JEB
Website : www.jeb.co.in
E-mail : editor@jeb.co.in

Journal of Environmental Biology

ISSN: 0254-8704 (Print)
ISSN: 2394-0379 (Online)
CODEN: JEBIDP

Studies on monitoring the heavy metal contents in water, sediment and snail species in Latipada reservoir

Bhalchandra Waykar and Ram Petare*

Department of Zoology, Dr. Babasaheb Ambedkar Marathawada University, Aurangabad - 431 004, India

*Corresponding Author E-mail: **rampetare@gmail.com**

Publication Info

Paper received:
28 May 2015

Revised received:
02 November 2015

Re-revised received:
15 December 2015

Accepted:
28 January 2016

Abstract

The concentrations of zinc, copper, cadmium and lead in surface water, sediments and two native snail species, *Bellamya bengalensis* and *Melanoides tuberculata* from Latipada reservoir were determined. The concentrations of cadmium and lead in surface water were higher than the WHO recommended limits for drinking water standards; where as those of zinc and copper were within the permissible limits. The concentrations of zinc, copper, cadmium and lead were higher in sediments than in water. The observed bioaccumulated level of zinc, copper, cadmium and lead in *Bellamya bengalensis* were Zn- 197.22, Cu- 172.14, Cd- 11.59 and Pb- 112.57$\mu g\ g^{-1}$, while in *Melanoides tuberculata* were Zn- 136.59, Cu- 132.04, Cd- 13.25 and Pb- 27.69$\mu g\ g^{-1}$. The metal concentrations in both species of snails were higher than those of the water and sediment. Bioaccumulated metal concentrations, Bio-Water Accumulation Factor (BWAF) and Bio-Sediment Accumulation Factor (BSAF) values indicated that *Bellamya bengalensis* had high potential for zinc, copper and lead bioaccumulation than *Melanoides tuberculata*, while *Melanoides tuberculata* had high potential for cadmium than *Bellamya bengalensis*. Therefore, *Bellamya bengalensis* is proposed as sentinel organism for monitoring zinc, copper and lead, while *Melanoides tuberculata* for monitoring cadmium in freshwater.

Key words

Bioaccumulation, BWAF values, BSAF values, Heavy metal toxicity, Latipada reservoir, Snail

Introduction

Heavy metal pollution in aquatic ecosystems has been recognized as a serious environmental issue. In many cases, heavy metals occur in natural water bodies at levels below their toxic thresholds. However, due to their non-degradable nature, such low concentrations may still cause toxic effects after uptake and subsequent bioaccumulation by organisms. In wetlands, sediments can accumulate large amounts of heavy metals thus becoming important reservoirs (Caccia *et al.,* 2003). Heavy metals accumulated in sediments can affect the concentration of heavy metals in the organisms that dwells in these sediments (Kim and Kim, 2006). Benthic gastropods in wetlands have a close relationship with the sediments that constitute their habitat and feeding site. Molluscs are capable of accumulating metals in their tissues many times higher than those in water concentrations (Waykar and Shinde 2011; Waykar and Deshmukh 2012).

Metal bioaccumulation can be of importance from the public health point of view, especially when a human consumes the accumulators (Soegianto and Irawan, 2008; Celechovska *et al.,* 2008). Secondly, this phenomenon is now being exploited for the assessment of environmental quality (Javanshir and Shapoori, 2011). Bioaccumulation of toxicants is one of the tools used in biomonitoring and is the only way to evaluate the bioavailability of pollutants present in water (Abdullah *et al.,* 2007). Snails are appropriate to be used as biomonitors *in situ*, because they are benthic animals which are in contact with polluted bottom sediments and have short generation time, abundant, with relative longevity, large, as well as can be easily collected and weighed (Lefcort *et al*., 2004).

Many species of snails have been studied to determine their potential as a biomonitoring organism (Hamed and Emara 2006; Kim and Kim 2007). Waykar and Petare (2013) studied bioaccumulation of heavy metals in freshwater snails *Ballamya bengalensis* and *Lymnea accuminata* from Malgaon wetland of Dhule district, India. Petare *et al.* (2014) reported that snails as sentinel animals for biomonitoring of heavy metals from freshwater ecosystem. These studies strongly support the use of snails as biomonitors of heavy metal pollution in aquatic ecosystems.

Anthropogenic activities in the study area have affected the hydrobiological qualities of Latipada reservoir. Panzara river flows from mountain to plain and weathering soil and rock have become source of heavy metal. Catchment area of reservoir is agricultural land, which is polluted by fertilizers and pesticides. Villages settled on bank of river, releases domestic wastes into the rivers. The small scale bricks industries are on the bank of river. High boating activity due to fishing in reservoir, changes the water quality of reservoir. The water of reservoir is used for drinking, irrigation and fishing purpose, therefore it is imperative to monitor the metal pollution of the reservoir.

There have never been any published reports on the background of metal accumulation in freshwater snail species, *B. bengalensis* and *M. tuberculata.* The snail species have potential to accumulate metals from surface water/sediments into its tissue can be determined using BWAF/BSAF values (Usero *et al.,* 2005) and these values are also used to find out most appropriate sentinel species to monitor heavy metal pollution in water and sediments.

The aim of the present study was to determine the concentrations of heavy metals zinc, copper, cadmium and lead in water, sediments and snail species, *B. bengalensis* and *M. tuberculata* inhabiting Latipada reservoir.

Materials and Methods

The Latipada reservoir was constructed in 1966 at village Latipada on Panzara river and is 80km away from Dhule city. Geographically, Latipada reservoir is located at 20°56'3"N 74°6'0"E having total catchment area of 215.14 sq. km (6478 ha). The total gross storage capacity of reservoir is 745.50 million cubic meters and the total live storage is about 43.11 million cubic meters.

Surface water, soil sediments and snail species were collected from various location of Latipada reservoir during the period of July to September 2009. Surface water samples were collected from 50 cm depth during morning hours and were filtered and mixed with concentrated HNO_3 (70%,from Merck) and preserved at 4°C before laboratory analysis. Soil sediments were collected from various locations of reservoir and were sieved by using a sieve (mesh size 0.5mm) and the fine fractions obtained were air dried. Air dried samples were then ground, powders and preserved in desiccators.

At least 100 specimen of each species of snail's were collected and medium, equal sized twenty animals of each species were selected The snails were dissected within 12 hrs of collection and their whole body tissues were removed, washed in distilled water and dried separately in oven at about 80°C. The dried tissues were powdered and stored separately. 500mg powder of whole soft body tissue of snails was digested in 10 ml mixture of nitric acid (70%, from Merck): perchloric acid (70% $HClO_4$, from Merck) in 5:1 ratio. After half hour stirring the samples were left overnight and were digested on hot plate till clear white fumes appeared. 10 ml volume of solution was maintained by adding acidic mixture of nitric acid: perchloric acid. The solution was then filtered through Whatman filter paper number 41. Surface water and soil sediments were also processed similarly. Analysis of metal concentrations in surface water, soil sediment and whole body tissue of snail was carried out by using Atomic Absorption Spectrophotometer (AAS) (Thermo Scientific, U. K. make, Solaar A series model). Dry weight of each animal was used to calculate the metal concentration per unit body weight ($\mu g\ g^{-1}$). The BWAF/BSAF values of metal in tissue were calculated (Usero *et al.,* 2005). Results were expressed as mean ±SD. The paired sample student't' test were used in order to access whether heavy metal concentrations varied significantly between the species. All the statistical calculations were performed with SPSS 21.0 version.

Results and Discussion

The concentrations of cadmium and lead in surface water were higher than the WHO (2008) recommended limits for drinking water standards; where as those of zinc and copper were within limits. This indicates that surface water of Latipada reservoir was polluted by lead and cadmium. The elevated concentrations of cadmium and lead recorded were attributable to the anthropogenic activities input through agricultural run-off, domestic untreated waste water, brick industries waste and high boating activity due to fishing in the reservoir. Catchment area of reservoir is agricultural land, chemical fertilizers and pesticides with heavy metal are used; this might be possible sources of cadmium and lead pollution (Kara *et al.,* 2004). Super phosphate is an important fertilizer used at the time of plantation of paddy seedlings and it contains 3mg Cd kg^{-1} super phosphate (Mason, 2002). Chopra *et al.* (2009) reported that use of cadmium containing fertilizers and sewage sludge is the main reason for enhance in the cadmium content in water. Cd enrichment also occurs due to the application of manure and limes (Ross, 1994). The catchment area of reservoir also brings the waste from brick industries and domestic waste water of villages. Aksoy *et al.* (2005) and Huang *et al.* (2007) reported that domestic waste and agricultural waste matter acts as major source of cadmium and lead.

High level of lead recorded was attributable due to high boating activity due to fishing in the reservoir and run-off from agricultural field and traffics. Many investigators have reported that high level of Pb in lake water could be attributed to drop of leaded petrol from fishing and ecotourism boats and dust which holds large amount of lead from the burning of petrol in automobile (Ebrahimpour and Mushrifah, 2008; Reddy *et al.,* 2012).

It was also observed that concentrations of zinc, copper, cadmium and lead were much higher in sediments as compared to water (Table 1). Sediment acts as indicators of the burden of metals in an aquatic environment, as they are the principal reservoirs for metals (Audry *et al.,* 2004; Yusuf and Osibanji, 2006). Heavy metals accumulation in the sediments can affect concentrations of heavy metals in aquatic organisms that inhabit in these sediments (Wildi *et al.,* 2004; Kim and Kim 2006). The amount of metals in sediments can lead to greater environmental problem when polluted sediments are taken up by filter feeder animals.

Data in Table 1 compares the mean heavy metal concentrations in soft body tissues of fresh water snail species, *B. bengalensis and M. tuberculata* collected from Latipada reservoir. Both the species showed different capacities for accumulating heavy metals. The concentrations of Zn (197.22 µg g^{-1}) Cu (172.14µg g^{-1}) and Pb (112.57µg g^{-1}) appeared considerably higher in *B. bengalensis* than those determined in *M. tuberculata.* On the other hand, mean concentration of Cd (13.25µg g^{-1}) appeared higher in *M. tuberculata* than those determined in *B. bengalensis.* The results of paired sample Student 't' test (Table 1) indicated difference between the mean value of heavy metal concentrations of both the species were statistically significant ($p<0.05$). It was observed that the metal concentrations in both species of snails were higher than those in water and sediments.

The values of Bio-Water Accumulation Factor (BWAF) and Bio-Sediment Accumulation Factor (BSAF) were determined to evaluate the potential of metal bioaccumulation in two snail species from surface water/sediments into their tissues. Table 1 shows higher mean values of BWAF and BSAF for zinc, copper and lead in *B. bengalensis* and for cadmium in *M. tuberculata.* The results of paired sample Student 't' test indicated that the difference between the mean values of BWAF and BSAF for the both species were (Table 1) statistically significant ($p<0.05$). High values of BWAF and BSAF indicated that *B. bengalensis* was able to accumulate higher quantity of zinc, copper and lead; while *M. tuberculata* was able to accumulate higher quantity of cadmium from water/ sediments into their tissues.

Many researchers have reported that sentinel or indicator species accumulate pollutant in their tissue higher than those of the surrounding medium (Hamed and Emara, 2006; Casas *et al.* 2008; Waykar and Shinde, 2011; Waykar and Deshmukh, 2012). The accumulated metals body burden in molluscs may reflect the concentration of metals in surrounding water and sediments, and thus might be an indicator of quality of the surrounding environment. Molluscs accumulate significant amount of contaminants from the environment that are near or below detection limits. Thus, such organisms have been largely used in biological monitoring of water (Avelar *et al.,* 2000; Rutzke *et al.,* 2000).

Table 1 : Metal concentrations, BWAF and BSAF values of surface water, soil sediment and snail species at Latipada reservoir

Metals	WHO standard (mg l^{-1})	Metal content in water (mg l^{-1})	Metal content in sediments (mg g^{-1})	Snail species	Metal content in tissue (mg g^{-1})	BWAF value	BSAF value
Zn	3000	103.65±1.13	122.03 ±0.99	*B. bengalensis*	197.22*±1.58	1.91*±0.009	1.62*±0.006
				M. tuberculata	136.59±4.06	1.31 ±0.006	1.12±0.005
Cu	2000	57.91±0.30	109.93 ±1.60	*B. bengalensis*	172.14*±1.72	2.98*±0.03	1.57*±0.04
				M. tuberculata	132.04±1.50	2.28±0.02	1.21±0.03
Cd	3	6.24±0.45	9.14 ±0.16	*B. bengalensis*	11.59±0.46	1.87±0.08	1.27±0.07
				M. tuberculata	13.25*±0.50	2.14*±0.23	1.45*±0.03
Pb	10	12.51±0.51	14.4 ±0.66	*B. bengalensis*	112.57*±0.76	9.01*±0.32	7.82*±0.32
				M. tuberculata	27.69±0.56	2.21±0.13	1.92±0.13

(±) indicate the standard deviations; Permissible limit of drinking water (WHO standard, 2008); *Indicates significant variation as per Paired sample student't' test at $p<0.05$ in the bioaccumulation potential of mentioned species

It was found that the magnitude of heavy metal accumulation in snail tissues depends upon the type of heavy metal and snail species. The observed difference in metal concentrations in tissues between snail species might be due to variation in genotype of the animal, difference in metabolic rate, body weight and presence or absence of enzyme system that can degrade the pollutants. Element concentrations in molluscs differ between different species due to species-specific ability/capacity to regulate or accumulate trace metals (Abdullah *et al.,* 2007; Christopher *et al.,* 2010) and might be related to species-specific digestive physiology and absorption rate of a metal across gut epithelium (Jung-suk and Byeong-Gweon, 2005). The response of organisms are specific for different element (Waykar and Shinde 2011; Waykar and Deshmukh, 2012). Therefore, two species that live in same place can differ in the type and concentration of metals they accumulate (Wang, 2002). Aquatic molluscs possess diverse strategies in handling and storage of accumulated metals (Rainbow, 2002).

The findings of the present study demonstrates that *B. bengalensis* is a sentinel organism for monitoring of zinc, copper and lead; while *M. tuberculata* for cadmium in fresh water ecosystem. The effective environmental monitoring exercise should be encouraged to check metal concentration from point and non-point sources of Latipada reservoir. Heavy consumption of other aquatic animals from Latipada reservoir by humans, as in the current situation poses several health implications.

Acknowledgment

The authors gratefully acknowledge Department of Zoology, Dr. B. A. Marathwada University, Aurangabad (M.S.) for providing laboratory facility for carrying out this work.

References

Abdullah, M. H., S. Jovita and Z. A. Ahmad: Heavy metals (Cd, Cu, Cr, Pb and Zn) in *Meretrix meretrix roding,* water and sediments from estuaries in Sabah. *N. Borneo. Int. J. Environ. Sci. Educ.*, **2**, 69–74 (2007).

Aksoy, A., D. Demirezen and F. Duman: Bioaccumulation, detection and analysis of heavy metal pollution in Sultan Marsh and its environment. *Water Air Soil Poll.*, **164**, 241-255 (2005).

Audry, S., J. Schafer, G. Blanc and J.M. Jouanneau: Fifty-year sedimentary record of heavy metal pollution (Cd, Zn, Cu, Pb) in the Lot River reservoirs (France). *Environ. Pollut*., **132**, 413–426 (2004).

Avelar, W.E.P., F.L.M. Mantelatto, A.C. Tomazelli, D.L. Silva, T. Shuhama and J.L.C. Lopes: The marine mussel *Perna perna* as an indicator of contamination by heavy metals in the Ubatuba bay, SaoPaula, Brazil. *Water Air Soil Poll.*, **118**, 65-72 (2000).

Caccia, V.G., F.J. Millero and A. Palanques: The distribution of trace metals in Florida Bay sediments. *Mar. Poll. Bull.*, **46**, 1420–1433 (2003).

Casas, S., J.L. Gonzalez, B. Andral and D. Cossa: Relation between metal concentration in water and metal content of marine mussels (*Mytilus galloprovincialis*): Impact of physiology. *Environ. Chem.*, **27**, 1543-1552 (2008).

Celechovska, O., L. Malota and S. Zima: Entry of heavy metals into food chains: A 20-year comparison study in northern Moravia (Czech Republic). *Acta Vet. Brno.*, **77**, 645–652 (2008).

Chopra, A.K., C. Pathak and G. Prasad: Scenario of heavy metal contamination in agricultural soil and its management. *J. Appl. Nat. Sci*., **1**, 99-108 (2009).

Christopher, B., U.B. Ndome, F.E. Ekaluo and A.E. Asuquo: Comparative bioaccumulation of heavy metals (Fe, Mn, Zn, Cu, Cd, and Cr) by some edible aquatic molluscs from the Atlantic coastline of South Eastern Nigeria. *World J. Fish Marine. Sci.*, **2**, 317-321 (2010).

Ebrahimpour, M. and I. Mushrifah: Heavy metal concentrations in water and sediments in Tasik Chini, a freshwater lake, Malaysia. *Environ. Monit. Assess.*, **141**, 297-307 (2008).

Hamed, M.A. and A.M. Emara: Marine mollusc as biomonitors for heavy metal levels in Gulf of Suez, Red Sea. *J. Marine Syst.*, **60**, 220-223 (2006).

Huang, H., J.Y. Wu and J.H. Wu: Metal monitoring using bivalve shellfish from Zhejiang Coastal water, East China Sea. *Environ. Monit. Assess.*, **129**, 315-320 (2007).

Javanshir, A. and M. Shapoori: Influence of water hardness (calcium concentration) on the absorption of cadmium by the mangrove oyster *Crassostrea gaster* (Ostreidae: Bivalvia). *J. Food Agric. Environ.*, **9**, 724-727 (2011).

Jung-suk, Lee and Lee Byeong-Gweon: Effect of salinity, temperature and food type on the uptake and elimination rates of Cd, Cr and Zn in the Asiatic clam *Corbicula fluminea*. *Oce. Sci. J.*, **40**, 79-89 (2005).

Kara, E.E., U. Pirlak and H.G. Ozdilek: Evaluation of heavy metals (Cd,Cu,Ni,Pb and Zn) distribution in sowing regions of potato fields in the province of Nigde. *Turkey Water Air Soil Pollut.*, **153**, 173-186 (2004).

Kim, H. and J.G. Kim: Heavy metal accumulation in *Oxyloma hirasei* from the UPO Wetland. *J. Ecol. Field Biol.*, **30**, 81-86 (2007).

Kim, H. and J.G. Kim: Heavy metal concentrations in the mollusc gastropod, *Cipangopaludina chinensis malleata* from Upo wetland reflect the level of heavy metal in the sediments. *J. Ecol. Field Biol.*, **29**, 453-460 (2006).

Mason, C.F.: Biology of freshwater pollution. 4th Edn., Essex Univ. England. **387**, pp. (2002).

Lefcort, H.D., P. Abbott, D.A. Cleary, E. Howell, N.C. Keller and M.M. Smith: Aquatic snails from mining sites have evolved to detect and avoid heavy metals. *Arch. Environ. Contam. Toxicol.*, **46**, 478–484 (2004).

Petare, R.K., S.P. Khodake and B.B. Waykar: Sanils as sentinel animals for biomonitoring of heavy metlas from Nakane lake in Dhule district of Maharashtra, India. *J. Environ. Res. Develop.,* **9**, 324-333 (2014)

Rainbow, P. S.: Trace metal concentrations in aquatic invertebrates: Why and so what? *Environ. Pollut.*, **120**, 497-507 (2002).

Reddy, V.V., B.K. Sagar and V. Balaram: Assessment of the effect of municipal sewage,immersed odols and boating on the heavy metal and other elemental pollution of surface water of the eutrophic

Hussainsagar Lake (Hydrabad). *Environ. Monit. Assess*., **184**, 1991-2000 (2012).

Ross, S.M.: Sources and forms of potentially toxic metals in soil-plant systems. In: Toxic metals in soil- plant systems (Ed.: S.M. Ross). Wiley and Sons, New York, pp. 3-25 (1994).

Rutzke, M.A., W.H. Gutenmann, D.J. Lisk and E.L. Mills: Toxic and nutrient element concentrations in soft tissues of Zebra and Quagga mussels from Lake Erie and Ontario. *J. Chemosphere*, **40**, 1353-1356 (2000).

Soegianto, A. and B. Irawan: Bioaccumulation of heavy metals in aquatic animals collected from coastal waters of Gecko Indonesia. *J. Water Environ. Poll.*, **2**, 95-100 (2008).

Usero, J., J. Marilla and I. Graccia: Heavy metal concentrations in mollusc from the Atlantic Coast of Sothern Spain. *Chemosphere*, **59**, 1175-1181 (2005).

Wang, W.X.: Interactions of trace metals and different marine food chains. *Marine Ecol. Prog. Ser.,* **243**, 295-309 (2002).

Waykar, B. and G.M. Deshmukh: Evaluation of bivalves as bioindicators of metal pollution in freshwater. *Bull. Env. Contam. Toxico*., **88**, 48-53 (2012).

Waykar, B. and R.K. Petare: Bioaccumulation of heavy metals in freshwater snails, *Bellamya bengalensis* and Lymnea accumulate from Malgaon wetland of Dhule District (Maharashtra) India. Bioscan, **8**, 1043-1047 (2013)

Waykar, B. and S.M. Shinde: Assessment of the heavy metal bioaccumulation in three species of fresh water bivalves. *Bull. Env. Contam. Toxico.*, **87**, 267-271 (2011).

WHO: Guidelines for drinking-water quality third edition incorporating the first and second addenda. Volume 1 (2008).

Wildi, W., D. Janusz, L. Jean-Luc, L. Richard, F. Thomas Pierre-Yves, H. Laurence, P. Antoine and P. Christophe: River, reservoir and lake sediment contamination by heavy metals downstream from urban areas of Switzerland, Lakes and Reservoirs: *Res. Manage*, **9**, 75 (2004).

Yusuf, K.A. and O. Osibanji: Trace metals in water and sediments from Ologe lagoon, southwestern Nigeria. *Paki. J. Sci. Indu. Res.*, **49**, 88-89 (2006).