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Review Paper

A REVIEW ON THE EFFECTS OF HEAVY METALS ON THE AQUATIC ANIMAL OF THREE DIFFERENT DISTRICTS OF WEST BENGAL

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Abstract

Heavy metals naturally exist in very little amount in watery places. Ecological condition of a water body is highly influenced by the sediment properties of the concerned water body. Industrial wastes in aquiculture cause toxic effects in aquatic organisms specially in fishes. Aquatic organisms absorb the pollutants directly from water and indirectly from food chains. Some of the toxic effects of heavy metals on fishes and aquatic invertebrates are; reduction of the developmental growth, increase of developmental anomalies, reduction of fishes survival- especially at the beginning of exogenous feeding or even cause extinction of entire fishes population in polluted reservoirs. These consequences can affect on geological, hydrological and finally on biological cycles. This study was based on the impact of various industrial effluent and their effect from different industrial-discharge of West Midnapur, East Midnapur and Burdwan District of West Bengal. The effect of heavy metals observed on the biodiversity specially on to the aquatic animals. In this review, the effects of accumulation of heavy metals (Cu, Cd, Pb, Hg and Zn) were evaluated in the benthic animals of different contaminated aquatic body. Thus it seems that more concern of bioconservation protocols are so important.

Key words: *Industrial effluent, Heavy metals, Macro-benthic invertebrates, Shrimp muscle and Chironomid larvae*.

INTRODUCTION

Water is one of the most valuable natural resources. The quality of water is of vital concern for the mankind since it is directly link with human welfare. Some of the Heavy metals act as essential micronutrients for organisms including aquatic animals. Aquatic organisms have ability to accumulate heavy metals from various sources including sediments, soil erosion and runoff, air depositions of dust and aerosol, and discharge of waste water [1]. Ground levels of heavy metal in the environment have been increased, especially at the industrial and agricultural fields, as well as mining activities [2]. Although some heavy metals have important physiological role, beyond certain threshold levels they can be very toxic to humans and other organisms including aquatic and can result in various illnesses and eventually death [3]. The accumulation of pollutant along the food chain can be responsible for adverse effects and ultimately death of organisms [4].

Heavy metal contamination may have severe effects on the ecological balance of environment and a diversity of aquatic organisms. Among aquatic species, fish and shellfish are so susceptible in their inhabitants that cannot escape from the deleterious effects of these pollutants [5].

These aquatic species can be used to determine the health of aquatic ecosystems with respect to chemical pollution. Pollutants accumulate in the tissues of aquatic organisms along the food chain and can be responsible for adverse effects and ultimately death of organisms [4]. Recently, world consumption of fish has increased simultaneously because of their growing concern of their nutritional and therapeutic benefits. The American Heart Association recommended eating fish at least twice per week in order to reach the daily intake of omega-3 fatty acids [6]. Fish are situated at the top of the aquatic food chain; therefore, they may accumulate heavy metals from food, water and sediments directly. Many international programmes have been established to assess the quality of fish for human consumption and to monitor the health of the aquatic ecosystem [7]. Concentrations of heavy metals in fish have been extensively studied in different parts of the world from the last few decades [8]. Alarming level of lead (Pb) and arsenic (As) has been found in the sediments as well as waters of Damodar, Ganga, Haldi rivers in West Bengal.

Effects of Heavy Metals at West Midnapur District

A study on the impact of industrial effluent discharge on the biodiversity of benthic macro-invertebrates and water quality of a fresh water pond was carried out, at Paschim Medinipur, near Tata Metallic (a metal refinery) by Chakravorty et al. [9]. Different aquatic bodies of surrounding area of the industry contain high heavy metal (lead, cadmium, cyanide and mercury) load, the concentration of metals of different seasons is given at table 1. The seasonal diversity of aquatic organisms is given at table 2.

Table 1: **Variation of toxic substances in pond**

Toxic substances	Summer Season	Rainy Season	Autumn Season	Winter Season	Spring Season
Mercury (mg/l)	0.001	<0.001	<0.001	<0.001	0.003
Lead (mg/l)	0.53	0.92	0.007	0.28	0.08
Cadmium (mg/l)	0.03	0.01	<0.01	<0.01	<0.01
Cyanide (mg/l)	0.13	0.14	0.15	0.24	0.08

Table 2 : Diversity of Benthic macro-invertebrates at study sites [9].

Diversity Indices	Summer Season Pond	Rainy Season Pond	Autumn Season Pond	Winter Season Pond	Spring Season Pond
No of Species	26	30	25	16	35
No of Individuals	81	230	104	303	326
Simpson's Index Of Diversity	0.941	0.864	0.939	0.796	0.894
Shannon Wiener Index (log)	4.212	3.659	4.182	2.756	3.954
Evenness Index	0.896	0.746	0.901	0.689	0.771

Anthropogenic influences can be evaluate by the changes of assemblages and distribution of benthic macro invertebrates due to pollution stress [10]. In the polluted pond (situated at Gokulpur near a metal refinery ,Tata Metalics) lot of species like *Baetis* (Ephemeroptera), *Micronecta, Nyschia* (Hemiptera), *Hydrovatus, Hydroglyphus, Amphiops, Globaria, Enochrus,*

Paracymus, Hydrochus (Coleoptera)*, Pseudagrion, Ischnura* (Odonata)*, Bezzia, Mochlonyx* (Diptera)*, Gabbia, Melanoides, Terebia, Indoplanorbis, Lymnaea* (Molluscs)*, Tubifex* (Annelids)*, Macrobrachium, Pseudocandona, Lynceus* (Crustacea)*, Hydrachna* (Arachnids) were absent and species like *Chironomous, Culex, Chrysogaster, Diplonchus* etc was dominated.
Chironomids are known as tolerant species are also sensitive to suspended solid [11]. So, in the polluted pond reduced benthic macro-invertebrates even chironomid larvae found in rainy and autumn season may be due to high concentration of suspended solid.Polluted Pond has very hard water which highly negatively affect the species richness and species diversity in that pond. Higher phosphorus level at the pond causes eutrophication and death of aquatic macro invertebrates due to lower level of DO. The cadmium concentration was higher than limit value 0.00066-0.002 mg/l but due to higher hardness its toxicity and bioavilability may be much lower in the polluted pond.

Effects of Heavy Metals at East Midnapur District
The River Ganga is located at the apex of Bay of Bengal. The Gangetic delta lobe is unique for its wilderness, mangrove gene pool and tiger habitat. Severe industrial activities from of Haldia port-cum-industrial complex(HPCL,HDOC) in the downstream region of the River Ganga (also known as the Hooghly River) has accelerated the pollution leading to serious impacts on biota . The organic and inorganic wastes released from industries and urban units contain substantial concentrations of heavy metals. The central part of the delta , surroundings of Matla River is relatively less stressful in terms of industrial discharge Mitra et al. [12] have highlighted the level of selective heavy metals (Zn, Cu, Pb and Cd) in the muscle of five commercially important species of shrimp collected from the aquatic subsystem of four stations **–**

1)Nayachar I sland(Stn. 1) Coordination- 88 15' 24" E .21 45 ' 24" N
2) Sagar South (Stn.2) Coordination 88° 01′ 47" E .21° 39′ 04" N
3)Gosaba (Stn. 3) Coordination 88° 39′ 46" E 22° 15′ 45" N
4) Annpur in Satjelia Island (Stn. 4) Coordination 88° 50′ 43" E 22° 11′ 52"

Five species of shrimps, namely *Penaeus monodon, Penaeus indicus, Penaeus semisulcatus, Penaeus marguensis* and *Metapenaeus brevicornis* were collected during high tide condition from the selected stations . From the Analysis of variance (ANOVA) data it was found that heavy metal concentrations varied significantly between sites and species.
The concentrations of Zn were within the permissible level values ranged from 4.11 to 353.45 ppm/dry wt.
In case of Cu concentrations significant differences were observed between the stations and also between the species. Copper level in shrimps ranged from 3.67 to 140.49 ppm/dry wt. The main sources of Zn in the present geographical location are the galvanization units, paint manufacturing units and pharmaceutical processes situated at Haldia.
Pb concentration ranged from 2.01 to 8.21 ppm/dry wt in the muscles of shrimp.
Concentration of Cd ranged from 1.09 to 3.66 ppm/dry wt. Cadmium levels in all the shrimp species from all station in the *Penaeus semisulcatus* was much above the normal range (0.02 μg/g). The values were also higher than the WHO (1989) recommended value for prawn consumption which is 1 ppm.
In this study heavy metals accumulated in the shrimp muscle in the order Zn > Cu > Pb > Cd.

Effects of Heavy Metals at Burdwan District:
The River Damodar originates in the Khamarpat bill and runs about 541 km to meet the River Hooghly. The Damodar is principally a rain fed river and was proverbially known as river of sorrow, particularly in its lower reaches. The Damodor river is the main source of water to the industries that produce 310 million tons of coal, 80 million tons of steel and 2,000 MW of thermal and hydro power , which together contribute substantially to the country's economy (Table 3) .

There are altogether 131 major industrial establishments excluding the coal mines along the river course which can be broadly classified as :

a) Coal mines
b) Coal washery, coal handling plant and coke oven plant
c) Thermal power station
d) Steel plant
e) Fertilizer, cement and chemical industry

Table 3: Quantum and Nature of Effluent Expelled Into the Damodar by Some Major Industries (CIFRI 1998).

INDUSTRY	Quantum Of Effluent Mm3/d	Quantum Of Main Effluents(Tones/Day)						
		TSS	TDS	Phenol	Ammonia	Oil & Grease	COD	Heavy Metal
THERMAL PLANT	Fly ash 10,000 TPD	3000	900	...	...	1,358	39.5	Fe, Cu, Zn, Cd 0.04-0.28
LIVE COAL MINE	0.2-0.3	..	...	...	...	...	16-20	0.05-0.60
COAL WASHERY	0.10	4.0-12.0	4.0-7.0	0.8-1.2	...	0.001-0.002	4.8-6.4	Fe, Cu, Zn, Cd, Cr 0.01-0.20
STEEL PLANT	0.16	200-300	..	13.0-15.0	5.0-7.0	2.0-3.0	80-100	Fe, Cu, Cr, Zn 0.02-0.19
SINDRY FERTILIZER & ACC	0.002	31.5	11.2	..	4.2	...	40-65	Fe, Zn 0.01-0.08
ASANSOL INDUSTRIAL COMPLEX	0.007	1.4	1.4	0.2	1.8	0.5	2.8	Fe, Cu
DURGAPUR INDUSTRIAL COMPLEX (Through Singram Nullah)	0.08	10.5	1.4	0.2	2.6	0.6	3.2	Fe, Cu, Zn etc 0.08-0.40
(Through Tamla Nullah)	0.12	49.3	18.3	1.6	2.3	1.2	41.6	-do-
DOMESTIC EFFLUENT	0.08	...	(47.495 TPD of BOD)					

The total toxic load that the coal mines water contributes to the river has been computed to be 16-20 tons/day COD and 0.05-0.60 tons per day of heavy metals. The average composition of heavy metals (mg/l) in mine water as registered were : Cu-0.23 to 0.72,Mn-0.25 to l.12,Fe-0.38

to 1.16,Ni-0.10 to 0.23,Zn-6.30 to 7.41,Co-O.08 to 0.12.Pb-0.97 to 1.19,Cd-0.41 to 0.56 and Cr-0.16 to 0.19.

Biotic Communities

1)Plankton

Fast flowing ecosystem with innumerable inlets often results failure in qualitative and quantitative study of Planktons as pollution indicator.

2)Benthos

Benthic organisms which are integral part of the bio communities and a vital component of the food chain are highly sensitive to the ecological changes.

Damodar river bed is unsuitable for proper growth and multiplication of benthic flora and fauna because of oil mixed fly ash.

The predominance of oligochaetes and chironomids have been observed over the river bed up to Durgapur (Table 4).

Table 4 : Distribution of benthic fauna in Damodar River (CIFRI 1998).

Zone	Dernsity(No/m3)	Important Forms
Rajarappa	25 (10-40)	Oligochaete **worms**
Bokaro	311 (NIL-3540)	Oligochaete worms Thiaras p. Pleuroeera sp. Chuonomid worn Fly nymphs
Durgapur	160 (30-603)	Oligochaete worms Thiara sp Pleurocera sp**.** Chironomid worms Fly nymphs Mosquito larvae
Burdwan	90-100	Gastropod shells

3)Fish and Fishery

Typical physiography of Damodar river has made it less important for potential fishery resource. Fishery resources of the river were investigated by CIFRI. Total 89 species of fish of 20 families were recorded and 25 species were considered to be of commercial importance (Table 5). Through clinical examination it was found that the normal growth and multiplication of the Indian major *carp* and *prawn* under the existing ecological status of the river and the reservoir are badly affected due to impact of these pollutants . According to a fish diversity report of 1957, already 33 species of fish have been found to be endangered out of which 9 are commercially important [13].

Table 5: List of Commercially Important Fish species From Damodar (1995-2005).

Commercially Important species	Upper (Tori Above Panchyet)	Middle (Disergarh-Durgapur)	Lower (Durgspur-Burdwan)
1. *Barilius bola*	+	+	+
2. *Puntius sarana*	+	+	+
3. *Catla catla*	-	-	+
4. *Cirrrhine mrigala*	-	+	+
5. *C. reba*	-	+	+
6. *Labeo rohita*	-	-	+
7. *L. calbasu*	+	+	+
8. *L. boga*	+	+	-
9. *L. boggul*	+	+	-
10. *L.* dyocheilus	-	+	-
11.*Ompak bimaculatus*	+	+	-
12. *Wallago attu*	-	+	+
13.*Mystus seenghala*	+	+	-
14. *M. aor*	+	-	+
I5. *R. rita*	-	+	+
16. *B. bagarius*	-	-	+
17. *Clupisoma garua*	+	+	+
18. *Labeo bata*	-	+	+

In situ Bioassay

To understand the impact of toxicants present in water in situ bio assay experiment was conducted in the four zones namely- Rajarappa, Bokaro, Durgapur and Burdwan.

Table :6 In situ fish toxicity-bioassay in river Damodar

Zone	LT50(hrs)	
	Observed	Extrpolated
Rajarappa	65-72	69
Bokaro	38-50	48
Durgapur	42-48	44
Burdwan	66-78	70

It is evident from the above (Table 6) that the exposure sites at Bokaro and Durgapur were more toxic to the test animals. The external examination of test fishes reveals that at Rajarappa and Bokaro exposure sites the test fishes suffered to respiratory stress due to the deposition of coal dust particles and fine silt on the gills. While at Durgapur and at Burdwan the external examination lacks coal dust deposition on the fish gills.

The microscopic studies of the fish gills showed various deformities at cellular levels. The damages mainly were noticed to occur in the primary and secondary lamellar structures. Erosion of epithelium was at various degrees and recorded at the highest level at Bokaro.

A study on Damodor river was based on the effect of heavy metals (Pb, Zn, Cu, Hg and Cd) on the composition of chironomid community and the incidence of larval deformities. The live Chironomid larvae were reared in laboratory. The larvae, pupae and the adults of both sexes were processed and mounted on micro slides [14]. Life cycle of Chironomid were identified according to Bhattacharya et al. [15]. From the sampling data of different stations which were designated as-

1. IISCo (Indian Iron and Steel Co.) Discharge Point (IDP) (23°41'N; 86°59'E);
2. Nunia Discharge Point (NDP) (23°52'N; 87°52'E);

3. Tainla Discharge Point,(TDP) (23°3YN; 87°.20'E); and
4. Sadarghat Reference Point (SRP) (23°26'N; 87°54'E).

Four sampling stations were considered because the industrial pollutants were discharged through three points during their passage through the industrial areas of Asansol-Durgapur. Further each substation were subdivided into 3 collection sites, i.e. site 1, site 2, site 3 except SRP which was free from heavy metal pollutants.

Table 7: Characteristics of the investigated sites during 1995-2005. IDP: IISCo discharge point ;TDP: Tamla discharge point;SRP: Sadarghat reference point [15].

Data	IDIP1	IDP2	IDP3	NDP1	NDP2	NDP3	TDP1	TDP2	TDP3	SRP
Water current(cm/s)	55.3	47.9	53.4	8.6	60.1	61.3	57.3	62.3	59.2	56.4
Water temp(c)	24.7	25.2	23.6	7.3	23.7	22.8	23.8	23.5	24.2	23.2
Water pH	7.3	7.4	7.5	6.9	7.5	7.3	7.4	7.7	7.5	6.9
Dissolved oxygen(mg/L)	7.3	7.5	7.4	6.6	7.6	7.4	7.7	7.9	8.1	7.6
Biological oxygen demand	5.0	4.0	4.4	5.8	4.0	3.9	4.5	4.0	4.0	4.1
Clay(%)	5.3	5.9	5.5	7.6	5.9	5.4	5.5	5.8	5.7	5.1
Sand	87.8	91.1	90.6	14.0	90.1	87.2	88.2	90.5	90.5	92.2
Silt(%)	6.9	3.5	4.2	11.1	3.8	3.5	5.8	3.9	3.8	2.8

Percentage of deformity was calculated with the following formula:

$$\% \text{ def.} = \frac{\text{Number of deformed larvae}}{\text{Total number of larvae examined}} \times 100$$

Deformity percentage was calculated for both the whole community as well as for individual subfamilies and in the most frequent species; then it was correlated with the environmental variables.

The occurrence of deformities in Chironominae and Tanypodinae was higher in the polluted sites than in the reference station. Maximum deformities were found in the larvae of TDP *2* followed by IDP 2 and NDP 2 and the minimum ones in up and downstream sections of the discharge point.

Deformities varies significantly from taxa to taxa. The taxa C. *circumdatus* and *C. samoensis* manifested comparatively more severe deformities in the point of pollution release than below its source. However, C. *striatipennis, S.polystictus* and *Procladius noctivagus* of the downstream section did not differ from each other in respect of deformity.

Individual subfamilies may be arranged according to the occurrence of deformities as Chironominae>Tanpodinae>Tanytarsini>Orthocladiinae. Differences in deformation between the member of subfamilies were significant (ANOVA, LSD, $P<0.05$).the taxa were arranged according to the frequency of deformities in two homogenous groups (ANOVA, LSD, $P<0.05$): Group one (*C. Saighestmoensis, C. Circumdatus and S. Polystictus)* with highest deformities and group two *(C. gloveri)* with lesser deformations [15] .

The number of taxa and their diversity decreased with an increase in the load of heavy metals. All these parameters correlated positively with the number of taxa, diversity, equitability and water current and negatively with the percentage of deformities. The taxa *Chironomus circumdatus, C. samoensis, C. judicius,* and *Stictochironomus polystictus*

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dominated in both the polluted and the reference sites. The chironomids *Stictochironomus obscurus; Clinotanypus fuseosignatus;* and *Microchironomus* sp. of the reference station were absent in the polluted sites.The number of taxa was reduced with an increase in the content of heavy metals, pH, and clay and with a decrease in water current. Clay content probably affected the chironomid community either directly or indirectly due to the accumulation of heavy metals in the sediment [15].

CONCLUSION

Due to rapid industrialization and urbanization a negative impact has been affected on the positive health of the aquatic system. The contamination of water is also transmitted in the biological compartment, many of which are consumed as food by the local people. The present study is important not only from the aquatic animal health status point of view, but it also presents a comparative account of heavy metals. Regulatory standards for emission and discharges from process plants should be strictly. Recycling/reprocessing of wastes containing heavy metals needs to be given greater emphasis not only from environmental and health considerations but also as a resource conservation measure. Monitoring of air, water and soil in the vicinity of the toxic metal processing units needs to be carried out more vigorously for the specific metal. Further study on accumulation of organochlorines pesticides, PCBs, PAHs, and dioxins in fish tissues should be undertaken due to usage of these chemicals in West Bengal as well as in India.

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REFERENCES:

[1] 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.

[2] Langston, W.J., 1990. Toxic effects of metals and the incidence of marine ecosystem, In: heavy metals in the Marine Environment (eds plmess RW, Rainbow PS),. CAC press, New York, 256 pp.

[3] Debelius, B., Forja, J. M., DelValls, A., and Lubian, L. M., 2009. Toxicity and bioaccumulation of copper and lead in five marine microalgae. Ecotoxicology and environmental safety 72 (5), 1503-13. doi: 10.1016/j.ecoenv.2009.04.006.

[4] Farkas, A., Salanki, J., and Specziar, A., 2002. Relation between growth and the heavy metal concentration in organs of bream Abramis brama L. populating Lake Balaton. *Archives of Environmental Contamination and Toxicology* 43 (2), 236-24.

[5] Olaifa, F. G., Olaifa, A. K., and Onwude, T. E., 2004. Lethal and sublethal effects of copper to the African Cat fish (Clarias gariepnus). African Journal of Biomedical Research 7, 65-70.

[6] Kris, E. P.; Harris, W., and Appel, L., 2002. Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Circulation ;106:2747-57.

[7] Meche, A., Martins, M.C., Lofrano, BESN, Hardaway, C.J., Merchant, M., and Verdade, L., 2010. Determination of heavy metals by inductively coupled plasma-optical emission spectrometry in fish from the Piracicaba River in Southern Brazil. Microchem J ;94:171-174.

[8] Elnabris, K.J., Muzyed, S.K., and El-Ashgar, N.M., 2013. Heavy metal concentrations in some commercially important fishes and their contribution to heavy metals exposure in Palestinian people of Gaza Strip (Palestine). J Assoc Arab Univ Basic Appl Sci;13:44-51.

[9] Chakravorty, P., Sinha, M., and Chakraborty, S.K., 2013. Impact of industrial effluent on water quality and benthic macro invertebrate diversity in fresh waterponds in Midnapore

district of west Bengal, India published on Journal Of Entomology and Zoology Studies;2(3):93-101.

[10] Saha, N.,Ditya, G.A., Bal, A., and Saha, G.K., 2007. Comparative study of functional response of common hemiptran bugs of east Calcutta wetlands, India. International Review of Hydrobiology; 92:242-257.

[11] Moran, R. (1998). Cyanide uncertainities, observations on the chemistry, toxicity and analysis of cyanide in mining related water In: S. Brackett (Ed.) Protecting communities and theenvironment, 1-13.

[12] Mitra, A., Banerjee, K., Ghosh, R., and Ray, S.K.,2010. Bioaccumulation Pattern of Heavy Metals in the Shrimps of the lower stretch of the River Ganga. Mesopot. J. Mar. Sci., 2010, 25 (2): 110 – 123.

[13] CICFRI, 1998 .The River Damodar and its Environment.Page,1-46.

[14] Wirth, W.W., and Marston, N., 1968. A method for mounting small insects on microscopic slides in Canada balsam. Amer. Ent. Soc. 61, 783-784.

[15] Bhattacharya, G., Mazumdar, A., and Chaudhuri, P.K., 1999. Incidence of deformed Chironomous Larvae in Contaminated sediment of the river Damodar, West Bengal (Diptera: Chironomidae). Poll. Res., 18, 79-82,

[16] Sokal, R.R., and Rohlf, F.J.,1995. Biometry. Third Edition. New York, W.H. Freeman and Company, 202 pp**.**