academicJournals

Vol. 8(22), pp. 2765-2768, 13 June, 2013
DOI: 10.5897/AJAR12.1312
ISSN 1991-637X ©2013 Academic Journals
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Bioaccumulation and distribution of heavy metals in water chestnut (*Trapa natans* var. *bispinosa* Roxb.) in the Lucknow Region

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Accepted 30 May, 2013

Water bodies are primarily contaminated with heavy metals due to increasing urbanization, intensive practices of agricultural and industrial developments, etc. Heavy metals have been reported to be highly toxic to human health since they are not easily disintegrated and decomposed and can be bioaccumulated along the food chain. Therefore, heavy metal contamination in aquatic ecosystems, such as those being used for the cultivation of edible aquatic plants like water cress, Trapa etc., is of primary concern. The present study was initiated to study the bioaccumulation of Pb, Cu and Fe by *Trapa natans* var. *bispinosa* Roxb. growing water bodies in Lucknow. The results indicates that the heavy metals accumulate in order viz., Pb: Leaf > root > peel> stem > kernel; Cu: root > leaf > stem > peel > kernel and Fe: root > stem > leaf > peel > kernel. The edible parts of *T. natans* accumulated metals from their surrounding water significantly. The metal accumulation potential of the plant parts varied considerably depending upon level of metal contamination in the water body in which the plants were growing.

Key words: *Trapa natans,* bioaccumulation, heavy metals.

INTRODUCTION

Water pollution resulting from human activities is gaining serious dimensions. Major cause of pollution is the increasing urbanization, intensive practice of agriculture and industrial developments. During the recent years, urbanization has forced us to utilize marginal lands and aquatic plants are being cultivated more intensively in ponds which are not suitable for agriculture. Despite the exploitation of such aquatic resources to meet increasing demand of food, contamination of these water bodies with toxic metals has become a frequent phenomenon (Chandra et al., 1993; Rai et al., 1996).

Water chestnut is widely distributed throughout the tropical and warm climate region of the world. It is cultivated for its fruit throughout India in ponds, ditches and lakes. The fruit of trapa is an important source of food and the kernel is a good source of carbohydrates and minerals. Processed kernels are used to fasts, and seem to be easily digestible. Its flour is used for making sweets for Holi festival and for preparing bread, halwa and biscuits. In certain tribal villages, the flour is used for treatment of diarrhoea and abdominal pain. However, they get laced with toxic metals growing in polluted water bodies (Rai et al., 1996). Although, the study regarding contamination of food crops with toxic metals and pesticides has received some attention, edible aquatic plants are virtually neglected. Dixit and Banerji (1994) have reported the presence of carbofuran residue in trapa fruits after application and advocated reduced application of the pesticide or any other remedial measure to control the pest of crop. Chandra et al. (1993)

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reported that the water chestnut growing in ponds under different agro climatic regions accumulate many toxic metals in its edible parts. Besides, habitats of water chestnut are threatened recently due to increasing load of metal pollution from municipal, agricultural and domestic wastes. However, no studies have been undertaken on water chestnut laden with toxic metals which may cause numerous health problems through food chain biomagnification. Hence, the present detailed investigation to quantify toxic metal accumulation in edible parts of *T. natans* growing in contaminated water bodies was undertaken to determine quantities of Pb, Cu and Fe in vegetative and reproductive organs of water chestnut.

MATERIALS AND METHODS

The sites (T_1 - T_5) selected for present study were situated in Lucknow, U.P. which varied with respect to the level of metal contamination. Lucknow lies between the parallels of 200 30' and 270 10' north latitude and 800 34'and 810 13' east longitude. The 5 sites have been represented by T_1 –Mohanlalganj, T_2 –Gosainganj, T_3 – Bakshi, ka Talab, T_4 - Chinhat and T_5 - Sarojninagar. All the water bodies were located near the highways having several anthropogenic activities in contaminated area. The natural water bodies in rural region supply daily to the local population in terms of bathing, cattle feeding and food shelter for waterfowl and other wild life. Since the water bodies are contaminated due to various pollution sources (Rai and Sinha, 2001). The toxic metals present in eatable products maybe a health threat to the local inhabitant.

In all the selected ponds *T. natans* was taken as a cultivated crop. The experimented sites received varied level of contaminants from domestic, industrial, recreational and agricultural wastes (Rai and Sinha, 2001). Water samples from each site were collected from different location in the pond for heavy metal analysis during November to December of 2010. Water (100 ml) was filtered, acidified, stored in acid washed plastic containers and brought to the laboratory for analysis of metal in accordance with standard methods (APHA, 1989). The plants and fruits of water chestnut were collected from these sites, washed thoroughly with distilled water and air dried for 2 days, after that oven dried in hot air oven at 70 to 80°C temperatures for 24 h. The dried samples were ground and sieved through muslin cloth. Both the samples (In triplicate) water (100 ml) and plant (0.5 g) were digested in HNO_3: $HClO_4$ mixture (3 : 1; v/v), the temperature was maintained at 120°C for 3 h during digestion and to determine the metal content in the samples by using inductively coupled plasma optical emission spectrometry (OPTIMA 5300 DV ICP-OES). The working wavelengths were as follows: Pb, 220.345 nm; Cu 327.393 nm and Fe, 238.204 nm (Marin et al., 2011).

Statistical analysis

The data were statistically analyzed using two-way analysis of variance (ANOVA) to assess the effect of different variables on the concentrations of heavy metals.

RESULTS AND DISCUSSION

Heavy metal content

Heavy metal contents in water, root, stem, leaf, peel and kernel of water chestnut (*T. natans* var. *bispinosa* Roxb.) collected from water chestnut growing ponds of different selected sites are shown in Table 1. The metal concentration significantly increased when the concentration were increased in water and ecosystem ($p < 0.005$).

Heavy metal content in water

The maximum concentrations in water of Pb, Cu and Fe were observed in site T_4 (0.059, 1.335 and 1.345 (mg/L), respectively). However, the minimum Pb, Cu and Fe concentrations were recorded in sites T_1, T_5 and T_2 (0.036, 1.132 and 0.975 (mg/L), respectively).

Heavy metal content in plant parts

Lead (Pb)

Lead is a non-essential trace element having functions neither in human’s body nor in plants. It induces various toxic effects at low doses. The typical symptoms of lead poisoning are colic, anemia, headache, convulsions and chronic nephritis of the kidneys, brain damage and central nervous system disorders. The same decreasing tendency in Pb concentration was in all the sites: Leaf > root > peel > stem > kernel (Table 1). For T_1 treatment the maximum concentration 16.40 mg/kg dry weight was in leaf followed by in root (14.60 mg/kg dry weight), while the minimum Pb concentration 5.40 mg/kg dry weight was found in kernel. For T_2 treatment the maximum Pb concentration 18.40 mg/kg dry weight was found in leaf then in root while the minimum concentration 6.80 mg/kg dry weight was found in kernel. For the T_3 treatment, higher Pb concentration 17.60 mg/kg dry weight was found in leaf and the lower concentration 6.20 mg/kg dry weight was found in kernel. For T_4 treatment the maximum concentration 20.80 mg/kg dry weight was recorded in leaf then 17.60 mg/kg dry weight was found in root while the concentration 7.60 mg/kg dry weight was recorded in the kernel. For T_5 treatment the highest Pb concentration 18.20 mg/kg dry weight was found in leaf and the lowest Pb concentration 6.60 mg/kg dry weight was found in kernel.

Copper (Cu)

Cu is an essential enzymatic element for normal plant growth and development but can be toxic at excessive levels. The concentration of Cu followed the same trend in all the treatments: root > leaf > stem > peel > kernel. For T_1 treatment the maximum concentration 16.40 mg/kg dry weight was in root followed by leaf (10.40 mg/kg dry weight), while the minimum Cu concentration (6.60 mg/kg dry weight) was found in kernel. For T_2

Table 1. Accumulation of heavy metal in water and different parts of *T. natans* var. *bispinosa* (Roxb.) collected from water chestnut growing ponds of different selected sites of Lucknow.

Treatment	Metals (mg/L)			Interaction CD at 5% (p<0.005)
Water				
	Pb	Cu	Fe	
T_1	0.036	1.201	1.325	
T_2	0.055	1.278	0.975	Treatment = 0.067
T_3	0.042	1.192	1.218	Metal = 0.052
T_4	0.059	1.335	1.345	Treatment * Metal = 0.116
T_5	0.046	1.132	1.200	
Root				
Treatment	Metals (mg/kg)			Interaction CD at 5%
	Pb	Cu	Fe	
T_1	14.60	16.40	4880.70	
T_2	16.40	17.40	3672.20	Treatment = 3.599
T_3	15.00	15.20	4840.60	Metal = 2.788
T_4	17.60	19.80	5218.72	Treatment * Metal = 6.234
T_5	15.80	14.20	4284.18	
Stem				
Treatment	Metals (mg/kg)			Interaction CD at 5%
	Pb	Cu	Fe	
T_1	8.40	9.20	1366.40	
T_2	9.80	10.40	1046.80	Treatment = 4.138
T_3	8.80	8.80	1290.60	Metal = 3.205
T_4	10.80	11.80	1486.40	Treatment * Metal = 7.167
T_5	9.20	8.20	1166.60	
Leaf				
Treatment	Metals (mg/kg)			Interaction CD at 5%
	Pb	Cu	Fe	
T_1	16.40	10.40	1202.02	
T_2	18.40	11.60	1024.66	Treatment =2.278
T_3	17.60	9.80	1198.18	Metal = 1.765
T_4	20.80	14.40	1366.24	Treatment * Metal = 3.947
T_5	18.20	9.20	1105.28	
Peel				
Treatment	Metals (mg/kg)			Interaction CD at 5%
	Pb	Cu	Fe	
T_1	9.60	7.80	480.40	
T_2	11.40	8.60	382.60	Treatment = 4.076
T_3	10.80	7.60	404.20	Metal = 3.157
T_4	12.60	10.60	620.20	Treatment * Metal = 7.060
T_5	11.30	7.20	465.20	
Kernel				
Treatment	Metals (mg/kg)			Interaction CD at 5%
	Pb	Cu	Fe	
T_1	5.40	6.60	219.20	
T_2	6.80	7.20	135.40	Treatment = 1.688
T_3	6.20	6.48	156.00	Metal = 1.307
T_4	7.60	8.80	297.60	Treatment * Metal = 2.924
T_5	6.60	5.60	181.00	

treatment the maximum Cu concentration (17.40 mg/kg dry weight) was found in root followed by leaf (11.60 mg/kg dry weight), while the minimum concentration (7.20 mg/kg dry weight) was found in kernel. For the T_3 treatment, the highest Cu concentration (15.20 mg/kg dry weight) was found in root and the lowest concentration (6.48 mg/kg dry weight) was found in kernel. For T_4 treatment the maximum Cu concentration (19.80 mg/kg dry weight) was recorded in root then in leaf (14.40 mg/kg dry weight), while the minimum concentration (8.80 mg/kg dry weight) was recorded in the kernel. For T_5 treatment the highest Cu concentration 14.20 mg/kg dry weight was found in root and the lowest Cu concentration 5.60 mg/kg dry weight was found in kernel.

Iron (Fe)

Iron is an essential element for human beings and animals and is an essential component of hemoglobin. The concentrations of Fe were in all the treatments as follow: root > stem > leaf > peel > kernel (Table 1). For T_1 treatment the maximum concentration (4880.70 mg/kg dry weight) was in root followed by that measured in stem (1366.40 mg/kg dry weight), while the minimum Fe concentration (219.20 mg/kg dry weight) was found in kernel. For T_2 treatment the maximum Fe concentration (3672.20 mg/kg dry weight) was found in root, followed bay that found in stem (1046.80 mg/kg dry weight), while the minimum concentration (135.40 mg/kg dry weight) was found in kernel. For the T_3 treatment, the highest Fe concentration (4840.60 mg/kg dry weight) was found in root followed by that in stem (1290.60 /kg dry weight), while the lowest Fe concentration (156.00 mg/kg dry weight) was found in kernel. For T_4 treatment the maximum Fe concentration (5218.72 mg/kg dry weight) was recorded in root then in stems (1486.40 mg/kg dry weight), while the minimum Fe concentration (297.60 mg/kg dry weight) was recorded in the kernel. For T_5 treatment the highest Fe concentration (4284.18 mg/kg dry weight) was found in root followed by that found in stem (1166.60 mg/kg dry weight) , while the lowest Fe concentration (181.00 mg/kg dry weight) was found in kernel.

T. natans possesses the potential to accumulate metals in its tissue. The results revealed that the accumulations of Pb, Cu and Fe by *T. natans* were increased when the concentration of metal were increased in the water bodies where chestnut grows.

Furthermore, the nature of soil of the production sites, the ability to take up heavy metals by the plants, deposition of heavy metals in the environment, use of untreated water, the nature of fruit, exposed surface area and the anthropogenic activities such as the use of metal based pesticides around production sites and urban industrial activities at market sites are some of the factors responsible to boost up the accumulation of heavy metals in the fruits in many parts of the developing countries (Rai and Sinha, 2001; Sharma et al., 2009).

Spontaneous urban and industrial developments have significantly contributed to the elevated levels of heavy metals in the urban environment of the developing countries (Tripathi et al., 1997; Khairaih et al., 2004; Sharma et al., 2008).

The results found in the current study suggest a great deal of monitoring and immediate measures to address this issue with respect to economic and health standpoint. Since, sufficient information on the nutritional status of water chestnut has been obtained along with the data on the variability in the concentration of heavy metals with respect to region. Hence, the whole set of information may provide a better understanding of the quality and safety of this minor fruit crop, water chestnut *T. natans* var. *bispinosa* Roxb. Since, the importance of the aquatic ecosystem on the uptake of heavy metals by the fruit is established. Therefore, further research is needed on the soil, water and air are significantly contributing factors to the elevated heavy metal content.

ACKNOWLEDGMENTS

The authors are grateful to the University Grant Commission (UGC), New Delhi for providing the financial assistance in the form of UGC Fellowship to carry out this research.

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