**Heavy Metal on Fish**

Mona S. Zaki1, Nabila El-Batraway2and Samy Shalaby3

1Department of Hydrobiology, National Research Centre, Dokki, Cairo, Egypt

2Animal Reproduction Institute Al Haram, Egypt

3Deptartment of Animal Reproduction, National Research Center, Cairo, Egypt

dr\_mona\_zaki@yahoo.co.uk

**Abstract:** In general, metals can be categorized as biologically essential and non-essential. The nonessential metals (e.g., aluminum (Al), cadmium (Cd), mercury (Hg), tin (Sn) and lead (Pb)) have no proven biological function (also called xenobiotics or foreign elements), and their toxicity rises with increasing concentrations. Essential metals (e.g., copper (Cu), zinc (Zn), chromium (Cr), nickel (Ni), cobalt (Co), molybdenum (Mo) and iron (Fe)) on the other hand, have a known important biological roles.

[Mona S. Zaki, Nabila El-Batrawayand Samy Shalaby. **Heavy Metal on Fish.** *Researcher* 2017;9(11):60-64]. ISSN 1553-9865 (print); ISSN 2163-8950 (online). <http://www.sciencepub.net/researcher>. 9. doi:[10.7537/marsrsj091117.09](http://www.dx.doi.org/10.7537/marsrsj091117.09).

**Keywords:** Heavy Metal; Fish; biologically essential and non-essential

**Introduction**

Due to feeding and living in the aquatic environments fish are particularly vulnerable and heavily exposed to pollution because they cannot escape from the detrimental effects of pollutants [1-3]. Fish, in comparison with invertebrates, are more sensitive to many toxicants and are a convenient test subject for indication of ecosystem health [4-17]. Heavy metals are produced from a variety of natural and anthropogenic sources [18]. In aquatic environments, heavy metal pollution results from direct atmospheric deposition, geologic weathering or through the discharge of agricultural, municipal, residential or industrial waste products, also via wastewater treatment plants (WWTPs) [19-22]. Coal combustion is one of the most important anthropogenic emission sources of trace elements and an important source of a number of metals [23]. The contamination of heavy metals and metalloids in water and sediment, when occurring in higher concentrations, is a serious threat because of their toxicity, long persistence, and bioaccumulation and bio magnification in the food chain [24,25]. Fishes are considered to be most significant biomonitors in aquatic systems for the estimation of metal pollution level [26,27], they offer several specific advantages in describing the natural characteristics of aquatic systems and in assessing changes to habitats [28]. In addition, fish are located at the end of the aquatic food chain and may accumulate metals and pass them to human beings through food causing chronic or acute diseases [29]. Studies from the field and laboratory works showed that accumulation of heavy metals in a tissue is mainly dependent on water concentrations of metals and exposure period; although some other environmental factors such as water temperature, oxygen concentration, pH, hardness, salinity, alkalinity and dissolved organic carbon may affect and play significant roles in metal's accumulation and toxicity to fish [30-35]. Ecological needs, size and age of individuals, their life cycle, feeding habits, and the season of capture were also found to affect experimental results from the tissues [36-38]. Fish have the ability to uptake and concentrate metals directly from the surrounding water or indirectly from other organisms such as small fish, invertebrates, and aquatic vegetation [39]. Fish accumulate pollutants preferentially in their fatty tissues like liver and the effects become apparent when concentrations in such tissues attain a threshold level [40].

The pollution of the aquatic environment with heavy metals has become a worldwide problem during recent years, because they are indestructible and most of them have toxic effects on organisms. Among environmental pollutants, metals are particular concern, due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems[41, 42].

There is increasing concern about the quality of foods in several parts of world. The determination of toxic elements in food has prompted studies on toxicological effects of them in food. Heavy metals are considered the most important form of pollution of the aquatic environment because of their toxicity and accumulation by marine organisms [43, 44].

Aquatic foods have essential amino acids, fatty acids, protein, carbohydrates, vitamins and minerals. Among sea foods, fish are commonly consumed and, hence, are a connecting link for the transfer of toxic heavy metals in human beings. Heavy metals have the tendency to accumulate in various organs of marine organisms, especially fish, which in turn may enter into the human metabolism through consumption causing serious health hazards.

Fishes are major part of the human diet and it is therefore not surprising that numerous studies have been carried out on metal pollution in different species of edible fish. Predominantly, fish toxicological and environmental studies have prompted interest in the determination of toxic elements in seafood [45-46].

A heavy metal is generally regarded as any relatively dense metal or metalloid of environmental concern. The term originated with reference to the harmful effects of metals like cadmium, mercury and lead, all of which are denser than iron. Commonly encountered heavy metals are chromium, cobalt, nickel, copper, zinc, arsenic, selenium, sliver, cadmium, antimony, mercury, thallium and lead.

Metals are introduced in aquatic systems as a result of the weathering of soils and rocks, from volcanic eruptions, and from a variety of human activities involving the mining, processing, or use of metals and/or substances that contain metal pollutants. The most common heavy metal pollutants are arsenic, cadmium, chromium, copper, nickel, lead and mercury.

**What Happens When an Excess of Metals Enters Freshwater Ecosystems?**

Where there is marked effect on speciation and strong binding of metal at the biological surface, the dominant effect of a decrease in pH will be to increase the metal availability.

Generally the ionic form of a metal is more toxic, because it can form toxic compounds with other ions. Electron transfer reactions that are connected with oxygen can lead to the production of toxic oxyradicals, a toxicity mechanism now known to be of considerable importance in both animals and plants. Some oxyradicals, such as superoxide anion (O2-) and the hydroxyl radical (OH-), can cause serious cellular damage. [47-48]

**Bioaccumulation of Heavy Metals:**

Metals in natural waters occur in particulates or in soluble forms, including labile and nonlabile fractions. The labile metal compounds are the most dangerous to fish. They include various ionic forms of different availability to fish. The results of many field studies of metal accumulation in fish living in polluted waters show that considerable amount of various metals may deposited in fish tissues without causing mortality. Various metals are accumulated in fish body in different amounts. These differences result from different affinity of metals to fish tissues, different uptake deposition and excretion. Generally, the higher metal concentration in the environment, the more it may be taken up and accumulated by fish. Relationship between metal concentrations in fish and water was observed in both, field and laboratory studies [49-50] (Fig. 1-4). Metals level in live fish usually follow the ranking; Fe>Zn>Pb>Cu>Cd>Hg



**Fig. 1: Hyperactivation of goblet cells.** Kargin, F. and C. Erdem, [50**]**



**Fig. 2: Gills of Tilapia fish exposed/reared in areas heavily polluted with heavy metals showing lamellar edema and separation** Kargin, F. and C. Erdem, [50**]**



**Figs. 3 & 4: Skin of fish reared in polluted area with heavy metals showing hyperactivation of goblet cells and dermal melanosis.** Kargin, F. and C. Erdem, [50**]**

**References:**

1. Yarsan E, Yipel M (2013) The important terms of marine pollution Biomarkers and biomonitoring, bioaccumulation, bioconcentration, biomagnification. J Mol Biomark Diagn S1
2. Mahboob S, Al-Balawi HFA, Al-Misned F, Al-Quraishy S, Ahmad Z (2014) Tissue metal distribution and risk assessment for important fish species from Saudi Arabia. Bull Environ Contam Toxicol 92: 61-66.
3. Saleh, YS, Marie M-A.S. (2014) Assessment of metal contamination in water, sediment, and tissues of Arius thalassinus fish from the Red Sea coast of Yemen and the potential human risk assessment. Environ. Sci. Pollut. Res., DOI 10.1007/s11356-014-3780-0.
4. Adams SM, Ryon MGA (1994) A comparison of health assessment approaches for evaluating the effects of contaminant-related stress on fish populations. J Aquat Ecosyst Health 3: 15-25.
5. Khallaf EA, Galal M, Authman M (1998) Assessment of heavy metals pollution and their effects on Oreochromisniloticus in aquatic drainage canals. J Egypt Ger Soc Zool 26: 39-74.
6. Whitfield AK, Elliott M (2002) Fishes as indicators of environmental and ecological changes within estuaries: a review of progress and some suggestions for the future. J Fish Biol 61: 229-250.
7. Khallaf EA, Galal M Authman M (2003) The biology of Oreochromisniloticus in a polluted canal. Ecotoxicology 12: 405-416.
8. Moiseenko TI, Gashkina NA, Sharova YN, Kudryavtseva LP (2008) Ecotoxicological assessment of water quality and ecosystem health: A case study of the Volga River. Ecotoxicol. Environ Saf 71: 837-850.
9. Authman MMN, Abbas HHH (2007) Accumulation and distribution of copper and zinc in both water and some vital tissues of two fish species (Tilapia zillii and Mugilcephalus) of Lake Qarun, Fayoum Province, Egypt Pak J Biol Sci 10: 2106-2122.
10. Authman MMN (2011) Environmental and experimental studies of aluminium toxicity on the liver of Oreochromisniloticus (Linnaeus, 1758) fish. Life Sci J 8: 764-776.
11. Authman MMN, Bayoumy EM, Kenawy AM (2008) Heavy metal concentrationsand liver histopathology of Oreochromisniloticus in relation to aquatic pollution. Global Vet 2: 110-116.
12. Authman MMN, Abbas WT, Gaafar AY (2012) Metals concentrations in Nile tilapia Oreochromisniloticus (Linnaeus, 1758) from illegal fish farm in Al-Minufiya Province, Egypt, and their effects on some tissues structures. Ecotoxicol Environ Saf 84: 163-172.
13. Authman MMN, Abbas HH, Abbas WT (2013) Assessment of metal status in drainage canal water and their bioaccumulation in Oreochromisniloticus fish in relation to human health. Environ Monit Assess 185: 891-907.
14. Authman MMN, Ibrahim SA, El-Kasheif MA, Gaber HS (2013): Heavy metals pollution and their effects on gills and liver of the Nile Catfish Clariasgariepinus inhabiting El-Rahawy Drain Egypt. Global Vet 10: 103-115.
15. Abumourad IMK, Abbas WT, Authman MMN, Girgis SM (2014) Environmental impact of heavy metal pollution on metallothionein expression in Nile Tilapia. Res J Pharm Biol Chem Sci 5: 998-1005.
16. Gaber HS, Abbas WT, Authman, MMN, Gaber SA (2014) Histological and biochemical studies on some organs of two fish species in Bardawil Lagoon, North Sinai, Egypt. Global Vet 12: 1-11.
17. Zaki, MS, Authman MMN, Hammam AMM, Shalaby SI (2014) Aquatic environmental pollution in the Egyptian countryside and its effect on fish production (Review). Life Sci J 11: 1024-1029.
18. Bauvais C, Zirah S, Piette L, Chaspoul F, Coulon ID (2015) Sponging up metals: Bacteria associated with the marine sponge Spongia officinalis. Mar. Environ. Res., 104: 20-30.
19. Demirak A, Yilmaz F, Levent Tuna A, Ozdemir N (2006) Heavy metals in water, sediment and tissues of Leuciscuscephlaus from a stream in southwestern Turkey. Chemosphere 63: 1451-1458.
20. Maier D, Blaha L, Giesy JP, Henneberg A, Köhler HR, et.al. (2014) Biological plausibility as a tool to associate analytical data for micropollutants and effect potentials in wastewater, surface water, and sediments with effects in fishes. Water Research (2014)
21. Dhanakumar S, Solaraj G, Mohanraj R (2015) Heavy metal partitioning in sediments and bioaccumulation in commercial fish species of three major reservoirs of river Cauvery delta region, India. Ecotoxicol. Environ. Saf., 113: 145-151.
22. Garcia JC, Martinez DST, Alves OL, Leonardo AFG, Barbieri E (2015) Ecotoxicological effects of carbofuran and oxidized multiwalled carbon nanotubes on the freshwater fish Nile tilapia: Nanotubes enhance pesticide ecotoxicity. Ecotoxicol. Environ. Saf., 111: 131-137.
23. Wagner, A. and Boman, J. (2003) Biomonitoring of trace elements in muscle and liver tissue of freshwater fish. Spectrochim. Acta, B 58(12): 2215-2226.
24. Eisler R (1993) Zinc Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service, Biological Report 10.
25. Has-Schön E, Bogut I, Strelec I (2006) Heavy metal profile in five fish species included in human diet, domiciled in the end flow of River Neretva. Arch Environ Contam Toxicol 50: 545-551.
26. Rashed MN (2001) Monitoring of environmental heavy metals in fish from Nasser Lake. Environ Int 27: 27-33.
27. Authman MMN (2008) Oreochromisniloticus as a biomonitor of heavy metal pollution with emphasis on potential risk and relation to some biological aspects. Global Vet., 2(3): 104-109.
28. Lamas S, Fernández JA, Aboal JR, Carballeira A (2007) Testing the use of juvenile Salmo trutta L. as biomonitors of heavy metal pollution in freshwater. Chemosphere 67: 221-228.
29. Al-Yousuf MH, El-Shahawi MS, Al-Ghais SM (2000) Trace metals in liver, skin and muscle of Lethrinuslentjan fish species in relation to body length and sex. Sci Total Environ 256: 87-94.
30. Benaduce APS, Kochhann D, Flores ÉMM, Dressler VL, Baldisserotto B (2008) Toxicity of cadmium for silver catfish Rhamdiaquelen (Heptapteridae) embryos and larvae at different alkalinities. Arch Environ Contam Toxicol 54: 274-282.
31. Has-Schön E, Bogut I, Kralik G, Bogut S, Horvatić J, et al. (2008) Heavy metal concentration in fish tissues inhabiting waters of “Buško Blato” reservoar (Bosnia and Herzegovina). Environ Monit Assess 144: 15-22.
32. Linbo TL, Baldwin DH, Mc Intyre J, Scholz NL (2009) Effects of water hardness, alkalinity, and dissolved organic carbon on the toxicity of copper to the lateral line of developing fish. Environ Toxicol Chem 28: 1455-1461.
33. Sassi A, Annabi A, Kessabi K, Kerkeni A, Saïd K et.al. (2010) Influence of high temperature on cadmium-induced skeletal deformities in juvenile mosquitofish (Gambusiaaffinis). Fish Physiol Biochem 36: 403-409.
34. Ebrahimi M, Taherianfard M (2011) The effects of heavy metals exposure on reproductive systems of cyprinid fish from Kor River. Iran J Fish Sci 10: 13-24.
35. Jitar O, Teodosiu C, Oros A, Plavan G, Nicoara M (2014) Bioaccumulation of heavy metals in marine organisms from the Romanian sector of the Black Sea. N. Biotechnol. 2014 Dec 9. pii: S1871-6784(14)02197-9. doi: 10.1016/j. nbt.2014.11.004. .
36. Kime DE, Ebrahimi M, Nysten K, Roelants I, Rurangwa E, et al. (1996) Use of computer assisted sperm analysis (CASA) for monitoring the effects of pollution on sperm quality of fish; application to the effects of heavy metals. Aquat Toxicol 36: 223-237.
37. Rurangwa E, Roelants I, Huyskens G, Ebrahimi M, Kime DE, et.al (1998) The minimum effective spermatozoa: egg ratio for artificial insemination and the effects of mercury on sperm motility and fertilization ability in Clariasgariepinus. J Fish Biol 53: 402-413.
38. Onen SA, Kucuksezgin F, Kocak F, Açik S (2015) Assessment of heavy metal contamination in Hedistediversicolor (O.F. Müller, 1776), Mugilcephalus (Linnaeus, 1758), and surface sediments of Bafa Lake (Eastern Aegean). Environ Sci Pollut Res, 2015.
39. Polat F, Akın Ş, Yıldırım A, Dal T (2015) The effects of point pollutantsoriginated heavy metals (lead, copper, iron, and cadmium) on fish living in Yeşilırmak River, Turkey. Toxicol. Ind. Health, 1-12. Toxicol Ind Health January 9, 2015 0748233714565709.
40. Omar WA, Saleh YS, Marie MAS (2014) Integrating multiple fish biomarkers and risk assessment as indicators of metal pollution along the Red Sea coast of Hodeida, Yemen Republic. Ecotoxicol. Environ. Saf., 110: 221-231.
41. Goldstein G.W., 1990, *Health Perspect*., 89, (1990), 91-94.
42. Gledhill M., Nimmo M, Hill S.J., and Brown M.T, *Journal of Phycology*, 33, (1997), 2-11.
43. Malik A., *Environmental International*, 30, (2004), 261-278.
44. 44 Gurnham A.S., *Journal of Fish Res*., 11, (1975), 920-925.
45. Begum Abida, S. Harikrishna, I. Khan, *International Journal of Pharm Tech Research*, 1 (2), (2009), 245-249.
46. Nasreddine L., D. Parent-Massin, *Toxicology Letters*, 127, (2002), 29-41.
47. Wong, C.K, P.P.K. Wong and L.M. Chu, 2001. Heavy metal concentration in marine fish collected from culture sites in Hong Kong. Archives of Environmental Contamination and Toxicology, 40: 60-69.
48. Ashraf, W, 2005, Accumulation of heavy metals in kidney and heart tissues of Epinephelusmicrodon fish from the Arabian Gulf. Environmental Monitoring Assessment, 101:311-316.
49. Singh, R. K. S. L. Chavan and P.H. Sapkale, 2006. Heavy metal concentrations in water, sediments and body tissues of red worm (*Tubifex* spp.) collected from natural habitats in Mumbai, Indian Environmental Monitoring Assessment, 129(1-3): 471-481.
50. Kargin, F. and C. Erdem, 1991. Accumulation of copper in liver, spleen, stomach, intestine, gills and muscle of Cyprinuscarpio. Doga-Turkish Journal of Zoology, 15:306-314.

11/11/2017