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A Radiotracer study on assessment of heavy metal accumulation in water hyacinth (*Eichhornia crassipes)*

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SUMMARY

The use of specially selected and engineered metal accumulating plants for environmental clean up is an emerging technology called phytoremediation. The present study was to understand the mechanism of metal accumulation in water hyacinth by a radiotracer technique. Water hyacinth samples were treated with solutions containing 0.5 mci of $ZnCl_2$ for a period of five days. The treated root and shoot samples were assessed for % absorption of radioactivity, disintegration rate and specific activity. These factors tend to decrease progressively in the root samples and increase significantly in the shoot samples as time proceeds revealing that heavy metal (Zn) is first absorbed in root and then translocated to shoot regions.

Key words : Phyto remediation, Water hyacinth, Metal accumulation, Per cent absorption of radioactivity, Specific activity

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. Phytoremediation, a process of using plants to remove contaminants from the environment, is an alternative approach and an efficient and economical method of contaminant removal to current remediation strategies (Prasad, 2007). Water hyacinth is a promising candidate for phytoremediation of waste water polluted with Cu, Pb, Zn, and Cd.

MATERIALS AND METHODS

Water hyacinth was collected from a local natural pond at Singanallur, Coimbatore. Before the start of the experiment the plants were cleaned properly using tap water to remove particles from their roots and leaves. The aquatic plants were treated with the metal ion solutions of 0.5 mci of zinc ($ZnCl_2$) and in another treatment they were exposed to water containing 20 ppm of $ZnCl_2$. The treated plant samples exposed to heavy metals were harvested after 24, 48, 72, 96 and 120 h and weighed. Two grams of the harvested root and shoot samples were dry ashed in silica crucible and transferred to a scintillation vial. The vial was then placed in Tellurium activated Na I crystal well type gamma ray spectrometer (type GRS 23B of Electronics Corporation of India Ltd, Hyderabad). The radioactivity of the sample was determined by differential counting keeping the single channel analyser at optimal window and lower level settings. The gross count per 100sec (cps) was noted and net count rate / 100 sec was calculated by subtracting the background count.

Disintegration rate was derived from net count rate by the expression:

$$\text{Disintegration rate (dps)} = \frac{\text{Net count rate(cps)}}{\text{\% efficiency of the instrument}} \times 100$$

The specific activity which denotes the activity / unit mass volume was obtained by the expression:

Specific activity (Bq / «g of Zn) = dps / Zn content

Percent absorption of radioactivity by root and shoot samples were calculated by the following expression:

Per cent absorption of radio activity =
Activity in plants (cps) / Activity in container x 100

The zinc content of the treated root and shoot samples with 20 ppm $ZnCl_2$ were then estimated by atomic absorption spectrometry (Black, 1965). 0.5g of each sample was digested with triple acid mixture over sand bath until a clear digest was obtained. The digested solution was fed to atomic absorption spectrophotometer (Spectra 20 of Varian, Australia)

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RESULTS AND DISCUSSION

The net count rate (cps) and disintegration rate (dps) of root and shoot samples of water hyacinth treated in ^{65}Zn solution for a retention period of five days is given in Table 1.

Table 1 : Net count rate (Cps) and Disintegration rate (Dps) of ^{65}Zn treated root and shoot samples of water hyacinth

Sample	Retention time (days)	Counts per second cps	Disintegration per second dps (Bq)
Root	1	5.2×10^3	3.7×10^4
	2	5.0×10^3	3.6×10^4
	3	3.3×10^3	2.4×10^4
	4	2.6×10^3	1.9×10^4
	5	1.8×10^3	1.3×10^4
Shoot	1	2.9×10^1	2.1×10^2
	2	1.6×10^2	1.2×10^2
	3	3.0×10^2	2.1×10^3
	4	5.2×10^2	3.7×10^3
	5	6.0×10^2	4.3×10^3

Values are mean of triplicates

The Table 1 clearly reveals that cps and dps of root samples decreases progressively with increase in the retention periods and those of shoot samples increases progressively with time. The dps in the root samples was 3.7×10^4 Bq on the first day and it decreased steadily to 1.3×10^4 Bq while in the shoot it was 2.1×10^2 on the first day and increased to 4.3×10^3 Bq on the fifth day revealing that the roots absorb the heavy metals and then transport to the shoot in slow pace. Also, the roots show highest heavy metal concentration than the shoot regions. Thus, it is evident that the roots absorb the metals but cannot accumulate more and these metals are accumulated in the remaining part of the plants. This result is in accordance with the works of Goel *et al*, (1984), Vora and Rao (1988) and Olaniya *et al* (1998). The existence of pH dependent charge densities on the root systems which have the variable affinities for cations might be the reason for the ability of *Eicchornia crassipes* to absorb and accumulate large amount of metal ions. (Yahya, 1990).

Specific activity denotes the activity per unit mass volume and it is the accurate measure of radioactivity that has been incorporated. Table 2 depicts the specific activity and % absorption of radioactivity by the roots and shoots of water hyacinth treated with ^{65}Zn solution.

In the present investigation, the initial specific activity in the root samples was 115.37 Bq/ µg of zinc and it decreases steadily reaching 46. 18 Bq / µg of zinc on the fifth day. Similarly, in the shoot samples the specific activity increases from 1.22 Bq /µg of zinc on the first day to 17.55 µg of zinc on the fifth day. Thus, the specific activity in the root samples decreases with time whereas specific activity in shoot samples increases constantly with time which is evident from Fig.1. The results further confirms the fact that the amount of metal absorbed and accumulated in the root decreases due to their translocation in to the shoot regions. The results are in par with the work of Kumar *et al* (1995).

Table 2 : Specific activity and % absorption of radioactivity by water hyacinth root and shoot samples treated with ^{65}Zn solution

Sample	Retention time (days)	Specific activity Bq / µg of Zinc	% absorption of radioactivity
Root	1	115.37	3.14
	2	120.96	3.05
	3	75.04	2.03
	4	65.52	1.61
	5	46.18	1.08
Shoot	1	1.22	0.01
	2	4.12	0.09
	3	8.50	0.18
	4	14.98	0.32
	5	17.55	0.37

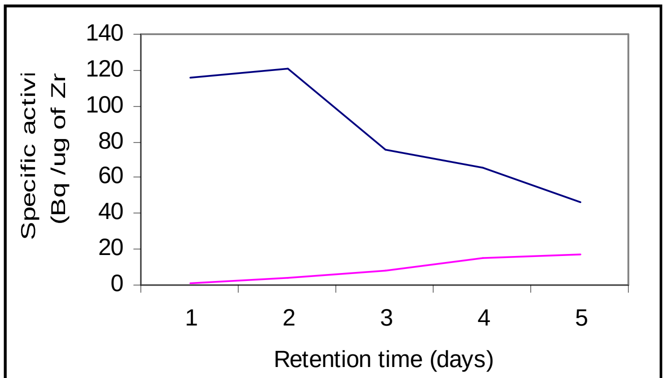

Fig.1 : Specific activity of Zn in root and shoot samples of water hyacinth

Similarly from the Table 2, it is evident that the percentage absorption of radioactivity by the root samples was 3.14 % on the first day which then subsequently decreases to 1.08 % on the fifth day. In the shoot samples the initial % of radioactivity was only 0.01 % which then increases slowly and reaches 0.37 % on the fifth day. Fig. 2 depicts the relationship of percentage of absorption of radioactivity by root and shoots samples of water hyacinth and retention time.

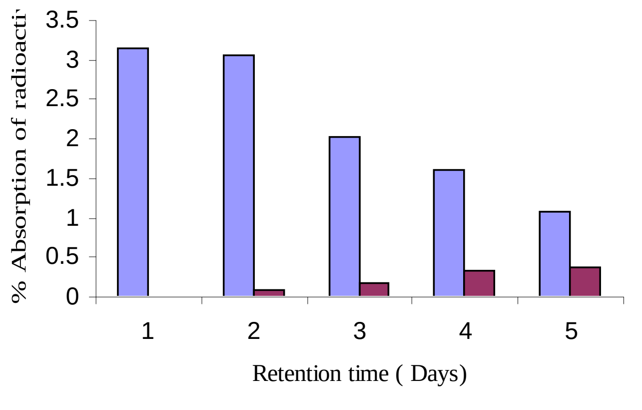

Fig.2 : Per cent absorption of radioactivity by the root and shoot samples of water hyacinth

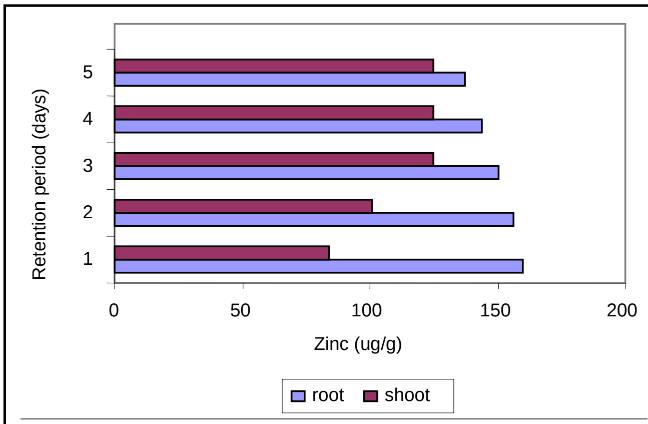

Fig.3 : Zinc content of roots and shoots of water hyacinth treated with heavy metal solution for retention period of five days

The results add still more conformity to the fact that Zn is not only accumulated in the root regions further they are transported to the shoot regions too. However, the maximum absorption by the roots took place on the first day.

Zinc content of the root and shoot samples of water hyacinth treated with 20 ppm $ZnCl_2$ solution by atomic absorption spectrophotometry was analysed. Accumulation of heavy metals by the root samples was 160 µg / g on the first day and subsequently it is lowered to 137 µg / g on the fifth day whereas in shoot regions it was 84 µg / g on the first day and later on increased to 125µg / g and thereafter remains constant. Fig. 3 illustrates the zinc content of roots and shoots of water hyacinth treated with 20 ppm $ZnCl_2$ solution for a period of five days.

The results confirm that the metal accumulating capacity of roots of water hyacinth is greater than that of the shoot. The findings are in line with those of Panda (1996).

Conclusion:

Radio tracer assessment of metal accumulation in water hyacinth has proved that heavy metal ions are rapidly accumulated in the root regions within 24 hours and subsequently translocated to shoot regions and thus the use of the aquatic macrophyte, water hyacinth presents a real time strategy for removal of contaminated metal ions and can be recommended for the treatment of zinc loaded waste water.

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