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COMMUNICATION III

Removal of Arsenic from Solution by Water Hyacinth (*Eichhornia crassipes* (Mart) Solms).

ABSTRAK

Potensi pokok kiambang (Eichhornia crassipes *(Mart) Solms) sebagai suatu biopenunjuk/biopengumpul arsenik dalam larutan cair telah dikaji. Keputusan menunjukkan tumbuhan ini dapat mengalih arsenik secara berkesan jika larutan tidak mengandungi fosfat yang mempunyai kepekatan yang tinggi. Walau bagaimanapun, dengan adanya kepekatan fosfat yang tinggi pengambilan arsenik direcatkan. Arsenik boleh juga dikeluarkan daripada tumbuhan di bawah keadaan ini. Jadi, kita mestilah berhati-hati apabila menganggar status arsenik dalam alam sekitar akuatik melalui tumbuhan ini.*

ABSTRACT

The potential of water hyacinth (Eichhornia crassipes *(Mart) Solms) as a bioacummulator/bioindicator of arsenic in dilute solution was investigated. Results show that in the absence of a high level of phosphate, it can remove arsenic effectively. However, in high phosphate concentration, arsenic uptake was inhibited. Arsenic could also be leached out from the plant. Hence caution must be exercised in interpreting the arsenic status of the aquatic environment as seen through water hyaçinth.*

INTRODUCTION

Arsenic is a toxic element whose hazardous effects on human life is well documented (Buchanan 1962; Ishinishi *et al.* 1986). It is a serious pollutant in the environment as it does not degrade like some organic materials. Lee *et al.* (1989) studied the arsenic contents of water and aquatic plants in mining pools in Selangor. Arsenic contents of 0.01-0.15 μg ml^{-1} and 10-600 μg g^{-1} for the water and plant samples respectively were reported. EPA guidelines for arsenic in drinking water is less than 0.05 ug ml^{-1} As some of these mining pools have the potential for fish cultivation, it is of interest to investigate the suitability of some of these aquatic plants to bioaccumulate arsenic.

Water hyacinth is one of the most studied aquatic plants as a bioaccumulator of pollutants especially for heavy metals (Prakash *et al.* 1987; Wolverston 1975). However, very little has been reported on its capacity to remove anions. The uptake of phosphorus as $^{32}PO_4$ was reported by Cooley *et al.* (1979). This paper reports the results of a preliminary study of the suitability of water hyacinth in the removal of arsenic as Na_2HAsO_4 in solutions. As arsenate and phospate are chemical analogues, the effect of phosphate on arsenic uptake was also investigated.

METHODS AND MATERIALS

Aquatic plants were collected from a mining pool along the Kuala Lumpur - Seremban Highway. Treatment of plants is as described by Low *et. al* (1984). In the comparative study of As uptake by water hyacinth and hydrilla, *Hydrilla verticillata,* plants of approximately 100 g were placed in beakers containing 1500 ml of 0.5 μg ml^{-1} As (V) solution. Controls without As were used to monitor phytotoxicity in plants. Samples of solution were withdrawn at regular intervals and HCI was added to render a final concentration of 1.2M. Analysis of As was by the hydride generation method using a Labtest-ICP-AES spectrometer. Water loss due to evaporation and transpiration was compensated by adding water to the same level prior to sampling.

The effect of initial concentration of As on its uptake by water hyacinth was studied by varying the concentration of As solution from 0.15 to 0.68 μg ml^{-1}

The competitive uptake of As and P was investigated in 0.8 $\mu g\ ml^{-1}$ As solution in various phosphate concentrations.

The leaching of As in water hyacinth was conducted by using phosphate solutions of various concentrations.

RESULTS AND DISCUSSION

The uptake of As in solution by water hyacinth and hydrilla is shown in *Fig. 1*. The rates of As removal are rapid for both the aquatic plants. Water hyacinth was capable of removing 90% of As after 24 h whereas hydrilla 70% after 48 h. Thereafter equlibria seemed to have been established and no appreciable uptake was noted.

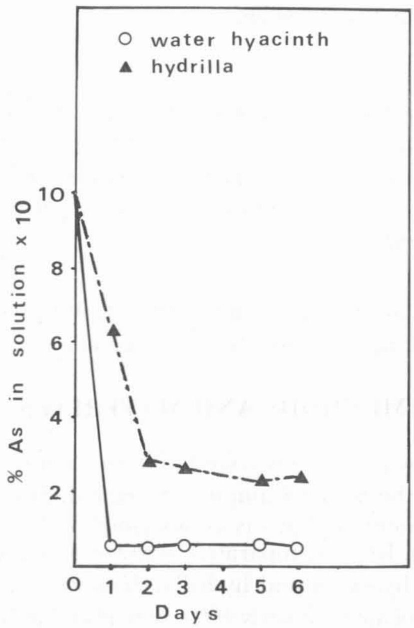

Fig. 1: Comparative uptake of As by water hyacinth and hydrilla.

Analysis of As content in water hyacinth shows that As was mainly located in the root system. Translocation of As appears to be a slow process in the plant. It could be due to the greater As affinity in the root system. In general all arsenic compounds are strongly adsorbed to root surfaces from solution. This adsorption is apparently limited only by availability. More toxic arsenic compound is less readily translocated from the root system. (Sachs and Michaels 1960). A typical As anaysis of a single water hyacinth plant is shown in Table 1. These values are comparable to the results reported by Anderson and co-workers (1980) on their study of uptake of arsenic in aquatic plants. Arsenic levels were found to be 15-1200 $\mu g\ g^{-1}$ for contaminated plants.

TABLE 1.

As contents in various parts of a water hyacinth plant

Parts	Dry weight (µg)	Total As (µg)	As (µg g^{-1} dry weight)
Roots	0.95	590	622
Floaters	0.75	30	40
Leaves	0.35	12	34

Both plants show good potential in removing As. Subsequent experiments, however, were conducted with water hyacinth only.

The uptake of arsenic by water hyacinth at various As concentrations is shown in *Figure 2*. The rate of uptake increases with increasing concentration. A similar observation is also reported by Prakash *et al.* in their study of cadmium uptake by the same plant (1987).

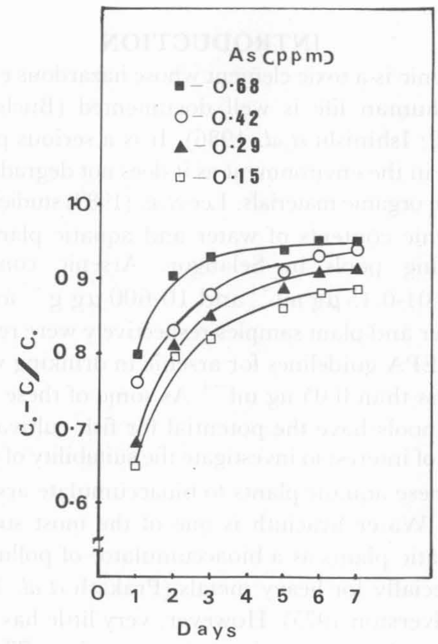

Fig. 2: Uptake of As by water hyacinth in solutions of different As concentrations (C_o - initial concentration and C-concentration at time t).

The pHs of solutions with varied levels of phosphate in a fixed amount of As are shown in Table 2.

TABLE 2
The pHs of solutions before and after uptake by water hyacinth (As: 0.8 ppm)

Phosphate concentration (ppm)	pH before	pH after
1	5.8	6.7
10	5.5	6.5
100	5.2	6.1
500	4.9	5.7

Initial pH depends on the phosphate concentration. At the end of the uptake (6 days) all solutions show an increase in pH. This is probably due to the reduction of phosphate concentration in the solution. Subsequent measurements confirmed the above statement.

Analysis of aquatic plants generally provide some information on the status of contamination of the aqueous system by a particular pollutant. This is true only if the presence of other substances do not affect its uptake. *Figure 3* shows the effect of phosphate on the uptake of As by water hyacinth. At low phosphate level (1 $\mu g\ ml^{-1}$), the As uptake was not affected. Presumably there were enough binding sites in the plant for both As and phosphate. At a higher phosphate level (>100 $\mu g\ ml^{-1}$), the uptake was not only suppressed but the original As in the plant tissues was displaced by the phosphate. This reflects that the plant has a greater affinity for phosphate than arsenate despite the fact that both are chemical homologues. Hence, caution must be taken in interpreting results of such a system. The absence or low level of As in plant does not necessarily reflect the same status in the aqueous environment.

Figure 4 shows the leaching of As from water hyacinth in various phosphate solutions. In the absence of low phosphate concentration, no displacement of As was noted. The displacement became more pronounced with increasing concentration. This result is in agreement with the earlier observation that in water hyacinth, phosphate binds more strongly in the plant tissues than arsenate.

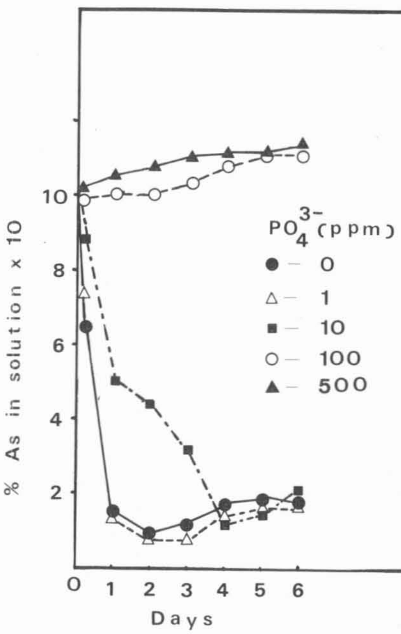

Fig. 3: Effect of phosphate on the uptake of As by water hyacinth.

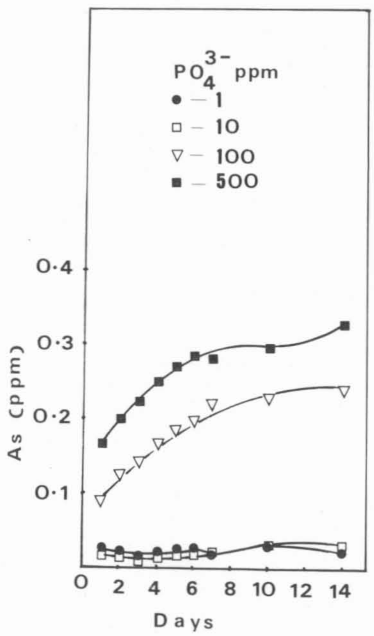

Fig. 4: Effect of phosphate concentration on the displacement of As in water hyacinth.

CONCLUSION

Preliminary results show that water hyacinth could be used as a bioaccumulator for As provided the solution contains no or low levels of phosphate.

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