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Accumulation of heavy metal ions in water, sediment and aquatic weeds: A case study of Sudha Dam, Bhokar, India

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ABSTRACT

The metal pollution in water, sediment and its accumulation in some aquatic weeds of the Sudha dam in Maharashtra (India) was assessed for Cr, Cu, Fe, Mn, Se and Zn. The samples of water, sediment and aquatic weeds were collected at random from different areas of the dam covering all directions. All the samples were analyzed for metal ion concentration using UV-spectrophotometer. The water and sediment samples from the Sudha dam contains considerable amount of the metal ions studied. It has been observed that, in root and leaf all the ions get absorbed, while the extent for each element found different in the parts analyzed. Thus it can be clear that, Typha angustifolia and Vallisneria amricana absorbs heavy metal ions and can be used for minimizing the pollution taking place due to toxic metals from industrial effluents.

Key words: Metal pollution, sediment, *Typha angustifolia*, *Vallisneria amricana*, UV-spectrophotometer.

INTRODUCTION

In recent years the accumulation of metals in the aquatic ecosystem has become a problem of great concern throughout the world. These metals may accumulate to a very high toxic levels and cause sever impact on the aquatic organisms without any visible sign. Increase in population, urbanization, industrialization and agriculture practices have further aggravated the situation [1]. Soils and waters in many parts of the world are polluted by all kinds of chemicals and toxic heavy metals like cadmium, lead, chromium and mercury. In several countries effluents are often disposed directly into the surface waters [2].

The introduction of metallic pollutants into a water system, whether it is natural (erosion) or artificial (anthropogenic), can occur in dissolved and particulate form. Depending on physico-chemical conditions, the pollutants in dissolved form can latter precipitate. Heavy metals are widely used in automobiles, mining industries, pesticides, house-hold appliances, dental amalgams, paints, photographic papers, photochemicals etc., pollution of surface water system through anthropogenic activities is the major environmental problem faced all around the globe [3,4]. Distribution of heavy metals in water, sediments, plants and fish, vegetables play a key role in detecting sources of heavy metal pollution in aquatic ecosystem [5, 6].

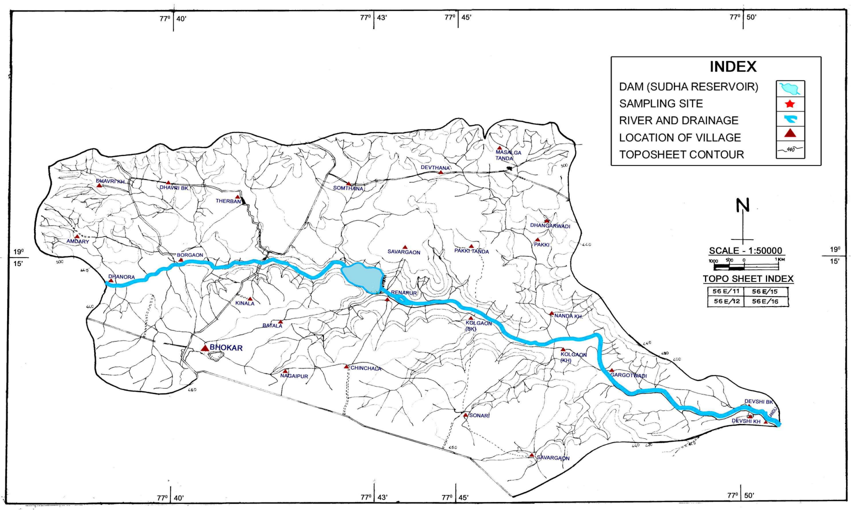
Trace metal contaminations are important due to their potential toxicity for the environment and human beings [7, 8, 9, 10]. Some of the metals like Cu, Fe, Mn, Ni and Zn are essential as micronutrients for the life processes in animals and plants while many other metals such as Cd, Cr, Pb and Co have no known physiological activities [11, 12, 13]. Concentrations of trace elements in water vary because of physiological, environmental and other factors. Some trace elements have several roles in living organism [14]. Chromium and its compounds are toxic metals introduced into natural water from a variety of industrial wastes. The major sources are from leather tanning, textile dyeing, electroplating and metal finishing industries which cause severe environmental and public health problems [15].

The results related to the metal concentrations determination by UV-spectrophotometer are presented and discussed in this paper.

MATERIALS AND METHODS

Description of site

The Sudha reservoir was constructed earlier and it is on the way to Kinwat road and at Bhokar towards eastern. The reservoir is situated 19^0 15' latitude 73^0 43' longitude. The catchments area of the reservoir is about 105.67 sq.kms. Sudha river is emerging from Sitakhandi near Bhokar of Nanded highways. The flow of water is from west to east in the direction. The area covered by this project is about 175.385 hectares. This project is highly benefited by several villages along with entire city of Bhokar. Several villages are benefited by this dam as the water from this dam was used in various sectors.



Water from the dam is mainly used for the purpose of agriculture, irrigation, drinking and domestic application. The water supplies to Bhoker and several villages, more than 75,000 peoples get benefited from this dam.

Collection of samples

Total 26 surface layer (0-10 cm) water samples were collected from different areas of the dam covering all the directions. Water samples were collected in 500 ml polythene bottles previously washed with deionized water and rinsed with the sample to be collected from different sites and acidified with concentrated nitric acid. Total 26 top sediment samples (1-5 cm deep top layer) were collected from different sites of the dam and stored in pre-cleaned polythene bags for processing. Total 60 aquatic plant i.e. thirty *Typha angustifolia* and thirty *Vallisneria amricana* were collected from different areas of the dam covering all the directions. These plants were brought into laboratory and washed to remove periphyton, dust and sediment particles. The material was stored in polythene bags.

Preparation of samples

Water sample (500 ml) was heated and reduced to 100 ml. sediment samples were dried, powdered and sieved. 50 gm soil samples were digested with a mixture of concentrated nitric acid (35 ml), perchloric acid (5 ml) and sulphuric acid (2.5 ml) at 75 – 80 ^oC for 4 -5 h on heating mantle till a clear solution is obtained. The plant materials were was sorted out in terms of roots and leaf, dried for 8 to 10 days and heated in an oven at 110 ^oC. The dried samples were grounded using mortar till finely dry powder was formed. The dried samples of root and leaf were weighed accurately and dissolved in nitric acid and perchloric acid in the ratio 3:1. The resulting mixtures were heated till a clear solution is obtained. The volume of each of the digested water, soil and plant samples was then made up to 100 ml with deionized water and kept for analysis.

Estimation of Metals

Standard procedures were used for quantitative estimation of metals Cr, Cu, Fe, Mn and Se by UV-Spectrophotometer. Chromium estimation was done by s-Diphenylcarbazide method at 540 nm, copper by neocuproine at 457 nm, iron by thiocyanate at 510nm, manganese by persulphte at 545nm, selenium by 3,3/ Diaminobenzidine method at 420nm and zinc by Dithizone method at 535nm. All analysis were done in triplicate and one blank was included for the final analysis.

RESULTS AND DISCUSSION

Trace metals in water

Results of metal concentrations with standard deviation of the study area from water were presented in the table 1. The water sample around the plants reveals that there is a considerable concentration of metal ions except chromium and selenium.

Table 1: Heavy metal accumulation in water from Sudha dam (n = 26).

Elements	Concentration (mg/l)	Standard Deviation
Cr	0.002	0.154
Cu	0.025	0.172
Fe	0.072	0.194
Mn	0.069	0.219
Se	0.009	0.180
Zn	0.63	0.236

Chromium

The concentration of Cr was found about 0.002 mg/l from the Sudha dam water. The concentration of chromium in water during the period of study remained below the WHO maximum allowable concentration of 50 µg/l.

Chromium naturally occurs in rocks, animals, plants, soil, and in volcanic dust and gases. It comes in several different forms including trivalent chromium and hexavalent chromium. Trivalent chromium is often referred to as Chromium (III) and is an essential nutrient for the body. Hexavalent chromium, or Chromium (VI), is generally used or produced in industrial processes and has been demonstrated to be a human carcinogen when inhaled.

The natural total chromium content of surface waters is approximately 0.5–2 µg/liter and the dissolved chromium content 0.02–0.3 µg/liter [16].

Copper

Copper is reddish, odorless metal. Most animals require copper for certain biological processes. The present study and analysis was undertaken for the determination of the concentration of copper of Sudha dam, Maharashatra. The concentrations of copper are shown in the table 1. Copper is rarely found in unpolluted water, although trace amount are sometime found in very soft, acidic moorland waters.

The water samples of River Sai and collected from ten different sites at Rai Bareli for the pre-monsoon period and after the onset of monsoon. He observed the maximum copper concentration in pre and after onset of monsoon 0.125 and 0.120 mg/L at sampling site no. X respectively. The minimum copper concentration 0.060 and 0.030 mg/L at sampling site No.VII and II respectively. Copper metal was present in moderate concentrations in River Sai water which may prove toxic to plants and algae [17].

The seasonal variation in heavy metal content of river Ganga at Varanasi. Copper and its compounds are ubiquitious in the environment and hence frequently found in surface water. The concentration of copper varying from lowest values of 1.04 to 3.24 µg/L at University and Bhadaini ghat (water intake point). Highest values of 3.1 to 6.0 µg/L at Rajendra Prasad ghat and Rajghat. Copper with maximum values in summer season (2.99 to 6.0 µg/L) and minimum during the rainy season (1.04 to 3.70 µg/L) [18].

Iron

During this study the average concentration of iron was recorded 0.072 mg/l. Surface waters generally contain less than 1 mg/l of iron. Some ground waters and acid surface drainage may contain much higher levels of iron. Water containing more than 2 mg/L iron cause staining of clothes (while washing) and porcelain, and imparts a bitter astringent taste.

The water samples collected from different sites of Godavari river analyzed for various physico-chemical parameters and heavy metals. They observed maximum iron concentration 13.6 µg/L at Thryambakeshwar (Nashik) sampling station and minimum of 4.2 µg/L at Gangakhed (Parbhani) sampling station (in Maharashtra) [19].

One of the work on the metal contents such as iron, cobalt, nickel, manganese, lead, zinc and copper were determined from the fresh water resources of remote area from Radhanagari forest. The iron content in the water resources from study area ranged from 0.018 µg/L to 6.23 µg/L. The highest iron content was recorded at sampling site H that is at Gidhadache pani, which is seasonal shallow water body present at higher platue region at Dajipur forest [20].

Manganese

The present study and analysis was undertaken for the determination of the concentration of manganese from the Sudha dam. The average concentration of manganese was found to be 0.069 mg/l.

One research work [21] on river Beas has been studied for trace metals in 470 km stretch from Manali to Pongdam. Observed the manganese concentration ranged from 0.051 mg/L at Pongdam (Downstream) to 0.580 mg/L at Mandi (Downstream) sampling station. The higher contamination of trace metals was found downstream of Mandi may be due to untreated or partial treated sewage or domestic waste discharge into the river itself.

Selenium

The concentration of Se was found about 0.009 mg/l from the Sudha dam water. The concentration of chromium in water during the period of study remained below the WHO maximum allowable concentration of 10 µg/l.

Selenium is an essential nutrient at low levels. The levels of selenium in groundwater and surface water range from 0.06 to about 400 µg/litre (5–7); in some areas, levels in groundwater may approach 6000 µg/litre (8). Concentrations increase at high and low pH as a result of conversion into compounds of greater solubility in water. Levels of selenium in tap water samples from public water supplies around the world are usually much less than 10 µg/litre [3]. Drinking-water from a high selenium area in China was reported to contain 50–160 µg/litre.

Zinc

During this study the average concentration of zinc was recorded 0.63 mg/l. Zinc tends to be found in only trace amounts in unpolluted surface waters and groundwater’s. However, it is often found in domestic supplies as a result of corrosion of galvanized iron piping and tanks and dezincification of brass fittings. The concentrations usually found in drinking water are unlikely to be detrimental to health. Zinc has a threshold taste at approximately 5 mg/L and can also cause opalescence above this value [22].

Some researcher [23] carried the work on Ramganga river water in a 25 km stretch at Moradabad has been studied for pollution with special emphasis on toxic metals during winter, summer and rainy seasons. They reported the maximum zinc concentration 0.752 mg/L at Katghar Bridge downstream during winter and summer seasons and minimum 0.246 mg/L at Agwanpur downstream in both the seasons. The zinc concentration was not very high.

Trace metals in sediment

Table 2 represents the concentrations of various metals during the study period from the sediments of the Sudha dam. The average concentrations of Cr, Cu, Fe, Mn, Se and Zn were 0.006, 0.98, 1.21, 1.34, 0.012 and 2.13 mg/gm. The order of heavy metal accumulation in sediment was Zn > Mn > Fe > Cu > Se > Cr. The data indicate that zinc was maximally accumulated in the dam sediment where as chromium got least concentrated.

Table 2: Heavy metal accumulation in sediment from Sudha dam (n = 26)

Elements	Concentration (mg/gm)	Standard Deviation
Cr	0.006	0.018
Cu	0.98	0.370
Fe	1.21	0.531
Mn	1.34	0.562
Se	0.012	0.142
Zn	2.13	0.366

The data from Table 2 reflect that the sediment from Sudha dam contained significant amount of heavy metals. Sediments acts as the most important reservoir or sink of metals and other pollutants in the aquatic environment. In general, metal concentration in the sediment increases with the decrease of particle size and increase of organic matter content [24]. Contaminated sediment can cause decrease in the ecosystem biodiversity and affect the aquatic system's food chain. The organisms of food chain have been used as biomarkers in assessing level of contaminants in sediments [25].

Trace metals in Aquatic weeds

Similar analysis as that of water and sediment carried out for two aquatic weeds from the Sudha dam. Table 3 and 4 shows the concentrations of different metals in root and leaf of the *Typha angustifolia* and *Vallisneria amricana*. The accumulation of all the metal ions is highest in the roots. The concentrations of the metal ions in root and leaf are compared and the order for *Typha angustifolia* is:

Root : Fe > Mn > Zn > Cu > Cr > Se.
Leaf : Zn > Mn > Fe > Cr > Cu > Se

The order for *Vallisneria amricana* is:

Root : Fe > Zn > Mn > Cu > Cr > Se.
Leaf : Zn > Fe > Mn > Cr > Cu > Se

Table 3: Heavy metal accumulation in *Typha angustifolia* parts from Sudha dam (n = 30)

Elements	Root		Leaf	
	Concentration (mg/kg)	Standard Deviation	Concentration (mg/kg)	Standard Deviation
Cr	0.23	0.263	0.17	0.115
Cu	0.71	0.322	0.11	0.112
Fe	1.93	0.616	0.54	0.235
Mn	1.42	0.573	0.62	0.364
Se	0.017	0.145	0.009	0.093
Zn	1.29	0.581	0.74	0.317

The metal mobility within the plant was in the descending order of Zn>Ni>C>Pb. Zinc is an essential element for plant metabolism [26].

Some researchers [27] mentioned that the accumulation of metal ions in various parts of aquatic macrophytes is often accompanied by cellular changes which decide the metal tolerance capacity of the plants. The present investigation shows that the biomass of *Typha angustifolia* and *Vallisneria amricana* is an effective and inexpensive adsorbent for many toxic metals ions. The plants can be used to purify the water from industrial effluents.

Recently, there has been growing interest in the use of metal-accumulating roots and rhizomes of aquatic or semi aquatic vascular plants for the removal of heavy metals from contaminated aqueous streams. For example, water hyacinths (Eichhornia crassipes), pennywort (Hydrocotyle umbellate) and water velvet (*Azolla pinnata*) [28] take up Pb, Cu, Cd, Fe and Hg, from contaminated solutions.

Table 4: Heavy metal accumulation in *Vallisneria amricana* parts from Sudha dam (n = 30)

Elements	Root		Leaf	
	Concentration (mg/kg)	Standard Deviation	Concentration (mg/kg)	Standard Deviation
Cr	0.16	0.182	0.12	0.093
Cu	0.63	0.293	0.09	0.074
Fe	1.71	0.576	0.52	0.219
Mn	0.94	0.468	0.43	0.155
Se	0.012	0.113	0.008	0.061
Zn	1.13	0.491	0.83	0.321

Floating wetland plants seem to be an exception because they accumulate Cu to higher levels of 300 to 15000 mg/kg in duckweed, 6000 to 7000 mg/kg in water hyacinth [29], 2500 to 3000 mg/kg in bacopa [30] and 10000 to 19000 mg/kg in watercress [31].

A significant database exists describing the bioaccumulation of various contaminants by algae and macrophysics. These are used in ecological survey as in situ indicators of water quality due to their ability to accumulate chemicals, and to the fact that they comprise the largest biomass in wetlands and are immobile. The bioaccumulation ability of macrophysics has been studied in the field and laboratory for metals [32, 33] and pesticides [34].

CONCLUSION

Now a day the discharge of industrial effluents containing heavy metals into aquatic ecosystem has become a great concern in many major cities of India. The present investigation shows that these aquatic plants in their major parts absorb metal ions including toxic metal ions. Although these weeds are notorious, these are useful for removing toxic metal ions and hence can be used in controlled way to minimize pollution hazards in industrial effluents.

REFERENCES

[1] Giguere, A., Campbell, P. G. C., Hare, L., Mc Donald, D. G., & Rasmussen, J. B., *Canadian Journal of Fisheries and Aquatic Sciences*, **2004**, 61, 702– 1716.

[2] Mane P. C, Bhosle A. B, Deshmukh P. D, Jangam C. M., *Advances in Applied Science Research*, **2010**, 1 (3): 212-221.

[3] WHO (World Health Organization) **1988**. *Global Fresh Water Quality Assessment Report* WHO Int.Rept./PEP/88, Geneva.

[4] Hutchinson, T. C., Gordon, C. A., & Meema, K. M. (Eds.) **1993**, *Global Perspectives on Lead,Mercury and Cadmium Cycling in the Environment*. (Wiley Eastern Ltd.).

[5] Forstner, U.,Wittman, G. T.W.: **1981**, *Metal Pollution in the Aquatic Environment*, Springer-Verlag, Berlin, Heidelberg, NY.

[6] Odoh Rapheal and Kolawole Sunday Adebayo. *Advances in Applied Science Research*, **2011**, 2 (5):590-601.

[7] Gueu, S.; Yao, B.; Adouby, K.; Ado, G., *Int. J. Environ. Sci. Tech*., **2007**, 4 (1), 11-17.

[8] Lee, C. L.; Li, X. D.; Zhang, G.; Li, J.; Ding, A. J.; Wang, T., *Environ. Pollut*., **2007**, 41 (2), 432-447.

[9] Adams, R. H.; Guzmán Osorio, F. J.; Zavala Cruz, J., *Int. J. Environ. Sci. Tech*., **2008**, 5 (4), 445-454.

[10] Vinodhini, R.; Narayanan, M., *Int. J. Environ. Sci. Tech*., **2008**, 5 (2), 179- 182.

[11] Kar, D.; Sur, P.; Mandal, S. K.; Saha, T.; Kole, R. K., *Int. J. Environ. Sci. Tech*., **2008**, 5 (1), 119-124.

[12] Suthar, S.; Singh, S., *Int. J. Environ. Sci. Tech*., **2008**, 5 (1), 99-106.

[13] Aktar, M. W.; Paramasivam, M.; Ganguly, M.; Purkait, S.; Sengupta, D., *Environ. Monitor. Assess*., **2010**, 160.

[14] Ogbonna O, Jimoh W.L, Awagu E. F. and Bamishaiye E.I. *Advances in Applied Science Research*, **2011**, 2 (2): 62-68.

[15] Pramod C. Mane, Arjun B. Bhosle & Pandurang A. Kulkarni. *Archives of Applied Science Research*, **2011**, 3 (1): 222-229.

[16] Slooff W. **(1989)**. Integrated criteria document chromium. Bilthoven, Netherlands, *National Institute of Public Health and Environmental Protection*, (Report no. 758701002).

[17] Sinha D.K., *Poll. Res*. **2004**, 23(1), P: 113-116.

[18] Dwivedi Smriti & Tiwari I.C., *Indian Jour. Environ. Prot*., **1996**, 17(4): 281-286.

[19] Patil P.R. & Shrivastava V.S., *Indian Jour. Environ. Prot*., **2003**, 23(6): 650-653.

[20] Mule M.B. & Patil R.K., *Indian Jour. Environ. Prot*., **2000**, 20(1): 55-59.

[21] Singh T.B., Gupta D. & Sharma Ashok, *Indian Jour. Environ. Prot*. **1997**, 17(1), P: 43-46.
[22] Trivedi P.R. & Gurudeepraj., *Environmental management of fresh waterecology* (Ist Ed^{n}). Akashdeep Publishing house, **1992**, New Delhi.
[23] Sharma S.D. & Pande K.S., *Poll. Res*. **1998**, 17(2), P: 201-209.
[24] Halcrow, W., Mackay, D. W., & Thornton, L., *Journal of Marine Biology and Assessment*, **1973**, U.K., 53 : 721–739.
[25] US-EPA, United States *Environmental Protection Agency* **(2001)**. 2001 update of ambient water quality criteria for cadmium (p. 166).WashingtonDC, USA: US-EPA Health and Ecological Effects Criteria Division.
[26] Nora, F. Y., Wong Y. S., *Hydrobiologia*, **1997**, 352 (1): 67-75.
[27] Prasad M N V, Malec P, Waloszek A, & Strzallka K., *Plant Sci*, **2001**, 161: 881 – 889.
[28] Jain, S.K., P. Vasudan and N.K. Jha, *Biol. Wastes*., **1989**, 28: 115–26.
[29] Low, K. S., Lee C. K., Tai C. H., *J. Environ. Sci. Health*., **1994**, A29(1): 171-188.
[30] Gupta, M., Sinha S., Chandra P., *J. Environ.Sci. Health*., **1994**, A29 (10): 2185-2202.
[31] Kara, Y., Phd thesis, **1994**, University of Dicle., Diyarbakýr, Turkey,143.
[32] Aulio, K., *Bullet. Environ. Contam. Toxicol*., **1980**, 25: 713-717.
[33] Tripathi, B. D., Chandra P., *Bullet. Environ. Contam. Toxicol*., **1991**, 47 (5): 764-769.
[34] Hinman, M. L., Klaine S. J., *Environ. Sci. Technol*., **1992**, 26 (11): 2234-2239.