Indian Journal of Weed Science **46**(4): 361–363, 2014

Heavy metal extracting potential of common aquatic weeds

P.J. Khankhane*, Sushilkumar and H.S. Bisen
ICAR - Directorate of Weed Research, Jabalpur Madhya Pradesh 482 004

Received: 4 September 2014; Revised: 19 November 2014

ABSTRACT

The various ponds receive untreated sewage effluents from residential areas in Jabalpur city affecting water quality of the ponds. The very survival of aquatic weed species in contaminated water is testimony of ability of accumulating heavy metals. A survey was made to identify weed species grown in various ponds of Jabalpur for assessing their heavy metal potential. The heavy metals exhibited the sequence of their concentration in pond water as Fe > Cd > Mn >Ni >Cu. Among the weeds, *Eichhornia crassipes* accumulated higher concentration of cadmium, nickel, iron and manganese in their roots than shoots whereas *Alternanathera philoxeroides* accumulated higher metals in shoots than its root parts. Except nickel, higher bioaccumulation factor of Fe, Cd, Mn, Ni, Cu was exhibited by *Alternanthera philoxeroides* followed by *Eichhornia crassipes.* These observations may be exploited while selecting plant species for removal of heavy metals from contaminated water in an artificial wetland system.

Key words: *Alternanthera philoxeroides*, Cadmium, *Eichhornia crassipes*, Heavy metals, Iron, Manganese, Nickel

The contamination by heavy metals is serious concern for surface water and ultimately for animal and human health (Hammer and Keller 2002). The use of shoot part of *Alternanthera philoxeroides* as a cattle fodder due to high nutritional value in the region is the major concern which could find metal entry into human food chain (Sushilkumar and Vishwakarma 2005). Heavy metals, unlike organic pollutants can not be destroyed or changed to forms that are harmless. Treatments for remediation of polluted waters, should therefore aim at extracting these substances from water and concentrating them before final disposal. Among macrophytes, weeds are more suited to remove heavy metals from water due to its fast growth resulting high biomass. Therefore, phytoremediation of heavy metals using locally available potential weeds get more attention as remedial measures in present context.

Among the aquatic plants, *Eichhornia crassipes*, (water hyacinth) is a common aquatic weed in many tropical countries which has the ability to take up and accumulate elements from water and has been successfully used as indicator of heavy metal pollution (Pleiffer *et al*. 1986). *Alternanthera philoxeroides* (alligator weed) is also a serious weed grown both in aquatic and terrestrial environment which were also found to be the potential scavengers of heavy metals from aquatic environment (Bingzhong *et al*. 2007). However, distribution of heavy metals in plant body depends on their concentrations, species or even the population and part of the plants. For instance, roots usually show higher heavy metal content than shoots as they come into contact with the toxic metals (Breckle 1991). Moreover, *Alternanthera philoxeroides* is commonly used as a green fodder to feed milch animals in the region. Very few reports are available on metal removal by weeds grown in agro-climatic situations of Central India and most are confined to studies on nutrient uptake. Therefore, the present investigation was carried out for identification of locally available weeds for phytoremediation of heavy metal contaminated pond water of Jabalpur, India.

***Corresponding author:** pjkhankhane@yahoo.com.ph

MATERIALS AND METHODS

Different aquatic weed species and water samples were collected from various pond sites such as Ranital, Gullowa, Mansingh, Mahanadda, and Adhartal in Jabalpur, during winter 2008 and 2009. Five composite water samples were collected randomly from the ponds on which the test plants were growing. The five water samples were mixed, filtered through 0.45 micron membrane filter for analysis. For each plant species, five plants were collected randomly at the maturity stage. The plant samples were thoroughly washed and dried at 70 ^{0}C for 48 hours, ground and mixed for metal analysis. Weed samples (1 g) were digested in concentrated nitric and perchloric acid (5:1) till a clear solution was obtained. The solution was filtered, reconstituted to the desired volume and analysed by atomic absorption spectrophotometer make Thermo Solar S4.

RESULTS AND DISCUSSION

The contaminated water in drain was neutral in reaction with pH values ranging between 7.08 to 7.46 (Table 1) and thereby being well within the permissible limits of pH (Patel *et al.* 1990). The electrical conductivity (EC) values of 395 to 1678 µS/cm were also within critical limits recommended by United States Salinity Diagramme (1954). The dissolved oxygen (DO) varied from 1.75 at Gullowa to 3.3 mg/L at Ranital Pond. The chloride content was above the permissible limit at Mahanadda, Ranital and Gullowa except at Mansing and Adhartal pond. The heavy metals exhibited the sequence of their concentration in pond water in the order of Fe > Cd > Mn >Ni >Cu.The concentration of nickel, copper and manganese in water was far below from the critical limit of 0.2, 1.5 and 0.5 mg/L for public uses, respectively.

The dominant weeds in ponds were *Alternanthera philoxeroides, Eichhornia crassipes* and *Canna indica*. *Eichhornia crassipes* was dominant in Ranital and Gulluwa pond, *Alternanthera philoxeroides* in Mansing and Mahanadda and *Canna indica* in Mahanadda and Adhartal pond.There were marked differences in metal uptake among weed species growing on the ponds. Among the weeds, *Eichhornia crassipes* accumulated higher average concentration of nickel, cadmium, copper, iron and manganese to the extent of 20.9, 1.14, 59.5 (Fig. 1a) 6171 and 352 mg/kg (Fig. 1b), respectively. The elevated metal accumulation in *Eichhornia crassipes* growing in the pond waters indicated as a potential source of bio-monitoring of copper (Barman *et al.* 2001). The higher accumulation of nickel, iron and manganese by water hyacinth may be due to its strong metal absorbing ability. Depending on the element, the metal concentration in water hyacinth found much higher than in water which resulted higher heavy metal ratio between water and water hyacinth (Table 2). The concentration ratio of cadmium, copper, iron and manganese were observed higher in water hyacinth roots as compared to *Alternanthera philoxeroides* and *Canna indica* roots. Similar observations were reported by Wolverton and Mc Donald (1976). In case of cadmium transfer from water to root of water hyacinth, the free site of uptake of these substances might have helped to bind metal to root which is absorbed and accumulated by tissues of water hyacinth root (Hardy and Keeffe, 1985).

Alternanathera philoxeroides absorbed higher concentration of nickel from water and translocated to the shoot portion. Contrary to metal accumulation pattern of water hyacinth, *A. philoxeroides* exhibited 79.4 per cent of cadmium translocation from root to the shoot part (Table 3). This trend were found in conformity with the findings of Naqvism (1993) and Lokeshwari (2007). Apart from cadmium, the translocation of iron, manganese and nickel also exhibited higher translocation to the tune of 439, 148 and 136 per cent, respectively. Higher accumulation of iron by the *Alternanthera sessilis* was also reported

Table 1. Water quality and heavy metal concentration in ponds of Jabalpur

Parameter	Contaminated sites					
	Ranital	Gullowa	Mansing	Mahanadda	Adhatal	Mean
pH (µS/cm)	7.15	7.26	7.16	7.46	7.08	7.22
EC (mg/L)	938	1150	591	1678	395	950
DO (mg/ L)	3.3	1.75	2.52	1.32	3.2	2.42
Chlorides (mg/ L)	190	180	130	225	100	165
Nickel (mg/ L)	0.158	0.092	0.12	0.03	0.126	0.105
Copper (mg/ L)	0.06	0.002	0.02	0.09	0.005	0.035
Iron (mg/ L)	1.27	0.108	0.14	1.10	0.168	0.557
Cadmium (mg/ L)	0.043	0.077	0.62	0.17	0.020	0.186
Manganese (mg/ L)	0.130	0.109	0.08	0.096	0.111	0.105

Table 2. Heavy metal concentration plant parts of aquatic weeds

Weed	Plant part	Heavy metals (mg/kg)				
		Ni	Cd	Cu	Fe	Mn
Alternanthera philoxeroides	Shoot	441	16.4	2448	3586	1666
	Root	149	12.0	2839	569	1196
Eichhornia crassipes	Shoot	56.8	1.44	552	2645	1014
	Root	253	21.8	2868	6576	6624
Canna indica	Shoot	392	0.63	445	1414	951
	Root	465	4.24	719	959	2173

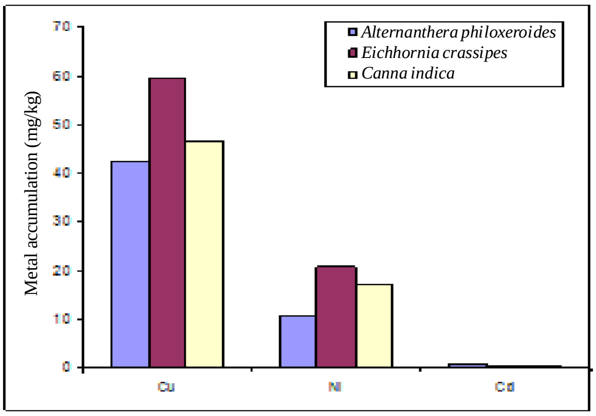

Fig. 1(a). Accumulation of copper and nickel by aquatic weeds

Table 3. Percentage of heavy metal translocation from root to shoot of aquatic weeds

Weed species	Ni	Cd	Cu	Fe	Mn
Alternanthera philoxeroides	136.2	79.4	34.4	439.2	148.1
Eichhornia crassipes	22.9	15.8	15.2	41.9	17.2
Canna indica	84.4	9.52	53.1	147.2	45.3

by Barman *et al* (2000). The *Canna indica* exhibited 53.1 per cent copper translocation from its root to the shoot. In view of the bio-magnification of heavy metals in the food chain, the higher toxic metal content such as cadmium and nickel in the shoot of *A. philoxeroides* were higher than the permissible level. Regular consumption of *A. philoxeroides* by milk animals may cause health problems in long term. The average normal concentration of cadmium is 0.05 µg/g (Elinder, 1988) and nickel is 1.5 ug/g of dry weight (PFA 1954).

Among the weed species, *E. crassipes* accumulated higher concentration of cadmium, nickel, iron and manganese. However, relatively higher metal concentration were found in roots of water hyacinth than its shoots whereas *A. philoxeroides* accumulated higher concentration of heavy metals in shoots than root part of the plants. In order to extract the heavy metals from water, both the plant species have utility for exploiting root of water hyacinth from lower layer of water and alligator shoot from top layer of water.

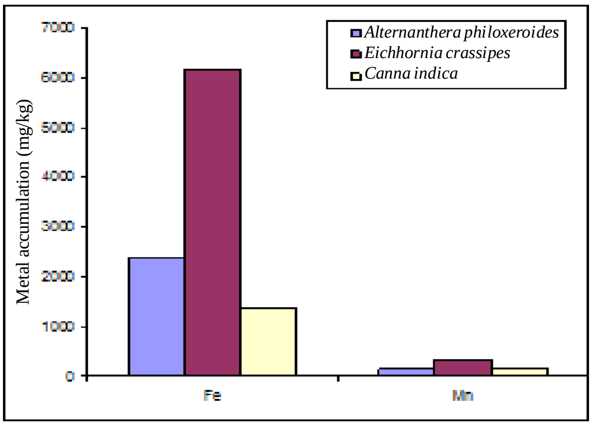

Fig 1(b). Accumulation of iron and manganese by aquatic weeds

REFERENCES

Barman SC, Sahu RK, Bhargava SK and Chatterjee C. 2000. Distribution of heavy metals in wheat, mustard and weed grown in field irrigated with industrial effluent. *Bulletin of Environmnetal Contamination & Toxicology* 64(4): 489-496.

Barman SC, Kisku GC, Salve PR, Mishra D, Sahu RK, Ramteke PW and Bhargava SK. 2001. Assessment of industrial effluent and its impact on soil and plant. *Journal of Environmental Biology* **22**(4): 251-256.

Bingzhong Ding, Guoxin Shi, Yexu, Jinzhao HU. Quinsong XU. 2007. Physiological response of *Alternanthera philoxeroides* (Mart) Griseb leaves to cadmium stress, *Environmental Pollution* **147**(3): 800-803.

Breckle SW. 1991. Growth under stress: Heavy metal, pp. 351-373. In: *Plant Roots: The Hidden Half* (Eds. waisel Y, Eshel A and Kafkafi U) Marcel Dekker, New York.

Elinder CG, Gerhardson L and Oberdaester G. 1988. Biological monitoring of cadmium. p. 145-147. In: *Biological Monitoring of Toxic Metals*. (Eds. Clarksm TW, Friberg L, Mordberg GF and Sager PR). Rochester series on Environmental Toxicity Pleneum Press.

Hammer D and Keller E. 2002. Changes in rhizosphere of metal accumulating plants evidenced by chemical extractants. *Journal Environmental Quality* **31**: 1561-1569.

Hardy JK and Keeffee O. 1985. Cadmium uptake by water hyacinth: Effects of root biomass, solution volume, complexes and other metal ions. *Chemoshere* **14**(5): 417-426.

Lokeshwari H and Chandrappa GT. 2007. Effect of heavy metal contamination from anthropogenic sources on Dasarathi tank, India. *Lakes & Reservoirs: Research and Management* **12**(3): 121-128.

Naqvism, Howell RD and Sholasm M. 1993. Cadmium and lead residues in field collected red swamp crayfish (*Procambarus clarkia)* and uptake by alligator weed, *Alternanthera philoxeroides. Journal of Environmental Science and Health*. Part B **28**:4: 475-485.

PFA. 1954. *Indian Prevention of Food Adulteration Act* (PFA) Govt. of India.

Patel JK, Desai NB, Pinge VL and Shah JC. 1990. River water quality of some river at Gujrat. pp. 57-62. In: *Proceedings of Symposia on Protection of Environment of City Waste Fronts*, New Delhi.

Pleiffer WC, Fiszman M, Malm O and Azque JM. 1986. Heavy metal pollution in the Pariabo do Sul River, Brazil. *Science of the Total Environment*. **58**: 73.

Sushilkumar and Viswakarma K. 2005. Nutritive value of alligater weed [*Alternanthera philoxeroides* (Mart.) Guised.] and its possible utility as a fodder in India. *Indian Journal of Weed Science* **37**(1&2): 152

US Salinity and Laboratory Staff. 1954. *Agriculture Handbook no. 60*, USDA, Washington, D.C.

Wolverton BC and McDonald RC. 1976. Water hyacinth (*Eichhornia crassipes*) for removing chemical and photographic pollutants from laboratory waste waters. *NASA Technical Memorandom TM-X-72731*.