International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Assessment of Elemental Accumulation in Gastropods Inhabiting River Ganga Upstream and Downstream Sites: A Biomonitoring Approach

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Abstract: ***The present study was attempted to estimate the elemental accumulation (Pb, Cd and Cr) in shell and soft part of gastropod species (Lymnaea luteola Lamarck) at bank of river Ganga near Berhampur site (upstream) compared to Chakdaha site (downstream), West Bengal. These metals were estimated in the water, sediment and tissues of gastropod specimens by using atomic absorption spectrophotometer (AAS) during pre and post-monsoon seasons. For water concentration, Pb, Cd and Cr were observed within the permissible limits. The metals content in the sediment was exceeded the permissioble limits. The data on Pb, Cd and Cr content (mg/Kg) in the sediment in which the value was increased significantly (P<0.001) in two sites of downstream when compared to upstream sites during pre-monsoon and post-monsoon season. The values of Pb, Cd and Cr metals (mg/Kg) in hard shell and soft parts samples were observed significantly (P<0.001 and P<0.01) higher in downstream sites (S3 and S4) compared to upstream sites (S1 and S2) during pre-monsoon and post-monsoon seasons. The bio-sediment accumulation factor (BSAF) in which the values of BSAF were maximum in S2 site for Pb element in shell and soft parts of gastropods during post-monsoon season. higher concentrations of toxic elements viz. Pb, Cd and Cr in this bioindicator species is a cause of concern. It is suggested regular monitoring of water and sediment quality in future along with other gastropod species around the point sources near the study sites.***

Keywords: Biomonitoring, Toxic elements, Bioaccumulation, Gastropods, Ganga river

1. Introduction

The river is contaminated by metals and metalloids is matter of great concern for inhabiting lower to higher organisms [1]. An established fact that living organisms provide valuable information by their presence, absence and abundance regarding their surrounding habitat and can be used to evaluate the local environmental impact by their physical, chemical and biological properties and their cumulative effects. [2]

Generally, macroinvertebrates have been well established for biological monitoring efforts because they are diverse group of longed lived, sedentary and used to predicting anthropogenic influence on aquatic ecosystem [3, 4]. The study of macroinvertebrates diversity and water quality parameters are interrelated and indicators of water quality by their presence, abundance and absence as tolerant or accumulators and/or sensitive species [5, 7] and easy to respond to organic and inorganic pollution load. [8]

From past, the bivalve molluscs have been widely utilized as biomonitors [9], gastropod molluscs like patellid limpets or top-shell snails are found increasing trend to employ in a similar activity. [10, 13] It was studied that gastropods are dominant group of molluscs in Iskenderun Bay. [14] Some studies have been published on determination of trace metals and contaminants in gastropod molluscs *Patella caerulea* from Iskenderun Bay. [15, 16] In the bank of river Ganga from Kalyani to Batanagar stretch the gastropod species observed as suitable indicators for sewage water. [17] Ghosh et al. [18] investigated metals like Zn, Cu, Fe, Ni, Mn, Co, Pb, Cr, and Cd in different seasons such as pre-monsoon, monsoon and post-monsoon at Nayachar Island, Hooghly estuary.

The present study was attempted to estimate the elemental accumulation in shell and soft part of gastropod species at bank of river Ganga near Berhampur site (upstream) compared to Chakdaha site (downstream).

2. Materials and Methods

Study area

The study sites were selected in the river Ganges in the upstream sites at Berhampur (Latitude = $24^0 6'$N and Longitude = 88^0 14′E) and downstream sites at Chakdaha (Latitude = 23^0 4′N and Longitude = 88^0 29′E), West Bengal, India.

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Figure 1: Google Earth image of study area and the sampling points (SP1, SP2, SP3 and SP4) (Source: Google Earth)
Sample collection

In the present study, four sampling stations as per designated study sites and in each site 4 samples of water and sediment and 5 samples of gastropod species (*Lymnaea luteola* Lamarck) as per higher richness value was randomly collected for two different seasons (Pre-monsoon and post-monsoon).

Analysis of elements in medium and tissues

The elements such as Pb, Cd and Cr in water, sediment and shell and soft part were analysed by using atomic absorption spectrophotometer (AAS) as per standard protocol. [9] Soft parts of the specific gastropods were separated from the shell and washed with double distilled water. Soft tissue and shell were dried separately in an oven at 80^{0}C. After drying completely, these were powdered in a gate mortar. Digestion for soft tissue and shell were performed separately according to Kotze et al. [19] Prior to estimation in AAS, all the water and sediment samples and tissue samples were digested according to the method of Goldberg et al. [9] in which concentrated nitric and perchloric acids with ratios of 5:5ml was used in beakers on a hot plate at 50°C for about 5hrs. till completed the decomposition of organic matter. The digested solutions were cooled to room temperature, filtered and diluted to a final volume of 50 ml using deionized distilled water.

Determination of bioaccumulation factor

Bio accumulation factor (BF) was calculated to assess the accumulation level of metals in the tissues of organisms as follows: [20]

Bio sediment accumulation factor (BSAF) = metals' concentration in snail tissues (mg/Kg dry weight)/metals' concentration in sediment (mg/Kg dry weight).

The value of BSAF separately estimated for shell and soft part for individual metal.

3. Results

Table 1 evaluates the data on Pb, Cd and Cr content in the water in which the valaue was below detection limit (<0.01, <0.01, and <0.05) for all the study sites during pre-monsoon and post-monsoon season.

Table 1: Pb content in water of river Ganga (n = 4 for each station)

Study sites	Pb (mg/L)	
	Pre-monsoon	Post-monsoon
S1	<0.01	<0.01
S2	<0.01	<0.01
S3	<0.01	<0.01
S4	<0.01	<0.01
	Cd (mg/L)	
S1	<0.01	<0.01
S2	<0.01	<0.01
S3	<0.01	<0.01
S4	<0.01	<0.01
	Cr (mg/L)	
S1	<0.05	<0.05
S2	<0.05	<0.05
S3	<0.05	<0.05
S4	<0.05	<0.05

Table 2 evaluates the data on Pb content (mg/Kg) in the sediment in which the value was increased significantly (P<0.001) in two sites of downstream when compared to upstream sites during pre-monsoon and post-monsoon season.

Table 2: Pb content in sediment of river Ganga (n = 4 for each station; Mean ± SD)

Study sites	Pb (mg/Kg)	
	Pre-monsoon	Post-monsoon
S1	2.40 ± 1.40	2.43 ± 1.18
S2	8.69 ± 2.38	1.87 ± 0.06
S3	17.23 ± 7.41*	15.05 ± 3.39*
S4	20.89 ± 3.44*	21.13 ± 3.83*

*P<0.001

Table 3 evaluates the data on Cd content (mg/Kg) in the sediment in which the valaue was increased significantly (P<0.001) in two sites of downstream when compared to upstream sites during pre-monsoon and post-monsoon season.

Table 3: Cd content in sediment of river Ganga (n = 4 for each station; Mean ± SD)

Study sites	Cd (mg/Kg)	
	Pre-monsoon	Post-monsoon
S1	0.45 ± 0.05	0.40 ± 0.04
S2	0.52 ± 0.07	0.41 ± 0.05
S3	0.72 ± 0.06*	0.63 ± 0.07*
S4	0.76 ± 0.0.7*	0.65 ± 0.09*

*P<0.001

Table 4 evaluates the data on Cr content (m/Kg) in the sediment in which the valaue was increased significantly (P<0.001) in two sites of downstream when compared to upstream sites during pre-monsoon and post-monsoon season.

Table 4: Cr content in sediment of river Ganga (n = 4 for each station; Mean ± SD)

Study sites	Cr (mg/Kg)	
	Pre-monsoon	Post-monsoon
S1	10.08 ± 1.29	9.41 ± 0.53
S2	11.02 ± 1.31	9.95 ± 0.51
S3	17.56 ± 2.00*	18.85 ± 0.74*
S4	17.87 ± 1.51*	19.09 ± 0.84*

*P<0.001

In Table 5, the value of Pb metal (mg/Kg) in shell and soft part samples were observed significantly (P<0.01) higher in downstream sites (S3 and S4) compared to upstream sites (S1 and S2) during pre-monsoon and post-monsoon seasons.

Table 5: Concentration of Pb in mollusc specimen (n = 5 for each station; Mean ± SD)

Study sites	Tissues	Pb (mg/Kg)	
		Pre-monsoon	Post-monsoon
S1	Shell	20.36 ± 2.07	19.20 ± 1.97
	Soft part	20.52 ± 2.64	18.20 ± 0.96
S2	Shell	20.0 ± 1.79	19.80 ± 2.34
	Soft part	20.7 ± 2.50	18.90 ± 2.66
S3	Shell	81.5 ± 4.95*	80.74 ± 6.41*
	Soft part	72.34 ± 11.80*	70.5 ± 11.49*
S4	Shell	81.36 ± 4.89*	79.16 ± 4.08*
	Soft part	68.96 ± 11.30*	65.96 ± 11.30*

*P<0.001

In Table 6, the value of Cd metal (mg/Kg) in shell and soft part samples were observed significantly (P<0.01 and P<0.001) higher in downstream sites (S3 and S4) compared to upstream sites (S1 and S2) during pre-monsoon and post-monsoon seasons.

Table 6: Concentration of Cd in mollusc specimen (n = 5 for each station; Mean ± SD)

Study sites	Tissues	Cd (mg/Kg)	
		Pre-monsoon	Post-monsoon
S1	Shell	5.08 ± 0.07	4.08 ± 0.07
	Soft part	1.48 ± 0.03	1.01 ± 0.04
S2	Shell	4.03 ± 0.06	3.57 ± 0.41
	Soft part	3.33 ± 0.09	2.23 ± 0.07
S3	Shell	5.77 ± 0.04**	4.31 ± 0.13*
	Soft part	5.31 ± 0.13*	2.46 ± 0.43**
S4	Shell	6.38 ± 0.04**	5.21 ± 0.08**
	Soft part	4.57 ± 0.05**	4.77 ± 0.04**

*P<0.01; **P<0.001

In Table 7, the value of Cr metal (mg/Kg) in shell and soft part samples were observed significantly (P<0.01 and P<0.001) higher in downstream sites (S3 and S4) compared to upstream sites (S1 and S2) during pre-monsoon and post-monsoon seasons.

Table 7: Concentration of Cr in mollusc specimen (n = 5 for each station; Mean ± SD)

Study sites	Tissues	Cr (mg/Kg)	
		Pre-monsoon	Post-monsoon
S1	Shell	5.08 ± 0.04	4.09 ± 0.07
	Soft part	0.55 ± 0.03	0.45 ± 0.06
S2	Shell	4.02 ± 0.04	3.57 ± 0.31
	Soft part	3.43 ± 0.05	2.13 ± 0.08
S3	Shell	5.57 ± 0.13*	4.39 ± 0.12*
	Soft part	5.17 ± 0.04**	2.66 ± 0.13**
S4	Shell	5.38 ± 0.04**	5.14 ± 0.08**
	Soft part	4.67 ± 0.05**	4.37 ± 0.04**

*P<0.01; **P<0.001

Table 8 estimates the bio-sediment accumulation factor (BSAF) in which the values of BSAF were maximum in S2 site for Pb element in shell and soft parts of gastropods during post-monsoon season.

Table 8: Bio sediment accumulation factor for studied elements in relation to shell and soft part of gastropods

Study sites	Seasons	Tissues	Pb	Cd	Cr
S1	Pre-monsoon	Shell	8.48	11.29	0.50
		Soft part	8.55	2.24	0.055
S2	Pre-monsoon	Shell	2.30	7.75	0.36
		Soft part	2.38	4.29	0.31
S3	Pre-monsoon	Shell	4.73	8.01	0.32
		Soft part	4.20	3.42	0.29
S4	Pre-monsoon	Shell	3.89	8.39	0.30
		Soft part	3.30	6.28	0.26
S1	Post-monsoon	Shell	7.90	10.20	0.43
		Soft part	7.49	2.53	0.048
S2	Post-monsoon	Shell	10.59	8.71	0.36
		Soft part	10.11	5.44	0.21
S3	Post-monsoon	Shell	5.36	6.84	0.23
		Soft part	4.68	3.90	0.14
S4	Post-monsoon	Shell	3.85	8.02	0.27
		Soft part	3.12	7.34	0.23

Paper ID: SR231218154707 DOI: https://dx.doi.org/10.21275/SR231218154707

4. Discussion

For water concentartion, Pb, Cd and Cr were observed within the permissible limits such as 0.01, 0.003 and 0.05 mg/L of drinking water (BIS, 2012). The metals content in the sediment was exceeded the permissioble limits. The data on Pb, Cd and Cr content (mg/Kg) in the sediment in which the value was increased significantly (P<0.001) in two sites of downstream when compared to upstream sites during pre-monsoon and post-monsoon season.

The values of Pb, Cd and Cr metals (mg/Kg) in hard shell and soft parts samples were observed significantly (P<0.001 and P<0.01) higher in downstream sites (S3 and S4) compared to upstream sites (S1 and S2) during pre-monsoon and post-monsoon seasons. The bio-sediment accumulation factor (BSAF) in which the values of BSAF were maximum in S2 site for Pb element in shell and soft parts of gastropods during post-monsoon season.

This unique seasonal variation of selected heavy metals may be attributed to several factors such as precipitation, evaporation, dilution etc., which was reported in the study of coastal zone in West Bengal [22]. A contrasting study by Chakraborty and Mitra revealed that during monsoon the heavy metals increased in the tissue of oyster (*Saccostrea cucullata*) at Sagar Island, West Bengal. [23] In the present study, maximum accumulation was observed in shells compared to soft parts of gastropod while other study revealed that soft tissue of snails (*Biomphalaria alexandrina* and *Melanoides tuberculata*) found higher accumulation of heavy metals at Mediterranean Sea and to the industrial area, Port-Said and Damietta sites, Egypt. [24]

Moreover, Arnot and Gobas classified the BAFs of heavy metals as per different values such as BAF<1000 (no probability of accumulation), BAF>1000 and <5000 (bio-accumulative) while BAF>5000 (extremely bio-accumulative). [25] In the present study, BAF especially for sediment (BASF) was below <1000, which is indicated no probability of accumulation but there was a tendency for accumulation in shells followed by soft tissues of gastropod specimens.

5. Conclusion

It is concluded that higher concentrations of toxic elements viz. Pb, Cd and Cr in this bioindicator species is a cause of concern. It is suggested regular monitoring of water and sediment quality in future along with other gastropod species around the point sources near the study sites.

Conflict of interest Authors declare none.

Funding source: This is non-funded project.

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