IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

Bio Accumulation of Heavy Metals In Relation To Three Freshwater Bivalve Species From Nandur-Madhmeshwar Reservoir, Nasik District (M.S.)

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ABSTRACT-
Advancement in human lifestyle due to science and technology causes contamination of environment. Heavy metals are one of such pollutants that may come from both natural and human activity and could be a serious problem/threat because of their toxicity, long persistence, and bioaccumulation and bio magnification of metals in the food chain. This is a study of determination the level of heavy metals Zn, Cu, Pb and Cd in surface water, soil sediments and whole soft body tissues of bivalve species Lamellidens corrianus, Lamellidens marginalis, and Parreysia cylindrica inhabiting in Nandur-Madhmeshwar reservoir of Nashik district during summer, monsoon and winter seasons. The bioaccumulation results revealed that mean values of concentrations of heavy metals in whole body tissues, metal body burden and BWAF and BSAF in dry soft body tissues of three bivalve species Lamellidens corrianus, Lamellidens marginalis, and Parreysia cylindrical collected from Nandur-Madhmeshwar reservoir of Nashik district.
This result indicates that Lamellidens marginalis have greater potential for copper bioaccumulation, and Lamellidens corrianus for lead bioaccumulation, while Parreysia cylindrica have greater potential for cadmium and zinc bioaccumulation. Therefore, Lamellidens marginalis is proposed as sentinel animal for monitoring for copper, Lamellidens corrianus for lead while Parreysia cylindrica for cadmium and zinc in the studied fresh water reservoir.
Keywords: Nandur-Madhmeshwar reservoir, bivalve species, Heavy metals, bio-accumulation, pollution.

INTRODUCTION-

Heavy metals pollution has become a major concern worldwide due to their toxicity, intrinsic persistence, non-biodegradable nature, and accumulative behaviors [Islam MS, Hossain MB, Matin A, Sarker MSI, 2018]. These metals differ from other toxic materials as they are inert in the environment and are often considered to be conservative pollutants if left undisturbed [Wilcock D., Nath B, Hens L, Compton P, Devuyst D. 1999]. However, the rapid industrialization, urbanization, population growth, agricultural and other human activities have resulted in severe pollution by heavy metals globally, especially in developing countries [Hossain MB, Ahmed ASS, Sarker MSI, 2018]. Heavy metals are of high ecological significance since they are not removed from water as a result of self-purification, but accumulate in reservoirs and enter the food chain [Loska K, Wiechuła D (2003)]. The elevation of metal levels in a reservoir is shown mainly by an increase of their concentrations in the bottom sediment. Accordingly, sediments represent one of the ultimate sinks for heavy metals discharged into the environment [Bryan GW, Langston W J (1992), Gibbs RJ (1973)]

Natural and Anthropogenic Sources of Heavy Metals

Table. Potential industrial and agricultural sources for metals in the environment

Sr.No.	Metal	Sources
1	Zn (Zinc)	Batteries and electrical; pigments and paints; alloys and solders; pesticides; glass; fertilizers; refiners; fuel.
2	Cu (Copper)	Batteries and electrical; pigments and paints; alloys and solid; fuel; catalysts; fertilizers; pesticides
3	Pb (Lead)	Batteries and electrical; pigments and paints; alloys and solders; pesticides; glass; fertilizer; refiners; fuel; plastic.
4	Cd (Cadmium)	Batteries and electrical; pigments and paints; alloys and solids; fuel; plastic; fertilizers

Heavy metals enter the aquatic ecosystem from both natural and anthropogenic sources. Entry may be as a result of direct discharges into both fresh and marine ecosystems or through indirect routes such as dry and wet deposition and land run-off [21 Biney C, Amuzu A, Calamari D, Kaba N, Mbome I, et al., (1994)]. Important natural sources are volcanic activity, continental weathering and forest fires. The contribution from volcanoes may occur as large but sporadic emissions due to explosive volcanic activity or as other low continuous emissions, including geothermal activity and magma degassing [22 FAO (1992)]. The anthropogenic sources include; mining effluents, industrial effluents, domestic effluents and urban storm-water run-off, atmospheric sources e.g. burning of fossil fuels and petroleum industry activities (Table 1)

In aquatic environments, heavy metals are produced from various natural and anthropogenic sources, such as atmospheric deposition, geologic weathering, agricultural activities, as well as residential and industrial products (Demirak et al. 2006). The contamination of aquatic ecosystems with heavy metals has become a serious worldwide problem. They are resistant to degradation under natural conditions and may accumulate in microorganisms and aquatic flora and fauna which, in turn, may enter terrestrial food chains (including human) and result in further contamination of the environment (Arnason and Fletcher 2003; Järup 2003; Milošković et al. 2013).

A broadly defined group of “heavy metals” is constituted of elements which are essential for living organisms in small quantities but toxic in higher concentrations (e.g., Cu, Fe, Mn, and Zn) and those which are not considered to have any specific metabolic role and are generally classified as toxic (e.g., Cd, Hg, and Pb) to living organisms (Singh et al. 2011). A wide range of adverse effects can be induced by heavy metals in biota and include alterations of growth, metabolic processes, and disease development (Järup 2003). Therefore, it is important to monitor their levels in the surface water of any human use. Recently, many studies have focused on the evaluation of trace metal bioaccumulation in the aquatic biota including microorganisms (Rzymski et al. 2013; Twining and Baines 2013), macroalgae (Rybak et al. 2012a, b, 2013), higher plants (Mishra et al. 2008; Obolewski et al. 2011), macroinvertebrates (Liu et al. 2010; Tunca et al. 2013). Only a few recent studies have suggested that the inter-site variations in these factors could play an important role in influencing the levels of bioaccumulation and bio magnification of metallic contaminants by affecting their bioavailability and the physiological conditions of organisms in estuarine ecosystems. [25,26] (Kumar, V.et al 2015; Aguirre-Rubí, J.R.et al. 2017)

Bivalves, including mussels, oysters, and clams, are common benthic filter feeders in coastal and estuarine regions worldwide. Due to their high capacity to bio accumulate chemical contaminants, bivalves are well-established bio indicators for monitoring and assessing the levels of metallic pollution in aquatic ecosystems [21,27–30].21.(Estrada, E.S.; et al. 2017) 27. Bayen, Set al.2019) (28. De Souza, Met al. 2011) (29. Shoults-Wilson, W.A. et al 2015) (30. Liu, J.; Cao, L.; Dou, S.. 2017) . As they are sessile animals, analyzing the tissues of exposed bivalves could reflect the bioavailability of metallic contaminants in the local environment [30,31].

The main objective of the present study was to investigate the metallic bioaccumulation and biomagnification extent of three dominant filter-feeding bivalves’ species, Lamellidens corrianus, Lamellidens marginalis, and Parreysia cylindrica inhabiting in Nandur-Madhmeshwar reservoir of Nashik district during summer, monsoon and winter seasons.

The concentrations of four metallic contaminants, including zinc (Zn), copper (Cu), lead (Pb) and cadmium (Cd) in the whole soft body of the three studied bivalves were analyzed and compared with the environmental concentrations based on the associated surface water and soil sediment from Nandur-Madhmeshwar reservoir of Nashik district during summer, monsoon and winter seasons. in order to evaluate the inter-site effects of the bioaccumulation and biomagnification of metallic contaminants in bivalves.

MATERIALS AND METHODS

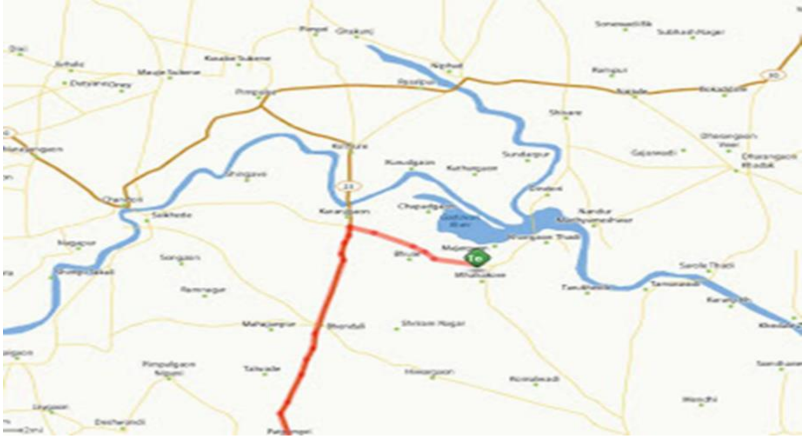
STUDY AREA

Through ceaseless efforts of Bombay Natural History Society, World Wildlife Fund and Forest Department of the Government of Maharashtra, this sanctuary which houses more than 220 species of birds, 400 species of vegetation, 24 species of fish and several smaller mammals came into existence along the Nandur Madhmeshwar dam at the confluence of Godavari and Kadwa. Spread over the protected area of 10000 hectares, lies the core area of 1765 hectares, where the large variety of water birds,resident and migratory birds congregate in season. It is now counted as one of the important water fowl habitats in the region by the International Union of Conservation of Nature.

Location: Niphad Tehsil Of Nashik District, Maharashtra
Known As: Bharathpur Of Maharashtra
Main Attractions: Paradise For Bird Lovers And Watchers
Best Time To Visit : December To March

Nandur Madhmeshwar Bird Sanctuary is located in Niphad Tehsil of Nashik district in Western Maharashtra. A stone pick up weir was constructed in 1907-13 across the river Godavari just below the confluence of Kodwa and Goadavari rivers at Nandur Madhameshwar. The water level is always fluctuating in Nandur Madhameshwar Lake.

The water released from Gangapur and Darana water reservoirs is stored at Nandur Madhameshwar and subsequently released from here through canals for irrigation. Silts and organic matter that are carried away with water flow are accumulated in the lake, due to which islands and shallow water ponds have been created. This resulted in the biological enriched conditions by which aquatic vegetation has been stabilized. Thus the site has turned into good wetland habitat aptly described as **'Bharatpur of Maharashtra".**



Sampling techniques:

Water and sediments samples were collected from different places of Girna reservoir during the period of November 2010 to October 2011. Surface water samples were collected from different places of reservoir from 50cm depth in morning hours in triplicates and were mixed together for each location so as to portray the average condition in the area. Determination of potential of heavy metal accumulation The Biowater Accumulation Factor (BWAF) and Biosediment Accumulation Factor (BSAF) values of the metals in the tissues of the bivalve species were calculated by dividing the concentration in the surface water/ soil sediments in which the animals were exposed (Szefer et al., 1999; Usero et al., 2005)

$$\textbf{BWAF} = \frac{\text{Concentration of heavy metal in animal tissue}}{\text{Concentration of heavy metal in water}}$$

Results were expressed as mean ± standard deviation (SD). The paired sample student's' test were used in order to access whether heavy metal concentrations varied significantly between species. The probabilities less than 0.05 ($p < 0.05$) were considered statistically significant. All statistical calculations were performed with SPSS 21.0 version.

$$\textbf{BSAF} = \frac{\text{Concentration of heavy metal in animal tissue}}{\text{Concentration of heavy metal in soil sample}}$$

RESULTS AND DISCUSSION

The heavy metals Zn, Cu, Pb and Cd concentrations in surface water, sediments and whole soft body tissues of freshwater bivalve, Lamellidnes corrianus, Lamellidens marginalis and Parresiya cylindrica sampled from **Nandur-Madhmeshwar**, reservoir of Nasik district were determined and obtained results are presented in Table 1. The concentrations of cadmium (0.0089 mg/L) and lead (0.0307 mg/L) in surface water were higher than the WHO (1998) recommended limits for drinking water standards; where as those of zinc (0.1373mg/L) and copper (0.0243mg/L) were within the limits. The highest concentrations of heavy metals Zn, Cu, Pb and Cd were recorded in surface water sampled from **Nandur-Madhmeshwar** reservoir might be due to heavy input of various pollutants through **Godavari** river. **Godavari** river originate from the hilly ranges of Sahyadries and flows from mountain to plain, and weathering soil and rock have become sources of heavy metal (Nriagu, 1989; Kennish, 1992; Florea and Busselberg, 2006).

Table-1

Heavy Metal Concentrations (µg/gm of dry tissue weight), body burden(µg/individual), Bio-Water Accumulation Factor values(BWAF) and Bio-Sediment Accumulation Factor values(BSAF) in *Lamellidensmarginalis and Lamellidenscorrianus* from Nandur –Madhmeshwar(NiphadTaluka) Reservoirs.

Metal	Highest permitted value for drinking water (Indian standard 1991	Concen tration of metals in water mg/L	Concentra tion of metals in sediments µg/g	Bivalve Species	Concentration of metals in tissue µg/g	Body dry weight (gm)	Body Burden	BWAF	BSAF
Zinc	15	0.1441 ± 0.0007	231.09 ± 1.74	*Lamellidensmarginalis*	707.89 ± 5.87	1.99 ± 0.19	1407.99±13.18	4912.49±24.68	3.06±0.25
				Lamellidenscorrianus	599.73 ± 5.27	1.76 ± 0.13	1057.92±11.25	4161.90±21.32	2.60±0.22
Copper	1.5	0.0328 ± 0.0005	77.23 ± 1.35	*Lamellidensmarginalis*	142.23 ± 1.35	1.99 ± 0.19	282.90±5.16	4336.28±22.75	1.84±0.17
				Lamellidenscorrianus	131.19 ± 1.72	1.76 ± 0.13	231.42±3.78	3999.70±21.13	1.70±0.18
Lead	0.05	0.0485 ± 0.0004	27.46 ± 1.32	*Lamellidensmarginalis*	108.76 ± 1.44	1.99 ± 0.19	216.32±3.27	2242.47±16.43	3.96±0.38
				Lamellidenscorrianus	137.75 ± 1.91	1.76 ± 0.13	242.99±3.48	2840.21±21.03	5.02±0.49
Cadmi um	0.01	0.0092 ± 0.0001	4.87 ± 0.83	*Lamellidensmarginalis*	29.27 ± 0.86	1.99 ± 0.19	58.22 ±1.94	3181.52±27.82	6.01±0.58
				Lamellidenscorrianus	25.03 ± 0.82	1.76 ± 0.13	44.15 ±0.99	2720.65±25.13	5.14±0.32

± indicates standard deviation

The data in table 1 compares the mean values of heavy metal concentrations in whole soft body tissues of three native freshwater bivalve species collected from **Nandur-Madhmeshwar** reservoir (µg/g dry tissue weight with ±SD). In the present investigation it was observed that different species of bivalves showed different capacities for accumulating different heavy metals. As mean lead (101.49 µg/g)101.49 concentrations appeared higher in Lamellidens corrianus, copper (107.71 µg/g)107.71 in Lamellidens marginalis, while cadmium (14.79 µg/g) 14.79 and zinc (343.84 µg/g) 343.84 in Parreysia cylindrica. The results of paired sample student't' test indicated that the differences between the mean values of heavy metal concentrations of the three bivalve species were statistically significant ($p < 0.05$) (Table no.1) The high values of BWAF and BSAF indicate Lamellidens corrianus are able to accumulate higher quantity of Pb and Lamellidens marginalis able to (1980), the elemental concentration of sediments not only based on anthropogenic sources, but also upon the organic matter content, textural characteristic, mineralogical composition, and depositional environment of sediments. Harland et al. (2000) reported that the metal concentrations in the sediments depend on organic matter and particle size. In the present study, it was observed that the magnitude of heavy metal accumulation depends upon type of heavy metal and the species of the bivalve. Waykar and Shinde (2011) and Waykar and Deshmukh (2012) reported that the element concentrations in molluscs differ between different species due to species-specific ability/capacity to regulate or accumulate trace metals. Therefore, two species that live in a same place can differ in the types and concentrations of metals they accumulate (Rainbow, 2002).accumulated higher quantity of copper, while Parreysia cylindrica are able to accumulate higher quantity of cadmium and zinc from water/ sediments into their tissues. The higher metal concentrations in water and soil sediments can be responsible for the highest metal accumulation in three bivalve species inhabiting at **Nandur-Madhmeshwar** reservoir. Shinde (2013) reported that metal concentrations in the soft body tissues of mollusc were related to metal levels in the water column. Deshmukh (2013) reported that metal concentrations in the soft body tissues of mollusc were related to metal levels in the environmental compartments (water, suspend particles and sediments). Thus, it can be concluded that the heavy metals are highly accumulated in sediments than water, since the sediments act as reservoirs for all contaminants (Saeed and Shaker, 2008). Fitchko and Hutchinson (1975) reported that soil sediments act as indicators of the burden of heavy metals in an aquatic ecosystem, as they are the principal reservoir of heavy metals. The numerous investigators reported that the sediments accumulated more heavy metals than the water (Lau et al., 1998; Besada et al., 2001; Chindah and Braide 2003; Eja et al., 2003). Qi et al. (2002); Zhang et al. (2002) and Ikem et al. (2003) also reported that the concentrations of heavy metals in soil sediments are much higher than those in the water. Casper et al. (2004) reported that aquatic sediments absorb constant and toxic chemicals to levels many times higher than the water column concentration. Many investigators also reported that sediment is the main sink for heavy metals in the aquatic ecosystems and also as source of pollutants (Burton and Scott, 1992; Caccia et al., 2003; Cheung et al., 2003; Ikem et al., 2003; Audry et al., 2004).

Abaychi and DouAbul (1985) reported that treated and untreated municipal, industrial wastes, agricultural run-off contribute to heavy metal Cu, Pb, Cd and Zn pollution source. Hutton et al. (1987) reported that sources of heavy metals Cd, Cu, Pb and Zn in surface water consist of leaching from Ni-Cd based batteries. The textile waste water is mixture of colorant (dyes and pigments). Large amount of chemically different dyes are employed for various industrial applications including textile dyeing (Pal and Brijmohan, 1990). The dyes used in these industries contain synthetic chemicals, which are generally metal based. Sharma et al. (1999) reported that waste water effluents from textile dyeing and printing industries contain dyes, bleaching agents, salts, acids and heavy metals like Cr, Cu, Pb and Zn. Chavan (2001) and Dubey et al. (2003) reported that major pollutant such as copper, lead, cadmium, zinc and chromium come mainly from the metal complex dyes. Aslam et al. (2004), Yusuff and Sonibare (2004) and Deepali and Gangwar (2010) reported that the textile industries effluent contains higher concentrations of Cu, Pb and Cd. Singh and Chandel (2006) conducted analytical study of heavy metals of industrial effluents at Jaipur, Rajasthan and concluded that textile industrial effluent contains Cu, Pb and Cd in higher

levels. Malarkodi et al. (2007) reported that higher levels of Cd, Pb and Cu in soil of textile industries. Lokhande et.al (2011) reported that dyes, paints, textile industries are the major industries contributing to the Cd, Pb and Cu pollution in the aquatic environment. Jaishree and Khan (2014) reported that waste water effluents from textile dyeing and printing industries contains dyes, bleaching agents, salts, acids and heavy metals like Cr, Cu, Pb, and Zn. Three sugar mills are in basin of reservoir, discharge effluents into the river, this might be sources of heavy metal pollution in the reservoir. Numerous investigators reported that sugar mill effluent contains heavy metals like Cu, Zn, Pb and Fe (Fakayode, 2005; Vermeulen and Vawada, 2008; Deshmukh, 2014; Saranraj and Stella, 2014. The **Godavari** river brings huge amount of domestic waste, textile, printing, dyeing industrial and other industrial effluents along with organic matter, run-off from agricultural filed and traffic run-off, this might be reason for higher concentrations of heavy metals Zn, Cu, Pb and Cd in sediments collected from **Nandur-Madhmeshwar** reservoir. Halcrow et al. (1973) have reported that heavy metal concentrations in sediment increase of organic matter content. According to Presley et al. (1980), the elemental concentration of sediments not only based on anthropogenic sources, but also upon the organic matter content, textural characteristic, mineralogical composition, and depositional environment of sediments. Harland et al. (2000) reported that the metal concentrations in the sediments depend on organic matter and particle size. In the present study, it was observed that the magnitude of heavy metal accumulation depends upon type of heavy metal and the species of the bivalve. Waykar and Shinde (2011) and Waykar and Deshmukh (2012) reported that the element concentrations in molluscs differ between different species due to species-specific ability/capacity to regulate or accumulate trace metals. Therefore, two species that live in a same place can differ in the types and concentrations of metals they accumulate (Rainbow, 2002).

Acknowledgement The authors gratefully acknowledge the Department of Zoology, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (M.S.) 43 1004, India, for providing laboratory facility for this work

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