Removal Of Cadmium And Zinc From Water By Water Lettuce (Pistia)

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ABSTRACT

Absorption of Zn and Cd from aqueous solutions by water hyacinth (Eichlornia crassipes) and water lettuce (Pistia) was studied under similar laboratory conditions. The uptake of the metals followed the same trend in both plants, with very insignificant variations in the amount removed. As the initial concentration increased the fractions of metal removed decreased although total amount of metal removed increased. The effect of pH was more pronounced outside the range 5-7. Increased solution volume increased the amount of metals removed. Strong complexing agents such as EDTA seriously retarded the removal of the metals by plants. Agitation of metal solutions was found to enhance the removal process.

INTRODUCTION

When humans introduce waste into the biosphere in kinds and amounts that the biosphere cannot neutralize or recycle, the result is environmental pollution. The pollution of water bodies occurs in various ways. Fertilizers applied to the land by farmers are a major source of pollution. Water bodies are also frequently polluted by industrial effluents. The major offenders are the paper, tanning, oil refining and metal smelting industries, all of which are faced with the problem of disposal of noxious chemical wastes.

Heavy metals such as Zn, Hg, Pb and Cd are dangerous pollutants and often deposited in the bottom sediment of streams and rivers. If these are deposited on flood plains, the heavy metals may become incorporated into plants, food crops and animals. If they are dissolved and such water is withdrawn for agricultural or human use, heavy metal poisoning can occur.

All Zn compounds are very toxic. In 1972 over 4000 deaths occurred[1] in Iraq when seed grains treated with Zn compounds to prevent the development of mildew was used for making bread. Cd is not required by the human body or plants. The onset of symptoms of cadmium toxicity is generally rapid and these consist of nausea, vomiting, cramps and headaches; in more severe cases diarrhoea and shock may occur[2].

Zn and Cd pollution is one the most serious [illegible]ment problems facing life on earth, the main medium of pollution being water. The concentration of these metals in water bodies has been progressively increasing [1,2] with the resultant adverse effects on the environment. Thus, any attempt to minimize these metals in water is desirable..

Although several methods such as precipitation, adsorption on activated carbon and ion exchange complexation have been suggested for the removal of toxic metals from polluted water, these are quite expensive. Cheaper and more readily available means are needed; hence vascular aquatic plants have been involved recently in water pollution studies[3-7]. These studies have shown that the water hyacinth is capable of removing heavy metals from waste water. Water lettuce, another hydrophyte, has not been evaluated for this purpose. This work therefore aims at evaluating natural or transplanted water lettuce for the removal of Cd and Zn from polluted water and comparing its performance with that of water hyacinth.

EXPERIMENTAL

Materials

Water lettuce and water hyacinth were collected from a site at Keffi in Nassarawa state, Nigeria and verified by a botanist in the Biological Sciences Department of University of Abuja.

The stock calcium and zinc solutions for the experiments were prepared from analytical grade $CdCl_2.2½H_2O$ and $ZnCl_2.2½H_2O$ (BDH) respectively. All other reagents were also of analytical grade and de-ionized water was used in the preparation of all solutions. All working solutions were freshly prepared just before use. For the analysis,a Milton Roy Sp [6] 200 Py [3] atomic absorption spectrometer was used.

Method

Soil particles and other foreign bodies were removed from plants by careful washing in tap water. The plants of approximately the same weight, were then left in de-ionized water for 24 hours before samples were picked for analysis. For each determination, individual plants were introduced into test solution beakers in such a way that only the roots of the plants were immersed in the solutions and left standing for 24 hours before analyzing each plant for Cd and Zn using the analytical procedure[7] reported below.

All experiments were performed in the laboratory at constant temperature *(25±1°C)* and all studies were done in triplicates.

Optimization of metal concentration

Single plant samples were transferred into solutions containing initial Cd or Zn concentrations ranging from lppm to 128ppm respectively as specified in Table 1.

Volume effects

Plant samples were introduced into 8ppm Cd or Zn solution of volumes ranging from 100ml to 800ml as specified in Table 2.

pH effect

Plant samples were also kept in solutions containing 8ppm Cd or Zn at pH ranging from 2 to 9. The pH was adjusted using KOH and HNO_3. The results are presented in Table 3.

Effect of Complexing agent

For each metal, a set of solutions were prepared each containing 8ppm metal and molar ratios of 100:1, 10:1, 1:1, 0:1 EDTA: metal. A single plant sample was then introduced into each solution and maintained for 24 hours before analyzing them for Cd and Zn. The results are presented in table 4.

Effect of agitation

Single plant samples were introduced respectively into a set of six solutions each containing 8ppm Cd or Zn. Three of the solutions were stirred using a magnetic stirrer at a low stirring rate for 24 hours. The others were similarly left standing unstirred. The results are presented in Table *5*.

Analytical procedure

Finely ground plant samples were dried at about 105°C for 24 hours. In a closed beaker 1 g of the sample was mixed with 5ml conc. HNO_3 and digested at about 130°C for 2 hours. After cooling to room temperature, a little de-ionised water was added. Heating was repeated where necessary until a clear solution was obtained. The solution was diluted to mark with de-ionised water in a 25ml volumetric flask. Plant blanks were similarly prepared and Cd or Zn quantities in plant samples were determined by atomic absorption spectroscopy.

RESULTS AND DISCUSSION

The results of the different parameters investigated are presented in tables 1 - *5*

Table 1: Effect of solution concentration on metal uptake

Initial metal Concentration (ppm)	Average metal concentration (mg/g) in dry matter			
	Zinc		Cadmium	
	Water hyacinth	Water lettuce	Water hyacinth	Water lettuce
0	0.00	0.00	0.00	0.00
1	0.20	0.05	0.19	0.20
2	0.45	0.90	0.61	0.80
4	1.20	1.12	1.01	1.25
8	2.20	2.22	1.98	2.24
16	3.61	3.71	3.81	4.33
32	5.81	5.65	5.02	6.77
64	7.29	7.85	7.54	7.47
128	16.20	18.43	15.94	16.62

Table 2: Effect of solution volume on metal uptake

Solution volume (ml)	Average metal concentration (mg/g) in dry Matter			
	Zinc		Cadmium	
	Water hyacinth	Water lettuce	Water hyacinth	Water lettuce
100	0.45	0.39	0.30	0.46
200	0.79	0.90	0.91	1.01
300	1.62	1.57	1.39	1.39
400	2.03	2.22	2.39	2.70
500	3.00	3.36	3.10	3.54
600	3.51	3.60	3.44	3.89
700	3.82	4.16	3.75	4.40
800	4.24	4.49	4.56	5.24

Table 3: Effect of pH on metal uptake.

Initial solution pH	Average metal concentration (mg/g) in dry matter			
	Zinc		Cadmium	
	Water hyacinth	Water lettuce	Water hyacinth	Water lettuce
2	5.01	541	4.63	5.29
3	5.80	5.96	5.15	5.84
4	6.62	6.61	5.68	6.48
5	7.01	6.83	6.15	6.82
6	6.82	6.80	6.07	6.77
7	6.89	7.27	6.09	6.87
8	5.90	6.57	5.76	6.52
9	5.41	6.13	4.84	6.11

Table 4: Effect of complexing agent

EDTA: Metal Ratio	Average% metal in dry matter			
	Zinc		Cadmium	
	Water hyacinth	Water lettuce	Water hyacinth	Water lettuc
100:1	0.69	0.70	0.63	0.70
10:1	1.42	1.43	1.29	1.44
1:1	14.88	15,00	13.51	15.13
0:1	68.31	68.85	62.28	69.40

Table 5: Effect of agitation

Condition	Average metal concentration (mg/g) in dry matter			
	Zinc		Cadmium	
	Water hyacinth	Water lettuce	Water hyacinth	Water lettuce
Agitated	716	4.45	7.41	2.90
Not agitated	5.37	0.05	6.47	0.29

The results in Table 1 indicate that both plants have the ability to remove Zn and Cd over a wide range of initial metal concentrations. Although the total amount of removed metal(s) increased, the removal rate decreased as the initial concentration of metal(s) increased. At concentrations above 8ppm plant damages were observed within 24 hours for both metals. Therefore 8ppm was chosen to be the standard in the subsequent experiments at the time limit of 24 hours.

Table 2 indicates that the solution volume is directly proportional to the total amount of metal(s) removed. The uptake of the metal(s) may have created an alternative metabolic pathway which may have changed the optimum absorption capacity of the plants. The variation in pH (Table 3) generally has very little effect on the metal(s) uptake. This effect is only manifested outside the range of 5-7 implying that removal process is independent of pH in the range 5-7. Extreme pH cases may have denatured the plants thereby impairing normal metabolic processes.

Experimental observation (Table 4) has shown that the removal of metal from solution was virtually non-existent in the presence of EDTA. Strong complexing agents like EDTA reduce concentration of free metal ions in solution. Thus, the result indicates that free metal ion is more effectively removed from solutions by plants than bound metal. Agitation of solution (Table 5) was also observed to enhance the removal process.

CONCLUSION

The results obtained from these studies indicate that water lettuce (pistia), like the others in its group, is suitable for the treatment of water pollution by heavy metals. Also, that it has as much potential as water hyacinth in removing heavy metals from polluted water.

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