A Review on the Impact of Heavy Metals on different Organs of Fishes

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Abstract

Environmental pollution is a universal problem throughout the world.The purpose of this review was to check the levels and accumulation of heavy metals like Cr, Cd, Zn and Pb in the various organs of fishes like liver, gills and kidney. These metals also effect upon reproductive and immune system of fishes. This is due to the fact that fishes in comparison with invertebrates are more sensitive to many toxicants. In aquatic environment heavy metal pollution results from direct atmospheric deposition, weathering or through the discharge of agricultural, municipal, residential or industrial waste products. Humans are also affected by intake of fishes for mostly people of those areas where main food is fish.

Key words: *Pollution, Heavy metals, Immune system, Toxicants, Weathering*

Introduction

Now-a-days developing countries are facing the problem of water pollution due to industrialization and civilization. High technology world produce large amount of polluted products that drained into nearby rivers and disturb aquatic ecosystem.There are several elements present in periodic table out of these, 23 are known as heavy metals. Due to human activities like mining, improper waste material disposal and fuel combustion, our environment is getting to be more and more polluted with these toxic heavy metals. Mainly heavy metals are those which have a relatively higher density in contrast to metal. In aquatic ecosystem, heavy metals are known as most important pollutants like chromium mercury, cadmium, copper, lead and zinc.

They are extremely dangerous for the health of fish. Aquatic organisms accumulate toxic metals from many sources like sediments, soil erosion and runoff,aerosol and discharge of waste water. (Goodwin, *et. al.*, 2003). These pollutants bio accumulate in the food chain and cause death of aquatic organisms (Farkas, Salanki, 2002) (Al-Yousuf *et. al.*1999). Some fish have more accumulation pattern than others because of the ability of fish to bio accumulate metals (Adeyeye, 1996).Out of the many heavy metals cadmium is more dangerous for fishes, which is released by effluents of battery, electroplating and metal finishing (Forstner and Prosi, 1979).

Fishes are known as significant bio-monitors in aquatic systems for the estimation of metal pollution level. In addition,fish are present at the end of the aquatic food chain and pass accumulate pollutants mainly in their fatty tissues like liver. However, this accumulation depends upon their intake, storage and elimination from the body. It means that metals which have high uptake and low elimination rates in tissues of fish accumulated to higher levels.

The pattern of bio accumulation of heavy metals are determined by the absorbance and excretion rates of fish. Different factors like physical and chemical properties of water as well as seasonal changes are the main reason of significant accumulation of metals in fish tissues (Pandey, *et. al.*, 2008) (Romeo *et. al.*,1999).

The order of heavy metal accumulation in the gills and liver was Pb>Cd>Ni>Cr and Cd> Pb> Cr.

Fish, as human food are a good source of protein and unsaturated fatly acids (Toth and Brown, 1997). In future seafood will be more important source of food protein than they are today. To increase fish production it is necessary to develop a normal and disease free embryo (Lubzens *et. al.* 2010). Heavy metals not only disturb the physiology but also biochemical mechanisms in fish.In this review the heavy metals like Cadmium, Chromium,Lead and Zinc are going to be investigated.

Effect of Chromium on Fish-

Chromium is a glossy, steel grey, crystalline metal. Its atomic number is 24 and

density is 7.14g/ml (Daugherty, 1992; Eisler R., 1986). It is present in Earth crust in several oxidation forms but most commonly forms are trivalent (+3) and hexavalent (+6) in the environment (Goyern, Clarkson, 2001). Chromium concentration in soil varies from 1 to 3000 mg/kg, in sea water varies from 5 to 800µg/L and in rivers from 26µg/L to 52mg/L. Hexavalent is more toxic because of its powerful oxidative potential and ability to cross cell membrane. It enters the aquatic ecosystem through industrial effluents mainly from leather tanneries, textiles, and electroplating, dyeing and printing industries (Farag, 2006; Arunkumar RI,Rajasekaran P *et. al.*,2000).

Chromium accumulation depends upon size and organs. It accumulates in fish tissues either directly from surrounding water or by ingestion. Chromium has toxic effects not only on gill,kidney and liver but also effect the metabolic and physiological activities. Acute poisoning by chromium causes excess mucous secretion and damage gill epithelium, fish suffocate and finally die. Chromium also cause kidney failure due to loss of osmoregulatory ability in fish (Mishra and Mohanty, 2009). In recent study conducted on *Nuria denricus* a teleost fish, chromium toxicity was found to be greatly affected by changes in pH. Biologists Virk and Sharma reported the effects of toxicity of chromium on fingerlings of *C.mrigala.*(Virk and Sharma, 2003*)* High concentration of chromium also damage the gills of fish that swim near the point of disposal.

Effect of Chromiumon Humans after the intake of affected fish–

Chromium (VI) is very dangerous for human health mainly for people who work in the steel industry and textile industry. It causes skin rashes, upset stomach, respiratory problem, liver and kidney problem, genetic problem, lungs cancer and at last causes death.

Effect of Cadmium on fish-

Cadmium(Cd), is known for its non-corrosive nature is widely used in paints and dyes, cement and phosphate fertilizers (Jarrap,2003).It has been observed that blood levels of cadmium above 5mcg/dL, is considered to be suggestive of Cd toxicity. This heavy metal accumulation (about 75%) in kidney, liver and gills of freshwater fish cause pathological changes in these organs. Higher dose of cadmium caused external lesions such as discoloration and necrosis on livers of *Cyprinus carpio, Carassius auratus and Corydoras paleatus* (Thophon et al., 2003).

Omer *et. al.*, (2012)has observed histopathological changes in liver, intestine and kidneys of tilapia fish (*Oreochromis niloticus)* exposed to cadmium. It also affects the glycogen and lipid levels of fish. Cadmium may also enter into the atmosphere from zinc, lead or copper smelter. It may enter water system through disposal of wastes from households or industries. Due to exposure of this heavy metal reproductive rate of aquatic organisms may also be affected and can lead to a gradual

extinction of generation.

Cadmium is also considered as endocrine disrupter and has been shown to interfere with the formation of steroids, eggs and sperm in rainbow trout (*Oncorynchus mykiss*). Bio enhancement of Cd transfer along a food chain was studied by See Baugh et al (2005). De Smet and Blust (2001) have reported that proteolysis is intended to increase the role of proteins in the energy production at the time of cadmium stress.

Cadmium damage the kidney and cause signs of chronic toxicity, poor reproductive capacity, hyper tension, tumours and hepatic dysfunction (Mansour and Sidky, 2002).Accumulation of Cd also indicate oxidative stress in several tissues of *Sparus aurata* were investigated by Souid *et. al.* (2013). Witeska *et. al.* (2014) studied effects of Cd on the embryonic, larval or both stages of the *Leuciscus idus*. Cadmium also showed a significant decline in carbohydrate content in body tissues of Anabas (Vijayram *et. al.*, 1989). Shukla *et. al.*, (2002) showed toxic effects of Cd on the nutritive value of fresh water fish *Channa punctatus.*

Effect of Cadmium on Human after the intake of affected fish-

Cadmium is very dangerous for human beings also. Wild fish collected from polluted area used as staple diet by man may be highly contaminated.Heavy metal like Cd, mercury, arsenic and lead have toxic effects on living organisms (Hanna LA, Peters JM *et. al.*,1997).When these chemicals enter food chain these cause physiological impairment at higher trophic levels and in human consumers.

Cadmium is first reached to the liver through the blood then it bonds to proteins and form complexes that are transported to the kidneys. It accumulates in kidneys and affected filtration mechanism of kidney. Other ill effects on health that can be caused by cadmium are- Diarrhoea, stomach pain, vomitting, D.N.A. damage, cancer development and bone fracture.

Effect of Lead on Fish-

Lead(Pb) is a main environmental pollutant. It is a persistent heavy metal which has been characterized as a priority hazardous substance. Its concentration in food chain increases by anthropogenic sources like metal mining, battery manufacturing Pb- based paints and leaded gasoline (Baker *et. al.*,1997;Mager, 2011).

Lead in aquatic ecosystem may come from industrial effluents, pesticides, fallout of lead dust and municipal waste water (Monteriro *et. al.*, 2011). Lead accumulated in fish by contaminated water rather than diet.It deposits in many organs like liver, kidney, spleen, gills and digestive tract of fish.

Different pollutants like industrial wastes pesticides and heavy metals have histopathological effects on the reproductive tissues of gonads (Johnson et al, 1991; Hanna *et. al.*; 2005). These effects disturb the development of germ cells and reduce reproductive ability of fish (Kumar and Pant, 1984). Raised levels of lead in the water can

cause generative damage, blood and nervous changes in fish and other animals that live there (Kalay *et. al.*1999;Weis and Weis,1989; McCoy *et. al.*, 1995). Lead decreases major antioxidants in the cell and increases in a reactive oxygen species (ROS) production and create a situation called "oxidative stress" which lead to dysfunctions in lipids, proteins and D.N.A (El-Badawi, 2005). Iger and Abraham (1997) find out a very high number of rodlet cells (RCs) in the epidermis of common carp and rainbow trout when kept in lead polluted water.

Hou *et. al.* (2011) observed deformities as spinal curvatures in Chinese sturgeon, *Acipenser sinesis*. Shah (2005) suggested that Pb may weaken the immune system and fish get more susceptibility to infection. Main symptoms of lead toxicity are hepatocyte vacuolization, hepatic cirrhosis, necrosis, shrinkage, parenchyma degeneration and increase of sinusoidal spaces in the liver of fish.

Effect of Lead on Human after the intake of affected fish-

Fish are usually among the top consumers. Through clinical examination it was found that normal growth and multiplication of Indian major carp and prawn greatly suppressed due to ecological status of river and reservoir. Pb concentration ranged from 2.01 to 8.21ppm/drywt in the muscles of shrimp which is toxic for every consumer. Lead accumulates in the blood, bones, muscles and fat. Continuous exposure with lead may also cause osteoporosis and reproductive disorders, New born babies and young children cannot tolerate even slightly increases in the Pb concentration (Elder *et. al.*1991). It damages brain and nerves in foetus and young children resulting low. I.Q. Extreme exposure to cause behavioural disorders, memorial problem, mood changes and mental retardation.

Effect of Zn on Fish –

Zinc (Zn) is the second most abundant trace element after Fe in living organisms. It is found almost in every cell and involved in nucleic acid synthesis and found in many enzymes (Sfakianakis *et. al.*, 2015).Despite being an essential trace element, Zn is toxic to most organisms above certain concentrations.Zinc is used in many forms as a result of human activities like mining, burning of coal and waste burning (Srivastava and Kaushik, 2001). But it works as toxicant for fishes when its level exceeds in aquatic ecosystem. The main target of waterborne Zn toxicity are the gills (Hogstrand, 2011). High concentration of Zn induces histopathological alterations in ovarian tissue of *Tilapia nilotica* (Abd El-Gawad, 1999). Zn toxicity may disturb the development of germ cells and may reduce the ability of fish reproduction (Kumar and Pant, 1984)

Zinc pollution also tempts changes in ventilators and heat physiology. Zinc could cause sub-acute effects that change fish behaviour like deficiency of balance, stationary fins, restless swimming periods of dormancy and death (S.Kori and Ubogu,

2008).

Vandyk et al (2007) reported that congestion of blood vessels after Zn toxicity especially with the portal veins. Senthil *et. al.*, (2008) reported that liver is the most important organ for Zn accumulation in *Channa punctatus*. The high concentration of Zn in liver can be ascribed to the bindings of Zn to metallothionein(MT) which was at highest concentration in liver. Zinc also causes disturbances of acid-base, disruption of gill tissue and hypoxia(Murugan *et. al.*, 2008).

Effect of Zn on Human after the intake of affected fish-

Zinc and its compounds are mainly used in commerce and in medicine. High concentration of Zn in commercial fish and shrimps observed by several scientists through food chain. Accumulation of heavy metals in tissues mainly depends upon concentration of metals in water and exposure period. Some other environmental factors like salinity, pH, hardness and temperature also play important roles in heavy metal accumulation (Blackmore G, Wang WX, 2003).

When humans consumed Zn they can experience a loss of appetite, slow wound healing and skin problems. It also causes birth defects very high levels of Zinc can damage the pancreas and also disturb protein metabolism. Zn in the form of chloride can cause respiratory problem. Samman and Roberts (1987) reported abdominal cramps, vomiting and nausea in 26 of 47 healthy volunteers following ingestion of Zinc sulphate tablets. In addition to zinc sulphate, zinc oxide and zinc gluccnate also show toxic effect on the gastrointestinal system.

Conclusion

The present review is important for the aquatic animal health status. The heavy metals analysed indifferent organs like gills, liver, kidney of the control fish. Most of the heavy metals were present in those portion of fish which are edible. Humans can also be affected by eating fish meat and can cause severe health problems. That is why it is recommended that treatment of all kinds of wastewater, sewage and agricultural wastes must be conducted before discharge into the aquatic systems. Also legislations regarding the protection of aquatic environments must be taken into considerations.

References

Abd El-Gawad AM (1999) Histopathological studies on the liver and gills of Tilapia nilotica (Oreochromisniloticus) exposed to different concentrations of lead acetate and zinc sulphate. *J Egypt Ger Soc Zool 30:* **13-22.**

Adeyeye E (1996). Determination of major elements in Illisha africana fish, associated water and soil sediments from some freshwater ponds. Bangladesh *J Sci Indust. Res. 31*:**171-184.**

Al-Yousuf M. El-Shahawi M (1999). Trace metals in Lethrinus lentjan fish from the Arabian Gulf (Ras Al-Khaimah, United Arab Emirates): metal accumulation in kidney and heart tissues. *Bull Environ*

Contam. Toxicol. 62:**293- 300.**

Arunkumar RI, Rajasekaran P, Michael RD (2000) Differential effect of chromium compounds on the immune response of the African mouth breeder, Oreochromis mossambicus (Peters). *Fish Shellfish Immunol 10:* **667-676.**

Baker RTM, Martin P, Davies SJ (1997) Ingestion of sub-lethal levels of iron sulphate by African catfish affects growth and tissue lipid peroxidation. *Aquat. Toxicol. 40*: **51-61.**

Blackmore G, Wang WX (2003). Comparison of metal accumulation in mussels at different local.

Daugherty ML. Toxicity Summary for Chromium, 1992, http://risk.lsd.ornl.gov/tox/profiles/chromium.doc.

De Smet H, Blust R (2001). Stress responsed and changes in protein metabolism in carp Cyprinus carpio during cadmium exposure. *Ecotoxicol Environ Saf.*, 48(3): **255- 262**.

Eisler R. Chromium Hazards to Fish, Wildlife, And Invertebrates: A Synoptic Review, Contaminant hazard reviews, Report No. 6, *Biological Report 1986*; **85 (1.6).**

El-Badawi AA (2005) Effect of lead toxicity on some physiological aspects of Nile tilapia fish, Oreochromis niloticus.

Elder JF, Collins JJ (1991). Freshwater molluscs as indicators of bioavailability and toxicity of metals in surface systems. *Rev. Environ. Contam. Toxicol. 122*: **37–79**.

Farag AM, May T, Marty GD, Easton M, Harper DD, et al. (2006) The effect of chronic chromium exposure on the health of Chinook salmon (Oncorhynchus tshawytscha). *Aquat. Toxicol 76*: **246-257.**

Farkas A, Salanki J, (2002). Specziar A. Relation between growth and the heavy metal concentration in organs of bream Abramis brama L. populating Lake Balaton. *Arc. Environ. Contam. Toxicol. 43:***236-243.**

Forstner U and Prosi F (1979). Heavy metal pollution in freshwater ecosystem. In "Biological aspects of Freshwater Pollution" : In O. Ravera (ed.), Pergamon Press, Oxford) **129-161**.

Goodwin T,h., Young, A.R.., Holmes, M.G.R., Old, G.H., Hewitt ,N.,Leeks, G.J.L., Packman, J.C., and Smith, B.P.G., 2003. The temporal and spatial variability of sediment transport and yields within the Bradford Beck catchment, West Yorkshire. *Sci. Total Environ, 314-316*: **475-494.**

Goyer RA, Clarkson TW. Toxic effects of metals, Cassarett and Doull's Toxicology, McGraw-Hill Companie Inc. 2001; 23:**811-867.**

Hanna MI, Shaheed IB, Elias NS (2005). A contribution on chromium and lead toxicity in cultured Oreochromis niloticus. Egypt. *J. Aquatic Biol. Fisher. 9:***177-209.**

Hanna LA, Peters JM, Wiley LM, Clegg MS, Keen CL (1997). Comparative effects of essential and nonessential metals on preimplantation mouse embryo development in vitro. *Toxicol. 116:***123-131.**

Hogstrand C (2011) Zinc. Academic Press, New York, USA.

Hou JL, Zhuang P, Zhang LZ, Feng L, Zhang T, Liu JY, et al. (2011) Morphological deformities and recovery, accumulation and elimination of lead in body tissues of Chinese sturgeon, Acipenser sinensis, early life stages: a laboratory study. *J Appl Ichthyol 27*: **514-519.**

Iger Y, Abraham M (1997) Rodlet cells in the epidermis of fish exposed to stressors. *Tissue Cell, 29*: **431-438**.

Jarrup L 2003. Hazards of heavy metal contamination. *Br Med Bull, 68*:**167-182.**

Johnson LL, Casillas E, Myers MS, Rhodes LD, Olson OP (1991). Patterns of oocyte development and related changes in plasma of 1.7P-oestradiol, vitellogenin and plasma chemistry in English sole Parophrys vetulus Girard. *J. Exp. Mar. Biol. Ecol. 152*:**161-185**. http://dx.doi.org/10.1016/0022-0981(91)90213-G

Kalay M, Ay O, Canli M (1999). Heavy metal concentrations in fish tissues from the Northeast Mediterrenean Sea. Bull. Environ. Contam. *Toxicol. 63*: **673–681**.

Kumar S, Pant SC (1984). Comparative effects of the sublethal poisoning of zinc, copper and lead on the gonads of teleost Puntius conchnofus Ham. *Toxicol. Lett. 23*:**189-194**. http://dx.doi.org/10.1016/0378-4274(84)90125-5

Lubzens E, Young G, Bobe J, Cerdae (2010). Oogenesis in teleosts: how eggs are formed. Gen. Com. *Endocrinol. 165*:**367-389**. http://dx.doi.org/10.1016/j.ygcen.2009.05.022

Mager EM (2011) Lead. Academic Press, New York, USA.

Mansour SA, Sidky MM, (2002). Ecotoxicological Studies, 3 Heavy metals contaminating water and fish from Fayoum Governorate. Egypt *J Food Chem. 78(1)*, **15-22**.

McCoy CP, Hara TM, Bennett LW, Boyle CR, Lynn BC (1995). Liver and kidney concentrations of zinc, copper and cadmium in channel catfish (Ictalurus punctatus): variation due to size, season and health status. Vet. Hum. *Toxicol. 37 (1)*: **11–15.**

Mishra AK, Mohanty B (2009) Chronic exposure to sublethal hexavalent chromium affects organ histopathology and serum cortisol profile of a teleost, Channa punctatus (Bloch). *Sci. Total Environ 407*: **5031-5038**.

Monteiro V, Cavalcante DGSM, Viléla MBFA, Sofia SH, Martinez CBR (2011) In vivo and in vitro exposures for the evaluation of the genotoxic effects of lead on the Neotropical freshwater fish Prochiloduslineatus. Aquat. *Toxicol. 104*: **291-298.**

Murugan SS, Karuppasamy R, Poongodim K, Puvaneswari S, (2008). Bioaccumulation Pattern of Zinc in Freshwater Fish Channa punctatus (Bloch.) After Chronic Exposure, *Turk. J. Fisher. Aqu. Sci. 8*:**55-59**.

Omer SA, Elobeid MA, Fouad D, Daghestani MH, Al-Olayan EM, et al.(2012) Cadmium bioaccumulation and toxicity in tilapia fish (Oreochromis niloticus). *J Anim Vet Adv 11*: **1601-1606**

Pandey S, Parvez S, Ansari R.A, Ali M, Kaur M, Hayat F, Ahmad F, Raisuddin S. (2008). Effects of exposure to multiple trace metals on biochemical, histological and ultrastructural features of gills of a freshwater fish, Channa punctate. Bloch. *Chem. Biol. Interact. 174*:**183-192.**

Romeo M, Siau Y, Sidoumou ZÌn, (1999). Gnassia-Barelli M. Heavy metal distribution in different fish species from the Mauritania coast. *Sci. Total Environ*. 232:**169-175.**

Samman S, Roberts DC. The effect of zinc supplements on plasma zinc and copper levels and the reported symptoms in healthy volunteers.*Med.J.Aust.1987; 146*:**246-249**.

Seebaugh DR, Goto D, Wallace WG 2005. Bioenhancement of cadmium transfer along a multi-level food chain. *Mar Environ Res. 59(5):* **473-491**.

Senthil MS, Karuppasamy R, Poongodi K, Puvaneswari S (2008). Bioaccumulation Pattern of Zinc in Freshwater Fish Channa punctatus (Bloch.) After Chronic Exposure .*Turkish J. Fisheries and Aquat. Sci., 8*: **55-59.**

Sfakianakis DG, Renieri E, Kentouri M, Tsatsakis AM (2015) Effect of heavy metals on fish larvae deformities: *A review. Enviro. Res., 137*: **246–255.**

Shah SL, Altindag A (2005) Alterations in the immunological parameters of Tench (Tinca tincaL. 1758) after acute and chronic exposure to lethal and sublethal treatments with mercury, cadmium and lead. *Turk J Vet Anim Sci 29*: **1163-1168**

Shukla V, Rathi P, Sastry KV (2002) Effect of cadmium individually and in combination with other metals on the nutritive value of fresh water fish, Channa punctatus. *J Environ Biol 23*: **105-110**.

S. Kori O, Ubogu O E, (2008). Sub-lethal hematological effects of zinc on the freshwater fish, Heteroclarias sp. (Osteichthyes:Clariidae), *Afr. J Biotech*. 7(12):**2068-2073**.

Souid G, Souayed N, Yaktiti F, Maaroufi K (2013) Effect of acute cadmium exposure on metal accumulation and oxidative stress biomarkers of Sparus aurata. Ecotoxicol. Environ. Saf 89: **1-7**.

Srivastava N, Kaushik N (2001). Use of fish as bioindicator of aquatic pollution In: Abstracts presented at international congress of chemistry and environment. 16th - 18th Dec., India. Srivastava N, Sharma R (1996). Toxicity of zinc in fish (Channa punctatus Bloch.) as influenced by temperature and pH of water. *Indian J. Anim. Nutr.*, 13(2): **87-90**.

Thophon S, Kruatrachue M, Upatham ES, Pokethitiyook P, Sahaphong S, et al. (2003) Histopathological alterations of white seabass, *Lates calcarifer*, in acute and subchronic cadmium exposure. Environ Pollut 121: **307-320.**

Toth J.F, Brown RB(1997). Racial and gender meanings of why people participate in recreational fishing. Leisure Sci. 19:**129-146.**

VanDyk JC, Pieterse GM, VanVuren JHJ (2007). Histological changes in the liver of Oreochromis mossambicus (Cichlidae) after exposure to cadmium and zinc. Ecotoxicol. Environ. Safety, 66(3): **432-440.**

Vijayram K, Geraldine P, Varadarajan TS, John G, Lognanthan P (1989) Cadmium induced changes in the biochemistry of an air breathing fish Anabas testudineus. *J. Ecobiol., 1*: **245–251**.

Virk S, Sharma A (2003) Changes in the biochemical constituents of gills of *Cirrhinus mrigala* (Ham.) following exposure to metals. I*ndian J Fish 50*: **113-117.**

Weis JS, Weis P (1989). Effects of environmental pollutants on early fish development. Rev. *Aquat. Sci. 1*: **45–73**.

Witeska M, Sarnowski P, Lugowska K, Kowal E (2014) The effects of cadmium and copper on embryonic and larval development of ide Leuciscus idus *L. Fish Physiol. Biochem 40*: **151-163.**