IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

TOXIC EFFECT OF CADMIUM ON FISH HEALTH

AMJAD FATMI, GIRRAJ SINGH MEENA, DURRESHAHWAR RUBY,

Department of Zoology, Government College Dholpur, Rajasthan (India)

Department of Botany, Government College Dholpur, Rajasthan (India)

Department of Zoology, B.S. College Patna, Bihar (India)

ABSTRACT

Increasing concentration of heavy metals in water bodies is posing serious threat to fish health and aquaculture. Several studies revealed that cadmium accumulates in the fish body tissues which causes significant toxic effects on fish health as well as possible toxic effect on human body. The toxic effects include release of reactive oxygen species (ROS), reduced activities of antioxidases and consequent tissue damage,renal and liver disfunction.

Keywords: fish health, aquaculture, toxic effects, heavy metals, liver disfunction

INTRODUCTION

Heavy metal toxicity in water is the emerging global concern in developed as well as developing countries. A variety of contaminants including toxic heavy metals such as Cadmium, Copper, Mercury, Arsenic and Zinc are reported to be ubiquitously present in the waste water which are generally released into aquatic ecosystems and are toxic for aquatic organisms [1,2] .These heavy metals are mainly discharged from industries, sewage treatment plants and drainage from urban and agricultural areas [3] Since heavy metals are not destroyed in living organisms through biological degradation, they have the ability to accumulate in various tissues and organs and even be biomagnifi ed in the food chain [4] When the amount of heavy metals in the medium reach to more than a certain limit it become toxic for those animals that live in that environment [5]. They pose serious hazards to freshwater fish resource for their toxicity and long persistence. They are also harmful to humans who relay on aquatic products as food sources. This element has a long-biological half-life in humans and it gets accumulated in vital organs-especially in liver and kidney throughout their lives [6]. The permissible levels for the concentration of Zn, Cd, Pb and Cu in water proposed by the United States Environmental Protection Agency are 5000, 5, 15 and 1300 µg/l respectively[7].However their concentration in aquatic organisms appear to be of several magnitudes higher than concentration present in the ecosystem [8]. This is attributed to bioaccumulation where by metal ions are taken up from the environment by the organism and accumulated in various organs and tissues and one such metal is cadmium which has been shown to accumulate in the various tissues of fish at higher concentration than appears in the environment. It is a non-essential element, with no known biological function and found in low concentration in natural water [9,10]. It can have severe toxic effects on aquatic organisms when present in excessive amounts [11], or even if present in extremely low concentrations [12] . Cadmium may enter into the atmosphere from zinc, lead or copper smelter [13]. Fertilizers often contain some cadmium. Burning of fossil fuels or incineration of municipal waste materials are known to be largest sources of cadmium release to the general environment such as coal or oil

[14].In its elemental form Cadmium does not break down but it can change form into different species and compounds. Some species can bind strongly to soil or sediment particles, depending primarily on the acidity of the surrounding water. In Sulfide ore bodies, cadmium is usually associated with sphalerite ,a zinc sulfide mineral .Fish living in metal polluted environment might either be exposed to the metals through food chain or via direct uptake from contaminated water. In the latter case, the gills are the first organs to suffer from this type of pollutants and show first clinical sign induced by water borne metal exposure[15]. The effect of the metals on the fish also depends on the size of the animal, hardness of test water, temperature and type of the animals that are exposed

Cadmium toxicity in fish

The toxicity of Cd in fishes vary from species to species [16]. The toxic effects may include both lethal and sublethal concentration which may change the growth rate, development, reproduction, histopathology, biochemistry, physiology and behavior [17]. Most of the total Cd in continental runoff is either retained in estuaries or deposited in deep-water ocean sediments.. Toxicity testing has been widely used as a tool to identify suitable organisms as a bio-indicator and to derive water quality standards for chemicals. It is also considered as an essential tool for assessing the effects and fate of toxicants in aquatic ecosystems [18].These tests are useful for rapid estimation of the concentration of the toxicants that cause direct irreversible harm to the test organism [19].cadmium damage the kidney and cause signs of chronic toxicity, including impaired kidney function, tumors ,hepatic dysfunction and poor reproduction rate which may lead to a gradual extinction of their generation[20,21]. Fish creates one of the major sources of protein for human beings and 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[22,23, 24]

Toxic effect on gills

The toxic effect on gillsof fish include inflammation ,apoptosis and necrosis of gill tissue and the effect increases with the increase in exposure time[25,26,27].

Liver toxicity

Liver isis the main detoxifying organ in fish and convert heavy metals into less toxic forms which are the excreted out from the body [28]. A long time exposure increases cadmium content in the liver beyond its detoxifying capacity that leads to irreversible damage of the liver to various degree[28,29,30].significant increase have also been observed in serum GPT and GOT [31].

Toxic effect on immune system

Chronic exposure to cadmium mainly affects non specific immunity that include decrease in WBC count, decreased phagocytic activities of neutrophil and macrophages[32,33,34] .Cadmium exposure also inhibits the proliferation of lymphocyte in fish[35].

Table of lethal effects of cadmium on different fish species.

species	concentrtion	time	Effect	reference
Rutilus frisii	12.22 mg/L	96h	Median lethal	[36]
Catla catla	5.36 mg/L	96h	Median lethal	[37]
Silurus meridionalis	6.85 mg/L	96 h	Median lethal	[38]
Gambusia holbruki	37.2	96 h	Median lethal	[39]
Rasbora sumatrana	0.1mg/L	96 h	Median lethal	[40]
Poecilia reticulata	0.17mg/L	96 h	Median lethal	[40]
Tautogolabrus adspersus	26 µg /ml	96 h	Median lethal	[41]
Morone saxatilis	26 µg/ml	96 h	Median lethal	[41]
Oreochromis niloticus	14.8 mg/L	96 h	Median lethal	[42]
Cyprinus carpio	84.8 mg/L	96 h	Median lethal	[43]
Clarias gariepinus	10.85 mg /L	96 h	Median lethal	[44]
Labeo rohita	24 mg/L	96 h	Median lethal	[45]
Tricogadter (colisa) fasciat	49.5 mg/L	96 h	Median lethal	[46]
Silurus soldatovi	2.74 mg/L	96h	Median lethal	[47]
Poecilia reticulata	30.4 mg/L	96h	Median lethal	[48]
Ophiocephalus striatus	0.58 gn/L	96 h	Median lethal	[49]
Scorpaena guttata	25gm/L	96 h	Median lethal	[50]
Uca rapax	43 mg/L	96 h	Median lethal	[51]
Mugil seheli	5.36 mg/L	96 h	Median lethal	[52]
Heteropneustis fossilis	50.51 mg/L	96 h	Median lethal	[53]
Oreochromis mossambiccus	96.41 mg/L	96 h	Median lethal	[54]
Arius arius	56.4 mg/L	96 h	Median lethal	[55]
Onchorhynchus mykiss	8 µg /L	96 h	Embryonic mortality (97.5%)	[56]

The toxic effect of Cd on fish is mainly reflected in the oxidative stress caused by excessive accumulation of ROS that lead to structural changes in biological macromolecules, such as proteins and DNA, disorder of DNA replication and repair, and eventually pathological changes [47]. Cadmium also reduces the antioxidant activity of the cell by reducing the activity of antioxidant enzyme [57].

EFFECTS OF CADMIUM ON HUMAN HEALTH BY INTAKE OF FISH

Unfortunately the chemical contaminants are stored within the lipid component of the fish so they are well protected when entering the human body. Wild fish from certain polluted areas may be highly contaminated. Metals such as cadmium, mercury, arsenic and lead are non-essential and therefore have toxic effects on living organisms[58,,559,60] These chemicals accumulate in the tissues of aquatic organisms at concentrations many times higher than concentrations in water and may be biomagnified in the food chain to levels that cause physiological impairment at higher trophic levels and in human consumers. Human take cadmium mainly through food. Foodstuffs that are rich in cadmium can greatly increase the cadmium concentration in human bodies. Examples are liver, mushrooms, shellfish, dried sea weed etc. Cadmium is first transported to the liver through the blood. There, it is bound to proteins to form complexes that are transported to the kidneys. Cadmium accumulates in kidneys, where it damages purifying mechanisms. This causes the excretion of crucial proteins and sugars from the body and further kidney damage. It takes a very long time before cadmium that as accumulated in kidneys is excreted from a human body.

REFERENCES:

1. Olsson PE. Disorders associated with heavy metal pollution. In: Fish Diseases and Disorders Volume 2 (Non-infectious Disorders). CABI International, U.K. 1998; Pp: 105-131.
2. Kumar P, Prasad Y, Patra AK, Ranjan R, Patra RC, Swarup D and Singh SP . Ascorbic acid, garlic extract and taurine alleviate cadmium induced oxidative stress in freshwater catfish (Clarias batrachus). Sci Total Environ.2009; 407: 5024–5030
3. Karbassi AR (2006) Origin and chemical partitioning of heavy metals in riverbed sediments. International Journal of Environmental Science & Technology 3: 35-42.
4. Saaba A (2015) Acute Toxicity of Some Heavy Metals on Zebrafish, Danio rerio. Trends in Biosciences 8: 1372-1378.
5. Alkarkhi AF, Ismail N, Ahmed A, Easa A (2009) Analysis of heavy metal concentrations in sediments of selected estuaries of Malaysia--a statistical assessment. Environmental monitoring and assessment 53: 179-185.
6. Ye J, Mao W, Wu A, Zhang N, Zhang C, et al. (2007) Cadmium-induced apoptosis in human normal liver L-02 cells by acting on mitochondria and regulating Ca(2+) signals. Environmental Toxicology and Pharmacology 24: 45-54.
7. U. S. Environmental Protection Agency. Edition of the Drinking Water Standards and Health Advisories. Washington, DC: Office of Water, U. S. Environmental Protection Agency, EPA 820-R-11-002; 2011.
8. Laws EA. Aquatic pollutants an introductory text. John Wiley and sons, New York, 2000; 309-430, 780
9. Eisler, R. 1985. Cadmium Hazards To Fish, Wildlife , And Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report 85 (1.2), Contaminant Hazard Reviews Report No. 2. 46 pp 10. 10.
10. Viarengo JS. Biochemical effect of trace metal, Mar. Pollut. Bull. 1985; 16(4):153-158. erences
11. Holis L, et al. Cadmium accumalation gill cadmium binding acclimation and physiological effect during longterm sublethal Cd exposure in Rainbow trout. Aquatic Toxicol. 1999; 46:101-119
12. Witeska M, et al. The enfluence of cadmium on common carp embryos and larvae, Aquaculture. 1989; 10:129-132.
13. Sidoumou Z (1991). Qualite des eaux du littoral mauritanien: etude ´ des metaux traces chez deux mollusques bivalves ´ Venus ¨errucosa et Donax rugosus. Thesis, University of NiceSophia-Antipolis, France
14. Nriagu JO, Pacyna JM (1988). Quantitative assessment of worldwide contamination of air, water and soils by trace metals. Nature. 333:134-139.

15. Guo Z, Ye H, Xiao J, Hogstrand C, Zhang L. Biokinetic Modeling of Cd Bioaccumulation from Water, Diet and Sediment in a Marine Benthic Goby: A Triple Stable Isotope Tracing Technique. Environ Sci Technol. 2018; 52: 8429−8437.
16. Singh Anu, Jain and Kumar Puneet. Determination of LC50 of cadmium chloride in Heteropneustes fossilis. GERF Bulletin of Biosciences, 2010; 1(1): 21-24
17. Preston S, Coad N, Townend J, Killham K and Paton GI. Biosensing the acute toxicity of metal interactions: are they additive, synergistic, or antagonistic. Environ Toxicoi. 2000; 19: 775-780.
18. Shuhaimi-Othman M, Nadzifah Y and Ahmad A. Toxicity of Copper and Cadmium to Freshwater Fishes. World Academy of Science, Engineering and Technology. 2010; 41.
19. Parrish PR 1985. Acute toxicity tests cited in Fundamental of Aquatic Toxicology, edited by G.M. Rand and S. R. Petrocelli, Hemisphere publishing Corporation, New York. 1985; Pp: 31- 57.
20. 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.
21. Sridhara CN, Kamala C, Samuel S, Raj D (2008). Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. Ecotoxicol. Environ Saf. 69:513-524.
22. Andersen JL, Depledge MH (1997). A survey of total mercury and methylmercury in edible fish and invertebrates from Azorean waters. Marine Environ Res. 44:331-350.
23. Prudente M, Kim EY, Tanabe S, Tatsukawa R (1997). Metal levels in some commercial fish species from Manila Bay, the Philippines. Marine Pollut. Bull. 34:671-674.
24. ErdoÄŸrul Ãz, AteÅŸ DA (2006). Determination of Cadmium and Copper in Fish Samples from Sir And Menzelet Dam Lake KahramanmaraÅŸ, Turkey. Environ. Monitor. Asses.117:281-290.
25. Manera M., Giari L., De Pasquale J.A., Sayyaf Dezfuli B. Local connected fractal dimension analysis in gill of fish experimentally exposed to toxicants. *Aquat. Toxicol.* 2016;175:12–19
26. Garcia-Santos S., Vargas-Chacoff L., Ruiz-Jarabo I., Varela J.L., Mancera J.M., Fontaínhas-Fernandes A., Wilson J.M. Metabolic and osmoregulatory changes and cell proliferation in gilthead sea bream (*Sparus aurata*) exposed to cadmium. *Ecotoxicol. Environ. Saf.* 2011;74:270–278
27. Da Silva A.O.F., Martinez C.B.R. Acute effects of cadmium on osmoregulation of the freshwater teleost Prochilodus lineatus: Enzymes activity and plasma ions. *Aquat. Toxicol.* 2014;156:161–168. 28.Franco-Fuentes E., Moity N., Ramírez-González J., Andrade
28. Vera S., González-Weller D., Hardisson A., Paz S., Rubio C., Gutiérrez A.J. Metal and metalloids concentration in Galapagos fish liver and gonad tissues. *Mar. Pollut. Bull.* 2021;173:112953
29. Dai Z., Cheng J., Bao L., Zhu X., Li H., Chen X., Zhang Y., Zhang J., Chu W., Pan Y., et al. Exposure to waterborne cadmium induce oxidative stress, autophagy and mitochondrial dysfunction in the liver of *Procypris merus*. *Ecotoxicol. Environ. Saf.* 2020;204:111051.
30. Li J., Xie X. Inconsistent responses of liver mitochondria metabolism and standard metabolism in *Silurus meridionalis* when exposed to waterborne cadmium. *Comp. Biochem. Physiol. Toxicol. Pharmacol. CBP*. 2018;214:17–22.
31. Nogami E.M., Kimura C.C., Rodrigues C., Malagutti A.R., Lenzi E., Nozaki J. Effects of dietary cadmium and its bioconcentration in tilapia *Oreochromis niloticus*. *Ecotoxicol. Environ. Saf.* 2000;45:291–295.
32. Choudhury C., Mazumder R., Biswas R., Sengupta M. Cadmium exposure induces inflammation through the canonical NF-κB pathway in monocytes/macrophages of *Channa punctatus* Bloch. *Fish Shellfish. Immunol.* 2021;110:116–126
33. Jiaxin S., Shengchen W., Yirong C., Shuting W., Shu L. Cadmium exposure induces apoptosis, inflammation and immunosuppression through CYPs activation and antioxidant dysfunction in common carp neutrophils. *Fish Shellfish. Immunol.* 2020;99:284–290. doi: 10.1016/j.fsi.2020.02.015. [PubMed] [CrossRef] [Google Scholar]
34. Naz S., Hussain R., Ullah Q., Chatha A.M.M., Shaheen A., Khan R.U. Toxic effect of some heavy metals on hematology and histopathology of major carp (*Catla catla*) *Environ. Sci. Pollut. Res. Int.* 2021;28:6533–6539
35. Albergoni V., Viola A. Effects of cadmium on lymphocyte proliferation and macrophage activation in catfish, *Ictalurus melas*. *Fish Shellfish. Immunol.* 1995;5:301–31
36. Zahedi S., Mehdi M., Hossein V., Musa Zarei D., Seyed MH.(2012).LC50 determinationand copper and cadmium accumulation in the gills of kutum (Rutilius fricii kutum) fingerlings.

37. Janardan RS., and Reddy DC.(2013). Impact of cadmium toxicity on behavioural and hematological parameters of fresh water fish Catla catla.Int.J.Bioassay2(9):1199-1204.
38. Liu W., Qiu H., Yan Y., Xie X. Acute Cd Toxicity, Metal Accumulation, and Ion Loss in Southern Catfish (*Silurus meridionalis Chen*) *Toxics.* 2021;9:202. doi: 10.3390/toxics9090202
39. Talib HA.,Ali AA.,Amal AE.(2016). Determination of the lethal concentration 50%(LC 50) of cadmium chloride in mosquito fish Gambusia holbrooki.Tikrit.J.Pure Sci. 2(1):41-44.
40. Shuhaimi-Othman M., Yakub N., Ramle N.-A., Abas A. Comparative toxicity of eight metals on freshwater fish. *Toxicol. Ind. Health.* 2015;31:773–782.
41. Robohm R.A. Paradoxical effects of cadmium exposure on antibacterial antibody responses in two fish species: Inhibition in cunners (*Tautogolabrus adspersus*) and enhancement in striped bass (*Morone saxatilis*) *Vet. Immunol. Immunopathol.* 1986;12:251–262
42. Garcia-Santos S., Fontaínhas-Fernandes A., Wilson J.M. Cadmium tolerance in the Nile tilapia (*Oreochromis niloticus*) following acute exposure: Assessment of some ionoregulatory parameters. *Environ. Toxicol.* 2006;21:33–46
43. Zeynab,A., Khalesi M, Eskandari SK and Rahmani H.(2012) Comparison of Lethal Concentrations (LC50-96 H) of CdCl2, CrCl3,and Pb (NO3)2 in Common Carp (Cyprinus carpio) and Sutchi Catfish (Pangasius hypophthalmus). Iranian J. Toxicol. 6(18):672-680
44. Annune P.A., Ebele S.O., Oladimeji A.A. Acute toxicity of cadmium to juveniles of *Clarias gariepinus* (*Teugels*) and *Oreochromis niloticus* (*Trewavas*) *J. Environ. Sci. Health Part A Environ. Sci. Eng. Toxicol.* 1994;29:1357–1365.
45. Asim UA.,Hameed UR.,Waqar S.,Mohammad AQ.,Zakir U.,Haroon RUR.,Sajid A.,Raqeeb U.,Waqar A.,Kauser S.(2016).Determination of 96 hr LC_{50} value ofcadmium for a fish Labeo rohita .J.Ent.zool.Stu.4(5):380-382.
46. Roy S., Karmakar D., Pal S. Acute Toxicity Bioassay and Determination of LC50 of Cadmium Chloride in Trichogaster (*Colisa*) *fasciata*. *Appl. Biochem. Biotechnol.* 2022;194:3890–3900.
47. Zhang H., Cao H., Meng Y., Jin G., Zhu M. The toxicity of cadmium (Cd^{2+}) towards embryos and pro-larva of soldatov's catfish (*Silurus soldatovi*) *Ecotoxicol. Environ. Saf.* 2012;80:258–265. doi: 10.1016/j.ecoenv.2012.03.013
48. Mehmet Y.,Ali G.,Erhan K.(2004).Investigation of acute toxicity and the effect of cadmium chlorid($CdCl_2$ .H_2O) meta salt on on the bahaviour of the Guppy(Poecilia reticulata).Chemosphere.56(4):375-80.
49. Bais UE and Lokhande MV.(2017).Toxicity evaluation of cadmium chloride in fresh water fish ophiocephalus striatus .Int.J.Fish.Aqua.Stud.5(1):519-521.
50. Brown DA, Bay SM, Alfafara JF, Hershelman GP and Rosenthal KD. Detoxification/toxification of cadmium in scorpionfish (Scorpaena guttata): Acute exposure. Aquatic Toxicol. 1984; 5(2): 93-107.
51. Zanders, I.P. and Rojas, W.E. 1996. Salinity effects on cadmium accumulation in various tissues of the tropical fiddler crab Uca rapax. Environmental Poll., 94(3), pp: 293- 299.
52. Emad H. Naga,A., khalid M., El-moselhy and Mohamed A., Hamed.(2005) toxicity of cadmium and copper and their effect on some biochemical parameters of marine fish Mugil seheli . Egy. J. Aqua Res. 31(2): 60-71.
53. Singh Anu, Jain and Kumar Puneet. Determination of LC50 of cadmium chloride in Heteropneustes fossilis. GERF Bulletin of Biosciences, 2010; 1(1): 21-24.
54. Benjamin D and Thatheyus AJ. Acute Toxicity of Nickel and Cadmium to the Cichlid Fish, Oreochromis mossambicus (Peters). Research in Zoology. 2012; 2(4): 19-22.
55. Mani R., Meena B.,Vallivittan K.(2013). Determination of LC50 of cadmium chloride in marine fish Arius arius .Int.J.Cur.pharm.Res.5(4):60-62.
56. Jurgelėnė Ž., Stankevičiūtė M., Kazlauskienė N., Baršienė J., Jokšas K., Markuckas A. Toxicological Potential of Cadmium Impact on Rainbow Trout (*Oncorhynchus mykiss*) in Early Development. *Bull. Environ. Contam. Toxicol.* 2019;103:544–550.
57. Chen J., Chen D., Li J., Liu Y., Gu X., Teng X. (2021)Cadmium-induced Oxidative Stress and Immunosuppression Mediated Mitochondrial Apoptosis via JNK-FoxO3a-PUMA pathway in Common Carp (*Cyprinus carpio* L.) Gills. *Aquat. Toxicol.*233:105775.

58. Amiard J, Amiard-Triquet C, Berthet B, Metayer C (1987). Comparative study of the patterns of bioaccumulation of essential (Cu, Zn) and non-essential (Cd, Pb) trace metals in various estuarine and coastal organisms. J. Exp. Marin. Biol. Ecol. 106:73-89.
59. Barka S, Pavillon JF, Amiard JC (2001). Influence of different essential and non-essential metals on MTLP levels in the Copepod Tigriopus brevicornis Comparative Biochemistry and Physiology Part C: Toxicol. Pharmacol. 128:479-493. Afshan et al RJCES Vol 2 [2] April 2014
60. 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.