Bull Environ Contam Toxicol (2012) 88:48–53
DOI 10.1007/s00128-011-0447-0

Evaluation of Bivalves as Bioindicators of Metal Pollution in Freshwater

Bhalchandra Waykar · Gajanan Deshmukh

Received: 29 June 2011 / Accepted: 18 October 2011 / Published online: 2 November 2011

Abstract The fresh water bivalves, *Lamellidens corrianus, Lamellidens marginalis,* and *Indonaia caeruleus* were exposed to chronic concentration of arsenic (0.1719 ppm), cadmium (0.1284 ppm), copper (0.033 ppm), lead (1.50 ppm), mercury (0.0443 ppm) and zinc (1.858 ppm) separately up to 30 days in laboratory. Dry weight of each animal was used to calculate metal concentrations (µg/g) and the metal body burden (µg/individual). It was observed that lead (1235.4 µg/g) and arsenic (37.9 µg/g) concentration were highest in *Lamellidens corrianus,* zinc (3,032.3 µg/g) was highest in *Lamellidens marginalis*, while mercury (5.87 µg/g), cadmium (142 µg/g) and copper (826.7 µg/g) was highest in *Indonaia caeruleus.*

Keywords Bivalve · Metal concentration · Body burden · Bioindicator

Many metals are released into the freshwater from natural and many other anthropogenic sources. The most important metals from the point of view of water pollution are Zn, Cu, Pb Cd, Hg, Ni and Cr. Some of these metals (e.g. Cu, Ni, Cr and Zn) are essential trace metals to living organisms, but become toxic at higher concentrations. Metals such as As, Hg, Cd, Cu, Cr, Mn and Zn etc. do not degrade. Therefore they accumulate throughout the food chain. Metal ions, even at very low level can cause serious health effect, including reduced growth and development, cancer, organ damage, nervous system damage and in extreme causes death.

Conventionally, metal monitoring of water has been carried out by analyzing the concentration of metals in water and sediments. However, information obtained through this method is inaccurate (Issam et al. 2003). This misleads decision-making for water quality assessment. To overcome this problem, most researchers use benthic organisms as monitors of both the levels and long term influence of pollutant within an ecosystem. Metal accumulation in living organisms lead to concentration several orders of magnitude higher than those of the surrounding water (Casas et al. 2008). According to Teodorovic et al. (2000) and Abdullah (2008) metal studies in aquatic biota give an idea that metals in aquatic organisms could be more reliable water quality indicators than chemical analysis of water column and sediment.

During the past few decades, many species have been studied to determine their potential as biomonitoring organisms and molluscs have become a popular choice for metal monitoring for several reasons (Hung et al. 2001). They are somewhat sedentary, regionally abundant, long lived, have adequate tissue mass for analysis, filter feeder; accumulate metals from food, water and also from the ingestion of inorganic particulate materials, hence fulfilling the criteria as good bioindicators (Huang et al. 2007). In comparison to fish and crustacean, bivalves have a very low level of activity of enzyme systems capable of metabolizing persistent organic pollutants. Therefore contaminants concentration in the tissues of bivalves more accurately reflects the magnitude of environmental contamination (Phillips 1990). Consequently, such organisms have been largely used in programmes of biological

B. Waykar · G. Deshmukh (✉)
Department of Zoology, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra 431004, India
e-mail: gmdeshmukh16@gmail.com

B. Waykar
e-mail: bbwaykar@gmail.com

monitoring in freshwater (Rutzke et al. 2000). Moreover, mussels and oysters are widely used as biological indicators in national and international monitoring programs (Garcia-Rico et al. 2001). In case of bivalves, physiological processes of the organisms, as well as abiotic factors such as the physical and chemical properties of the environment and the chemical nature of the metal influence on the metal accumulation (Shulkin and Presley 2003).

Generally these indicators are able to evaluate the level of metal pollutants, but the problem of individual variability within and between sample batches still remains and this causes problems on the interpretation of the results. For this instance, body size or weight of the organism is one of the parameters that influence the uptake and bioaccumulation of the elements in the body. If the metal concentrations are expressed as concentration per unit body weight (μg/g), then one can expect the highest value to be recorded amongst the smallest individuals and could therefore render a misleading interpretation (Boyden 1974). Ibrahim and Mat (1995) shown that the total metal content is directly proportional to the body weight. The body burdens of metals in most bivalves have been used to identify and map areas with exceedingly high levels of trace metals and organic pollutants; hence they can be used as biomonitors for aquatic environment.

It is well established that organisms vary widely in their sensitivity to different pollutants, and that no single species or monitoring system is sensitive or suitable for the detection of all possible toxic pollutants (Forbes and Forbes 1994). The knowledge of concentration of metal in native species is very important with respect to nature management, human consumption of these species and to determine the most useful biomonitor species.

In order to use the bivalve as bioindicators in pollution-monitoring programmes, there is a need to develop a bioaccumulation database using various bivalve species which might be used in finding the most appropriate sentinel bivalve species for metal pollution monitoring programme for lentic and lotic ecosystems.

Lot of studies on bivalve associated with heavy metal accumulation in marine environment have been done by many researchers, but very few studies have been published related to fresh water bivalves (Waykar and Shinde 2011). Interest in these species was motivated by the fact that they are native, abundant and there have never been any published reports on the background of metal accumulation in these fresh water bivalve species.

Therefore in the present study different native species of fresh water bivalves, *Lamellidens corrianus, Lamellidens marginalis,* and *Indonaia caeruleus* were selected to establish a local environmental monitoring network using bivalves as bioindicator species to assess trends of Cu, Cd, Hg, As, Pb and Zn in the fresh water ecosystem.

Materials and Methods

Three species of fresh water bivalve, *Lamellidens corrianus, Lamellidens marginalis* and *Indonaia caeruleus* were collected from Jayakwadi dam Paithan, Aurangabad district of Maharashtra state, India. After collection animals were brought to laboratory and were cleaned and acclimatized in aquarium containing dechlorinated tap water for 10 days. During acclimatization and experiment, the animals were fed with fresh water algae and water of aquarium was changed after every 24 h. Physico-chemical parameters of water were analyzed (APHA 1998).

After acclimatization, the active, medium, uniform sized and healthy bivalves of each species were selected by measuring their shell length and divided into seven groups as below.

1st group was maintained as control
2nd group was exposed to chronic concentration 0.1719 ppm ($LC_{50/10}$) of As up to 30 days
3rd group was exposed to chronic concentration 0.1284 ppm ($LC_{50/10}$) of Cd up to 30 days
4th group was exposed to chronic concentration 0.033 ppm ($LC_{50/10}$) of Cu up to 30 days
5th group was exposed to chronic concentration 0.0443 ppm ($LC_{50/10}$) of Hg up to 30 days
6th group was exposed to chronic concentration 1.50 ppm ($LC_{50/10}$) of Pb up to 30 days
7th group was exposed to chronic concentration 1.8589 ppm ($LC_{50/10}$) of Zn up to 30 days

For each metal and each bivalve species LC_{50} values for 96 h were determined by Probit analysis method (Finney 1971). The average values of LC_{50} for all three bivalve species for each metal were calculated and average concentration was diluted ten times to expose each species of bivalve for each metal, so that every species received equal dose to study comparative bioaccumulation potential. In nature all animals in the same habitat are exposed to same concentration and hence to develop sentinel model average of LC_{50} values were used. Ten animals from each of experimental and control groups were dissected after 10, 20 and 30 days of exposure period and the whole body mass of each animal was dried in oven at 70°–80°C. After oven drying dry weight of the whole body was measured.

Five hundred milligram dry powder of whole soft body tissue of control and experimental bivalves was digested in 10 mL mixture of Nitric acid: Perchloric acid in (5:1) ratio. After half hour stirring the samples were left overnight and on next day samples were digested on hot plate till the clear white fumes appeared. 10 mL volume of solution was maintained by adding acidic mixture of Nitric acid: Perchloric acid drop by drop. After allowing the flask to cool, double distilled water was added to bring the volume to

50 mL by using volumetric flask and then solution was filtered through Whatman filter paper number 41. From each sample, respective metal was analyzed by using Atomic Absorption Spectrophotometer (AAS).

Dry weight of each animal was used to calculate the metal concentration per unit body weight (µg/g) and metal body burden (µg/individual).

Results are expressed as mean ± standard deviation (SD). Difference among the means of control and treatment was analyzed by Student's *t* test. Differences were considered statistically significant when, $p < 0.05$.

Results and Discussion

The physico-chemical parameters of water analysed during experiment are summarized in Table 1. The levels of accumulated metals studied in three freshwater species of bivalves, after exposure to chronic concentration of As, Cd, Cu, Hg, Pb and Zn separately for 10, 20 and 30 days and are summarized in Tables 2, 3 and 4. The data revealed a significant gradual increase in metal concentration and total body burden levels in the soft whole body tissues of experimental bivalves with increase in exposure period as compared to the bivalves maintained as control. It was observed that different species of bivalves showed different levels of different metals. The values of metal per gm dry tissues as shown in Tables 2, 3 and 4 shows that Pb (1,235.4 µg/g) and As (37.9 µg/g) concentration was highest in the *Lamellidens corrianus,* Zn (3,032.3 µg/g) was highest in *Lamellidens marginalis*, while Hg (5.87 µg/g), Cd (142 µg/g) and Cu (826.7 µg/g) concentration were highest in *Indonaia caeruleus.*

The average metal concentration and body burden observed during present study exhibited in the order Zn > Pb > Cu > Cd > As > Hg in *Lamellidens corrianus, and* Zn > Cu > Pb > Cd > As > Hg in *Lamellidens marginalis* and *Indonaia caeruleus.*

Based on these results it showed that the magnitude of heavy metal accumulation in bivalve tissues depend on the type of heavy metal and the species of the bivalve. Concentration of metals observed in the control animal's body indicates presence of these metals in natural ecosystem of experimental bivalves. A reduced metal level in control bivalves indicates slow and gradual depuration of metals by bivalves.

The observed differences in tissue metal concentration and body burden between bivalve species might be due to variation in body size, growth, fitness, reproductive condition, genotype of the animal, difference in metabolic rate and weight. Variability in metal body concentration between closely related species are mainly caused by interspecific difference in the biokinetics of uptake, elimination and different physiological rates such as pumping, filtration and respiration. Both physiological/biochemical responses and metal geochemistry might be responsible for the difference in metal bioaccumulation as observed in different species. At the same time the attitude of the organism is specific for different element and substance.

The interspecific difference in the metal concentrations was evidence that different organisms display a range of capacities from low accumulation of certain elements to very high accumulation (Paez-Osuna et al. 2000). Wang et al. (2002) reported that the interactions between metal geochemistry and animal physiology determine the differences in the bioavailability among metals. The interspecific differences of metal assimilation efficiencies might be related to the species –specific digestive physiology and absorption rate of a metal across gut epithelium (Lee and Lee 2005). Abdullah et al. (2007) and Christopher et al. (2010) reported that the element concentrations in molluscs differ between different species due to species-specific ability/capacity to regulate or accumulate metals.

Table 2, 3 and 4 showed that metal body burden gradually decreased in the order from the least metal sensitive to the most metal sensitive. The history of an organism's

Table 1 Physico chemical parameters of tap water

Sr. No.	Sample	Parameters						
		pH	Temperature (°C)	Conductivity (µmho/cm)	Chlorides (mg/L)	Salinity (mg/L)	Total alkalinity (mg/L)	Total hardness (mg/L)
1	Tap water	7.32 ± 0.57	24 ± 1.28	218.3 ± 6.14	57.13 ± 1.87	103.15 ± 3.17	109.4 ± 1.94	197.2 ± 6.23
2	$ZnSO_4$	7.41 ± 0.54	24 ± 1.28	226.8 ± 5.07	59.24 ± 1.73	106.96 ± 3.74	118.3 ± 2.04	218.3 ± 7.52
3	$CuSO_4$	7.53 ± 0.41	24 ± 1.28	232.6 ± 7.32	64.13 ± 1.42	115.78 ± 4.08	122.7 ± 2.24	224.8 ± 7.74
4	$PbNO_3$	7.48 ± 0.64	24 ± 1.28	228.1 ± 4.26	61.24 ± 1.31	110.57 ± 3.63	134.2 ± 2.38	231.5 ± 8.12
5	$CdCl_2$	7.39 ± 0.81	24 ± 1.28	219.5 ± 6.24	58.07 ± 1.08	104.85 ± 3.26	127.1 ± 2.12	214.2 ± 6.27
6	$HgCl_2$	7.61 ± 0.76	24 ± 1.28	223.4 ± 7.89	57.34 ± 1.58	103.53 ± 3.82	131.5 ± 2.23	228.9 ± 8.05
7	$AsHNa_2O_4$	7.69 ± 0.61	24 ± 1.28	227.3 ± 5.37	60.14 ± 1.67	108.58 ± 3.07	126.14 ± 2.07	238.1 ± 8.22

Table 2 - Metal concentration (µg/g) and body burden (µg/individual) in fresh water bivalve *Lamellidens corrianus* after chronic exposure to the different metals

Sr. No.	Treatment	Exposure period								
		10 days			20 days			30 days		
		Body dry wt. (gm)	Metal concentration	Metal body burden	Body dry wt. (gm)	Metal concentration	Metal body burden	Body dry wt. (gm)	Metal concentration	Metal body burden
1	Control	2.24 ± 0.22	925.4 ± 9.76	2,072.9 ± 13.48	2.19 ± 0.24	672.4 ± 7.38	1,472.56 ± 11.34	2.16 ± 0.2	356.2 ± 5.28	769.40 ± 9.62
2	$ZnSO_4$	$2.41^{NS} \pm 0.25$	1,271.5* ± 13	$3,064.32^{NS} \pm 20$	$2.26^{NS} \pm 0.2$	$1,569.3^{NS} \pm 13$	$3,546.62^{NS} \pm 15$	$2.24^{NS} \pm 0.22$	$1,639.6^{NS} \pm 12$	$3,672.7^{NS} \pm 19$
3	Control	2.24 ± 0.19	1.13 ± 0.32	2.53 ± 0.83	2.19 ± 0.23	1 ± 0.26	2.19 ± 0.74	2.16 ± 0.21	0.85 ± 0.11	1.84 ± 0.43
4	$HgCl_2$	1.97* ± 0.17	3.18* ± 0.83	6.26* ± 1.04	1.89* ± 0.17	3.96* ± 0.81	$7.49^{NS} \pm 1.52$	1.76* ± 0.18	4.38* ± 0.46	$7.71^{NS} \pm 0.87$
5	Control	2.24 ± 0.21	33.28 ± 2.13	74.55 ± 4.35	2.19 ± 0.22	96.4 ± 5.18	211.17 ± 5.48	2.16 ± 0.23	196.4 ± 4.38	424.22 ± 6.59
6	$PbNO_3$	$2.24^{NS} \pm 0.24$	$288.1^{NS} \pm 3.31$	$645.34^{NS} \pm 9$	$2.15^{NS} \pm 0.2$	$927.1^{NS} \pm 10$	$1,993.27^{NS} \pm 15$	2.04* ± 0.21	1,235.4* ± 12	$2,520.22^{NS} \pm 16$
7	Control	2.24 ± 0.2	8.09 ± 1.41	18.12 ± 2.03	2.19 ± 0.20	8.08 ± 1.57	17.70 ± 2.17	$2.16^{NS} \pm 0.23$	7.08 ± 0.48	15.29 ± 1.48
8	$CdCl_2$	2.10* ± 0.21	26.06* ± 2.17	54.73* ± 2.91	2.01* ± 0.19	49.53* ± 4.12	99.56* ± 2.98	1.92* ± 0.18	$83.28^{NS} \pm 2$	$159.9^{NS} \pm 3.62$
9	Control	2.24 ± 0.22	232.2 ± 3.81	520.13 ± 7.46	2.19 ± 0.22	147.1 ± 7.22	322.15 ± 3.29	2.16 ± 0.22	50.5 ± 1.87	109.08 ± 2.57
10	$CuSO_4$	$2.20^{NS} \pm 0.25$	236.6* ± 3.1	$520.52^{NS} \pm 8$	2.17* ± 0.24	$548.8^{NS} \pm 7$	$1,190.9^{NS} \pm 10$	$2.03^{NS} \pm 0.21$	613.4* ± 5.23	$1,245.2^{NS} \pm 12$
11	Control	2.24 ± 0.23	2.84 ± 0.87	6.36 ± 1.04	2.19 ± 0.21	2.26 ± 0.57	4.95 ± 0.53	2.16 ± 0.24	1.74 ± 0.71	3.76 ± 0.34
12	$AsHNa_2O_4$	1.95* ± 0.24	$12.37^{NS} \pm 1.73$	24.12* ± 1.78	1.97* ± 0.18	19.64* ± 1.26	$38.69^{NS} \pm 2.17$	1.89* ± 0.18	$37.9^{NS} \pm 2.3$	71.63* ± 1.76

Where, * $p < 0.05$ (Significant *t* test), *NS* not significant

Table 3 - Metal concentration (µg/g) and body burden (µg/individual) in fresh water bivalve *Indonaia caeruleus* after chronic exposure to the different metals

Sr. No.	Treatment	Exposure period								
		10 days			20 days			30 days		
		Body dry wt. (gm)	Metal concentration	Metal body burden	Body dry wt. (gm)	Metal concentration	Metal body burden	Body dry wt. (gm)	Metal concentration	Metal body burden
1	Control	0.87 ± 0.09	1,111 ± 11.78	966.57 ± 8.42	0.84 ± 0.09	1,108.2 ± 8.05	930.89 ± 7.35	0.84 ± 0.11	977.8 ± 7.38	821.35 ± 5.48
2	$ZnSO_4$	$0.90^{NS} \pm 0.11$	$1,208.3^{NS} \pm 10$	1,087.47* ± 7.89	0.90* ± 0.1	1,483.9* ± 12	$1,335.51^{NS} \pm 11$	0.89* ± 0.1	$2,661.4^{NS} \pm 15$	$2,368.65^{NS} \pm 14$
3	Control	0.87 ± 0.08	1.61 ± 0.26	1.40 ± 0.47	0.84 ± 0.10	1.32 ± 0.26	1.11 ± 0.26	0.84 ± 0.09	1.3 ± 0.28	1.092 ± 0.14
4	$HgCl_2$	$0.72^{NS} \pm 0.07$	4.61* ± 0.89	3.32* ± 0.73	$0.77^{NS} \pm 0.1$	$5.12^{NS} \pm 0.84$	3.94* ± 0.38	$0.67^{NS} \pm 0.08$	5.87* ± 0.82	$3.93^{NS} \pm 0.37$
5	Control	0.87 ± 0.10	256.7 ± 3.54	223.33 ± 3.38	0.84 ± 0.09	189.2 ± 2.62	158.93 ± 3.39	0.84 ± 0.12	117.6 ± 1.29	98.78 ± 1.48
6	$PbNO_3$	0.76* ± 0.08	275.4* ± 2.64	$209.30^{NS} \pm 2$	0.8* ± 0.12	355.7* ± 4.18	$284.56^{NS} \pm 3.6$	0.75* ± 0.08	$656.1^{NS} \pm 3.3$	492.07* ± 5.64
7	Control	0.87 ± 0.12	5.73 ± 0.78	4.99 ± 0.37	0.84 ± 0.13	6.2 ± 0.81	5.21 ± 0.73	0.84 ± 0.08	6.7 ± 0.49	5.63 ± 0.84
8	$CdCl_2$	$0.76^{NS} \pm 0.09$	$64.87^{NS} \pm 2.37$	49.30* ± 1.58	0.72* ± 0.1	$111.08^{NS} \pm 2.2$	$79.98^{NS} \pm 1.40$	0.68* ± 0.07	$142^{NS} \pm 0.64$	$96.56^{NS} \pm 1.38$
9	Control	0.87 ± 0.10	190.7 ± 2.94	165.91 ± 2.49	0.84 ± 0.11	117.7 ± 2.54	98.87 ± 1.13	0.84 ± 0.11	89 ± 1.75	74.76 ± 1.47
10	$CuSO_4$	0.74* ± 0.08	334.4* ± 3.72	$247.46^{NS} \pm 2$	0.70* ± 0.09	$424.5^{NS} \pm 5.4$	297.15* ± 2.48	$0.78^{NS} \pm 0.07$	826.7* ± 4.09	$644.83^{NS} \pm 4$
11	Control	0.87 ± 0.11	2.62 ± 0.27	2.28 ± 0.26	0.84 ± 0.11	2.31 ± 0.59	1.95 ± 0.35	0.84 ± 0.08	1.93 ± 0.26	1.62 ± 0.18
12	$AsHNa_2O_4$	0.67* ± 0.07	$12.28^{NS} \pm 1.3$	8.23* ± 0.88	0.72* ± 0.08	17.84* ± 1.03	$12.84^{NS} \pm 1.42$	$0.79^{NS} \pm 0.09$	$33.6^{NS} \pm 1.97$	26.54* ± 1.14

Where, * $p < 0.05$ (Significant *t* test), *NS* not significant

Table 4 Metal concentration (μg/g) and body burden (μg/individual) in fresh water bivalve *Lamellidens marginalis* after chronic exposure to the different metals

Sr. No.	Treatment	Exposure period 10 days: Body dry wt. (gm)	Metal concentration	Metal body burden	20 days: Body dry wt. (gm)	Metal concentration	Metal body burden	30 days: Body dry wt. (gm)	Metal concentration	Metal body burden
1	Control	2.32 ± 0.25	935.1 ± 7.38	2,169.43 ± 12	2.19 ± 0.23	694.9 ± 6.39	1,521.83 ± 11.24	2.04 ± 0.20	552.4 ± 5.49	1,126.9 ± 11.37
2	$ZnSO_4$	2.43^{NS} ± 0.21	1,326.5* ± 11	$3{,}223.4^{NS}$ ± 15	2.27* ± 0.25	$1{,}704.4^{NS}$ ± 14	$3{,}868.99^{NS}$ ± 17	2.24* ± 0.24	$3{,}032.3^{NS}$ ± 14	$6{,}792.35^{NS}$ ± 27
3	Control	2.32 ± 0.22	1.43 ± 0.47	3.32 ± 0.39	2.19 ± 0.21	1.19 ± 0.34	2.61 ± 0.48	2.04 ± 0.21	0.9 ± 0.21	1.84 ± 0.28
4	$HgCl_2$	2* ± 0.24	3.84* ± 0.68	7.68* ± 0.87	1.99^{NS} ± 0.18	4.68* ± 0.87	9.31^{NS} ± 0.89	1.98^{NS} ± 0.2	5.34* ± 0.87	10.57* ± 1.73
5	Control	2.32 ± 0.25	46.2 ± 1.85	107.18 ± 1.85	2.19 ± 0.20	34.7 ± 1.38	75.10 ± 1.48	2.04 ± 0.17	30.12 ± 1.34	61.44 ± 2.18
6	$PbNO_3$	2.04^{NS} ± 0.19	169.4^{NS} ± 3	345.58^{NS} ± 3.3	1.95* ± 0.19	180.6* ± 2.37	352.17* ± 3.57	1.94^{NS} ± 0.2	235.6^{NS} ± 5.3	457.06* ± 5.95
7	Control	2.32 ± 0.24	7.65 ± 1.31	17.75 ± 1.68	2.19 ± 0.21	5.14 ± 0.87	11.26 ± 0.83	2.04 ± 0.21	2.52 ± 0.48	5.14 ± 0.87
8	$CdCl_2$	2.12* ± 0.21	37.02^{NS} ± 2	78.48* ± 2.32	2^{NS} ± 0.22	70.06^{NS} ± 1.2	140.12^{NS} ± 3.17	1.98* ± 0.18	88.71* ± 1.24	175.65^{NS} ± 4.7
9	Control	2.32 ± 0.24	70.5 ± 2.87	163.56 ± 2.93	2.19 ± 0.24	56.6 ± 1.57	123.95 ± 2.19	2.04 ± 0.22	33.9 ± 1.15	69.16 ± 2.58
10	$CuSO_4$	2* ± 0.18	318.5^{NS} ± 3.4	637^{NS} ± 5.64	1.92* ± 0.18	572.5* ± 5.39	$1{,}099.2^{NS}$ ± 12.3	1.92* ± 0.18	783.23^{NS} ± 7	$1{,}503.8^{NS}$ ± 13
11	Control	2.32 ± 0.22	2.31 ± 0.58	5.36 ± 0.83	2.19 ± 0.22	2.13 ± 0.38	4.66 ± 0.57	2.04 ± 0.20	1.70 ± 0.67	3.47 ± 0.64
12	$AsHNa_2O_4$	2.10^{NS} ± 0.23	11.02* ± 1	23.14^{NS} ± 1.23	2.15^{NS} ± 0.23	17.48* ± 1.48	37.58^{NS} ± 1.89	2.17^{NS} ± 0.2	31.23* ± 1.37	67.77^{NS} ± 2.18

Where, * $p < 0.05$ (Significant *t* test), *NS* not significant

metal exposure determines its body burden and may influence its physiological or behavioral response to metals (Widdows et al. 1984). Body burden data have been useful in identifying source/magnitude and calculating concentration of bioavailable metals, assessing comparative levels of stress affecting biota of different habitats, tropics or behavioral characteristics and quantifying ecological impact traceable to pollution (Birge et al. 1998). When uptake of any metal exceeds depuration, the accumulated body burden provides an in vivo index to chronic exposure. The species which are more tolerant to respective metal accumulate more metal (Barbour et al. 1997), while less tolerant species accumulate less metal or may not survive. The body burdens of heavy metals in most bivalves have been used to identify and map areas with exceedingly high levels of heavy metals and organic pollutants; hence they can be used as biomonitors for aquatic environment (Davies and Pirie 1980). They readily accumulate many metals and their body burden seems to reflect mean exposure levels over time (Naimo 1995). Bivalve accumulates measurable contaminant body burdens from environmental condition that are near or below the limit of detection in chemical analysis (Ullven 1993).

Further in the present study it was observed that Pb and As concentration was highest in the *Lamellidens corrianus,* Zn was highest in *Lamellidens marginalis*, while Hg, Cd and Cu were highest in *Indonaia caeruleus.* Therefore *Lamellidens corrianus* is being proposed as sentinel organism for monitoring of Pb and As, *Lamellidens marginalis* for Zn and *Indonaia caeruleus* for Hg, Cd and Cu in fresh water ecosystem.

Acknowledgments Financial assistance from University Grants Commission is appreciatively acknowledged.

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