The Bioscan 8(3): 1043-1047, 2013 (Supplement on Toxicology)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

BIOACCUMULATION OF HEAVY METALS IN FRESHWATER SNAILS *BELLAMYA BENGALENSIS*, AND *LYMNEA ACCUMINATA* FROM MALANGAON WETLAND OF DHULE DISTRICT (MAHARASHTRA) INDIA

WAYKAR BHALCHANDRA* AND PETARE RAM
*Department of Zoology, Dr. Babasaheb Ambedkar Marathawada University,
Aurangabad - 431 004 (M. S.) INDIA
Karm. A. M. P. and N. K. P. A. S. C. College, Pimpalner Tal. Sakari,
Dhule - 424 306 (M. S.) INDIA
e-mail: bbwaykar@gmail.com.

KEYWORDS
Metals
Snail
Concentration
Biowater accumulation factor
Biosediment accumulation factor
Malangaon dam

Received on :
11.05.2013

Accepted on :
26.08.2013

***Corresponding author**

ABSTRACT
The levels of heavy metals zinc, copper, cadmium and lead were determined in surface water, soil sediments and whole soft body tissues of native freshwater snail species, *Bellamya bengalensis*, and *Lymnea accuminata* from Malangaon dam. The result showed that in surface water the cadmium (0.0259mg/L) and lead (0.0730 mg/L) concentration exceed higher limit of WHO drinking water standard (WHO, 1993). It was observed that, concentration of four metals zinc (1565.6μg/g), copper (1371.3μg/g), cadmium (90.16μg/g) and lead (125.3μg/g) were higher in soil sediments as compare to surface water. The bioaccumulation levels of zinc, copper, cadmium, and lead in *Bellamya bengalensis* were 3498.6, 4655.3, 83.5 and 1541.3μg/g respectively and for *Lymnea accuminata* were 1798.8, 690.1, 107.63 and 603.3.5μg/g respectively. The metal concentrations in whole soft body tissues of snail's species were higher than the surface water and soil sediments. The metal concentration, BWAF and BSAF values suggested that the *Bellamya bengalensis* have greater capacity for zinc, copper and lead accumulation than *Lymnea accuminata,* while *Lymnea accuminata* has greater capacity for cadmium accumulation than *Bellamya bengalensis*.

INTRODUCTION

Heavy metal pollution in aquatic ecosystem has been recognized as a serious environmental problem. 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 pose risk of damage via uptake and subsequent bioaccumulation by organisms, which cannot effectively metabolize and excrete the absorbed metals. Several scientific observations have shown that heavy metals are bioconcentrated or bioaccumulated in one or several compartments across food webs (Soegianto and Irawan, 2008, Celechovska *et al.,* 2008). Besides, the contamination of resources with trace elements may have devastating effect on natural ecosystem functioning, as well as decrease of biodiversity and extinction of sensitive taxa (Bogatov and Bogatova, 2009; Bonanno and Giudice, 2010). Metal bioaccumulation can be of importance from the public health point of view, especially when a human consumes the accumulators. Secondly, this phenomenon is now being exploited in the assessment of environmental quality, in addition to chemical surveys of water and sediment (Javanshir and Shapoori, 2011).

In this respect, bottom sediments and invertebrates are very important links in metal cycles in the aquatic environment. Generally sediments can accumulate large amount of heavy metals and become their main reservoir in the wetlands (Svobodova *et al.,* 2002). Heavy metals accumulated in sediments can affects concentration of heavy metals in the organisms that dwells in these sediments (Kim and Kim, 2006). Benthic gastropods in wetlands have an especially close relationship with the sediments that comprises their habitat and feeding site. Gastropods in turn are used as food source by birds and fish, which in turn make them accessible for human consumption through food chain and eventually pose great health risk (Altindag and Yigit, 2005). Therefore they are regarded as an important link for transfer of heavy metals from the soils to organisms at a higher trophic level through aquatic food chain.

From many years, gastropods are known for their great capacity for accumulation of metals so actively under natural environments through water or food and for that reason are commonly studied around the world from the ecotoxicological point of view (Elder and Collins, 1991). Zhou (2008) reported that the snails accumulate metals to high concentrations than any other group of invertebrate and demonstrated the ability as potential bioindicator. Bioaccumulation of metals in snail species has been reported by several investigators from past two decades. Reed-Judkins *et al.* (1998) studied bioaccumulation of heavy metals in *Lymnaea stagnalis*. Snyman *et al.* (2000) studied bioaccumulation of metals in snail *Helix aspersa*. Enzemonye *et al.* (2006) studied bioaccumulation of heavy metals (Cu, Zn, Fe) in freshwater snail (*Pliaovota*; Oliver 1804) from Ikpoba River of south Nigeria. Kim and Kim (2007) studied heavy metals accumulation in *Oxyloma hirasei* from the Upo wetland. Jan Sychra *et al.* (2011) studied metal accumulation in pond snail *Lymnaea stagnalis* in freshwater. Astani *et al.* (2012) studied bioaccumulation of heavy metals in soft body tissues of gastropods *Thais mutabilis* and sediments from intertidal zone of Bandar Abbas.

There have never been any published reports on the background of metal accumulation in freshwater snail species *B. bengalensis* and *L. accuminata*. The bioaccumulation database might be used for metal monitoring programme in fresh water ecosystem.

A mollusc potential to accumulate metals from surface water/ soil sediments into its tissue can be estimated using BWAF/ BSAF values (Usero *et al.* 2005). By comparing BWAF/BSAF values, one can compare the potential of different snails to uptake metals from medium into body.

Therefore the objective of this study was to determine the concentrations of heavy metals zinc, copper, cadmium and lead in surface water, soil sediments and snail's species, *B. bengalensis* and *L. accuminata* inhabiting at the Malangaon dam and to find out suitable snail species as sentinel animal for monitoring of metal pollution in the freshwater ecosystem.

MATERIALS AND METHODS

Study area

The Malangaon dam was constructed in 1967, situated on Kan River near Malangaon village and is 14 km away from Pimpalner. The storage capacity of the dam is 11.33 million sq. meter. The dam is earthen type its length is 1091 meters and the height is 23 meter. The average area of the dam is 1587 hectares. The Malangaon wetland has input load of anthropogenic activities which is a subject of great concern. The Kan River flows from mountain to plain, resulting in weathering of soil and rocks which are the sources of heavy metals. Agricultural, industrial and domestic effluents containing various organic and inorganic pollutants, like solvents, oils, heavy metals, pesticides and fertilizers etc are invariably discharged into river without their proper treatment. These lead to changes in the water quality. The water of dam is being used for a public, industrial supply, irrigation and fishing purpose, therefore it is imperative to monitor the metal pollution. Furthermore there have never been any published reports on this background.

Surface water, soil sediments and snail species were collected during the period of July to September 2009 from different sites of Malangaon dam. Surface water samples were collected from 50 cm depth at morning hours and were filtered and mixed with concentrated HNO_3 and preserved in a refrigerator at 4ºC before laboratory analysis. Soil sediments were collected at 5, 10 and 15 cm depth by Core 1, Core 2 and Core 3 vertical cores respectively. Immediately after collection soil samples were sieved by using a sieve (mesh size 0.5mm) and the fine fraction obtained were air dried. Air dried samples were then ground by using a glass mortar and again sieved thoroughly and obtained homogeneous powders, were preserved in a desiccators till digestion.

At least 50 specimens of each snail species were collected different sites of dams and brought in the same water to the laboratory. From these snails, medium, equal sized ten animals of each species were selected by measuring the length and width of the animals. The snails were dissected within 12 hours of collection and their whole body tissues were removed, washed in distilled water and dried separately in oven at about 80ºC. After complete drying the tissues were powdered in mortar and pastel and stored separately by labeling the specimen with date and species name.

500 mg dry powder of whole soft body tissue of snails was digested in 10mL mixture of Nitric acid: Perchloric acid in 5:1 ratio. After half h stirring the samples were left overnight and on next day samples were digested on hot plate till the clear white fumes appeared. 10mL volume of solution was maintained by adding acidic mixture of Nitric acid: Perchloric acid drop by drop. After allowing the flask to cool, double glass 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. Surface water and soil sediments were also similarly processed. The analysis of metal concentrations in surface water, soil sediments and whole body tissue of snails were carried out by Atomic Absorption Spectrophotometer (AAS).

Dry weight of each animal was used to calculate the metal concentration per unit body weight (μg/g). The BWAF/BSAF values of the metals in the tissues of the snails were calculated by dividing the concentration in the surface water/ soil sediments in which the animals were exposed. Results were expressed as mean $\pm$ standard deviation (SD). Difference among the mean values of bioaccumulated metals of snails were analyzed by Student's t-test.

RESULTS AND DISCUSSION

Metal concentration of surface water, soil sediments and snail's species were determined and summarized in Table 1. The results showed that in surface water the cadmium (0.0259mg/ L) and lead (0.0730 mg/L) concentrations were exceeding higher limit of WHO drinking water standard (WHO, 1993). The levels of zinc (0.3117 mg/L) and copper (0.0235 mg/L) concentrations were observed below the WHO standard limit. The results indicated that Malangaon dam water was polluted by cadmium and lead.

It was found that the concentrations of zinc (1565.6μg/g), copper (1371.3μg/g) and lead (125.3μg/g), in soil sediments were higher than cadmium (90.16μg/g) as given in Table 1. It was also observed that concentrations of all four metals zinc

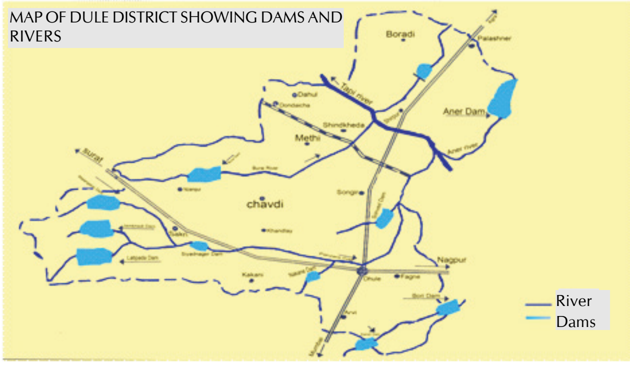

Figure 1: Map showing study area- Malangaon Dam

(1565.6µg/g), copper (1371.3µg/g), cadmium (90.16µg/g) and lead (125.3µg/g) were much more higher in soil sediments than surface water.

Levels of heavy metals per gm dry tissues as showed in Table 1 indicated that the freshwater snail, *B. bengalensis* accumulated higher concentrations of zinc (3498.6µg/g), copper (4655.3µg/g) and lead (1541.3µg/g) than *L. accuminata,* while *L. accuminata* accumulated higher concentration of cadmium (107.63µg/g) than *B. bengalensis*. It was also observed that the metal concentrations in both snails' species were higher than the surface water and soil sediments.

Bioaccumulation of metals, by aquatic life is dangerous since these metals could be transported directly upon consumption to humans (Asuquo *et al.,* 2004). Through biological magnification, some aquatic organisms may build up concentration of metals present in low concentration in environment to levels which are harmful to life and exceed public health standard (Philips, 1976).

The BWAF/BSAF values were determined to evaluate the potential of metal bioaccumulation in the snail species, from surface water/soil sediments into their tissues. In this study BWAF values refers to the concentration of a particular metal in a tissue of a snail per concentrations of that metals in water. Table 1 showed higher values of biowater accumulation factor (BWAF) for zinc (11.22×10^2), copper (198.6×10^2) and lead (21.11×10^2) in *B. bengalensis* as compared to *L. accuminata,* while higher value of biowater accumulation factor (BWAF) for cadmium (4.15×10^2) were observed in *L. accuminata,* than *B. bengalensis*. Such high value of (BWAF) indicated that the snail accumulated these metals in considerably high quantity in their tissues. The high BWAF values showed that these snail species are best bioindicators for monitoring these metals as pollutants in water and vice versa.

Biosediment accumulation factor (BSAF) is defined as the ratio of metal concentration in the snail to that in soil sediments. Table 2 showed higher (BSAF) values for zinc (2.24), copper (3.40) and lead (12.4) in *B. bengalensis* compared to *L. accuminata,* while higher (BSAF) values for cadmium (1.19) in *L. accuminata,* than *B. bengalensis*. Thus, this investigation indeed indicated that *B. bengalensis* was able to accumulate higher quantity of zinc, lead and copper, while *L. accuminata* was able to accumulate higher quantity of cadmium.

During the present study, it was observed that the magnitude of heavy metal accumulation in snails tissues depend upon type of heavy metal and the species of the snail. The observed differences in tissues metal concentrations between snail species might be due to variation in reproductive condition, genotype of the animal, difference in metabolic rate, body weight, trophic position, presence or absence of enzyme system that can degrade the pollutants (Valavanidis and Vlachogianni, 2010). Variability between closely related species was reflected by difference in the biokinetics of uptake, elimination and different physiological rates such as pumping, filtration and respiration. These qualities are specific for different species. 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 the species-specific digestive physiology and absorption rate of a metal across gut epithelium (Jung and Byeong, 2005; Lee and Lee, 2005). Differences in metal efflux rates are also important in determining interspecific differences in accumulated metal concentrations among the snail's species. Interaction of metals in body tissues seems to vary from species to species. At the same time the responses of the organism is specific for different element and substance (Waykar and Shinde, 2011; Waykar *et al.* 2011; Waykar and Deshmukh, 2012). Therefore, two species that live in a same place can differ in the types and concentrations of metals they accumulate (Wang, 2002). Intraspecific and interspecific variation has been observed across many taxa with respect to resistance to natural environmental stressors (Arad *et al.,* 1993). The species which are more tolerant to respective metal accumulate more metal, while less tolerant species accumulate less metal or may not

Table 1: Metal concentration and BWAF and BSAF values in surface water, soil sediments and snail species (tissue dry weight basis) of study area (Malangaon dam), permissible value for drinking water (WHO, Standard, 1993)

Metal	(WHO, standard 1993) (mg/L)	Concentration of metals in water mg/L	Concentration of metals in sediment µg/g	Snail species	Concentration of metals in tissue ¼g/g	BWAF value	BSAF value
Zinc(Zn)	3	0.3117±0.00954	1565.6±19.56	*B. bengalensis*	3498.6±8.073	11.22×10^2	2.24
				L. accuminata	1798.8± 2.43	5.77×10^2	1.15
Copper	2	0.0235±0.0012	1371.3±6.51	*B. bengalensis*	4655.3 ± 5.76	198.0×10^2	3.4
				L. accuminata	690.1 ± 6.53	29.36×10^2	0.51
Cadmium	0.003	0.0259±0.00165	90.16±0.6028	*B. bengalensis*	83.5± 0.3605	3.22×10^2	0.93
				L. accuminata	107.63± 0.3484	4.15×10^2	1.19
Lead	0.01	0.073±0.0002121	125.3±0.5527	*B. bengalensis*	1541.3± 18.175	21.11×10^2	12.4
				L. accuminata	603.3± 0.5567	8.26×10^2	3.96

Values in (±) indicates the standard deviation survive (Barbour *et al.,* 1997). It was also known that aquatic molluscs possess very diverse strategies in the handling and storage of accumulated metals (Rainbow, 2002).

The finding of this study showed that the heavy metal concentrations, BWAF and BSAF values for zinc, copper and lead was highest in the *B. bengalensis*, while for cadmium it was highest in *L. accuminata*. Therefore these results indicated that *B. bengalensis* is sentinel organism for the biomonitoring of zinc, copper and lead and *L. accuminata* for cadmium in fresh water ecosystem. This study showed that water samples analyzed had higher lead and cadmium concentrations than the limit value set by regulating agencies (WHO, 1993). Here it necessary to control indiscriminate anthropogenic activities. Effective environmental monitoring exercise should be encouraged to check metal concentration from point and non-point sources. Heavy consumption of other aquatic animals from Malangaon dam by humans, as in the current situation, is therefore, at a risk of health implications**.**

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the department of Zoology, Dr. B. A. Marathwada University, Aurangabad (M.S.) 431004 India for providing laboratory facility for this work.

REFERENCES

Abdullah, M. H., Jovita, S. and Ahmad, Z. A. 2007. 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(3):** 69-74.

Altndag, A. and Yigit, S. 2005. Assessment of heavy metal concentrations in the food web of Lake Beysehir, Turkey. *Chemosphere* **60:** 552-556.

Arad, Z., Goldenberg, S., Avivi, T. and Heller, J. 1993. Intraspecific variation resistance to desiccation in the land snail Theba pisana. *Int. J. Biometeor.* **37:** 183-189

Astani, M., Vosoughi, A. R., Salimi, L. and Ebrahimi, M. 2012. Comparative study of heavy metals (Cd,Fe,Mn and Ni) concentrations in soft tissue of gastropods *Thais mutabilis* and sediments from intertidal zone of Bandar Abbas. *Advances in Environmental Biol.* **6(1):** 319-326.

Asuquo, F. E., Ewa-Oboho, I., Asuquo, E. and Udo, P. 2004. Fish species used as biomarker for heavy metal and hydrocarbon contamination for Cross River, Nigeria. *Environ* **24:** 29-37

Barbour, M. T., Gerritsen, J., Snyder, B. D. and Stribling, J. B. 1997. Revision to rapid bioassessment protocols for use in streams and rivers: periphyton, benthic macroinvertebrates, and fish. *EPA 841-D-97–002. US Environmental Protection Agency, Washington DC.*

Bogatov, V. V. and Bogatova, L. V. 2009. Heavy metal accumulation by freshwater hydrobionts in a mining area in the south of the Russian Far East. *Russ. J. Ecol.* **40:** 187-193

Bonanno, G. and Lo Giudice, R. L. 2010. Heavy metal bioaccumulation by the organs of *Phragmites australis* (common reed) and their potential use as contamination indicators. *Ecol. Indic.* **10:** 639-645

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

Christopher, B. N. dome Ekaluo, U. B. and Asuquo, F. E. 2010. 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 and Marine Sciences.* **2(4):** 317-321.

Elder, J. F. and Collins, J. J. 1991: Freshwater molluscs as indicators of bioavailability and toxicity of metals in surface water systems. *Rev. Environ. Contam. Toxicol.* **122**: 37-79.

Enzemonye, L. I. N., Enobakhare, V. and Ilechie 2006. Bioaccumulation of heavy metals (Cu, Zn, Fe) in freshwater snail (Pliaovota; Oliver 1804) from Ikpoba River of south Nigeria. *J. Aquatic sciences.* **21(1):** 23-28.

Jan Sychra, Olga Celechovska, Zdenka Svobodova, Oldrich Sychra, 2011. Lead, mercury and cadmium content in bottom sediments, reed (*Phragmites australis*) beds and great pond snails (*Lymnaea stagnalis*) in fishponds and the role of littoral zones in their accumulation. *Acta. Vet. Brno.* **80:** 313-321.

Javanshir, A. and Shapoori, M. 2011. Influence of Water hardness (Calcium concentration) on the absorption of Cadmium by the mangrove oyster *Crassostrea gaster* (Ostreidae; Bivalvia). *J. Food, Agriculture and Environment.* **9(2):** 724-727.

Jung, S. L. and Byeong, G. L. 2005. Effects of Salinity, Temperature and Food Type on the Uptake and Elimination Rates of Cd, Cr, and Zn in the Asiatic Clam Corbicula fluminea. *Ocean. Sci. J.* **40(2):** 79-89.

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

Kim, H. and Kim, J. G. 2007. Heavy Metal Accumulation in Oxylomahirasei from the UPO Wetland. *J. Ecol. Field Biol.* **30(1):** 81-86.

Lee, J. S. and Lee, B. G. 2005. Effects of salinity, temperature and food type on the uptake and elimination rates of Cd, Cr and Zn in the Asiatic Clam Corbicula fluminea. *Ocean. Sci. J.* **40(2):** 79-89.

Phillips, D. J. H. 1976. The common Mussel, *Mytilus edulis* as an indicator of pollution by zinc, cadmium, leads and copper II. Relationships of metals in the mussel to those discharged by industry. *Marine. Biology.* **38:** 71-80.

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

Reed-Judkins, D. K., Farris, J. L., Cherry, D. S. and Cairns, J. 1998. Food borne uptake and sub lethal effect of copper and zinc to freshwater snails. *Hydrobiologia.* **364:**105-118.

Snyman, R. G., Reinecke, S. A. and Reinecke, A. J. 2000. Hemocylic Lysosome response in the snail *Helix aspersa* after exposure to fungicide copper oxychloride. *Arc. Envriron. Conta. Toxicol.* **39:** 480-485.

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

Svobodava, Z., Celechovska, O., Machovo, J. and Randak, T. 2002. Content of arsenic in market ready rainbow trout (*Concorhynchus mykiss*). *Acta. Vet. Brno.* **71:** 361-367.

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

Valavanidis, A. and Vlachogianni, T. 2010. "Integrated Biomarkers in Aquatic Organisms as a Tool for Biomonitoring Environmental Pollution and Improved Ecological Risk Assessment". *02.2010, Available from chem-tox-ecotox.org/wp/wp-content/.../01-January-20101.pdf*

Wang, W. X. 2002. Interactions of trace metals and different marine food chains. *Marine Ecology Progress Series.* **243:** 295-309.

Waykar, B. and Deshmukh, G. M. 2012. Evaluation of bivalve as biomonitors of heavy metal pollution. *Bull. Env. Contam. Toxicol.* **88(1):** 48-53.

Waykar, B. and Shinde, S. 2011. Assessment of the heavy metal bioaccumulation in three species of fresh water bivalves. *Bull. Env. Contam. Toxico.* **87(3):** 267-271.

Waykar, B., Shinde, S. and Deshmukh, G. M. 2011. Bioaccumulation of Metal in Freshwater Pelecypod Molluscs under Experimental Condition. *The Bioscan.* **6(4):** 537-542.

WHO 1993. Guideline for drinking water quality second edition, *http://www.lenntech.com/who-eu-water-standards.htm*

Zhou, Q., Zhang, J., Fu, J., Shi, J. and Jiang, G. 2008. Biomonitoring: An Appealing Tool for Assessment of Metal Pollution in the Aquatic Ecosystem. *Analytica Chimica Acta.* **606(2):** 135-150.