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PHYTOREMEDIATION POTENTIAL OF WATER HYACINTH TO REMEDIATE METALS FROM THREE DIVERSIFIED LENTIC WATER BODIES OF NADIA DISTRICT, WEST BENGAL, INDIA

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ABSTRACT
The present study was carried out to determine the effectiveness of using a hyper accumulating plant like *Eichornea crassipes* for the removal of metals from three different wetlands of Nadia district, West Bengal. The selected wetland (W1) receives sewage, agricultural runoff etc., the second wetland (W2) is an extensive fish culture pond and the third wetland (W3) is a ditch which receives rain water runoff. The metal concentrations such as iron, zinc and copper in water and water hyacinth were investigated. The results showed that they were in the order Fe > Zn > Cu. The concentration of Cu, Zn and Fe both in water and water hyacinth were recorded from W1 (0.033 ± 0.001, 0.143 ± 0.001 and 0.171 ± 0.001 ppm &753, 161 and 15 mg/kg),W2 (0.005 ± 0.0007, 0.117 ± 0.0014 and 0.146 ± 0.0007 ppm & 9.41, 85 and 435 mg/kg) and W3 (0.002 ± 0.0007, 0.089 ± 0.001 and 0.134 ± 0.0007 ppm &9.92, 69 and 497 mg/kg). Biomass of water hyacinth as dry weight was estimated and the maximum weight was recorded from W1 (711.15 ± 17.32 g/m^2), followed by W3 (670.23 ± 10.06 g/m^2) and W2 (224.90 ± 3.76 g/m^2). Dissolved metal concentration in water followed the order as W1 > W2 > W3, where as metals absorbed by the plant followed the order as W1 > W3 > W2 which is similar to the order of biomass of plant. The study reveals the potential of water hyacinth in the removal of metals from different wetlands which are loaded with different levels of metals,so as to prevent the wetlands from the succession of metal pollution

INTRODUCTION

Wetlands are indispensable for the countless benefits or "ecosystem services" that they provide humanity ranging from fresh water supply, food, flood control, groundwater recharge and climate change mitigation (Bandyopadhyay *et al.,* 2004). Yet study after study demonstrates that wetland area and quality continue to decline in most regions of the world. As a result, the ecosystem services that wetlands provide people are compromised.

As in many countries, India too has witnessed considerable degradation of environment due to industrial and other developmental activities. Metals discharged from composite effluents into wetland ecosystems pose a serious threat to the wetlands (Chatterjee *et al.,* 2006).Application of bio-remediation techniques for different wetlands to remove environmental contaminants as heavy metals, trace elements, organic compounds *etc*., in water is the basic idea of this paper.

The remarkable ability of aquatic plants, particularly the water hyacinth to extract compounds and elements from water efficiently has become well recognized (Ajibade *et al.,* 2013). The water hyacinth (*Eichhornia crassipes*) appears to be one of the most promising aquatic plant for the treatment of wastewater, and has received the most attention in this regard. Water hyacinth is used to improve the quality of water by reducing the heavy metals (Soltan and Rashed, 2003). Presence of its fibrous root system and broad leaves help them to absorb higher concentrations of heavy metals (Mishra, 2008). This capability makes them a potential biological alternative to secondary and tertiary treatment for wastewater (Cossu *et al.,* 2001).

Several studies have documented that water hyacinths are good metal-accumulating plants, but the studies which documented the ability of this plant under different conditions to remove heavy metals from water bodies which are encumbered with different metal concentrations are few. This paper, therefore, elucidates the phytoremediation potential of water hyacinth**,** for removal of heavy metals from three different wetlandswhich are having different water sources.

MATERIALS AND METHODS

The three water bodies selected for the study, were as follows: water body one (W 1) which is having connection with the Mathura beel, and receives sewage, waste water from dairy farm, agricultural runoff etc., choked entirely with macrophytes dominated by *Eichornea crassipes*. Water body (W 2) is a Jheel which receives rain water runoff, agricultural runoff *etc.* Extensive fish culture is being practiced in this water body. Macrophytes mainly *Eichornea crassipes* were present only at the margin of this water body. Water body (W 3) is a perennial road side ditch which is a long stretch of about 2 km. and the water depth ranges from 0.75 m to 1.25 m throughout the

year. The major source of water is rain water runoff from surrounding areas. It is mostly covered with macrophytes and *Eichornea crassipes* is the dominant one. For the present study, the sampling was done for a period of twelve months with monthly interval.

The surface water samples were collected in new high grade 1 liter Teflon plastic bottles which were thoroughly washed with de-ionized water with the addition of 2 ml concentrated HNO3 in order to preserve the metals. Suitable preservation techniques were adopted as per standard methods (APHA, 1998).

For the analysis of heavy metals water samples (100 mL) were digested with di-acid mixture (HNO3 and H2SO4) in digestion chamber and filtered by Whatman No. 1 filter paper and made up the volume to 15 ml by de-ionized water.

Then iron, zinc and copper concentration in the aliquot was estimated by using atomic absorption spectrophotometer (Perkin Elmer model analyst - 100).

Plant samples were collected from a square meter area of the sampling points of the water bodies by using a wooden frame quadrate. Collected plant samples were taken to the laboratory and washed thoroughly with deionized water. Excess water drained to record wet weight of the plant sample. Then the plant samples were placed in aluminum trays and oven dried at 60ºC for 48 hours to record dry weight. One gram of each dried and powdered plant samples were transferred into digestion flask. Then plant absorbed metals were extracted by tri-acid digestion (Perchloric acid, Sulphuric acid & Nitric acid). The digestion was continued till the contents in the digestion flask turned to colorless. After cooling, the extract was diluted upto 100 ml with deionized water and mixed thoroughly to dissolve the metals. The resultant liquid was filtered through Whatman No.1 filter paper to get the aliquot. Then iron, zinc and copper concentration in the aliquot was estimated by using atomic absorption spectrophotometer (Perkin Elmer model analyst - 100) (Tandon, 1995). The data obtained from three water bodies were statistically analyzed by analysis of variance (ANOVA) in order to know the significance between three water bodies and between the months.

RESULTS AND DISCUSSION

Population of *A. besseyi* was examined individually from each 19 proso millet germplasm on the basis of seed colour , their look either abnormal and apparent healthy looking seeds Germplasm looking black harboured high (284) nematodes/ 250 seeds, whereas off white, mixed and slight red coloured seeds recorded 198, 147 146.5 respectively the population *A.besseyi*. Maximum (237.5) population of *A. besseyi* was encountered in apparent healthy seeds over small sized s abnormal seeds to the tune of 168 nematodes/250 seeds.

Losses in 1000 seed weight were found in both abnormal and apparent healthy seeds. The extent of losses in 1000 seed weight was maximum (0.867) abnormal seeds of TNAU-197 than rest of the germplasm.However, comparatively there was less losses/ 1000 seed weight was evidenced in normal and apparent healthy seeds (Table 1)

Among 19 germplasms namely K-1, RAUM-8 and TNAU-155

Table 1: Estimated metals concentration in water sample of the selected water bodies

S.No.	W 1 (mg/l)			W 2 (mg/l)			W 3 (mg/l)		
	Copper	Zinc	Iron	Copper	Zinc	Iron	Copper	Zinc	Iron
Jul	0.028± 0.0007	0.145±0.001	0.166±0.002	0.0075±0.0007	0.123±0.0014	0.147±0.0007	0.001±0.0007	0.092±0.001	0.132±0.0007
Aug	0.026± 0.001	0.141±0.0007	0.163±0.0007	0.0080±0.0007	0.119±0.0007	0.143±0.0007	0.003±0.0007	0.092±0.0007	0.126±0.0007
Sept	0.021± 0.001	0.137±0.001	0.166±0.001	0.0075±0.0	0.115±0.0007	0.137±0.0007	0.003±0.0	0.091±0.0007	0.124±0.0007
Oct	0.019± 0.001	0.134±0.001	0.165±0.002	0.0055±0.0007	0.116±0.0021	0.134±0.0014	0.002±0.0007	0.091±0.002	0.121±0.001
Nov	0.020± 0.0007	0.135±0.001	0.165±0.001	0.0045±0.0007	0.120±0.0014	0.133±0.0014	0.003±0.0007	0.090±0.001	0.124±0.001
Dec	0.023± 0.001	0.133±0.0007	0.161±0.002	0.004± 0.0007	0.121±0.0014	0.135±0.0007	0.004±0.0007	0.086±0.001	0.125±0.0007
Jan	0.025± 0.001	0.131±0.001	0.164±0.001	0.004± 0.0007	0.118±0.0014	0.136±0.0007	0.005±0.0007	0.084±0.001	0.127±0.0007
Feb	0.023± 0.0007	0.129±0.001	0.167±0.002	0.0045±0.0007	0.115±0.0007	0.138±0.0007	0.006±0.0007	0.085±0.0007	0.128±0.0007
Mar	0.026± 0.0007	0.128±0.001	0.168±0.001	0.004± 0.0007	0.112±0.0014	0.137±0.0014	0.005±0.0007	0.083±0.001	0.131±0.001
Apr	0.027± 0.0007	0.125±0.0007	0.169±0.0007	0.0035±0.0007	0.111±0.0014	0.138±0.0007	0.006±0.0007	0.082±0.001	0.134±0.0007
May	0.031± 0.001	0.123±0.001	0.171±0.001	0.003± 0.0007	0.109±0.0007	0.141±0.0014	0.006±0.0007	0.080±0.0007	0.137±0.001
Jun	0.033± 0.001	0.143±0.001	0.169±0.001	0.0055±0.0007	0.117±0.0014	0.146±0.0007	0.002±0.0007	0.089±0.001	0.134±0.0007

Table 2: Biomass of the water hyacinth of the selected water bodies

S.No.	W 1 Wet weight (kg / m^2)	W 1 Dry weight (g / m^2)	W 2 Wet weight (kg / m^2)	W 2 Dry weight (g / m^2)	W 3 Wet weight (kg / m^2)	W 3 Dry weight (g / m^2)
Jul	16.59 ± 3.478	644.95 ± 21.566	2.43 ± 0.658	152.033 ± 6.047	10.816 ± 1.097	613.566 ± 29.482
Aug	15.825 ± 2.071	650.8 ± 13.576	2.14 ± 0.475	137.266 ± 6.299	9.44 ± 1.44	594.6 ± 31.897
Sept	11.565 ± 0.629	649.1 ± 71.842	1.866 ± 0.055	112.766 ± 3.563	7.616 ± 0.893	550.833 ± 20.286
Oct	13.11 ± 1.470	600.45 ± 28.637	1.123 ± 0.055	98.10 ± 8.51	6.573 ± 0.654	531.966 ± 17.118
Nov	10.045 ± 1.336	614.15 ± 22.839	1.416 ± 0.066	119.066 ± 1.401	6.25 ± 1.068	529.033 ± 21.001
Dec	11.695 ± 0.700	575.25 ± 63.568	1.816 ± 0.225	169.6 ± 15.649	6.89 ± 0.356	537.733 ± 20.286
Jan	13.39 ± 1.569	644.9 ± 19.798	3.166 ± 0.104	204.133 ± 3.33	6.953 ± 0.44	581.6 ± 10.095
Feb	15.40 ± 1.979	669.2 ± 15.556	4.546 ± 0.050	208.066 ± 11.271	8.65 ± 1.011	580.466 ± 26.459
Mar	16.165 ± 1.308	680.65 ± 13.93	3.806 ± 0.045	216.233 ± 0.55	10.17 ± 0.956	617.2 ± 17.421
Apr	18.010 ± 1.449	693.3 ± 12.869	3.013 ± 0.045	219.33 ± 1.361	13.8 ± 1.041	651.9 ± 10.245
May	19.935 ± 1.633	711.15 ± 17.324	3.786 ± 0.045	224.9 ± 3.764	15.53 ± 0.931	670.233 ± 10.505
Jun	18.15 ± 1.442	664.95 ± 21.566	3.003 ± 0.061	205.533 ± 8.746	12.65 ± 0.981	641.166 ± 9.009

harbored 301-500 nematode whereas GPUP-21, TNAU-145, 164, 194, RAUM-11 extracted population between 201to 300 in present investigation. Low number of nematode incidence was evidenced in TNAU-151 and TNAU-183 where their population was noticed from 51 to 100 nematodes (Table 2).

The population of also compared with rice and foxtail millet to understand any variations in their maophology was carried and findings are summarized as:

I.Body length (L) and greatest body width of *Aphelenchoides besseyi* was greater (681.97 μm and 18.43 μm) in rice than foxtail millet (665.62 μm and 18.22 μm) and prosomillet (541.86 μm and 17.59 μm). Similarly, oesophageal length, tail length, length of ovary were also measured on examination of *A.besseyi* morphology from rice, fox tail millets and prosomillets and compared with each other population. The findings of ovary Length with *A. besseyi* in proso millet, foxtail millet and rice were 267.09 μm, 328.85 μm and 337.69 μm respectively. Oesophagus and tail length of female in rice , foxtail millet and proso millet were 65.2 μm and 102.57 μm; 63.99 μm and 97.26 μm and 62.14 μm and 95.84 μm respectively while, difference in male population extracted from rice, foxtail millet and proso millet were 35.87 μm and @ &-37.18 μm, 31.32 μm - 32.03 μm and 28.12 μm and 28.71 μm respectively (table 3).

Attempts were also made to find out *A. besseyi* population from seeds and their after harvest from K-1 where *A. besseyi* was maximum (430.5) harboured than RAUM-8, TNAU-151, RAUM-11, TNAU-145, TNAU-137, TNAU-149, DC-4, TNAU155, DC-6, GPUP-23, GPUP-22, TNAU-164, GPUP-21, PRC-403, DHPM-50-1-1, TNAU197, TNAU-183 and TNAU-194. Trend of nematode development from the seeds sown and their harvest. The observed findings were compared and found that , K-1, GPUP-21, GPUP-22, GPUP-23, TNAU-155, TNAU-164, TNAU-164, TNAU-183, TNAU-194, TNAU-197, RAUM-8, RAUM-11 and PRC-403 decreased nematode population after harvest, whereas germplasm DC-4, DC-6, TNAU-137, TNAU-145, TNAU-149, TNAU-151 and DHPM-50-1-1 harbored increased number of nematodes from harvest seeds (Table 4).

Coloured seed coat revealed significant relationship between nematode population and their and seed colour. Black coloured showed heavily infestation of A. besseyi might be geotrphism verses phototrophims and completion of life cycle took less duration resulted population of fourth stages pre-adults, however offwhite seed showed significant nematode number, but less than black do not suggest any relationship for their development. It has been further noticed that the Tamil Nadu germplasm favoured more development of *Aphelenchoides bessey* as compared to other sources may be due to environmental effect. Present investigation was carried for the first time in the world on proso towardswards

present investigations need not require evidences of investigators on rice and foxtail millet. Ratio of male and female are in accordance with Tiwari (1978) where he suggested difference in reproductive parameters in different Germplasm of rice. Similar trend was also evidenced with our findingsin studied germplasm. The findings on other aspects of investigations are in accordance with the result of Renata *et al*. (1994), Gokte *et al*. (2001), Jamali *et al*. (2006), Salawu and Bolufawi (2007) and Swain *et al*. (2011). Morphometrics attributes were worked out on *A. besseyi* populations from India (Dastur, 1936) and Senegal (Fortuner, 1970). There were considerable variations in measurements among the populations from India, Senegal and Sri Lanka due to genetic variation and or host-induced variability. B'Chir (1977) observed that the population reared on *Impatiens balsamina* was longer than the ones reared on *Alternaria citri*. Rajan and Mathur (1990) proposed two groups of *A. besseyi* from India and Philippines isolates based on morphometry and culturability on fungal hosts and considered Cuttack (eastern India) and Pune (western India) populations belonged to one and Hyderabad (southern India) and Philippines isolates (Philippines) to another group. However, in the present study, appreciable variation in morphometry between rice foxtail millet and proso millet populations of *A. besseyi* central India is noticed.

The plant biomass per square meter was determined from the three water bodies. Highest plant biomass was recorded from W1 followed by W3 and W2. Both wet weight and dry weight of water hyacinth collected from all the three water bodies were estimated. The water hyacinth biomass as wet weight varied from 19.96 ± 1.63 to 10.04 ± 1.35 kg/m^2, 3.78 ± 0.045 to 1.123 ± 0.055 kg/m^2 and 15.53 ± 0.931 to 6.256 ± 1.068 kg/m^2 from W1, W2 and W3 respectively. Dry weight of water hyacinth ranged in W1, W2 and W3 ranged from 711.15 ± 17.32 to 575.25 ± 63.56 g/m^2, 224.90 ± 3.76 to 98.10 ± 2.85 g/m^2 and 670.23 ± 10.06 to 529.03 ± 21.00 g/

Table 3: Estimated metals concentration in water hyacinth of the selected water bodies

S.No.	W 1 (mg/kg)			W 2 (mg/kg)			W 3 (mg/kg)		
	Copper	Zinc	Iron	Copper	Zinc	Iron	Copper	Zinc	Iron
Jul	13.55±0.021	159.00± 0.014	738.00±2.828	8.64± 0.014	63.50±0.707	427.00±1.414	9.27± 0.014	62.00±1.414	471.50±2.121
Aug	12.08±0.007	155.50± 0.070	732.00±0.656	7.26± 0.014	57.00±1.414	415.50±0.707	8.54± 0.021	57.00±1.414	466.50±2.121
Sept	10.95±0.014	152.50± 0.070	716.50±2.121	5.36± 0.021	51.50±2.121	401.00±1.414	7.37± 0.021	51.00±1.414	451.00±1.414
Oct	10.21±0.014	151.00± 1.414	703.50±2.121	4.81± 0.014	43.50±2.121	400.50±0.707	7.07± 0.014	49.00±1.414	436.50±4.949
Nov	11.01±0.021	147.50± 0.707	711.00±1.414	5.61± 0.021	46.50±2.121	395.50±0.070	7.53± 0.021	55.00±1.414	446.50±2.121
Dec	11.57±0.530	143.50± 2.121	717.00±1.414	6.09± 0.021	46.50±0.707	406.00±1.414	7.30± 0.007	56.00±1.414	450.50±2.121
Jan	12.26±0.014	147.00±1.414	728.50±2.121	7.33± 0.021	56.00±1.414	416.00±1.414	8.06± 0.021	58.50±0.707	460.50±0.707
Feb	12.68±0.007	150.50±0.707	740.50±2.121	7.91± 0.021	64.50±0.707	421.00±1.414	8.53± 0.021	61.00±1.414	473.00±1.414
Mar	13.25±0.014	153.50±2.121	747.00±2.828	8.53± 0.014	71.50±2.121	427.00±1.414	9.04± 0.014	64.00±1.414	483.50±2.121
Apr	14.81±0.014	158.50±0.707	751.00±1.414	8.85± 0.014	81.00±1.414	432.50±0.707	9.63± 0.021	66.00±1.414	491.00±1.414
May	15.65±0.007	161.0±1.414	753.50±0.707	9.41± 0.014	85.00±1.414	435.50±2.121	9.92± 0.028	69.00±1.414	497.00±1.414
Jun	14.63±0.021	160.5±0.707	746.50±0.707	9.03± 0.014	71.00±1.414	431.50±2.121	9.55± 0.014	67.00±1.414	483.50±2.121

m^2 respectively. The biomass was high in peak summer and low in early winter. The fluctuations were similar from all the three selected water bodies. Similar observations were recorded by Sugunan and Bhattachariya (2000).

Two way ANOVA for the wet weight and dry weight of water hyacinth revealed that the variation between water bodies and between months were significant at 5% level.

The copper, zinc and iron concentration of water hyacinth whole body, collected from three water bodies was estimated. Copper concentration was varied between 15.66 ± 0.01 to 10.21 ± 0.01 mg/kg, 9.41 ± 0.01 to 4.81 ± 0.01 mg/kg and 9.92 ± 0.03 to 7.07 ± 0.01 mg/kg in W1, W2 and W3 respectively. The iron concentration of macrophyte was fluctuated between 753.50 ± 0.71 to 703.50 ± 2.12 mg/kg, 435.50 ± 2.12 to 395.50 ± 0.71 mg/kg and 497.00 ± 1.41 to 436.50 ± 4.95 mg/kg in W1, W2 and W3 respectively. The zinc concentration in W1, W2 and W3 ranged from 161.00 ± 1.41 to 143.50 ± 2.12 mg/kg, 85.00 ± 1.41 to 43.50 ± 2.12 mg/kg and 69.00 ± 1.41 to 49.00 ± 1.41 mg/kg. The overall trend of fluctuations in metals concentration are as same as in case of biomass.

The water hyacinth have high tolerance against contaminants like heavy metals and are able to absorb large quantities (Mary and Madhu, 2011). Ndimele and Jimoh studied the use of Water Hyacinth in Phytoremediation of Heavy Metal Polluted Water of Ologe Lagoon, Nigeria and this study revealed that E. crassipes can accumulate heavy metals even when the concentrations of the metals in the abiotic components (water and sediment) of the aquatic environment is low.

Dissolved metal concentration followed the order as $W1 > W2 > W3$, where as metals absorbed by the plant followed the order as $W1 > W3 > W2$. Biomass of water hyacinth was estimated from the selected water bodies and the maximum density was recorded from W1 followed by W3 and W2. The absorption in relation to biomass of plant follows the order as $W1 > W2 > W3$. It can be stated that, the higher the density of plant (water hyacinth) on water body, the more the absorption of pollutants that is, the best of purification will be obtained. On the other hand, plant absorbed metal concentration in different water bodies highlighted the significant differences on the pattern of bioaccumulation of heavy metals vis - a – vis concentration in the contrasting aquatic systems. The present study corroborates the other research studies (Ajibade *et al.*, 2013 and Landis, 2011).

The seasonal variation in the metal composition in the water hyacinth belonging to the three water bodies were more or less similar. Maximum concentrations of metals were recorded during pre monsoon period and that is the flowering season of the water hyacinth, where as lower values were observed during winter. Similar observations were reported by Mohan and Hosetti (1998).

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