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Monica K. Kale

Dept. Of Zoology, J. E. S. College Jalna. Maharashtra.

TOXICITY AND BIOACCUMULATION OF CADMIUM IN THE FISH, RASBORA - DANICONIUS

Abstract:-

Among heavy metals cadmium is of great concern since it is more toxic to aquatic organism such as fishes etc. which are important components of food chain. The toxicity of cadmium to the fish Rasbora- daniconius for 24h was tested according to the OECD (1992) guidelines No. 203. The toxicity 24h (Lc5o) of cadmium chloride (Cdcl2 2 ^ H2O) was found to be 110 ppm for R- daniconius. Bioaccumulation of cadmium in gills, intestine and tail muscles of the fish R- daniconius was analyzed using Pc based AAS. The fishes were exposed to sub lethal concentration (20ppm) of cadmium chloride for 24h, 48h, 72h, and 96h. It was observed that the trend of degree of accumulation of cadmium in different tissues was as follows gills> intestine> muscles. Cadmium appeared to be toxic to fish.

Keywords:

Fish, Cadmium, Toxicity, Ioaccumulation.

INTRODUCTION

The matching revelation of accumulation of heavy metals, organic toxicants, and pesticides in the aquatic biota is causing alarming concern to environmental biologists who are constantly striving for restoration of the environmental quality through formulating rules and norms for release of toxicant to cause least damage to the organisms. The aquatic environment in recent times witnessing an unprecedented impour of various kinds of biocides in alarming quantities and sources of such release are too numerous to be mentioned. Rapid industrialization and consequents discharge of effluents into water system made heavy metals major pollutants of aquatic ecosystems. Heavy metals are important contaminants of liquid discharged from a number of industries such as electroplating, dyes and dye intermediates, textiles, tanneries, oil refineries, pesticides, mining, smelters, etc. The common toxic metals found in industrial effluents are cadmium, chromium, nickel, manganese, mercury, lead, copper and zinc. It used for many purposes, especially for aquaculture industry, irrigation and domestic needs Swarup et.al. (2006). Cadmium is a naturally occurring toxic heavy metal with no known biological function in human and animals and their for considered nonessential (USFDA, 1993. Pinot et.al. 2000). Cadmium is used in electroplating and galvanizing due to its non-corrosive and cumulative nature. It is used as color pigments for paints, plastic and as cathode material for nickel cadmium batteries. (Ahmed et.al. 2002; Khan et. al. 2003; Shukry et.al. 2001; Midrar- Ul-Haq et.al. 2005); Kalaisalvi et.al. 2010).

Industrial effluents including toxic metal compound are major source of water pollution besides sewage, agricultural discharges and other house hold residues Saxsena and Garg, 2010.

Metals exist in variety of state, the toxicity of metals depends on its nature and chemical form whether it in ionic form or in an oxidized reduced state in combination with organic substances and other metals. Shandilyas and Banergee (1989) studies effect of sublethal toxicity of zinc and chromium on peripheral hemagron in the fish, Heteropneustesfossilis. Zyadah and Abdel (2000) studied toxicity and bioaccumulation of copper, zinc and cadmium in some aquatic organism like fishes, mollusk etc.

Cadmium occurs in freshwater at a concentration of less than 0.01 ppb but at much higher levels in polluted waters. Cadmium concentration of less than 10ppb and in aquatic organism are considered safe for human ingestion (US Environmental Protection Agency, 1980)

The biological accumulations of metals by the aquatic organism pose a serious problem to human populations. Minemata disease in Japan due to mercury contamination and Hindigedu syndrome of Karnataka have been attributes to long term consumption of metal and pesticides contaminated fishes and crabs (Rao,1983). Bioaccumulation of metals includes Itai-Itai disease in Japan resulted from cadmium released due to mining activities and introduced into the irrigation water (Yamagata and Shigmatsu 1970). Bioaccumulation is the ability of an organism to concentrate an element or a compound from food and water to level higher than that of its environment (Menjer and Nelson, 1980).

In the present study the toxicity of cadmium chloride to a freshwater fish, Rasbora- danicunius is determined along with bioaccumulation of cadmium in the gills, intestine and muscles. Shindhe VR (2005) reported on Gonadosomatic and hepatosomatic indices of the freshwater fish Notopterusnotopterus (Pallas) in response to some heavy metals exposure. The Toxicity tests for mercuric cholide (HgCl2), cadmium chloride (CdCl2) and their mixture on Notopterusnotopterus was determined by using 96h LC50 concentration on fish N. notopterus which indicated that cadmium chloride (CdCh) was less toxic and mercuric chloride (HgCh) was most highly toxic. The order of toxicity is mercuric chloride> mixture> cadmium chloride.

MATERIALS AND METHODS:

Rasbora - danicunius (Hamilton- Buchanan), an indigenous freshwater fish were collected from freshwater ponds in MIDC area Waluj, Aurangabad and stored in large aquaria containing top water. Care was taken to avoid overcrowding of fishes. Fishes were acclimatized to laboratory for a week prior to toxicity larvae continued aeration was provided for optimum oxygen supply.

TOXICITY DETERMINATION:

The aqueous stock solution of cadmium chloride (Clch. 2 V2 H2O) was used in the toxicity testing with appropriate dilution by tap water. Static bioassay tests were performed according to standardized procedure of spraque (1973) and OECD (1992) guideline No. 203 for the period of 24h. Initially several exploratory tests with random concentration were conducted. Each test tank (10 liter capacity) contained appropriately diluted stock solution. One tank was of control 10 fishes of irrespective of sex and of approximately equal length (7-9cm) and weight (5 to 7g) were selected for testing. The fish was considered dead when there was no movement of gills and no response to gentle probing. The tests were repeated thrice and the mortality was noted for 24h. The data collected were extrapolated statically by means of the probits methods and transforming the toxicity curve (% mortality/ concentration) into regression lines (mortality in probits/ concentration i.e. probit kill/ concentration) according to the method of Finney (1952) which allows the calculation of average lethal concentration(Lc50)

DETERMINATION OF CADMIUM BIOACCUMULATION:

The fishes were exposed to 20ppm sublethal concentration of cadmium chloride for the period of 24h, 48h, 72h and 96h to determine the bioaccumulation of cadmium in different tissues like tail muscles, intestine and gills. Using the procedure as APHA (1985) using Pc- based AAS. Basha PS (2003) reported on cadmium- induced antioxidant defense mechanism in freshwater teleost Oreochromismossambicus (Tilapia). Obodo, G.A., (2003) reported on the bioaccumulation of heavy metals in fish from Anambra river.

Bioaccumulation of some heavy metal effect Abdel Baki. A.S. et. al (2011) Studied in tilapia fish Shukala et.al (2007)

The tissues were dissected out after the end of each exposure period and tissues were dried in oven at 700C for 3 days for detection of cadmium accumulation. The dried tissue was powdered using mortar and pestle and 500mg dried tissue powder was taken in beaker and 10ml of concentrated nitric acid was added. The mixture was shaken well and kept on hot plate to evaporate the solution. After its complete evaporation again added 10ml of nitric acids and 2ml of 5N perchloric acid. Mixed well and kept on hot plate and waited till the solution evaporates and solution becomes colorless. The third time added again 10ml of concentrated nitric acid, mixed the contents wells and kept on hot plate for digestion till 5ml remains in the beaker. It was cooled and made up 25ml with 2M solution of concentrated nitric acid. This 25ml sample solution was used for metal estimation directly following the nitric acid digestion method of APHA (1985) ,andusing the Pc-Based Atomic Absorption Spectrophotometer (AA 1275 BD Varian Techtron, USA) at 228.9mm wavelength. The unit given is ug cadmium/g of tissue. The data was statistically analyzed using student 't' test (Mungikar,1997).

RESULT:

The observed lethal concentration of cadmium chloride for 50% mortality of the fish Rasbora-danicunius for 24h was found to be 110 ppm whereas the statistically calculated nLc50 value with the help of regression analysis was found to the 110.40ppm.

Results presented in table 3 show the bioaccumulation of cadmium in different tissues like gill intestine and tail muscles of the fish, Rasbora- danicunius after exposing to sublethalconcentration(20ppm) of cadmium chloride for 24, 48, 72, and 96 hours. Gills showed maximum accumulation where found intermediate with the values of muscles as compared to controls. The degree of cadmium accumulation was found to be as gills> intestine > muscles. As the time of exposure increased from 24h trough 96h, the bioaccumulation of cadmium also increased concurrently.

DISCUSSION:

The toxicity is defined as harmful effect of a pollutant ion target organism OECD(1992) defined acute toxicities as " the adverse effect occurring within a short time total administration of a single dose of substance or multiple doses given within 24h statistically derived single dose of a substance that can be exposed to cause death in 50%of the animals. The Lc50 in its simplest form is dose of a compound that causes 50% mortality in a population. As per the opinion of the panel of experts of OECD (1992). The statistically calculated value for 50% mortality (Lc50) of the fish Rasbora - danicunius due to cadmium chloride after 24h of exposure was 110.40ppm against observed experimental value of 110ppm which are not significantly different. In this fish the effect of lethal concentration of cadmium chloride prior to death are shown by erratic swimming, difficulty with respiration, loss of balance and convulsions. The mortality of the fish increased with an increase in the concentration of cadmium chloride. The relationship between the observed toxicity value and statistically ascertained value have been varying in the same directions. This implies that there is appositive correlation between experimentally. Observed and statistically calculated values which is desirable as shown in Table 1 and 2. It was observed that the degree of bioaccumulation of cadmium in various tissues of Rasbora- danicunius was as follows: gills> intestine> muscle. Canli et.al (2001) reported on cadmium accumulation in tissues of Sardinavilchardus and found increased levels in gills, liver and pancreas. Shukla et.al.(2001) reported on effect of toxicants on the intestine transport in fishes Channapunctatusand Heteropneustesfossilis exposed to sublethal concentration of cadmium and zinc (1.12 and 4.0 ppm, respectively) showed decrease in the rate of transport of glucose and fructose, which was more marked after 30 days as compared to 15 days in the two fishes. Sinha AK et.al.(2002) reported on Bioaccumulation of heavy metals in different organs of some of the common edible fishes of Kharkai river, Jamshedpur. Gills, liver, kidney, intestine and muscle of the some of the common edible fishes captured from Kharkai river were analyzed for their iron, zinc, nickel, lead, copper, manganese, chromium and cobalt contents.

It appears that Rasbora-danicunius has efficient depuration mechanism perhaps through the process of depuration mechanism perhaps through the process of depuration. Fishes appeared normal just within 48h after returning to the freshwater.

Table No. 1

Calculation of probit regression line for some experiments in which the fish, Rasbora daniconius were exposed to different concentration ofcadmium hloride for 24h.

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
Sr No.	Conc. Of (ppm)	Log of Conc.	No. of Animal Exposed	Mortality for 24hrs	% Mortality p=100 xy/n	Empiricalprobit value	Expectedprobit	Weigh t coefficient	Weight probit	Working y=y0+kp						Improvedexpected probit
		X	n	y	p		Y	w	W=nw	y	Wx	Wy	Wx^2	Wy^2	Wxy	Y^1
1	100	2.0	10	1	10	3.718 4	3.72	0.335 89	3.3589	3.72	6.7178	12.4952	13.4356	46.4821	24.9902	4.139 63
2	105	2.023	10	3	30	4.475 6	4.5	0.580 99	5.8099	4.48	11.7535	26.0284	23.7774	116.608	52.6556	4.590 4
3	110	2.042	10	5	50	5.000 0	5.10	0.634 31	6.3431	5.00	12.953	31.7155	76.4500	158.578	64.765	4.845 2
4	112	2.049	10	6	60	5.253 3	5.30	0.616 09	6.1609	5.25	12.624	32.3448	25.8665	169.8102	66.276	4.708
5	115	2.061	10	7	70	5.524 4	5.40	0.600 50	6.0052	5.52	12.377	33.1948	25.5089	182.4814	68.3210	4.472 8
				Total					**SW=27.678**		**SWx=56.4253**	**SWy=135.7327**	**SWx^2=115.0384**	**SWy^2=674.4597**	**SWxy=274.0078**	

Table No.2

Calculation of Lcso values using probit analysis for the freshwater fish, Rasbora daniconius after exposure to cadmium chloride for 24, 48, 72,and 96h.

Sr. No.	Time of exposure hours	Regression Equation $y^{1=}$(~- bx")+bx	Lc50 values (ppm)	Chisquare (C^2)	Variance	Fudicial limit upto 95% limit confidence	
						M1	M2
1	24	y^1=35.0604+19.60x	110ppm	3.95002	0.00009951	2.01544	2.05456

Table No. 3.

Bioaccumulation of cadmium chloride in different tissues of the fish, Rasbora daniconius exposed to sub lethal concentration (20ppm) cadmium chloride for different periods. (Mean cadmium concentration in the habitat waters: 0.017 ^g/ml ± 0.003)

Tissue		Mean concentration of cadmium (^g/g) ± SEM after --------------------- h			
		24	48	72	96
Gill	Control Experimental	05.2 ± 0.8 20.7 ± 1.3	05.4 ± 0.6 28.8 ± 1.7	0 5 5 ± 0.5 3 9 6 ± 1.4	05.4 ± 0.6 48.8 ± 1.2
Intestine	Control Experimental	04.8 ± 0.7 14.3 ± 1.7	05.1 ± 0.5 21.8 ± 1.2	05.5 ± 0.6 32.4 ± 1.1	05.2 ± 0.8 40.6 ± 10.4
Muscles	Control Experimental	02.0 ± 0.5 06.3 ± 0.7	02.0 ± 0.5 10.5 ± 1.5	02.2 ± 0.8 14.7 ± 1.3	02.3 ± 0.7 19.2 ± 1.8

SEM: Standard Error of Mean.

REFERENCES:

1.Swarup et.al. (2006) Small Ruminant. Res. 63:309-313 Deficiency of copper and cobalt in goals reared around lead zinc smelter

2.USFDA 1993 United States food and drug administration, center for food safety and applied nutrition guidance documents for cadmium in shellfish

3.Pinot F. et al (2000) - Rev Environ Health. 2000 Jul-Sep; 15(3):299-323 Cadmium in the environment, sources, mechanism of biotoxicity, and biomarkers.

4.Ahmed et.al (2002) Asian J. Plant Sci. 1:70-72 Monitoring and wastewater quality of Gadoonamazai industrial estate NWFP Pakistan.

5.Shukry et.al (2001) Pak. J. Biol. Sci, 4:1153-1159 - Effect of Industrial Effluents Polluting the River Nile on Growth, Metabolism and Productivity of Triticumaestivum and Viciafaba Plants.

6.Kumar et.al (2008) Accumulation pattern of cadmium in tissues of Indian catfish clariasbatrachus. Animnut.feed technol. 8:115-119.

7.KalaiselviPet. Al. (2010) Impact of Industrial Effluents in seed invigoration: A review Asian J. Plant Sci. 9:249-255

8.Saxena and Garg (2010) Vitamin E provides protection against in vitro oxidative stress due pesticides (Chlorpyrifos and Endosulfan) in goat RBC.. GERF Bull. Bio. Sci, 1(1): 1-6

9.Shandilya, S.; Banerjee, V. (1989) Effect of Sublethal toxicity zinc and chromium on peripheral hemogram in the fish, Heteropneustesfossilis J. Env. Eco. 7(I):16-23

10.Zyadah and Abdel (2000) Toxicity and bioaccumulation of copper zinc and cadmium in some aquateic organism. Bull. Environ, contamToxicol. 64:740-747

11.Meyer and Nelson (1980) 7thedn. McMillan New York 123-147

12.Shinde V R (2004) Gonadosomatic and hepatosomatic indices of the freshwater fish Notopterusnotopterus (Pallas) in response to some heavy metal exposure. . J. Environ Bio.

13.Finney (1952) Probit analysis Cambridge University Press, London pp.33-3

14.Mungikar A M (1997) SaraswatiPubli. Aurangabad

15.Basha P S (2003) Cadmium induced antioxidant defense mechanism in freshwater teleost achromous mossambicus (tilapia) Ecotoxicol. Environ. Saf 2003 oct. 56(2) 218-21

16.Canli et.al. (2001) Bull Environ ContamToxical 65:580-586

17.Shukla et al. (2001) effect of toxicants on the intestine transport in fishes Himalayan J. Env. Zoo 15(2)(2001) 129-136, (26 Ref)
18.Sinha A K et al. (2002) Bioaccumulation of heavy metals in different organs of some of the common edible fishes of kharkai river Jamshedpur, Indian J. Environ Health 44(2) (2002), 102-107 (13 Ref)
19.APHA (1985) (16thEdn), Washington DC
20.Yamagata. N. and I. Shigematsu. (1970) Cadmium pollution in perspective. Bull. Inst. Public Health 19: 1-27
21.WHO 1984 Guidelines for drinking water quality, WHO, Geneva, Noll
22.WHO, 1992 Environmental Health criteria No. 134 Environmental aspect Geneva WHO
23.AS Abdel-Baki, MA Dkhil, S Al-Quraishy (2011) Bioaccumulation of some heavy metals in tilapia fish relevant to their concentration in water and sediment of WadiHanifah, Saudi Arabia. Abr. J. Biotechnol, 10: 2541-2547