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# Removal of lead by water hyacinth

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**Lead removal from synthetic lead spiked water by water hyacinth (*Eichhornia crassipes* Mart) solms has been investigated to explore the performance of the aquatic plants as lead accumulator. The batch kinetics sorption studies have been described by a linearised Freundlich isotherm which indicate that 85-92% of lead removal is possible for a retention period of 10 days at *p*H 7.0-7.5 between initial lead concentration range 0.5-10 mg/L under specified environmental condition. It is observed that the sorption of lead is not much dependent on *p*H although the cessation of growth and wilting up of the plant occurred below *p*H 4.5.**

Many techniques are available for the removal of lead from aqueous solution such as ion exchange, adsorption, chemical precipitations, coagulation and filtration[1]. These methods are efficient, but costly and require a large amount of chemicals. The present work explores the possibility of utilising water hyacinth to remove lead from aqueous phase by studying its absorption capacity through experiments.

Water hyacinth are large floating aquatic plants having broad glossy green leaves found in the water bodies rich in nitrogen and phosphorus. It has been found that luxuriant growth of water hyacinth occurs in the temperature and *p*H ranges of 26-35°C and 5.5-7.5, respectively[2,3]. Its growth appears to be restricted between *p*H 4.5-5.5 and 7.5-8, while in other *p*H condition the plant cannot withstand. Water containing 0.03-1.6 mg/L of $NO_3$-N, 0.21-7.98 mg/L $NH_4$-N, 0.41-6.4 mg/L $PO_4$-P and dissolved oxygen 2-9.9 mg/L appear to be critical for its growth.

It has been reported that the water hyacinth can readily absorb some heavy metals like chromium, nickel, cadmium, silver, copper and even mercury from wastewater[4-8]. In the laboratory experiments such metals were either absorbed or metabolized at the rate of 0.54-0.67 mg/g of dry plant/day. In the field condition, however, the above constituents were removed at the rate of 0.13-0.16 mg/g of dry plant/day.

In the present work, attempts have been made to study the lead adsorption capacity of water hyacinth (*Eichhornia crassipes* Mart) through laboratory experiments considering the requirements of necessary lead removal from the industrial waste discharge stream. The initial lead level for the study was taken in the range between 0.5-12.0 mg/L. The study covers most of the lead containing wastewater emanated from various industries.

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## Experimental Procedure

The aquatic plants *Eichhornia crassipies* approximately 15-20 days old were collected from a pond near Indian Institute of Technology, Kharagpur. The average pond water quality as determined in the laboratory has been shown in Table 1.

Table 1—The characteristics of pond and tap water

| *Characteristics* | *Pond* | *Tap* |
|---|---|---|
| Temperature | 30 ± 2°C | 28 ± 3°C |
| *p*H | 7.5 ± 0.3 | 7 ± 0.4 |
| Hardness | 65 | 110 |
| TDS | 640 | 350 |
| TSS | 28 | 10 |
| Ca | 25 | 40 |
| Mg | 40 | — |
| Chlorides | 52 | 32 |
| Lead | — | Not detectable |
| Sulphate | 49 | — |
| Phosphate | 4 | — |
| TKN | 12 | 2 |
| Turbidity | — | 5 NTU |
| Alkalinity | — | 130 |
| Dissolved oxygen | 7.8 | — |
| COD | 30 | — |

Note: Except temperature and *p*H all values are in mg/L

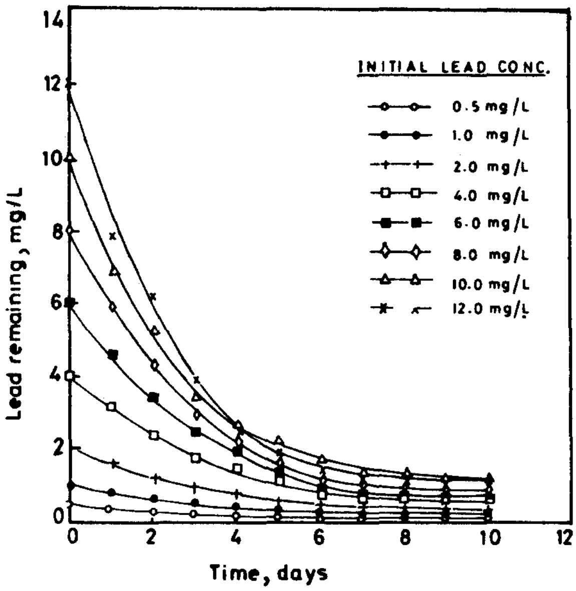


Fig. 1—Removal of lead with time

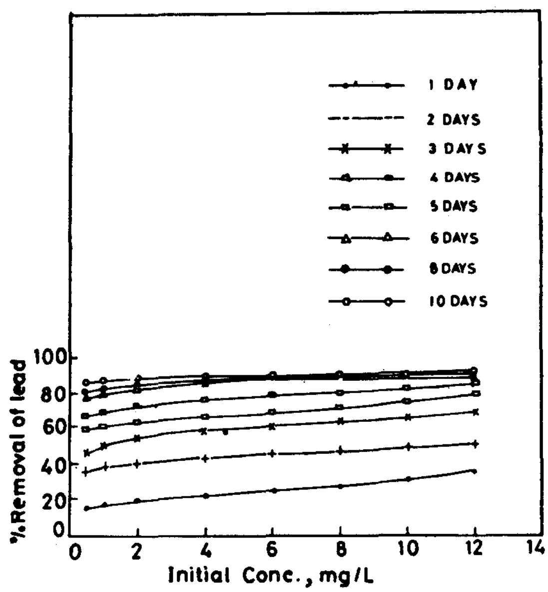


Fig. 2—Removal of lead w r t initial concentration

All the chemicals used were of AR grade. A stock (1000 mg/L) lead solution was prepared by dissolving lead nitrate in doubly distilled water. Lead concentration in aqueous solution was determined using Flame Atomic Absorption Spectrophotometer AA-670 (Shimadzu, Japan).

Batch experiments were conducted in ten-litre capacity plastic buckets. Suitable synthetic waste solution was prepared by adding stock lead solution to tap water in required quantity to give the desired lead concentration. The characteristics of tap water as determined have been shown in Table 1.

About 400 g of water hyacinth plants were introduced to one bucket covering about 75% of the total surface area. Another bucket without hyacinth served as a control. These buckets were kept under a covered shed with translucent sheet over the roof to have an exposer of penetrating sunlight. In addition to natural light, two bulbs (200 W) were also installed inside the shed to provide necessary lighting. Periodically aliquots of solution were taken from buckets and lead concentrations were estimated. Volume of water in the buckets were adjusted to 10 L, after aliquots were taken for analysis and to make up the loss due to evaporation. The total retention period for each set of experiment was 10 days.

Standard methods were followed for determining various other water quality parameters[9].

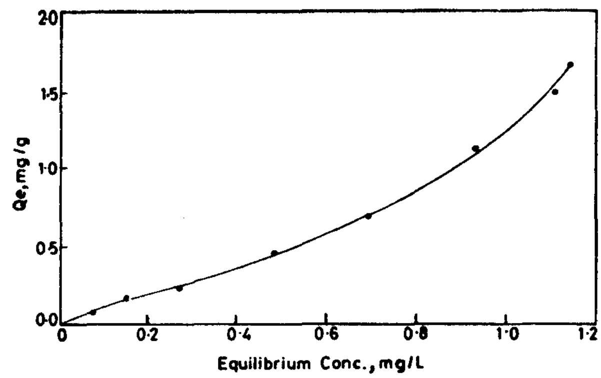


Fig. 3—Adsorption isotherm

## Results and Discussion

*Sorption kinetics*—The root system of water hyacinth is considered as a sorbent which absorbs the lead from aqueous soltuion. The uptake of lead at *p*H 7.5 for different initial lead concentration is shown in Fig. 1. The percentage removal of lead with time is shown in Fig. 2. From Figs 1 and 2, it is observed that initially the adsorption rates are faster and then decrease gradually to approach equilibrium after 8 days. It can be also noted that about 85-90% removal of lead is achieved after 8 days.

*Sorption isotherm*—The sorption isotherm for the lead-water hyacinth system has been shown in Fig. 3. Experimental data are fitted to the linearised Freundlich's equation, which is of the form,

$$\log\left(\frac{X}{M}\right) = \log K + \frac{1}{n}\log C_e$$

in which $\left(\frac{X}{M}\right)$ is the quantity of lead adsorbed per unit weight of absorbent, $C_e$ is the equilibrium concentration of lead remaining in the solution in

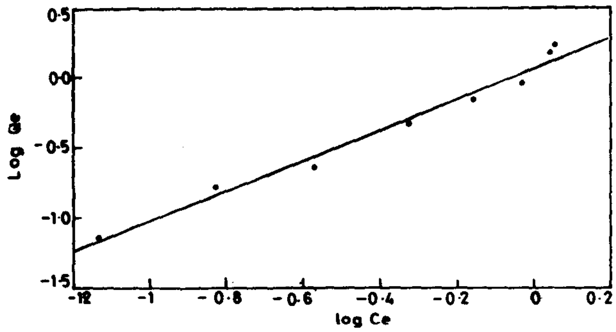


Fig. 4—Linearised Freundlich isotherm

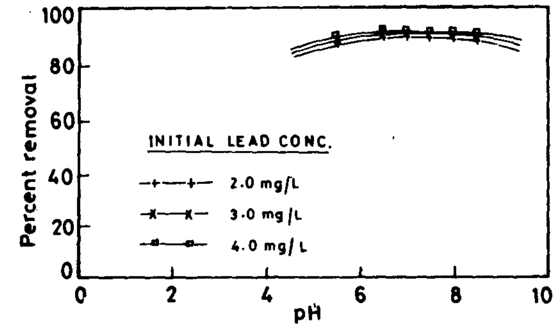


Fig. 5—Effect of *p*H

mg/L, $K$ is constant which measures sorption capacity and the slope and $1/n$ is a measure of sorption intensity.

Fig. 4 indicates that sorption of lead by *E. crassipies* follows the Freundlich isotherms.

The equation established on the basis of the experimental data can be written as

$$\frac{X}{M}=0.562\ C_e^{0.344}$$

From the above equation, it can be said that for 1 mg/L equilibrium concentration of lead, each gram of water hyacinth can adsorb 0.562 mg of lead under the present experimental conditions.

*Effect of p*H—Fig. 5 shows the effect of *p*H on lead removal by water hyacinth. At *p*H 3-4 the adsorption occurs but the biosynthesis and metabolism of plants were inhibited and after 3 days contact time plants were wilted. With increase in *p*H adsorption rate enhances, at the same time, it appeared that, the rate of removal is marginally increased from *p*H 6 to 8.5 without any wilting of the plant.

From Fig. 1, it is observed that the rate of uptake of lead initially is very high during first 3 days. Fig. 2 indicates that the percentage removal rate also depends on initial concentration of lead in aqueous solution. However, it is seen that, equilibrium state was reached in lead uptake systems after 8 days time period which does not much depend on initial concentration of lead in the solution. From the experimental results it is found that the adsorption of lead is in between 10-150 mg/g/day. However, in the field condition it can be achieved more by adopting continuous harvesting technique with more exposure to sunlight or better photosynthesis. The increase in initial rate of removal with increment of initial lead concentration may be due to the difference of concentration between the solution and root system. The rapid uptake might be due to an initial phase of exchange phenomenon followed by a slow phase due to metabolic regulation after satisfying the trace element requirements by the plant for thin growth. This uptake is probably due to the formation of stable complex with protein molecules present in the plant root. About 92% reduction of lead is possible with 10 days of contact time for an initial concentration of lead 10 mg/L.

## Conclusion

From the experimental results it can be concluded that the water hyacinth (*Eichhornia crassipes*) have the capacity to adsorb lead from the aqueous solution which can be utilised for its scavenging from wastewater for water purification. It was observed that both kinetics and removal capacity are favourable within 10 days of contact time for 85-92% reduction of lead for an initial concentration of lead in the range 0.5-10 mg/L. The adsorption isotherm indicates that the removal of lead is in between 7.27 to 148.8 mg/kg of dry plant/day in the stated range of initial lead concentration. The process is not much dependent on *p*H. Though the water hyacinth can effectively be utilised for removal of lead from the aqueous solution but there are certain hazards associated with it particularly when it finds entry in natural water bodies. It will produce a nuisance and decrease dissolved oxygen level in water. After harvesting proper disposal of the plant will also pose a problem to environment. Dissociation of soluble matters in water bodies from the plant shall increase the pollutant levels. This is a serious limitation of using hyacinth as a medium of lead removal.

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