

SHORT COMMUNICATION

REMOVAL OF LEAD IONS FROM INDUSTRIAL WASTE WATER BY USING BIOMATERIALS – A NOVEL METHOD

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ABSTRACT. A simple cost effective and eco-friendly method for the remediation of lead from industrial wastewater has been investigated. A novel biomaterial, *Tridax procumbens* (Asteraceae) a medicinal plant, was used for the removal of lead ions from synthetic wastewater and the method was also applied for real sample analysis. The operational pH of the experimental solution was fixed as 4.5. The optimum amount of bioadsorbent was 3.5 g. The Pb(II) ions removal efficiency of the raw bioadsorbent was also determined. The removal efficiency of the activated carbon of the bioadsorbent was excellent. 98 % removal of Pb(II) ions was achieved at the dose rate of 3.5 g. The optimum contact time was estimated to be 160 minutes.

KEY WORDS: Removal of lead ions, Industrial wastewater, Biomaterial, *Tridax procumbens* (Asteraceae)

INTRODUCTION

Extensive pollution of fresh water is posing a serious and growing threat to sustainable development as well as protection of the environment. Human health, agricultural development, industrial development and the ecosystems are all at risk, unless water and land systems are effectively managed [1]. Best water management systems based on scientific methods and effective control of industrial waste and preventing the water resources from pollution is an important aspect.

The presence of various heavy metals in the water and land systems causes serious concern [2] in nature as they are non-biodegradable and may accumulate at high levels. Industrial wastewater, particularly in electroplating, metal finishing industries, tannery operators, chemical manufacturing and battery manufacturing industries is an important pathway for entry of metals in the environment. There are also releases of other heavy metals into the environment.

Lead is an industrial pollutant, which enters the ecosystem through soil, air and water. Inorganic lead is an enzyme inhibitor, which also affects the nervous system [3]. It is very toxic in nature [4]. According to the WHO, the maximum permissible limit (MPL) of lead in drinking water is 0.05 mg/L [5]. Hence proper treatment of industrial wastewaters which are releasing lead into the aquatic and land systems is very important.

There are several methods such as chemical precipitations, conventional adsorption [6-11], ion exchange [12], membrane separation methods [13] and electro-remediation methods [14] available for treatment of wastewater. However, most of the methods are costly and not economically feasible and also not eco-friendly nature due their secondary effluent impact on the recipient environment.

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In this context, a search for newer eco-friendly method is essential. A biotechnological approach involving application of medicinal plant leaves in the removal of heavy metals from the industrial wastewater can offer a complete solution. In our earlier studies, we have used novel biomaterials, *Tridax procumbens* (Asteraceae) a medicinal plant largely populated in southern part of Tamilnadu, India, for the color removal of industrial wastewater [15]. In the present work, we have used the same biomaterials for the removal of lead from synthetic wastewater samples.

EXPERIMENTAL

Synthetic wastewater samples were prepared by using analytical grade lead nitrate by using double distilled water. The concentration of lead in the solution was 0.1 M. The stock solution was prepared by dilution with double distilled water, which contains 100 ppm of Pb(II) ions. The pH of the solution was adjusted to 4.5 by using dilute sulphuric acid.

Raw bioadsorbent was collected from the agricultural field, air-dried and powdered. The homogeneous powder was used for the experiments. Activated carbon of the biomaterial was prepared by treating with the concentrated sulphuric acid (Sp. gr.1.84) in a weight ratio of 1:1.8 (biomaterial:acid). The resulting black product was kept in an air-free oven maintained at 160 ± 5 °C for 6 hours followed by washing with distilled water until free of excess acid dried at 105 ± 5 °C. The activated carbon obtained from biomaterial was ground and the portion retained between 90 and 125 μm sieves was used for metal adsorption experiments [17]. The batch experiments were conducted by using different amounts of Pb(II) in five 250 mL conical flasks. The volume of the test solution was maintained as 100 mL and 2.0 – 4.0 g of activated carbon was used. All the samples were mechanically agitated in low speed. The experiments were conducted at room temperature (30 °C). The duration of the experiments was 220 minutes. The amount of Pb(II) adsorbed on the raw bioadsorbent of the biomaterial and the activated carbon of the bioadsorbent (ACBA) were recorded by employing modified dithizone reagent method at 510 nm by using Systronics UV – Visible spectrophotometer. Double distilled water was used as reagent blank.

From a South Indian lead acid battery recharge unit, wastewater sample was collected and diluted to required volume by using double distilled water. Adsorption of Pb(II) on the activated carbon of the bioadsorbent in wastewater sample was performed in similar way of synthetic water samples.

The percent removal of Pb(II) on the adsorbents was calculated from

$$\% \text{ removal} = \frac{C_o - C_f}{C_o} \times 100$$

where C_o is the initial concentration of Pb(II) and C_f is the final concentration of Pb(II) in ppm.

RESULTS AND DISCUSSION

Effect of pH and temperature on the adsorption

In these studies, the effect of pH on the adsorption of Pb(II) ions on the activated carbon of the bioadsorbent was studied by using the initial concentration of the experimental solution as 100 ppm. The adsorbent dose was optimized and fixed as 3.5 g. The maximum adsorption of Pb(II) on the surface of the bioadsorbent was 98 percent. The desired pH value for this achievement was 4.5. The analytical results are presented in Figure 1. A further study indicated that increasing the pH of the experimental solution leads to desorption of Pb(II) ions from the

surface of the bioadsorbent. It is a well known fact that upon increasing the temperature, the rate of adsorption also increases [16, 17].

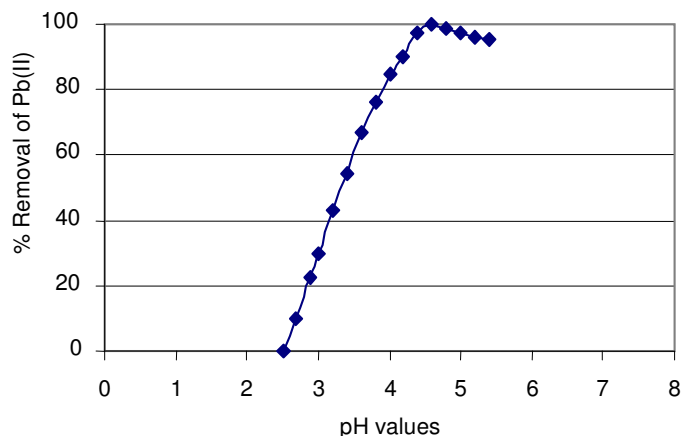


Figure 1. Effect of pH on the adsorption of Pb(II).

Effect of amount of adsorbent on the adsorption

Optimization of the amount of the adsorbent is necessary to design the optimum treatment systems and for a quick response of the analysis. To achieve this aim, five batch experiments were conducted with the adsorbent dose as 2.0, 2.5, 3.0, 3.5 and 4.0 g per 100 mL of test solution. When the addition of the adsorbent dose increased, the percent removal of Pb(II) also increased. It attains a maximum (98%) at 3.5 g of the activated carbon of the bioadsorbent. From the results, it is clearly observed that, 3.5 g of the bioadsorbent was sufficient for the effective removal of Pb(II) in aqueous solutions. A further increase in the quantity of adsorbent up to 4.0 g led to a complete removal of lead ions from the solution (100% adsorption) and hence the quantity of lead ions adsorbed remained constant. The results are presented in Figure 2.

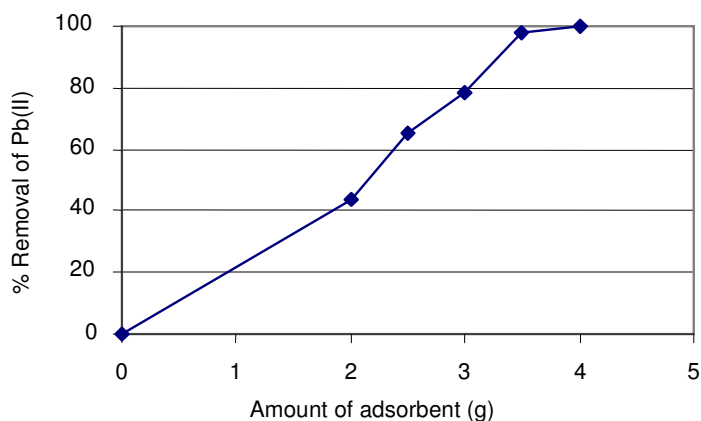


Figure 2. Effect of amount of adsorbent on the adsorption of Pb(II).

Effect of contact time on the adsorption

By fixing the amount of bioadsorbent at 3.5 g per 100 mL test solution and the pH at 4.5, the effect of contact time for the efficient removal of Pb(II) ions was studied. When the time of agitation increases, the percent removal also increases. In these studies, 98 % removal was achieved at 160 minutes. Further, no significant changes were observed in the removal of Pb(II) ions from the solution after 24 hours of equilibration. The analytical results are presented in Figure 3.

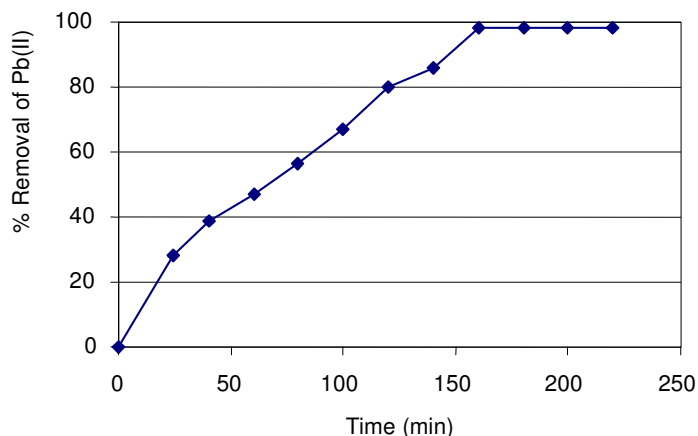


Figure 3. Effect of contact time on the adsorption of Pb(II) on 3.5 g of ACBA.

Effect of concentration of Pb(II) ions

In the present study, we have selected 25 ppm and 50 ppm as initial concentration for the comparative study for the removal of Pb(II). Fixing the amount of adsorbent as 3.5 g, the effect of the concentration of Pb(II) on the removal of Pb from solution was tested. The removal of Pb(II) was completed within 80 minutes in dilute solutions of 25 ppm. However, at higher concentrations (50 ppm), the removal was completed only after 160 minutes. This observation clearly indicates that the removal of Pb(II) purely depends on the amounts of adsorbents and contact time. The analytical results are shown in Figure 4.

Removal efficiency of raw bioadsorbent

In the present study, finely powdered raw bioadsorbent was used for testing the efficiency of removal of Pb(II) ions from the experimental solution. The amount of adsorbent dose was 3.5 g. The experimental conditions were maintained similar to those of the experiments with activated carbon of the bioadsorbent. The results of the study indicate that around 65 percent removal of Pb(II) was possible. But the chemical oxygen demand (COD) of the resulting solution increases to a large extent. The recorded value of COD was 1200 ppm. Hence, it is not advisable to use the raw bioadsorbent for removal of heavy metals from industrial wastewater.

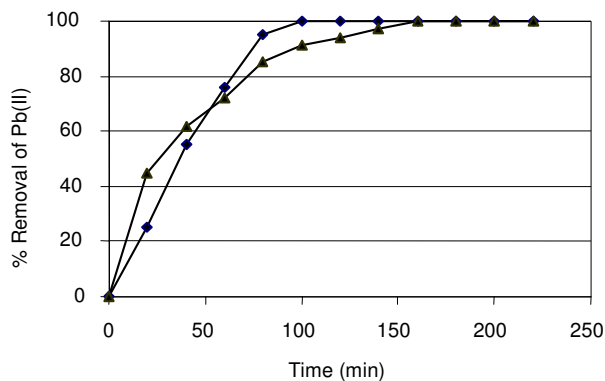


Figure 4. Effect of concentration on the adsorption of Pb(II). (◆ 25 ppm ▲ 50 ppm).

Treatment of industrial wastewater

The suitability of the bioadsorbent materials for the removal of Pb(II) was tested with the tannery industry wastewater. The composite sample pH value was maintained as 4.5. The effect of contact time with the adsorbent dose of 3.5 g on Pb(II) removal is shown in Figure 5. It has been found that increase in contact time increased the percentage adsorption. The data reveals that the treatment of Pb(II) in industrial wastewater is significantly good. Almost complete removal of Pb(II) from 100 ppm wastewater was possible with 3.5 g of the selected bioadsorbent. Thus, the results are in good agreement with the results obtained from the batch experiments conducted for the Pb(II) removal in synthetic wastewater samples. This demonstrates that the selected bioadsorbent successfully used for the removal of Pb(II) from battery recharging unit wastewater.

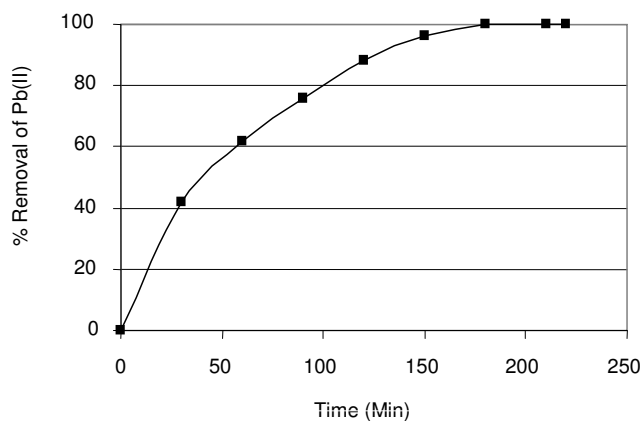


Figure 5. Treatment of industrial wastewater.

CONCLUSION

The removal of Pb(II) in synthetic wastewater by using bioremediation technology was studied in batch experimental systems. Based on the results, the following conclusions can be drawn. Activated carbon is an efficient biomaterial for removal of lead from industrial waste water. The percent removal of Pb(II) under the conditions employed here, is 98 with an effective dose of 3.5 g of bioadsorbent. Complete removal of Pb(II) in battery recharge unit wastewater is achieved. The handling of the biomaterial is very easy and harmless. This process can be effectively used in Pb(II) and other heavy metals removal in industrial wastewater. The raw bioadsorbent is not suitable for the direct industrial wastewater treatment operation.

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