Lead Uptake in Acidic Medium by *Lemna minor*

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The present paper discussed the assimilation of lead by *Lemna minor* in acidic (acetic acid and nitric acid) medium (pH ranging from 4-6).

Key Words: *Lemna minor*, Lead removal, Nitric acid, Acetic acid.

INTRODUCTION

The heavy metals of widespread concern to human health are mercury, cadmium, lead, arsenic, chromium, copper and zinc[1,2]. Nriagu[3] estimated that over one billion human beings are currently exposed to elevated concentrations of toxic metals and metalloids in the environment and several million people may be suffering from subclinical metal poisoning. Some of the heavy metals are carcinogenic[4]. Some heavy metals such as lead are neurotoxic and children are particularly vulnerable because of the rapidly developing nervous system[5]. Lead is known to inhibit the activity of three critical enzymes (5-aminolaevulinate dehyratase (ALA-D), coproporphyrinogen oxidase (COPRO-O) and ferrochelatase (FERRO-C)) critical in haem synthesis, causing abnormal concentrations of haem precursors in blood and urine[6].

The toxicity of heavy metals in wastewater depends on factors like metal species and concentration, pH, sludge concentration, wastewater pollution load[7,8] and solubility of the metal ions[9]. Permissible limits for lead in drinking water given by the U.S. Environmental Protection Agency (U.S. EPA) is 0.015 mg/L and for wastewaters is 0.1 mg/L[10,11]. Thus it becomes mandatory for removal of lead from drinking and wastewaters. According to the literature, traditional remediation methods for contaminated water are costly compared to the use of biomaterials[12,13].

Several studies indicate that aquatic plants have large potential for the removal of organic and inorganic pollutants from wastewater. Among the plants studied, floating macrophytes (macro algae, duckweed and water hyacinth) provide advantages over emergent plants or microorganisms because they are much easier to harvest[14]. Duckweed was chosen because of rapid growth and vegetative reproduction, small

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size, relative structural simplicity and genetically identical populations[15]. Lemna species are able to remove different kind of pollutants from water, as nutrients[16], organic compounds[17] and heavy metals[18,19].

Lead is more soluble in acidic medium. Many of the industrial discharges come in acidic medium. The objective of this study is to evaluate the uptake of lead in contaminated water with variable pH in acid medium by duckweed (*Lemna minor*). Acetic acid and nitric acid were chosen for the study in the pH range of 4-6.

EXPERIMENTAL

Duckweed plants were picked up from a stream of waste water from the main campus of IIT, Delhi. They were identified as *Lemna minor* and were cultured in a water tank in Micro model IIT Delhi (an experimental site).

Experiments were conducted in triplicate in plastic containers of 10 L capacity and average values were reported. These containers were kept in an open environment to get enough sunlight. A known quantity of *Lemna minor* was taken out of culturing tank and treated with lead nitrate (*i.e.* 20 and 1 mg/L) under acidic pH conditions (4, 5 and 6). Acidic pH was maintained by using acetic acid and nitric acid. The plants were allowed to grow and tap water was added daily to compensate water loss through plant transpiration, sampling and evaporation. Samples were collected in an interval of 7 days. The biomass weights were taken by drying these plants on filter paper for 10 min (fresh weight). Plants were analyzed for relative growth, metal accumulation and bioconcentration factor (BCF). In addition, the metal that remained in the solution was also analyzed to assess the removal potential of *Lemna minor*.

Relative growth of control and treated plants were calculated as follows[20]:

$$\text{Relative growth} = \frac{\text{Final fresh weight (FFW)}}{\text{Initial fresh weight (IFW)}}$$

The BCF provides an index of the ability of the plant to accumulate the metal with respect to the metal concentration in the substrate. The BCF was calculated as follow[18]:

$$\text{BCF} = \frac{\text{Concentration of metal in plant tissue}}{\text{Initial concentration of metal in external solution}}$$

Detection method: The dried plant samples were heated in a muffle furnace at 500 °C for 6 h. The ash of each sample was dissolved in 5 mL of 20 % hydrochloric acid (HCl) to dissolve the residue. Samples were heated on a hot plate to boiling. Required amount of HCl (20 %) was added to avoid sample drying. The resulting solutions were filtered and diluted to 50 mL with deionized water in volumetric flasks. The lead contents of these plant samples and water samples were determined using flame atomic absorption spectrophotometry (AAS model no. AAS4129) with the following settings: wavelength 217 nm, lamp current 5 mA, slit 1 nm, fuel-acetylene and oxidant air.

RESULTS AND DISCUSSION

The results obtained, out of the experiments, have been shown in Figs. 1-4. The *Lemna* biomass was harvested to get its yield and the metal analysis after the seven days of experiments. The water remaining in the tub was also analyzed for metal content.

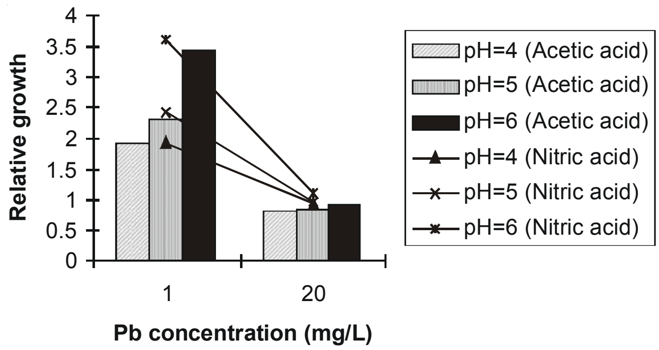

Fig. 1. Relative growth of *Lemna minor* at different acidic pH

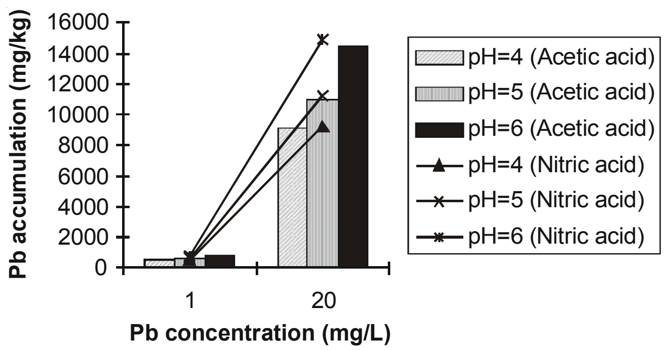

Fig. 2. Lead accumulation in *Lemna minor* at different acidic pH

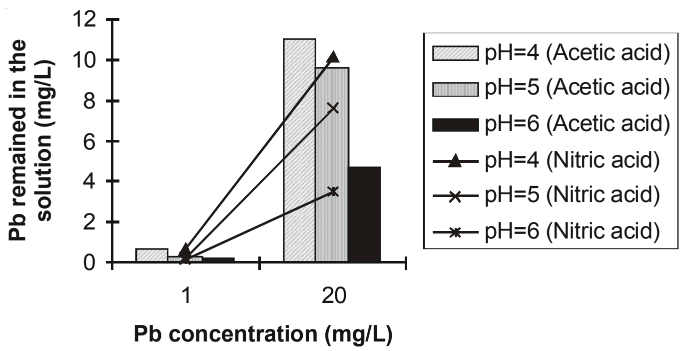

Fig. 3. Lead remained in the solution at different acidic pH

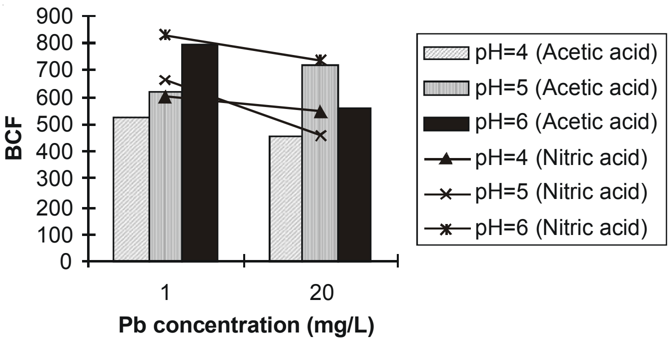

Fig. 4. Bioconcentration factor (BCF) values at different acidic pH

Relative growth: Fig. 1 shows the effect of lead on relative growth of *Lemna minor* at different acidic pH generated by using acetic acid and nitric acid. From the figure obtained, it is clear that with the increase in lead concentration there is a decrease in growth of *Lemna minor*. Relative growth of *Lemna minor* was better at pH 6 as compared to pH 4 and pH 5 in nitric acid medium. The highest value of relative growth was 3.62 for plants treated with 1 mg/L lead at pH 6 (nitric acid).

Metal accumulation: Graphical representation of lead accumulation by *L. minor* at different acidic pH and lead concentrations is shown in Fig. 2. It showed better accumulation at pH 6 as compared to pH 5 and pH 4. Plants treated with 20 mg/L of lead at pH 6 (nitric acid) accumulated the highest level of metal (14845 mg/kg).The lowest lead accumulation was found to be 532 mg/kg for *L. minor* treated with 1 mg/L lead at pH 4 (acetic acid).

Metal remained in the residual solution: Concentration of lead (mg/L) remained in the water samples at different acidic pH are shown in Fig. 3. The lowest value of lead remained in the residual solution was 0.176 mg/L at pH 6 (nitric acid) for 7 d treated with 1 mg/L lead while highest value was shown by 20 mg/L lead at pH 4 (acetic acid).

Bioconcentration factor (BCF): Bioconcentration factor was calculated for quantifying the lead removal potential of the *L. minor*. Effect of acetic acid and nitric acid with BCF at different acidic pH are shown in Fig. 4. Bioconcentration factor values decreased with increase in lead concentration in the feed solution. The maximum BCF of 832 was obtained in plants treated with 1 mg/L lead at pH 6 (nitric acid) and the minimum of 457.9 in plants treated with 20 mg/L Pb at pH 4 (acetic acid).

Conclusion

The results show that 1 mg/L lead acts as a nutrient for *Lemna minor* showing very good relative growth, whereas when the concentration of lead goes to 20 mg/L the growth is hampered.

Comparing the effect of acetic acid and nitric acid, the effect of nitric acid is more marked in the accumulation. Though both acids dissolve lead, accumulation is more pronounced with nitric acid.

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