The Bioscan 11(1): 27-31, 2016
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

# BIO ACCUMULATION OF HEAVY METALS IN THREE FRESHWATER BIVALVE SPECIES FROM GIRNA RESERVOIR, NASIK (M.S.)

**RAHANE BALASAHEB[1], BHALLA RESHAM*[2] AND WAYKAR BHALCHANDRA[3]**
[1]Department of Zoology,
Swami Muktanand College of Science, Yeola, Nashik - 423 401, Maharashtra, INDIA
[2]Department of Zoology,
LVH Arts, Sci. & Comm. College, Panchavati, Nashik - 422 003, Maharashtra, INDIA
[3]Department of Zoology,
Dr. Babasaheb Ambedkar Marathwada University, Aurangabad - 431 004, Maharashtra, INDIA
e-mail: dr.resham.bhalla@gmail.com

**KEYWORDS**
Heavy metals cadmium
zinc
Copper and lead
Fresh water bivalves
Biomonitoring
Bioaccumulation
Girna reservoir

**Received on :**
16.09.2015

**Accepted on :**
17.12.2015

***Corresponding author**

**ABSTRACT**

The concentrations of heavy metals cadmium, zinc, copper and lead in surface water, sediments in three native freshwater bivalve species, *Lamellidens marginalis, Lamellidens corrianus* and *Parreysia cylindrica* were determined from Girna reservoir. The concentrations of all studied heavy metals were higher in the sediment than water. It was observed that the mean concentrations of lead (129.72¼g/g) was highest in *Lamellidens corrianus,* copper (134.27¼g/g) was highest in *Lamellidens marginalis,* while cadmium (24.72¼g/g) and zinc (443.26 ¼g/g) were highest in *Parreysia cylindrica*. The heavy metal concentrations in three species of bivalves were higher than those of the water and sediments. The bioaccumulated metal concentrations, BWAF and BSAF values indicate that *Lamellidens corrianus* have greater potential for lead bioaccumulation, and *Lamellidens marginalis* for copper, while *Parreysia cylindrica* have greater potential for cadmium and zinc bioaccumulation. Therefore, *Lamellidens corrianus* is proposed as sentinel animal for monitoring of lead and *Lamellidens marginalis* for copper, while *Parreysia cylindrica* for cadmium and zinc in freshwater reservoir

## INTRODUCTION

Mollusc, specially the species from bivalve class is frequently used to assess the bioavailability of metals in water (Aysun *et al.,* 2005; Abdullah *et al.,* 2007; Idown *et al.,* 2014). Molluscs are capable of achieving tissue concentrations of metals many times higher than those in water concentrations (Hartwig, 1995; Waykar and Shinde, 2011; Waykar and Deshmukh, 2012). Bivalves are filter-feeder, sedentary, widespread and having a long life span and ability to accumulate heavy metals in their body to elevated levels reaching concentrations that are much higher than those of ambient water concentrations makes these organisms useful for assessment purpose (Davies *et al*., 2006; Huang *et al*., 2007 and Casas *et al.,* 2008). In wetlands bivalves have an especially close relationship with the sediments that comprises their habitat and feeding site. The natural aquatic systems are extensively contaminated with heavy metals released from anthropogenic activities (Dirilgen, 2001; Vutukuru, 2005). The term "heavy metals" refers to any metallic element that has a relatively high density and is toxic at low concentration (Lenntech, 2004). Heavy metals, pesticides find their path from the medium into the body of animals and accumulate in different tissues (Himanshu Bhushan Mahananda et.al.,2013) Research has shown that metals have the ability to bio concentrate in organisms directly from the water and bio accumulated and biomagnified heavy metals within food chains, cause higher trophic organisms to become contaminated with higher concentrations of chemical contaminants than their prey (Hargrave *et al.,* 2000 and Lee *et al.,* 2000; Boran and Altinok, 2010; Shariati *et al.,* 2011). The heavy metals received major attentions because of their persistent toxic effect and their ability to bio accumulate within compartments of environment (Sarabjeet and Dinesh, 2007 and Otitoloju and Don- Pedro, 2002a). Generally sediments can accumulate large amount of heavy metals and become their main reservoir in the wetlands (Svobodova *et al.,* 2002). The capacity of sediment to accumulate pollutants makes them one of the most significant tools to assess environmental impact on aquatic ecosystems (Silva and Rezende, 2002). Heavy metals accumulated in sediments can affects concentration of heavy metals in the organisms that dwells in these sediments (Yap *et al.,* 2002; Kim and Kim, 2006

Bioaccumulation of toxicants is one of the tools used in bio monitoring (Chapman, 1997) and is the only way to evaluate the bioavailability of pollutants present in the water. Many species have been studied to determine their potential as a biomonitoring organism and bivalve have become a popular choice for metal monitoring (Kljakovic-Gaspic *et al.,* 2007) *Lamellidens corrianus, Lamellidens marginalis* and *Parreysia cylindrica* inhabiting the Girna reservoir. The bivalve's potential to accumulate metals from surface water/ sediments into its tissue can be determined using BWAF/BSAF values (Szefer *et al.,* 1999; 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. Therefore the aim of this study is to determine the concentrations of heavy metals zinc, copper, cadmium and lead in water, sediment and native freshwater bivalve species, *Lamellidens corrianus, Lamellidens marginalis* and *Parreysia cylindrica* inhabiting the Girna reservoirs and to determine BWAF/BSAF values to find out suitable bivalves species as sentinel animal for monitoring of metal pollution in the fresh water ecosystem.

## MATERIALS AND METHODS

**Study site - Girna reservoir**

Girna reservoir is earthen dam constructed in 1969 on Girna river at Nandgaon in Nasik district of Maharashtra state, India. Geographically, reservoir is located at 20º29'16" N and 74º39'41" E. The reservoir water is used for irrigation, industrial as well as for drinking purpose. The location of the reservoir is shown in Fig. 1.

**Sampling techniques**

Water and sediments samples were collected from different places of Girna reservoir during the period of November 2010 to October 2011. Surface water samples were collected from different places of reservoir from 50cm depth in morning hours in triplicates and were mixed together for each location so as to portray the average condition in the area.

**Determination of potential of heavy metal accumulation**

The Biowater Accumulation Factor (BWAF) and Biosediment Accumulation Factor (BSAF) values of the metals in the tissues of the bivalve species were calculated by dividing the concentration in the surface water/ soil sediments in which the animals were exposed (Szefer *et al.,* 1999; Usero *et al.,* 2005).

$$\text{BWAF} = \frac{\text{Concentration of heavy metal in animal tissue}}{\text{Concentration of heavy metal in water}}$$

Results were expressed as mean ± standard deviation (SD). The paired sample student's' test were used in order to access whether heavy metal concentrations varied significantly between species. The probabilities less than 0.05 ($p<0.05$) were considered statistically significant. All statistical calculations were performed with SPSS 21.0 version.

$$\text{BSAF} = \frac{\text{Concentration of heavy metal in animal tissue}}{\text{Concentration of heavy metal in soil sample}}$$

## RESULTS AND DISCUSSION

The heavy metals Zn, Cu, Pb and Cd concentrations in surface water, sediments and whole soft body tissues of freshwater bivalve, *Lamellidnes corrianus*, *Lamellidens marginalis* and *Parresiya cylindrica* sampled from Girna, reservoir of Nasik district were determined and obtained results are presented in Table 1. The concentrations of cadmium (0.007 mg/L) and lead (0.0250 mg/L) in surface water were higher than the WHO (1998) recommended limits for drinking water standards; where as those of zinc (0.1008mg/L) and copper (0.0193mg/l) were within the limits. The highest concentrations of heavy metals Zn, Cu, Pb and Cd were recorded in surface water sampled from Girna reservoir might be due to heavy input of various pollutants through Girna river. Girna river originate from the hilly ranges of Sahyadries and flows from mountain to plain, and weathering soil and rock have become sources of heavy metal (Nriagu, 1989; Kennish, 1992; Florea and Busselberg, 2006). The data in table 1 compares the mean values of heavy metal concentrations in whole soft body tissues of three native freshwater bivalve species collected from Girna reservoir (¼g/g dry tissue weight with ±SD). In the present investigation it was observed that different species of bivalves showed different capacities for accumulating different heavy metals. As mean lead (129.72 ¼g/g) concentrations appeared higher in *Lamellidens corrianus*, copper (134.27 ¼g/g) in *Lamellidens marginalis,* while cadmium (24.72 ¼g/g) and zinc (443.26 ¼g/g) in *Parreysia cylindrica*. The results of paired sample student't' test indicated that the differences between the mean values of heavy metal concentrations of the three bivalve species were statistically significant ($p<0.05$) (Table 1). The metal concentrations measured reflect a clear influence of anthropogenic activities. It was also observed that the metal concentrations in three bivalve species were higher than the water and sediment.

The values of Bio water Accumulation Factor (BWAF) and Bio sediment Accumulation Factor (BSAF) were determined to evaluate the potential of metal bioaccumulation in bivalve species from surface water/sediments into their tissues. Table 1 showed the higher values of BWAF and BSAF for Pb in *Lamellidens corrianus,* for Cu in *Lamellidens marginalis*, while for Zn and Cd in *Parreysia cylindrica*. The results of paired sample student 't' test indicated that the differences between the mean values of BWAF and BSAF for the three bivalve species were statistically significant ($p<0.05$) (Table 1). The high values of BWAF and BSAF indicate *Lamellidens corrianus* are able to accumulate higher quantity of Pb and *Lamellidens marginalis* able to accumulated higher quantity of copper, while *Parreysia cylindrica* are able to accumulate higher quantity of cadmium and zinc from water/ sediments into their tissues. The higher metal concentrations in water and soil sediments can be responsible for the highest metal accumulation in three bivalve species inhabiting at Girna reservoir. Shinde (2013) reported that metal concentrations in the soft body tissues of mollusc were related to metal levels in the water column. Deshmukh (2013) reported that metal concentrations in the soft body tissues of mollusc were related to metal levels in the environmental compartments (water, suspend particles and sediments). Thus, it can be concluded that the heavy metals are highly accumulated in sediments

**Table 1: Metal concentrations, BWAF and BSAF values of surface water, soil sediments and bivalve species (tissue dry weight basis) of Girna reservoir, Nasik**

| Metal | WHO Standard mg/L | Conc. of Metals in water mg/L | Conc. of Metals in Sediments $\mu$g/g | Bivalve species | Conc. of metals in tissues $\mu$g/g | BWAF | BSAF |
|---|---|---|---|---|---|---|---|
| Zn | 03 | 0.1008 ± 0.0005 | 167.32 ± 2.68 | *L. corrianus* | 432.08 ± 5.37 | 2996.39 ± 22.23 | 1.90 ± 0.12 |
| | | | | *L. marginalis* | 437.21 ± 5.81 | 3031.97 ± 23.14 | 1.92 ± 0.18 |
| | | | | *P. cylindrica* | 443.26* ± 5.62 | 3073.93* ± 25.61 | 1.95* ± 0.20 |
| Cu | 02 | 0.0193 ± 0.0005 | 48.54 ± 0.54 | *L. corrianus* | 112.26 ± 1.63 | 4301.15 ± 26.13 | 1.58 ± 0.14 |
| | | | | *L. marginalis* | 134.27* ± 1.56 | 5144.14* ± 32.68 | 1.89* ± 0.21 |
| | | | | *P. cylindrica* | 132.17 ± 1.92 | 5063.98 ± 32.17 | 1.86 ± 0.17 |
| Pb | 0.01 | 0.0250 ± 0.0002 | 14.92 ± 0.53 | *L. corrianus* | 129.72* ± 2.24 | 3837.87* ± 20.26 | 5.35* ± 0.56 |
| | | | | *L. marginalis* | 110.72 ± 1.95 | 3275.74 ± 19.23 | 4.56 ± 0.49 |
| | | | | *P. cylindrica* | 101.72 ± 2.63 | 3009.47 ± 18.20 | 4.19 ± 0.26 |
| Cd | 0.003 | 0.007 ± 0.0003 | 2.85 ± 0.27 | *L. corrianus* | 20.16 ± 0.78 | 2144.68 ± 13.24 | 4.57 ± 0.51 |
| | | | | *L. marginalis* | 23.92 ± 0.95 | 2544.68 ± 24.27 | 5.42 ± 0.61 |
| | | | | *P. cylindrica* | 24.72* ± 1.23 | 2629.79* ± 621.46 | 5.61* ± 0.68 |

Values in (±) indicates the standard deviation; Permissible limit of drinking water (WHO standard, 1998); *Indicates significant variation as per Paired sample student't' test at $p < 0.05$ in the bioaccumulation potential of mentioned species

than water, since the sediments act as reservoirs for all contaminants (Saeed and Shaker, 2008). Fitchko and Hutchinson (1975) reported that soil sediments act as indicators of the burden of heavy metals in an aquatic ecosystem, as they are the principal reservoir of heavy metals. The numerous investigators reported that the sediments accumulated more heavy metals than the water (Lau *et al.,* 1998; Besada *et al.,* 2001; Chindah and Braide 2003; Eja *et al.,* 2003). Qi *et al.* (2002); Zhang *et al.* (2002) and Ikem *et al.* (2003) also reported that the concentrations of heavy metals in soil sediments are much higher than those in the water. Casper *et al.* (2004) reported that aquatic sediments absorb constant and toxic chemicals to levels many times higher than the water column concentration. Many investigators also reported that sediment is the main sink for heavy metals in the aquatic ecosystems and also as source of pollutants (Burton and Scott, 1992; Caccia *et al.,* 2003; Cheung *et al.,* 2003; Ikem *et al.,* 2003; Audry *et al.,* 2004).

Abaychi and DouAbul (1985) reported that treated and untreated municipal, industrial wastes, agricultural run-off contribute to heavy metal Cu, Pb, Cd and Zn pollution source. Hutton *et al.* (1987) reported that sources of heavy metals Cd, Cu, Pb and Zn in surface water consist of leaching from Ni-Cd based batteries. The textile waste water is mixture of colorant (dyes and pigments). Large amount of chemically different dyes are employed for various industrial applications including textile dyeing (Pal and Brijmohan, 1990). The dyes used in these industries contain synthetic chemicals, which are generally metal based. Sharma *et al.* (1999) reported that waste water effluents from textile dyeing and printing industries contain dyes, bleaching agents, salts, acids and heavy metals like Cr, Cu, Pb and Zn. Chavan (2001) and Dubey *et al.* (2003) reported that major pollutant such as copper, lead, cadmium, zinc and chromium come mainly from the metal complex dyes. Aslam *et al.* (2004), Yusuff and Sonibare (2004) and Deepali and Gangwar (2010) reported that the textile industries effluent contains higher concentrations of Cu, Pb and Cd. Singh and Chandel (2006) conducted analytical study of heavy metals of industrial effluents at Jaipur, Rajasthan and concluded that textile industrial effluent contains Cu, Pb and Cd in higher levels. Malarkodi *et al.* (2007) reported that higher levels of Cd, Pb and Cu in soil of textile industries. Lokhande et.al (2011) reported that dyes, paints, textile industries are the major industries contributing to the Cd, Pb and Cu pollution in the aquatic environment. Jaishree and Khan (2014) reported that waste water effluents from textile dyeing and printing industries contains dyes, bleaching agents, salts, acids and heavy metals like Cr, Cu, Pb, and Zn.

Three sugar mills are in basin of reservoir, discharge effluents into the river, this might be sources of heavy metal pollution in the reservoir. Numerous investigators reported that sugar mill effluent contains heavy metals like Cu, Zn, Pb and Fe (Fakayode, 2005; Vermeulen and Vawada, 2008; Deshmukh, 2014; Saranraj and Stella, 2014 The Girna river brings huge amount of domestic waste, textile, printing, dyeing industrial and other industrial effluents along with organic matter, run-off from agricultural filed and traffic run-off, this might be reason for higher concentrations of heavy metals Zn, Cu, Pb and Cd in sediments collected from Girna reservoir. Halcrow *et al.* (1973) have reported that heavy metal concentrations in sediment increase of organic matter content. According to Presley *et al.,*

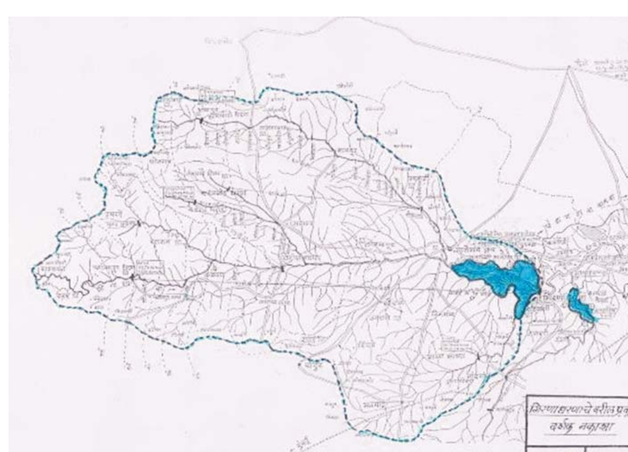

**Figure 1: Map of Girna reservoir**

(1980), the elemental concentration of sediments not only based on anthropogenic sources, but also upon the organic matter content, textural characteristic, mineralogical composition, and depositional environment of sediments. Harland *et al.* (2000) reported that the metal concentrations in the sediments depend on organic matter and particle size.

In the present study, it was observed that the magnitude of heavy metal accumulation depends upon type of heavy metal and the species of the bivalve. Waykar and Shinde (2011) and Waykar and Deshmukh (2012) reported that the element concentrations in molluscs differ between different species due to species-specific ability/capacity to regulate or accumulate trace metals. Therefore, two species that live in a same place can differ in the types and concentrations of metals they accumulate (Rainbow, 2002).

## ACKNOWLEDGEMENT

The authors gratefully acknowledge The Department of Zoology, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (M.S.) 431004, India, for providing laboratory facility for this work.

## REFERENCES

**Abaychi, J. K and Dou Abul, A. A. Z. 1985.** Trace metals in ShattAl-Arab river, Iraq. *Water Res.***19(4):** 457-462.

**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 Internat. *J. Environ. Sci Edu.* **2(3):** 69-74.

**Aslam, M. M., Baig, M. A., Hassain, I., Qazi, I. A., Malik, M. and Saeed, H. 2004.** Textile waste water characterization and reduction of its COD and BOD by oxidation. *Electronic J. Environ. Agricultural and Food Chemistry*. **3(6):** 804-11.

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

**Aysun Tiirkmen, Mustfa Tiirkmen and Yacin, T. 2005.** Biomonitoring of heavy metals from Iskenderum Bay using two bivalve species Chama pacifica Broderip,1834 and Ostrea stentina Payraudeau 1826. *Turkish J. Fisheries and Aquatic Sci.* **5:** 107-111.

**Besada, V., Fumega, J. and Vaamond, A. 2001.** Temporal trends of Cd, Cu,Hg, Pb and Zn in Mussel (*Mytilus galloprovinciatis*) from the SpanishNorth atlantic coast 1991-1999. *The Science of the Total Environment.* pp. 1-15.

**Boran, M. and Altýnok, N. 2010**. A Review of heavy metals in water, sediment and living organisms in the black sea. *Turkish J. Fisheries and Aquatic Sciences.* **10:** 565-572.

**Burton, Jr., G. A. and Scott, K. J. 1992**. Sediment toxicity evaluation, their niche in ecological assessment. *Environ. Sci. Tech.* **26:** 2068-2075.

**Caccia, V. G., Millero, F. J. and Palanques, A. 2003**. The distribution of trace metals in Florida Bay sediment. *Mar. Pollut. Bull.* **46(11):** 1420-1433.

**Casas, S., Gonzalez, J. L., Andral, B. and Cossa, D. 2008.** Relation between metal concentration in water and metal content of marine mussels (Mytilus galloprovincialis): impact of physiology. *Environ. Toxicol. Chem.* **27(7):** 1543-1552.

**Casper, S. T., Mehra, A., Farago, M. E. and Gill, R. A. 2004.** Contamination of surface soils, river water and sediments by trace metals from copper processing industry in the Churnet River Valley, Staffordshire, UK, Environ. *Geochem. and Health.* **26:** 59.

**Chapman, P. M. 1997.** Is bioaccumulation useful for predicting impacts. *Mar. Bull.* **34(5):** 282-283.

**Chavan, R. B. 2001.** Indian textile industry - environmental issues. *Indian J. Fiber and Textile Research.* **26:** 11-21.

**Chindah, A. C., Braide, S. A. and Osuamkpe, A. 2003.** Levels of hydrocarbons and heavy metals in sediment and a decapods crustacean (crab- *Uca tangeri*) in the Bonny/ New Calabar RiverEstuary, Niger Delta.

**Davies, O. A., Allison, M. E. and Uyi, H. S. 2006.** Bioaccumulation of heavy metals in water sediment and peiwinkle (Tympanotonous Fuscatus var radula) form the Elechi Creek, Niger Delta. *Afr. Jr. of Biotech.* **6:** 968-973.

**Deepali, K. K. and Gangwar, K. 2010.** Metals concentration in textile and tannery effluents, associated soils and ground water. *New York Science J.* **3(4):** 82-89.

**Deshmukh, G. M. 2013.** Biomonitoring of heavy metal pollution of jayakwadi reservoir at Paithan by using bivalves as bioindicators. Ph.D.thesis submitted to Dr.B.A.M.University,Aurangabad, (M.S.) India .

**Dirilgen, N. 2001.** Accumulation of heavy metals in freshwater organisims : assessment of toxic interactions. *Turk. J. Chem.* **25:** 173-179.

**Dubey, S. K., Yadav, S. P. and Chaturvedi, K. R. 2003.** Spatial changes in ground water quality as a result of land disposal of sewage effluent, A case study: International Conference on " Water Quality Management",New Delhi. pp. 13-15.

**Don-Pedro, K. N., Oyewo, E. O. and Otitoloju, A. A. 2004.** Trend of heavy metal concentrations in Lagos lagoon ecosystem. *Nigeria. WAJAE.* **5:** 103-114.

**Eja, M. E., Ogri, O. R. A. and Arikpo, G. E. 2003.** Bioconcentration of heavymetals in surface sediments from the Great kwa Rivers Estuary,Calabar, South Eastern Nig. *J. Nig. Environ. Soc.* **(2):** 247-256.

**Fakayode, S. O. 2005.** Impact of industrial effluents on water quality of the receiving Alaro River in Ibadan, Nigeria, Ajeam-Ragee, 10, 1-13.

**Fitchko, J. and Hutchinson, T. C. 1975.** A comparative study of heavy metal concentrations in river mouth sediments around the Great Lakes Res. **1:** 46-78.

**Florea, A. M., Büsselberg, D. 2006.** Metals and metal compounds: occurrence, use, benefits and toxic cellular effects. *Biometals.* **19:** 419-427.

**Halcrow, W., Mackay, D. W. and Thornton, I. 1973.** The Distribution of Trace Metals and Fauna in the Firth of Clyde in Relation to the Disposal of Sewage Sludge. *J. the Marine Biological Association of the United Kingdom.* **53:** 721-739.

**Hargrave, B. T., G. A. Phillips, W. P. Vass, P. Bruecker, H. E. Welch, and Siferd, T. D. 2000**. Seasonality in bioaccumulation of organochlorines in lower trophic level Arctic marine biota. *Environmental Science and Technology.* **34(6):** 980-987.

**Harland, B. J., Taylor, D. and Wither, A. 2000.** The distribution ofmercury and other trace metals in the sediments of the MerseyEstuary over 25 years: 1974-1998. *The Science of the Total Environment.* **253:** 45-62

**Hartwig, A. 1995.** Current aspects in metal genotoxicity. *Biometals.* **8(1):** 3-11.

**Himanshu Bhushan Mahananda., Behera, R. and Behera, M. K. 2013.** Heavy metal bio-accumulation in some selected tissues of channa punctatus (bloch): *The Ecoscan* **IV:** 23-26.

**Hutton, M., Chaney, R. l., Krishina, C. R., Murti, M., Olade, A. and**

**Page A. l. 1987.** Group Report In: Hutchinson TC and Meema KM (eds) Lead, mercury, cadmium and arsenic in the Environmental. *J. Wiley*, New York. pp. 35-41.

**Ikem, A, Egiebor, N. O. and Nyavor, K. 2003.** Trace elements in water, fishand sediment from Tuskegee Lake, southeastern USA. *Water, Air and Soil Pollution*. **149:** 51-75.

**Idown Emmanuel Taiwo, Amaeze Nnamdi Henry, Adie Peter Imbufe and Otubanjo Olubunmi, A. 2014.** Heavy metal bioaccumulation and biomarkers of oxidative stress in the wild African tiger frog, Hoplobatrachus occipitalis. *Afr. J. Environ. Sci. Tech.* **8(1):** 6-15.

**Jaishree and Khan T. I. 2014:** Monitoring of heavy metal in textile waste water of Sanganer, Jaipur (Rajasthan). *International J. Scientific and Research Publications.* **4(3):** ISSN 2250-3153.

**Kennish, M. J. 1992**. Ecology of Estuaries: Anthropogenic Effects, CRC Press, Inc., Boca Raton. pp. 1-494.

**Kim, H. and Kim, J. G. 2006.** 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.

**Kljakoviæ-Gašpiæ Z., Ujeviæ, I., Zvonariæ, T. and Bariæ, A. 2007.** Biomonitoring of trace metals (Cu, Cd, Cr, Hg, Pb, Zn) in Mali Ston Bay (Eastern Adriatic) using the Mediterranean blue mussel (1998-2005). *ACTA ADRIATIC.* **48(1):** 73-88.

**Lau, S., Mohamed, M., Tan Chi Yen, A. and Suut, S. 1998**. Accumulation of heavy metals in freshwater molluscs. Sci Total Environ **214:** 113-121.

**Lee, B. G., Grimscom, S. B., Lee, J. S., Choi, H. J., Koh, C. H., Luoma, S. N. and Fisher, N. S. 2000.** Influences of dietary uptake and reactive sulfides on metal bioavailability from aquatic sediments. *Science.* **287:** 282-284.

**Lenntech 2004**. Water Treatment and Air purification. Water Treatments Published by enntech, Rotterdam Sereg, Netherlands (www. excewater. com/hhp/filers/waterpurificcationhtm). *Retrieved* 23/12/2007.

**Lokhande, R. S., Singare, P. U. and Pimple, D. S. 2011.** Study of physicochemical parameters of wastewater effluents from Tajoja Industrial area of Mumbai, *India. Intern J. Ecosystem*. **1(1):** 1-9.

**Malarkodi, M., Krishnasamy, R., Kumaraperumal, R. and Chitdeshwari, T. 2007.** Characterization of heavy metal contaminated soils of Coimbatore district in Tamil Nadu. *J. Agronomy.* **6(1):** 147-151.

**Nriagu, J. O. and Pacyna, J. M. 1988.** Quantative assessment of worldwide contamination of air, water and soils by trace metals. *Nature.* **333:** 134-139.

**Otitoloju, A. A. and Don-Pedro, K. N. 2002a.** Bioaccumulations of heavy metals (Zn,Pb,Cu and Cd) by Tympanotonus fuscatus var radula (L) exposed to sublethal concentrations of the test metal compounds in laboratory bioassays. *WAJAE.* **3:** 17- 29.

**Pal, P. B. and Brijmohan 1990.** Management of occupational environment in textile industry. *Indian J. Environ Prot.* **10(10):** 767-772.

**Presley, B. J., Trefry, J. H. and Shokes, R. F. 1980.** Heavy metals inputs to Mississippi deltasediments, a historical view, Water, Air andsoil Pollution **13:** 481-494.

**Qi, J. S., Fu, C., Huang, X. S. and Tan, J. 2002.** Transfer of trace elements in water area ecology systems of the Three Gorges Reservoir (inChinese). *J. Chonqing Univers (Nat Sci Edn)* **25:**17-20.

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

**Saeed, S. M. and Shaker, I. M. 2008.** Assessment of heavy metals pollution in water and sediments and their effect on *Oreochromis niloticus* in the Northern Delta Lakes, Egypt. 8th International Symposium on Tilapia in Aquaculture. pp. 475-490.

**Sarabjeet Singh Ahluwalia and Dinesh, G. 2007**. "Microbial and plant derived biomass for removal of heavy metals from wastewater", *Bioresource Technology.* **(12):** 2243-2257.

**Saranraj, P. and Stella, D. 2014.** Impact of sugar mill effluent to the environment: A Review. *World Applied Science J.* **30(3):** 299-316.

**Shariati, S. R. P., Bonakdarpour, B., Zare, N. and Ashtiani, F. Z. 2011.** The effect of hydraulic retention time on the performance and fouling characteristics of membrane sequencing batch reactors used for the treatment of synthetic petroleum reûnery wastewater. *Bioresour. Technol.* **102(17):** 7692-7699.

**Silva, M. A. L. and Rezende, C. E. 2002.** Behavior of selected micro and trace elements and organic matter in sediments of freshwater system in Southeast Brazil. *Sci. Total Environ.* **292:** 121-128.

**Singh, Virendra and Chandel, C. P. Singh 2006.** Analytical Study of Heavy Metals of Industrial Effluents at Jaipur, Rajasthan (India), Journal of Environ. *Science and Engg.* **48(2):** 103-108.

**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.

**Szefer, P., Ali, A. A., Ba-Haroon, A. A., Rajeh, A. A., Geldonn, J. and Nabrzyski, M. 1999.** Distribution and relationships of selected trace metals in molluscs and associated sediments from the Gulf of Aden, Yemen. *Environ. Pollut.* **106:** 299-314.

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

**Vermeulen, P. L. M. and Vawada, A. S. 2008.** Impact of sugar factory effluent on the growth and biochemical characteristics of greengram and maize. *J. Environmental Science.* **81(5):** 449-454.

**Vutukuru, S. S. 2005.** Acute effects of hexavalent chromium on survival, oxygen consumption, hematological parameters and some biochemical profiles of the Indian Major carp, *Labeo rohita*. *Int. J. Environ. Res. Public Health.* **2(3):** 456-462.

**Waykar Bhalchandra and Deshmukh, G. M. 2012.** Evaluation of bivalves as bioindicators of metal pollution in freshwater. *Bull Env Contam Toxico.* **88(1):** 48-53.

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

**WHO 1998.** Guideline for drinking water quality second edition, *http://www.lenntech.com/who-eu-waterstandards. htm*

**Yap, C. K., Ismail, A., Tan, S. G. and Omar, H. 2002.** Correlations between speciation of Cd, Cu, Pb and Zn in sediment and their concentrations in total soft tissue of green-lipped mussel *Perna viridis* from the west coast of Peninsular Malaysia. *Environment International*. **28:** 117-126.

**Yusuff, R. O. and Sonibare, J. A. 2004.** Characterization of textile industries' effluents in Kaduna, Nigeria and pollution implications. **Global Nest.** *The International J.* **6(3):** 211-220.

**Zhang, X. H., Xiao, B. D., Chen, Z. J., Hui, Y. and Xu, X. Q. 2002.** Characteristics of the distribution of Cu, Pb, Cd, Cr, Zn in Xiangxi River (inChinese). *Resour Environ Yangtze Basin.* **11:** 269273.

..........From P. 022

be distinguished in the text and in the references by letter arranged alphabetically followed by the citation of the years eg.2004a, 2004b.

Standard abbreviations and units should be used, SI units are recommended. Abbreviations should be defined at first appearance and their use in the title and abstract should be avoided. Generic names of chemical should be used. Genus and species names should be typed in italics.

**PROOFS AND REPRINTS**

Page proofs will be sent by e-mail to the corresponding author. The corrected proofs should be returned to the Executive Editor within 7 days of receipt. The delay in sending the proofs may shift the paper to the next issue. Correspondence through e-mail will be preferred to avoid delay.

No gratis reprints are supplied. Authors have to purchase 25 or a multiple of it (as ordered) by paying the cost decided on the basis of number of printed pages. The paper will not be printed without proper payment of reprint cost in due time.

**MEMBERSHIP OF THE JOURNAL**

The individual membership is open only for students and authors. Others can become members of the journal by paying the institutional rates. The membership form should be neatly filled preferably in BLOCK letters. All the authors should become subscribers.

**CORRESPONDENCE**

Any correspondence regarding the manuscript should be made with Executive Editor to whom the paper has been submitted.

All correspondence regarding subscription, non-receipt of the issues etc. should be made with the managing editors.

**REMITTANCES**

All payments must be made by DD in the name of "The Bioscan" payable at Ranchi. Outstation cheques will not be accepted.

**Address for correspondence**
Dr. M. P. Sinha
Executive Editor
D-13, Harmu Housing Colony
Ranchi - 834002, Jharkhand (India)
e-mail: m_psinha@yahoo.com

**THE BIOSCAN : SUBSCRIPTION RATES**

| | | India (Rs.) | SAARC Countries | Other Countries |
|---|---|---|---|---|
| Individuals | One Year | 1,000 | 2,000(I:C) | US $200 |
| | Life Member* | 10,000 | | |
| Institutions | One Year | 3,000 | 6,000(I:C) | US $400 |
| | Life Member* | 30,000 | | |

*Life Member will receive the journal for 15 years while other benefits will continue whole life

**THE BIOSCAN : MEMBERSHIP FORM**

Please enter my subscription for the above journal for the year ........................................... / life member.

Name: ..........................................................................................................................................

Address: .......................................................................................................................................

E-mail: .........................................................................................................................................

Payment Rs. : ............................................................................................ by DD / MD in favour of

National Environmentalist Association payable at Ranchi, No. ..................................... Dated .................................. is enclosed.

**NOTE: FOR MEMBERSHIP THE ABOVE INFORMATION CAN BE SENT ON SEPARATE SHEET**