	3.02 ± 0.91	0.15

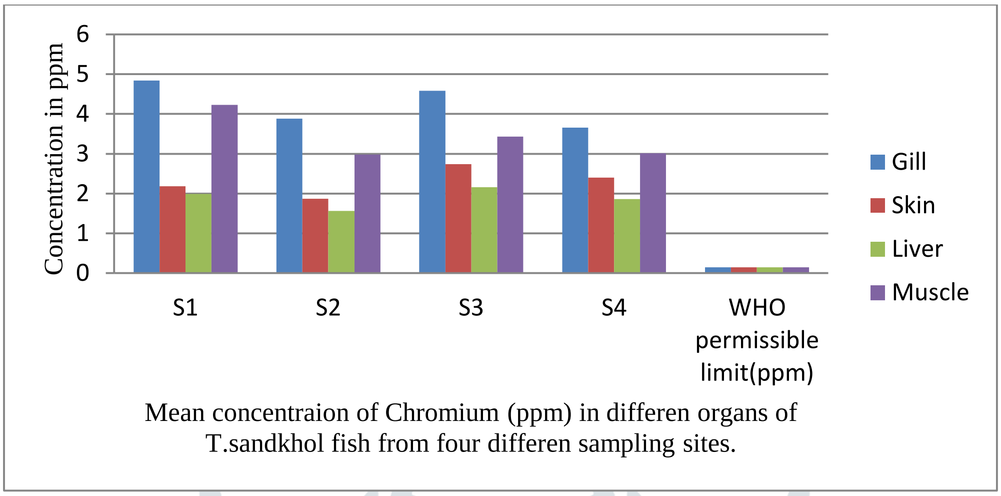

Figure 3: Distribution of Chromium (Cr) (ppm) in the Gills, Skin, Liver and Muscle, from four different water bodies of Aurangabad.

From above analyzed data for Chromium metal, mean concentration of Chromium is higher in all the fish organs collected from sampling site S1 to S4. The distribution trend of mean concentration of Cr is like Gill > Muscle > Skin > Liver from all sampling sites. The highest concentration of Cr in Gill from sampling site S1 is 4.85 ppm and lowest is in Liver from sampling site S2 i.e. 1.57 ppm, all other values of concentration lies in between the range of these two values of concentration. These values of concentration of Cr are much higher than the permissible limit given by WHO for fish food i.e. 0.5 ppm.[31] It is well known that Cr is a cancer-, mutation-, and malformation-causing agent classified as a Group I carcinogen by the International Agency for Research on Cancer.[9, 13] Nickel enters the blood circulation of the fish through the gill or mucous epithelium of the mouth and finally finds their way into different tissues of the body where they affect normal metabolism. The chronic effect of sub-lethal concentrations of copper on fish and other creatures is damage to gills, liver, kidneys and the nervous system. It also interferes with the sense of smell in fish.

From overall analyzed data, it was observed that the total concentration of Chromium in all the organs studied was significantly higher when compared with concentration that of Copper and Nickel from all sampling sites with respect to WHO standards [31] for fish food. Next higher concentration is Nickel i.e. less than Chromium but more than Copper. Overall trend of the concentration of these heavy metals is Chromium > Nickel > Copper and most targeted organ is Gill. Gill is the primary site of osmoregulation and respiration in aquatic vertebrates. It is the main target organ, which gets affected easily when the organism is exposed to dissolved heavy metal. Fish, on exposure to high levels of metals in an aquatic environment, absorb the bio-available metals either through gills and skin or through ingestion of contaminated water or food. The concentration of heavy metals in fish is related to several factors such as the food habits and foraging behaviours of the organism [17;] tropic status, source of a particular metal , distance of the organism from the contamination source and presence of other ions in the milieu[11] biomagnifications of a particular metal[5] food availability, metallothioneins and other metal detoxifying proteins in the body of the animal [8] temperature, transport of metal across the membrane and the metabolic rate of the animal [18] physical and chemical properties of the water and the seasonal changes in the taxonomic composition of the different trophic levels affecting the concentration and accumulation of heavy metals in the body of the fish [7] and the adaptation capacity of the fish to heavy metal load.[27]

4. CONCLUSION

From the present study, it can conclude that, the concentration of Chromium and Nickel is noticeable. In view of the importance of fish as a diet of man, it is necessary that biological monitoring of the water and fish meant for consumption should be done regularly to ensure continuous safety of the fish food. Safe disposal of domestic sewage and industrial effluents should be practiced and where ever is possible, recycle to avoid these metals and other contaminants from going into the environment. The values reported in this study may serve as baseline data to monitor future anthropogenic activities in dam and river water located in the area.

5. ACKNOWLEDGEMENT

The author thankful to the Principal of S.B.E.S. College of Science, Aurangabad for co-operation, suggestion and providing necessary facilities.

REFERENCES

1. ATSDR (1990). Toxicological Profile for Copper. U.S Public Health Service. Agency for Toxic Substances and Disease Registry, Atlanta, G.A.
2. Arruti A, Fernández-Olmo I, Irabien A. Evaluation of the contribution of local sources to trace metals levels in urban PM2.5 and PM10 in the Cantabria region (Northern Spain) J Environ Monit. 2010; 12(7): 1451–1458.
3. Bradl H, editor. Heavy Metals in the Environment: Origin, Interaction and Remediation Volume 6. London: Academic Press; 2002.
4. Beyersmann D, Hartwig A. Carcinogenic metal compounds: recent insight into molecular and cellular mechanisms. Arch Toxicol. 2008; 82(8): 493–512.
5. Barlas, N A pilot study of heavy metal concentration in various environments and fishes in the upper Sakaryia River basin, Turkey. Environ. Toxicol., 1999; 14: 367-373.
6. Chang LW, Magos L, Suzuki T, editors. Toxicology of Metals. Boca Raton. FL, USA: CRC Press; 1996.
7. Chen, C. Y; Folt, C.L. Bioaccumulation and diminution of arsenic and lead in a freshwater good web. Environ.Sci. Technol. 2000; 34: 3878-3884.
8. Deb, S.C.; and Fukushima, T. Metals in aquatic ecosystems: Mechanism of uptake, accumulation and release.Int. J. Environ. Stud. 1999; 56: 385-492.
9. EISLER, R., Chromium hazards to fish, wildlife, and invertebrates: A synoptic review. Biol. Report, 1986; 85: 1-38.
10. Fergusson JE, editor. The Heavy Elements: Chemistry, Environmental Impact and Health Effects. Oxford: Pergamon Press; 1990.
11. Giesy, J.P and Weiner, J.G. Frequency distribution of trace metals concentrations in five fresh water fishes.Trans. Am. Fish. Soc. 1977; 106: 393-403.
12. He ZL, Yang XE, Stoffella PJ. Trace elements in agro ecosystems and impacts on the environment. J Trace Elem Med Biol. 2005; 19(2–3): 125–140.
13. IARC IAFROC (1990), Chromium, Nickel and Welding. Monographs on the Evaluation of Carcinogenic Risks to Human. IARC Scientific Publications 49.
14. Kabata- Pendia A 3rd, editor. Trace Elements in Soils and Plants. Boca Raton, FL: CRC Press; 2001.
15. Nriagu JO. A global assessment of natural sources of atmospheric trace metals. Nature. 1989; 338: 47–49.
16. Otitoloju, AA. Ecotoxicol. Environ. Saf. 2002; 53: 404 -415.
17. Obasohan, E.E. and Oronsaye, J.A.O. Bioaccumulation of heavy metals by some cichlids from Ogba River, Benin City, Nigeria. Nigerian Annals of Natural Sciences, 2004; 5(2):11 – 27.
18. Oronsaye, J.A.O. Historical changes in the kidneys and the gills of stickleback (Gesterosteus aculeatus) exposed to cadmium. Ecotoxicol and Environ. Safety, 1989; 17: 279-290.
19. Oguzie, F.A.; Okosodo, C.I. Nigeria Journal of Aquatic field studies, 2008; 4: 51-56.
20. Pacyna JM. Monitoring and assessment of metal contaminants in the air. In: Chang LW, Magos L, Suzuli T, editors. Toxicology of Metals. Boca Raton, FL: CRC Press: 1996, pp. 9–28.
21. Patlolla A, Barnes C, Field J, Hackett D, Tchounwou PB. Potassium dichromate-induced cytotoxicity, genotoxicity and oxidative stress in human liver carcinoma (HepG2) cells. Int J Environ Res Public Health. 2009; 6: 643–653.
22. Patlolla A, Barnes C, Yedjou C, Velma V, Tchounwou PB. Oxidative stress, DNA damage and antioxidant enzyme activity induced by hexavalent chromium in Sprague Dawley rats. Environ Toxicol. 2009; 24(1): 66–73.

23. S. Karthikeyan, PL. RM. Palaniappan and Selvi Sabhanayakam April 2007, Influence of pH and water hardness upon nickel accumulation in edible fish Cirrhinus mrigala.
24. Sträter E, Westbeld A, Klemm O. Pollution in coastal fog at Alto Patache, Northern Chile. Environ. Sci. Pollut. Res. Int. 2010 [Epub ahead of print].
25. Sutton DJ, Tchounwou PB. Mercury induces the externalization of phosphatidylserine in human proximal tubule (HK-2) cells. Intl J Environ Res Public Health. 2007; 4(2): 138– 144.
26. Sutton D, Tchounwou PB, Ninashvili N, Shen E. Mercury induces cytotoxicity, and transcriptionally activates stress genes in human liver carcinoma cells. Intl J Mol Sci. 2002; 3(9): 965–984.
27. Shah, S.L. and Attinag, A. Effects of heavy metals accumulation on the 96-h Lc50 values in Tench (Tincatinca L.) 1758. Turk. J. Vet. Anim. Sci. 2005; 29: 139-144.
28. Tchounwou PB, Centeno JA, Patlolla AK. Arsenic toxicity, mutagenesis and carcinogenesis - a health risk assessment and management approach. Mol. Cell Biochem. 2004; 255: 47–55.
29. Tchounwou PB, Ishaque A, Schneider J. Cytotoxicity and transcriptional activation of stress genes in human liver carcinoma cells (HepG2) exposed to cadmium chloride. Mol. Cell Biochem. 2001; 222: 21–28.
30. Tchounwou PB, Yedjou CG, Foxx D, Ishaque A, Shen E. Lead-induced cytotoxicity and transcriptional activation of stress genes in human liver carcinoma cells (HepG2) Mol Cell Biochem. 2004; 255: 161–170.
31. WHO/FAO/IAEA. World Health Organization. Switzerland: Geneva; 1996.Trace Elements in Human Nutrition and Health.
32. Wang S, Shi X. Molecular mechanisms of metal toxicity and carcinogenesis. Mol Cell Biochem. 2001; 222: 3–9.
33. Yedjou CG, Tchounwou PB. Oxidative stress in human leukemia cells (HL-60), human liver carcinoma cells (HepG2) and human Jerkat-T cells exposed to arsenic trioxide. Metal Ions Biol Med. 2006; 9: 298–303.
34. Yedjou GC, Tchounwou PB. In vitro cytotoxic and genotoxic effects of arsenic trioxide on human leukemia cells using the MTT and alkaline single cell gel electrophoresis (comet) assays. Mol Cell Biochem. 2007; 301: 123–130.
35. Yedjou GC, Tchounwou PB. N-acetyl-cysteine affords protection against lead-induced cytotoxicity and oxidative stress in human liver carcinoma (HepG2) cells. Intl J Environ Res Public Health. 2008; 4(2): 132–137.