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Cadmium Toxicity and Its Impact on Metabolic Activities in Fishes

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ABSTRACT: *Fishes are sensitive indicator of body burden of Cd^{2+} Many Patho-physiological actions of Cd^{2+} are related to the interaction of the Cd^{2+} with body stores of essential elements. Fish species were collected from fresh water and the water, from heavily polluted areas, in the year 2002, 2003 and year 2004 (April). Gill, Kidney, liver and visceral organs were air dried and preserved for analysis. The present study has found the statistically significant (P<0.0001) higher concentration of serum creatinine, Na^+ Blood glucose and melanoaldehyde. The higher deposition of cadmium were found in the kidney and liver of polluted water fishes whereas the concentration of K^+ were found similar in the polluted and unpolluted water fishes.*

KEY WORDS: *Cadmium, enzyme, deposition, pollution, blood glucose.*

I. INTRODUCTION

Heavy industrialization and increasing population have increased coal utilization in the Bilaspur district. The toxic metals are disposed into the river by iron and ore industries in this area. The Sirgitti and Tifra in Bilaspur districts are major producers of fly ash in Chhattisgarh which is mortally disposed into Arpa River. Arpa is a shallow river, contain $Pb^{2+}$and Cd^{2+} species Cadmium occurs in nature in association with Zn minerals [1]. The major portion of Cd ingested into our body is trapped in the Kidneys and eliminated. A small fraction bound most effectively by body protein as metallothionein, present in the kidneys, while the rest is stored in the body and it gradually accumulates with age [2]. When excessive amount of Cd^{2+} is injected, it replaces Zn^{2+} at key enzymatic sites, causing metabolic disorders [3]. Fishes are sensitive indicator of body burden of Cd^{2+} Many Patho-physiological actions of Cd^{2+} are related to the interaction of Cd^{2+} with body stores of essential elements especially, Zn^{2+} and Ca^{+}. Intra Cellular pool of Cd^{2+} supports the contractile response to a significant degree [4]. With a view of increasing industrialisation and release of toxic substances to the river, rivulet and tanks, in the present work, study of the changes in the concentration of Cd in the various body organs of fish species C. fasciatus, A testudiners and M. vitatus has been undertaken. The change from fresh water species to that in the polluted water has been found to be spectacular.These species are sensitive indicators of body burden of Cd.

II. MATERIALS AND METHODS

Methods of sampling and preservation: Fish species were collected from fresh water and the water, from heavily polluted areas, in the year 2002, 2003 and year 2004 (April). Gill, Kidney, liver and visceral organs were air dried and preserved for analysis. 1 gm. of the sample was put into kjeldahl flask, digested. - 12: h 12 mL of cone. $HN0_3$ and 5 ml of cone. $HClO_4$ and analyzed for Cd using atomic absorption spectroscopy.

Spectrophotometer Determination of Glucose and criatinine in Blood: glucose was estimated in the fishes by ortho- toludine method. Blood sample was heated at 100°C in ortho-toludine and glacial acetic acid. It forms bluish green derivative [5].

Estimation of lipid per oxidation: Lipid per oxidation in liver was recorded by estimating melanodialdehyde by thiobarbituric acid method [6].

Statistical analysis: The obtained data were used as statistical raw data which was compared with one another to examine the statistically significant difference by ANOVA.

III. RESULTS

The results of effect of cadmium on the serum concentration of creatinine, sodium, potassium is presented in the Table-1. The present study has found the statistically significant (P<0.0001) higher concentration of serum creatinine in fishes living in polluted water. Serum sodium was also found statistically significant in the polluted fishes as compare than unpolluted water. The serum potassium concentration in the fishes was found similar in polluted and unpolluted fishes. The concentration of cadmium was found

significantly higher in polluted water fishes than unpolluted water fishes. The deposition of cadmium in kidney was found significant in polluted water fishes than unpolluted water fishes.

Table-1Comparative Accounts of Creatinine, Na^+, K^+, Cd^{2+} in blood and Kidney Cd^{2+}

S. No.	In fresh water fish			In polluted water			ANOVA
	A	B	C	A	B	C	
1. Serum creatinine (mg/dL)	0.56	0.55	0.54	0.60	0.68	0.67	P<0.0001
2. Serum Na^+(M.eq/L)	60	59	57	69	65	66	P<0.0001
3. Serum K^+. Meq/L	3.0	2.5	2.8	3.0	2.8	2.6	P = 0.823
4. Blood Cd^{2+} mg/dL	4.0	4.5	4.8	5.5	2.8	2.6	P<0.0001
5. Kidney Cd^{2+} mg/g dry wt.	6.0	6.1	6.2	8.0	8.5	8.2	P<0.0001

The blood glucose level, melanoaldehyde and cadmium deposited in liver of polluted water fishes and unpolluted water fishes were analyzed and the results are presented in the Table-2. The blood glucose was fond higher in the polluted water fishes and the results of t-test were found significant. The concentration of melanoaldehyde was found double in the polluted water fishes as compare to unpolluted water. The deposition of cadmium in the liver was found higher in the polluted water fishes.

Table-2 The difference in the blood glucose, Melanoaldehyde and liver deposited cadmium in polluted and unpolluted fishes.

S.No.	Fresh water fish	Polluted water fish	t-test
1. Blood glucose mg/dL	45.0	65.0	P<0.0001
2. Melanoaldehyde (ng/dL)	0.05	0.10	P<0.0001
3. Cd^{2+} in liver(mg/g) dry weight	0.03	1.05	P<0.0001

IV. DISCUSSION

In these three cases, C. fasciatus, A testudiners and M. vitatus showed a great deal of tolerance for the increased exposure to pollution. However, M. Vitatus required oxygen to survive and was more susceptible to pollution as compared to the other two counter parts. This is also confirmed by higher values of serum creatinine (mg/dL) in the M. vitatus living in the polluted areas, It is universally accepted that technological development and rapid urbanization resulted in considerable adverse effects on the environment. Considering the Pollution effect of different cations, Cd^{2+} is the most toxic element to fresh water biota, animals and humans in the environment [4]. Many harmful effects of Cd^{2+} on man and animals have been reported by several workers [6]. Since Cd^{2+} is excreted primarily through kidney, it exerts the most toxic effects on renal function and causes nephrotoxicity in fishes and animals [4]. which result in higher value of blood pressure and blood glucose. In the present study Cd^{2+} toxicity causes change in blood pressure and increase in blood sugar [7]. This is due to inefficient utilization of blood sugar. Increased concentration of blood sugar damages delicate organs of kidney (nephrotoxicity). Many harmful effects of Cd^{2+} on man and animals have been reported by several workers. Accordingly Glucose - 6 P.D. is retarded in the Cd^{2+} affected fishes. Cd^{2+} is mainly located in RBC of fishes and animals [8].Even in cyclostomes, pancreas is a separate organ derived from the billiary duct. The ilset represents an aggregation of the small lobules surrounded by connective tissues. The cells are well defined in lampreys and they form follicles of langerhans enclosing a cavity probably serving as storage site for the insulin. According to Winbladh, about 33% of the endocrine cells in the pancreas of Petromyzon fluviatilis are like cells of myxme [2,7,8,]. Like other vertebrates,

A,B,C and D cells have been reported in certain species of cytostomes and fishes. Insulin have two polypeptide chains (A and B) linked with two disulphide bridges. Presence of Zn^{2+} in the islet is responsible for the storage and release of insulins. Insulin has hypoglycaemication [8,9].The role of Zn^{2+}, played in the release of insulin is seriously impaired by Cd^{2+}, as it replaces Zn^{2+} from the Zn containing enzymes and ultimately blood sugar level is raised in the fishes of polluted area. These data suggest that downstream river suffer high degree of pollution and Cd^{2+} concentration has considerably increased in the river, Nullah and tank. These fish are notable for sustaining adverse situation of survival. But Cd^{2+} causes toxicity due to its power to replace Zn^{2+} from many enzymatic sites in the body. The ability of Cd^{2+} to react with many organic compounds of biological importance leads to the speculation on the mechanism of its toxic effects. The general chemistry of Cd suggests several characteristics for analyzing the interactions of the element with biological macromolecules.

V. CONCLUSION

Cd^{2+} has a high affinity for sulphur. Some toxic effects of Cd are due to its reaction with essential sulphydryl groups in enzymes. The study found that Cd^{2+} and Zn^{2+} are associated with certain purine and pyrimidine bases. Cd^{2+} binds to DNA in appreciable amount and causes strand breakages in DNA. Cd^{2+} is found to alter - RNA_{Tyr} and$t\text{-}RNA_{Leu}$ [(11)]

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