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HEAVY METAL POLLUTION OF INDIAN RIVER AND ITS BIOMAGNIFICATIONS IN THE MOLLUSCS

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Abstract: River water is the reliable source of freshwater, which forms the basis of life for variety of creatures. Good water quality of river satisfies the basic need of these organisms. Now day's due to the continuous water contamination, deterioration of water quality is becomes the serious concern in front of mankind. However, amongst these aquatic contaminants, heavy metals are of major concern. So, present investigation was carried out in order to assess the exact level of heavy metal contaminants and its impact over the aquatic creatures. Panchganga river MS, India was selected for the present study, because of its continuously polluting status. Freshwater mollusc species were selected to assess the biomagnifications due to its easy availability and bio-monitoring properties. Annual investigation concludes the alarming level of heavy metals contamination in the river and its severe deposition or biomagnification in the molluscan body. Contamination affects the total health of the river and hence, there is requirement of advanced scientific skill with practical approach to keep check on them.
Key words: Contaminants; Heavy metals; Molluscs; River.
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INTRODUCTION

Water is crucially important parameter for survival of the life form. Earth is the unique planet so far known to have water. Amongst world widely distributed freshwater water resources, Asiatic continent alone contributes to the 36 percent of the water. Major proportion of the freshwater is in the terms of rivers, lakes, reservoirs, swamps, streams and ponds. Amongst these resources, rivers are immensely important due to its higher water retaining capacity and widely distributed flows of water. It plays vital role in concretion of biotic community along the marginal area and so forms main basis of topography of the area. It contributes in the hydrological cycle and confirms the regular availability of water. These rivers perform the major role in integrating and organizing the landscape of Indian continent and hence regarded as cradle of India civilization (Kar, 2008). Along with Indian rivers worldwide distributed riverine systems also facing the dreadful problem of pollution. The excess contamination of organic and inorganic contaminants creates huge burden, which has altered its water quality and adversely affected the rich biodiversity of the river (Adeyeye, 2004). Pollution is global problem in front of mankind, amongst which heavy metal pollution is of major concern. The heavy metals have prolonged persistence i.e. non-biodegradability in the nature. Excess deposition of heavy metals and its accumulation in organism causes toxic effect over the body (Kaur, 2012 and Kwon, 2001). The major source of contaminants is untreated or partially treated effluents of the industries, which directly discharged in to the river streams (Sehgal, 2012). Biomagnification of heavy metals has severe health problems to the flora and fauna including humans and other organisms (Mc Cormick *et al*., 2005). Amongst invertebrates, molluscs are of prime importance due to its susceptibility to the contaminants (Lovjoy, 1999). Molluscs showed the behavioural alterations in altered environmental conditions and hence called bioindicators of the ecosystems (Gupta, 2011). Molluscs comprise second largest population of the animals from which number of species can be effectively utilised as bioindicators. At stressed heavy metal contamination, it shows weight loss, altered respiration, improper reproduction, excess mucus secretion and other hampered physiological conditions which can be used to assess the total health of the ecosystem (Khayatzadeh, 2010). The only reliable way to overcome the problem of the heavy metal pollution is regular and periodic monitoring of the aquatic resources, which helps to keep check on the concentration of the contaminants and prevents the further pollution (Bellingham, 2012). Hence, by keeping in view the availed conditions of the river, present investigation was conducted to assess the heavy metal pollution and its biomagnification in the molluscs.

EXPERIMENTAL

Study area: Union or combination of five rivers Kumbhi, Kasari, Bhogawati, Tulsi and saraswati forms the river Panchganga, which is considered as one of the important and sacred river of eastern Maharashtra's Kolhapur district. The river is lifeline for the number of cities, town and villages situated all along the flow of river. Its 85 kms stream is most reliable source of freshwater for drinking, agricultural and industrial activities of the nearby areas, which in turns contaminates the river by depositing tremendous amount of waste produced per day (Gaikwad and Kamble, 2013). Panchganga river is situated at average height of 550 meters above the sea level. Its large catchment area provides ample water and forms the sinks or basin for dumping of domestic waste and industrial effluents of the nearby situated villages and industries. Such a huge disposal creates a burden over the water quality of the river and causes heavy metals contaminations.

Monitoring Sites: Five monitoring sites viz. S_1, S_2, S_3, S_4 and S_5 were selected for regular monitoring of the river. S_1 and S_2 were from upstream, whereas, S_3, S_4 and S_5 were located downstream of the river. Their geographic position was illustrated in the Figure 1 and Table 1.

Table 1. Location of monitoring sites from river Panchganga

Code	Name	Longitude	Latitude	Elevation from Sea level
S_1	Prayag-Chikhli	16º 44' N	74 º 10' E	1780 ft.
S_2	Shivaji Bridge	16º 42' N	74 º 13' E	1786 ft.
S_3	Rukdi	16º 42' N	74 º 20' E	1770 ft.
S_4	Narsobawadi	16º 41' N	74 º 36' E	1754 ft.
S_5	Ichalkaranji	16º 41' N	74 º 35' E	1763 ft.

Water samples were monthly collected in between the period of February, 2012 to January 2013 from selected monitoring sites. Samples were collected well below the water surface using one-litter acid leached polythene bottle.

Animal collection: For the investigation 3 molluscan species viz. *Bellamya bengalensis*, *Lamellidens corrianus* and *Parreysia corrugata* were collected all along bank area of river. Water samples and molluscs were carried to the laboratory for laboratoric analysis.

Laboratoric analysis: Water samples were filtered and treated with 6N of HNO_3 for metal detection (APHA, 2005). Sampled molluscan species were dissected immediately. Gonadal and foot tissues were kept in oven at 120°C for drying reaching until to the constant weight. One gm of each dried tissue in triplicate were taken and then digested with diacid (HNO_3 and $HClO_4$ in 2:1 ratio) on hot plate as prescribed by Canli *et al*. (1998) and Malik, (2010). Completely digested samples were further diluted with distilled water in the range of standards and subjected to metal determinations. Heavy metals concentrations in the water sample and tissues were determined by Atomic Absorption Spectrophotometer (Chemito AA 201).

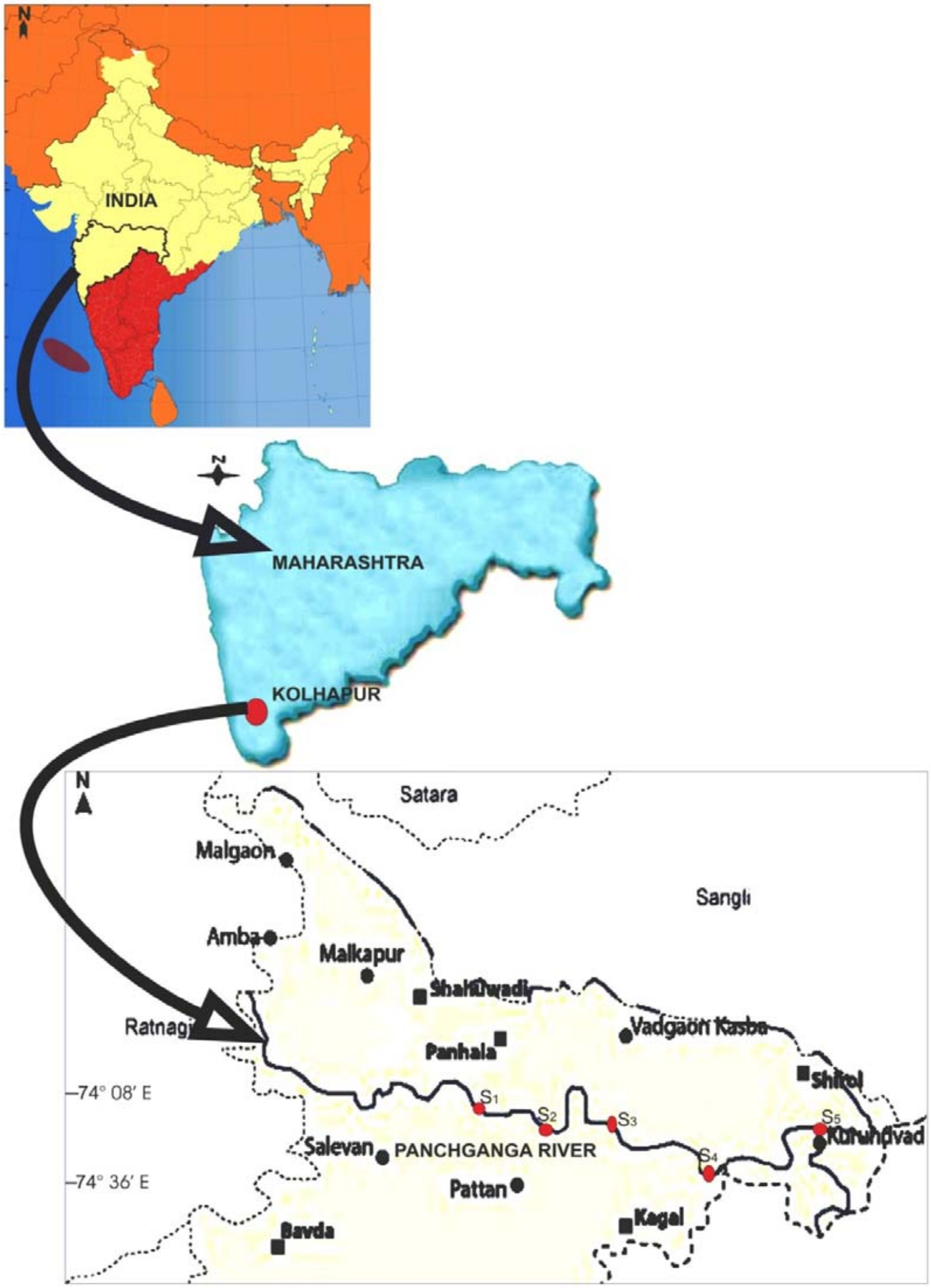


Figure 1. Geographical location of Panchganga river, MS, India.

RESULTS AND DISCUSSION

Heavy Metal Concentration in Water: Water samples collected from different sites were analysed for metals like Zn, Cu, Mg, Cd, Co, Pb, and Hg. The mean concentration of essential metals viz. Zn, Cu and Mg were recorded as with 0.121 ppm, 0.101 ppm and 0.209 ppm respectively. However, non-essential and toxic metals viz. Cd, Co, Pb, and Hg were noted below the level of detection (BDL). Amongst analysed metals the richest concentration was noted for Mg, whereas Cu content was lower in the water sample. The optimal concentration of Mg, Zn and Cu were essential for conduction of physiological activities (Underwood, 1977). However, excess concentration of these metals resulted in to the serious health hazards as described by the Pillai, (1983) and USEPA, (1999). The observed values of Mg and Cu were above the BIS limit, which has indicated the serious contamination of the region. The average values of the metal with their standard deviation at different seasons were represented in the Table 2.

Table 2. Heavy metals concentrations at different monitoring sites

Metals	S_1		S_2		S_3		S_4		S_5		BIS limits
	Dry season	Wet Season	Dry season	Wet Season	Dry season	Wet Season	Dry season	Wet Season	Dry season	Wet Season	
Zn	0.1767 ± 0.0153	0.098 ± 0.007	0.1237 ± 0.0032	0.0563 ± 0.0045	0.1513 ± 0.0369	0.055 ± 0.0036	0.217 ± 0.005	0.1687 ± 0.004	0.107 ± 0.002	0.055 ± 0.0036	15
Cu	0.0833 ± 0.0115	0.033 ± 0.0036	BDL	BDL	0.1737 ± 0.004	0.085 ± 0.0026	BDL	BDL	0.1337 ± 0.0045	0.1007 ± 0.0181	1.5
Cd	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01
Co	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
Pb	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.1
Hg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.001
Mg	BDL	BDL	BDL	BDL	0.3337 ± 0.0055	0.2967 ± 0.0051	0.1487 ± 0.0038	0.0567 ± 0.0015	BDL	BDL	

Evaluated values of metals Mg, Cu, Zn were noted with highest pick during dry season and observed with lowest range during wet season. The seasonal variations amongst the metal concentration were illustrated in the Figure 2 a, b and c.

The mean concentration showed the range of Mg > Zn > Cu. Similar trend of metals was also observed by Kar (2008), for Ganga river system. No significant correlations were observed between the noted heavy metal concentrations. However, ANOVA reveals highly significant seasonal alterations amongst the compared monitoring sites. Zn showed significant alteration ($p < 0.001$) during the wet season, whereas elucidated the moderate level of alterations or difference ($p < 0.01$) during dry season. Exactly reverse trend of the level of significance was noted for Cu, as it denoted higher significance ($p < 0.001$) during dry season and moderate significance ($p < 0.01$) during wet season. However, although having the richest concentration the Mg remains non significant for both the season. Higher concentration of these heavy metals at dry season may be the result of heavy rainfall and rapid discharge of water from upstream areas, which was followed by metals chelate effect during dry season as mentioned by Khan *et. Al,* (1998) and Aktar, (2010). When compared with the other monitoring sites S_3 was found with serious level of contaminations, the probable reason of which may be the dumping of agricultural waste, domestic sewage and industrial effluents from the Kolhapur city along with little precipitation of metals than other downstream sites. Monitoring sites S_4 and S_5 were also noted as rapidly contaminating region of the river, whereas S_1 and S_2 were observed with least contamination and remarked as suitable for domestic usage.

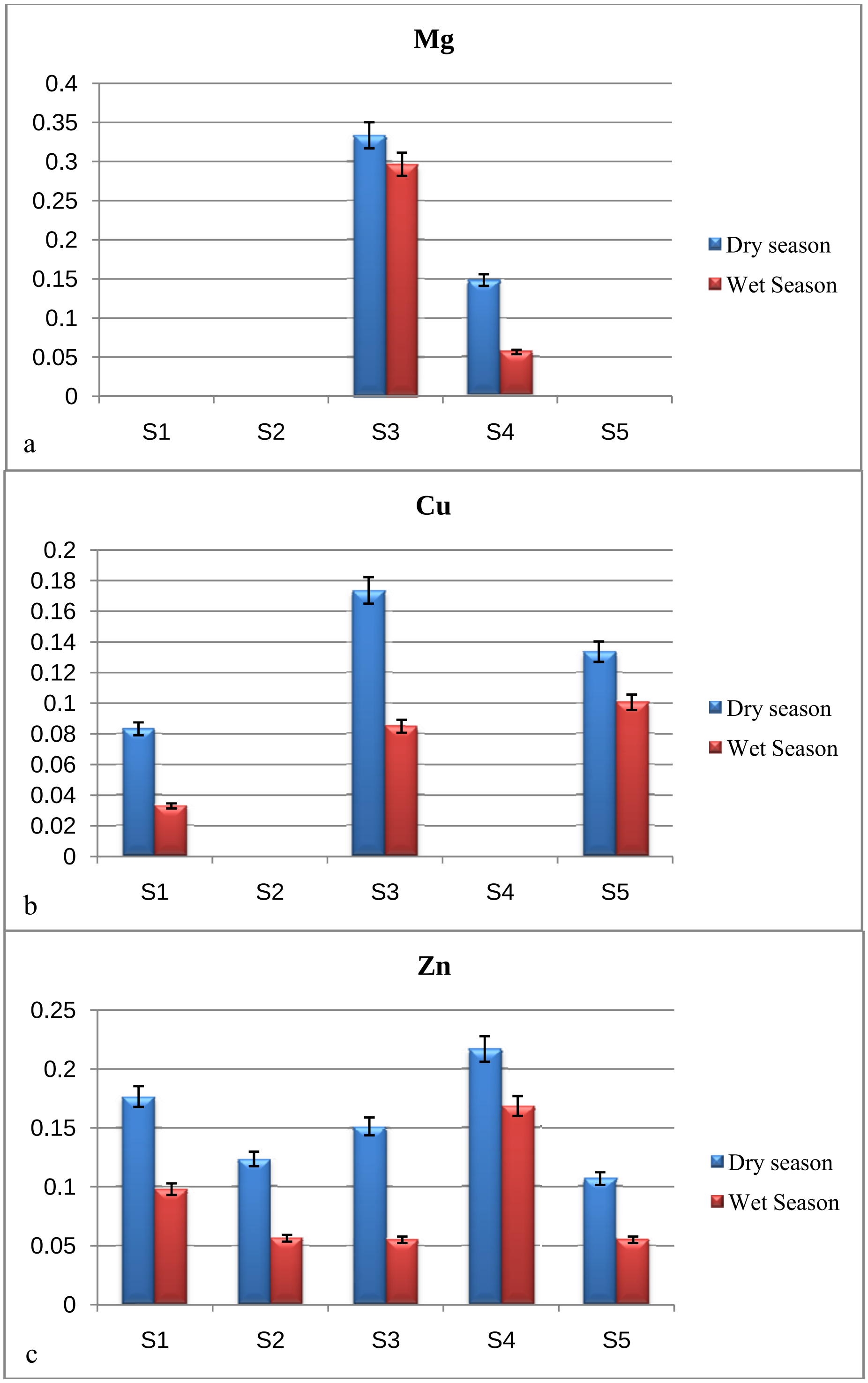


Figure 2. Heavy metal concentration at selected monitoring sites

Heavy Metal Concentration in molluscs: Bioaccumulation of metals among the tissues of molluscs showed clear differentiation. The mean concentration of Zn, Cu, Cd and Pb were noted as 0.39 ppm, 0.27 ppm, 0.00005 ppm and 0.34 ppm respectively. The average concentrations with ± S.D. were illustrated for *B. bengalensis* in Table 3, for *L. marginalis* in Table 4 and for *P. corrugata* in Table No. 5 respectively.

Table 3. Heavy metal content in various tissues of *B.bengalensis*

B. bengalensis (micrograms per gram)					FAO limits (1983)
Gonad (Mean with SD)			Foot (Mean with SD)		
Metals	Dry season	Wet Season	Dry season	Wet Season	
Zn	0.653333333 ± 0.061101009	0.156667 ± 0.025166	0.456667 ± 0.035119	0.186667 ± 0.035119	0.05
Cu	0.483333333 ± 0.085049005	0.073333 ± 0.020817	BDL	BDL	0.01
Cd	9.33333E-05 ± 9.29157E-05	1.33E-05 ± 5.77E-06	BDL	BDL	-
Co	BDL	BDL	BDL	BDL	-
Pb	BDL	BDL	0.143333 ± 0.035119	0.041667 ± 0.005508	0.004
Hg	BDL	BDL	BDL	BDL	-

Table 4. Heavy metal content in various tissues of *L. marginalis*

L. marginalis (micrograms per gram)					FAO limits (1983)
Gonad (Mean with SD)			Foot (Mean with SD)		
Metals	Dry season	Wet Season	Dry season	Wet Season	
Zn	0.12 ± 0.026457513	0.04 ± 0.01	0.15 ± 0.03	0.053333 ± 0.025166	0.05
Cu	BDL	BDL	BDL	BDL	0.01
Cd	BDL	BDL	BDL	BDL	-
Co	BDL	BDL	BDL	BDL	-
Pb	BDL	BDL	BDL	BDL	0.004
Hg	BDL	BDL	BDL	BDL	-

Table 5. Heavy metal content in various tissues of *P. Corrugata*

P. corrugata (micrograms per gram)					FAO limits (1983)
Gonad (Mean with SD)			Foot (Mean with SD)		
Metals	Dry season	Wet Season	Dry season	Wet Season	
Zn	0.32 ± 0.02	0.15 ± 0.03	0.183333 ± 0.015275	0.063333 ± 0.011547	0.05
Cu	BDL	BDL	BDL	BDL	0.01
Cd	BDL	BDL	BDL	BDL	-
Co	BDL	BDL	BDL	BDL	-
Pb	0.433333333 ± 0.02081666	0.243333 ± 0.025166	0.336667 ± 0.025166	0.196667 ± 0.015275	0.004
Hg	BDL	BDL	BDL	BDL	-

The concentrations of metals were higher in the body tissues as previously mentioned by Taylor (2003), for two gastropod snails. The probable reason for such excess bioaccumulation was continuous exposure and excessive mucus secretion as noted by Shanmugum (2007), for *Cymbium melo.* During the investigation, maximum deposition was noted in the snail *B. bengalensis*, which was followed by bivalve species *P. corrugata* and *L. marginalis* in decreasing order of metal uptake. Zn showed richest concentration in the body tissues, whereas Cd was found with least concentration. When compared seasonally, the gonad of *B. bengalensis*, *P. corrugata* and *L. marginalis* showed maximum deposition of Zn during dry season whereas it tends to be less deposited during the wet season (Figure 3 a). The higher deposition of Zn in the *B. bengalensis* would be the result of its rapid and high accumulation in the host plant species on which snail feeds. The Laskowski (1996), for viviparous snail *H. aspersa* mentioned similar observations, which accumulate 60% more amount of Zn through food plants only. Cu also showed its maximum deposition during the dry season and drastically lowered down during the wet period of investigation. The deposition was noted with pick for *B. bengalensis* whereas it remains below detectable level for the other two-uninoid species (Figure 3 b). Deposition of Cu in the snail body may be the impact of environmental parameters along with dietary deposition as stated by Synman (2002), for *H. aspersa.* Similar results as that of Cu were noted for Cd with only exception for its concentration of deposition (Figure 3c).

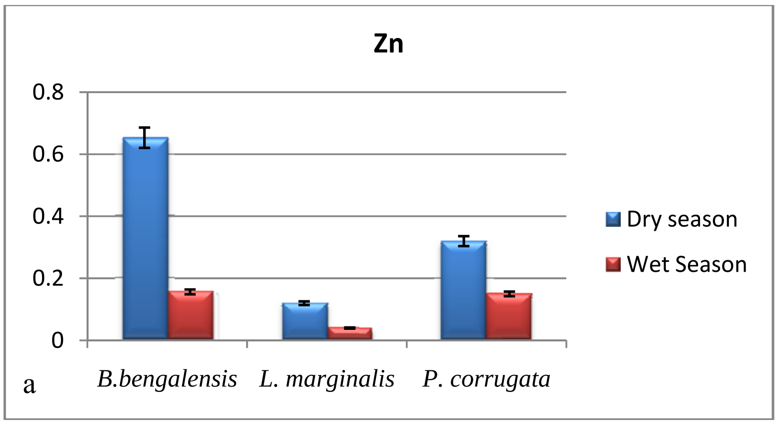


Figure 3a. Zinc concentration in the gonad of freshwater molluscs

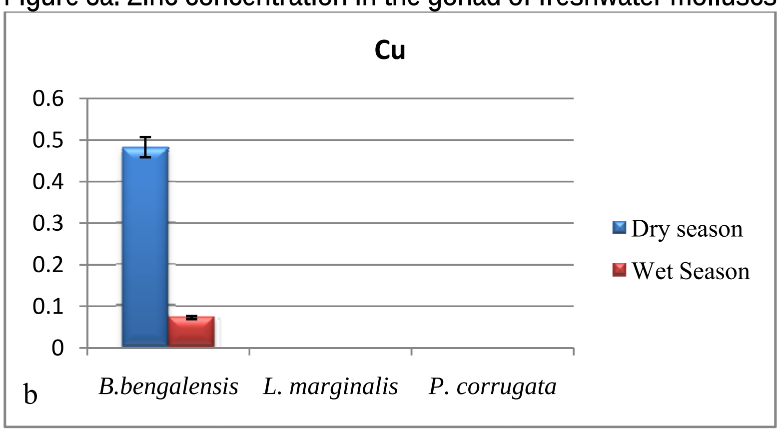


Figure 3b. Copper concentration in the gonad of freshwater molluscs

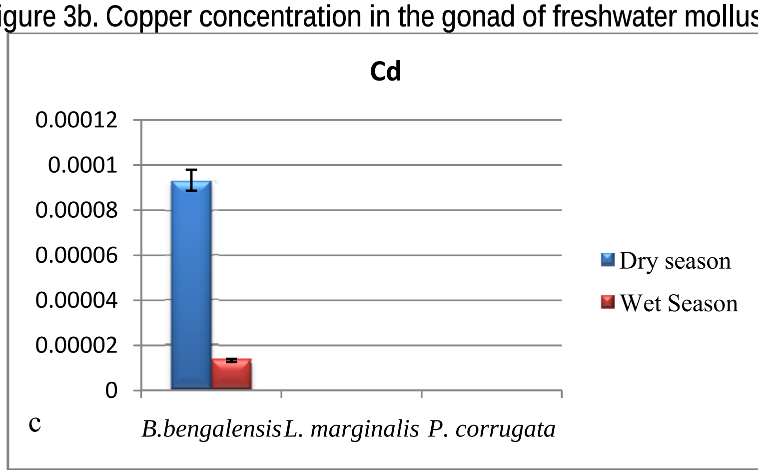


Figure 3c. Cadmium concentration in the gonad of freshwater molluscs

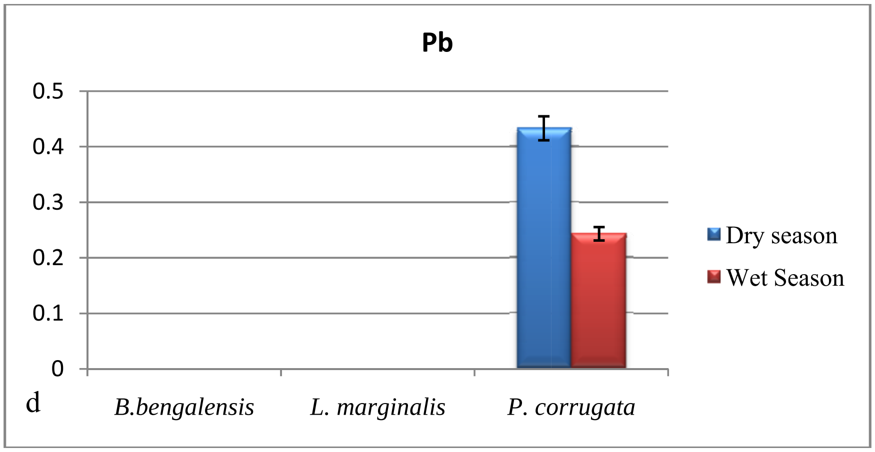
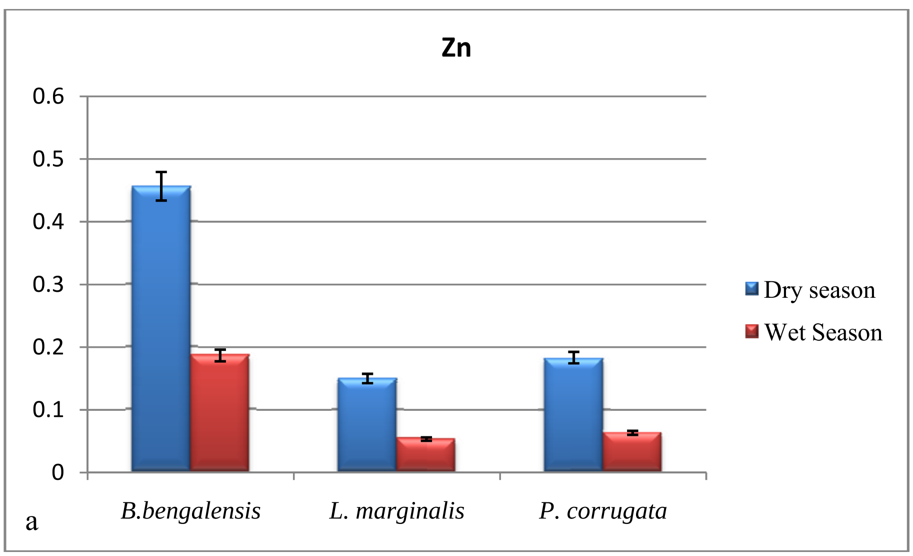


Figure 3d. Lead concentration in the gonad of freshwater molluscs

When compared amongst the gonad and foot muscles, metal deposition was less in the foot tissues than the gonad. In foot only Zn and Pb concentrations were determined, which represented similar seasonal and depositional trends as that of gonad (Figure 4 a and b). Hence, the overall metal uptake in tissues was noted as Zn > Cu > Pb > Cd in both the investigated seasons. Islam (2004) and Ismail (2005), observed the similar trends of metal uptake for the costal molluscan species. Wayker (2013) also noticed the similar accumulation of metals in the different body parts of *P. corrugata*. Therefore, the result achieved complies with prior investigation made by the number of workers on the diverse molluscan fauna. The values obtained were above the FAO standards, which represented the threatened contamination of the region that in turns affects the biology of the river basin.



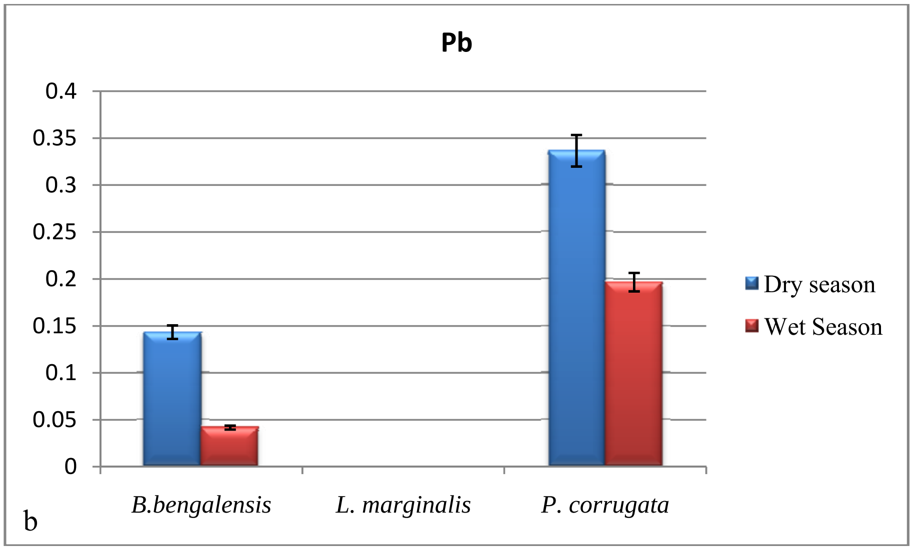


Figure 4 a and b. Heavy metal concentration in the foot of freshwater molluscs

CONCLUSION

The preliminary results of this investigation conclude that, the river Panchganga is continuously exposed to the toxic contaminants and hence day by day facing serious problems of metal pollution. This in turns affects the water quality along with physiological health of the flora and fauna inhabited in the river. So, there is need of practical approach to regulate the concentration of toxicant contaminations in to the aquatic bodies for the sustainable development of animals.

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CONFLICT OF INTEREST: Nothing