EQUILIBRIUM STUDIES OF ADSORPTION OF LEAD ON COCONUT SHELL FROM TANNERY EFFLUENT

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ABSTRACT

The aim of the present study is to explore the feasibility of using coconut shell as adsorbent for the removal of lead ions from tannery effluent. Batch studies have been conducted to investigate the influence of various parameters such as pH, contact time and metal ions concentration on the adsorption of lead by coconut shell. It has been observed that adsorption percentage of Pb(II) increases to 81.66% within 20 minutes on increase in pH range 4 to 6 and decreases with increase of metal ion concentration. The highest value of R^2 = 0.9918 for Fruendlich isotherm indicates that adsorption of Pb(II) by coconut shell obey Fruendlich isotherm more appropriately than Langmuir. These results suggested that coconut shell can be effectively used for the removal of lead from tannery effluent.

Keywords: Adsorption, batch process, Coconut shell, Fruendlich, Langmuir and tannery effluent.

I. INTRODUCTION

For decades, urban and industrial pollution has led to a gradual degradation of the natural environment. The fast paced development of industries such as metal mining operations, leather industries, fertilizers and paper industries and pesticides have deliberately discharge various types pollutants into the environments especially in developing countries. Lead as a pollutant is a major concern as it has been used as one of the raw materials for battery manufacturing, printing, pigments, fuels, photographic materials and explosive manufacturing. EPA has determined that lead is a probable human carcinogen. Permissible limit of lead in drinking water by EPA, SUEPA and WHO is 0.05 mgL^{-1} and that of Bureau of Indian Standards (BIS) is 0.1 mgL^{-1}. Lead can affect every organ and system in the body. Long term exposure of adults can results in decrease performance of nervous system, weakness in fingers and wrists or ankles, increase in blood pressure and anaemia [1].

Many conventional techniques have been used to reduce the concentration of heavy metals present in wastewater but adsorption has found to be superior both in terms of cost and efficiency of the process. In this context many researchers used number of adsorbents to remove heavy metals from aqueous systems. Among them saw dust [2], fruit peel of orange [3], rice husk [4], flyash [5], zeolite prepared from Egyptian kaoline, dried activated sludge biomass [6] have recently been reported. In this article potentiality of coconut shell has been investigated to remove lead from tannery effluent [7].

II. MATERIALS AND METHODS

2.1 Preparation of adsorbent

The raw coconuts were purchased and after removing pulp, shells were collected, washed and dried for three days in sunlight. Then shells were broken into small pieces and dried again in an oven at 105 °C for 3 hours. These shells were crushed into fine particles to increase surface area for adsorption. The particles were washed with double distilled water (DDW), dried in oven at 100 ± 5 °C and sieved through 300 µ mesh size ASTM sieve. The adsorbent was then finally stored in airtight container for further use.

2.2 Adsorption Studies

Batch process was conducted at room temperature to study the adsorption of Pb(II) ions on coconut shell. An accurately weighed 0.5 g of coconut shell was placed in 100 ml conical flask containing 50 ml of Pb(II) ions solution of 50 mg/L in pH range of 1 to 10. The effect of concentration were studied in range of 25 to 200 mg/L of Pb(II) ions concentration. After predetermined time interval solutions were filtered and the concentration of Pb(II) ions in filtrate was analysed by AAS (Atomic Absorption Spectrophotometer).

The removal percentage (R%) of metal ions and adsorption capacity or amount of metal adsorbed per unit mass of adsorbent(q_e) were calculated for each run by the following expression-

$$R\% = \frac{(Ci - Ce)}{Ci} \text{ x } 100$$

$$q_e = \frac{(Ci - Ce)}{m} \text{ x } V$$

where C_i is the initial concentration of metal ions, C_e is the final concentration of metal ions in the solution, V is the volume of the solution (L) and m is the mass of the adsorbent (g).

III. RESULTS AND DISCUSSION

3.1 Adsorption studies

3.1.1 Effect of pH

The pH of solution is one of the important controlling parameter in the adsorption process. The percentage removal of Pb(II) at various pH values are shown in “Fig. 1”. It has been observed that the removal efficiency of lead increases from pH 1 to 3 slowly and reaches maximum (81.66%) at pH 4 remain almost constant upto pH 6. On further increasing pH the adsorption of Pb(II) by coconut shell found to decreased. At a higher pH, Pb(II) ions gets precipitated as hydroxides which decreases the rate of adsorption and subsequently the removal efficiency of metal ions also decreased [8].

3.1.2 Effect of concentration of metal ion on adsorption

The effect of Pb(II) concentration in the solution for five different concentrations (25, 50, 100, 150 and 200 mg/L) is shown in “Fig. 2”. It has been observed that the adsorption capacity of Pb(II) increased from 2.33 mg/g to 14.18 mg/g whereas the adsorption percentage decreased from 93.34 % to 69.84 % with the increase in concentration of metal ions in the solution. This was due to the fact that empty adsorbent sites adsorbed Pb(II) ions rapidly at lower concentration but at higher concentration adsorption of Pb(II) ions occurred by diffusion (slower step) into the inner sites of the adsorbent. The maximum adsorption was observed at 25 mg/L (93.34%) and minimum adsorption observed at 150 mg/L (69.84%) [9].

3.1.3 Effect of contact time

Adsorption of metal on adsorbent used increases with increasing contact time until equilibrium is attained. The Pb(II) uptake versus time curve in "Fig. 3" shows that equilibrium is attained in 20 min, where maximum adsorption percentage of Pb(II) ions was 80.34%. The equilibrium time of 20 minutes investigated in the present work was much shorter than other adsorbents reported earlier for Pb(II) adsorption [10].

3.1.4 Effect of adsorbent dose

The adsorbent dose is an important parameter in adsorption studies because it determines the capacity of adsorbent for a given initial concentration of metal ion in the solution. The adsorption percentage of Pb(II) at different doses of adsorbent is shown in "Fig. 4". It was observed that increasing the adsorbent dose increased the percentage removal of Pb(II) upto 96.66%. The adsorption percentage of Pb(II) increased with the increase of adsorbent dose due to increase in surface area of adsorbent leading to more adsorption sites [11].

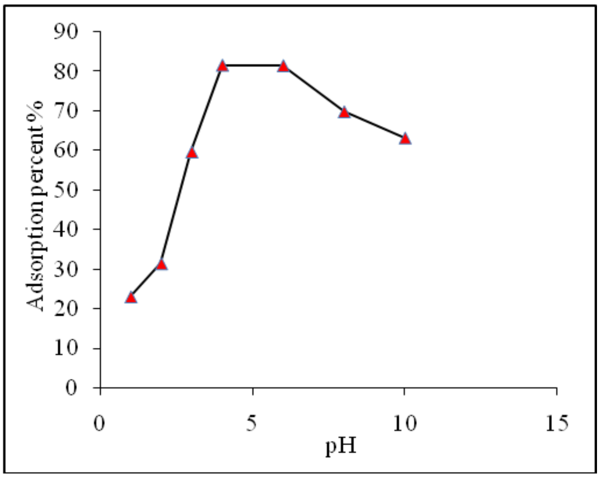

Fig. 1 Effect of pH on adsorption of Pb(II)

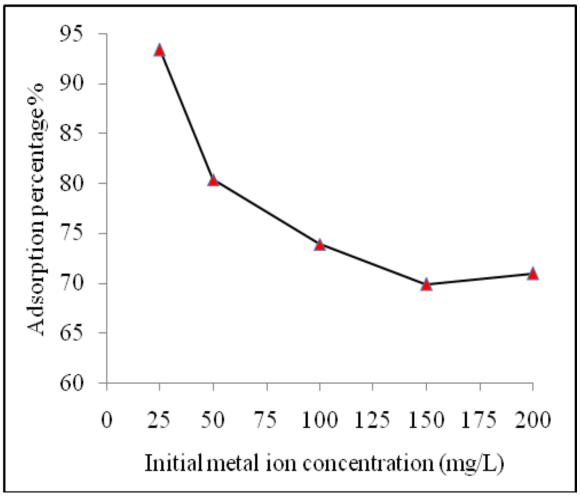

Fig. 2 Effect of concentration on adsorption of Pb(II)

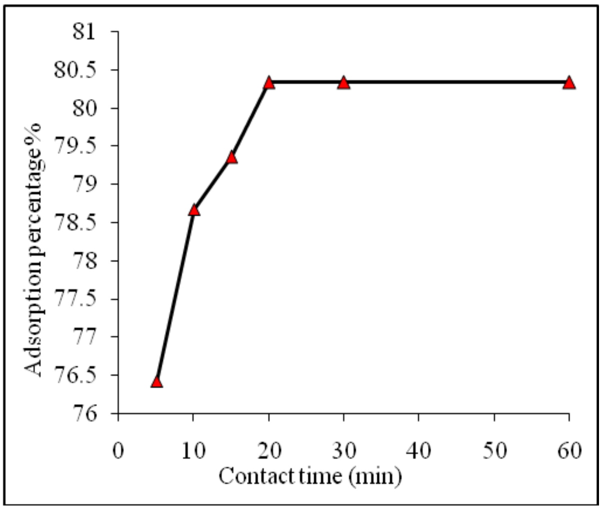

Fig. 3 Effect of contact time on adsorption of Pb(II)

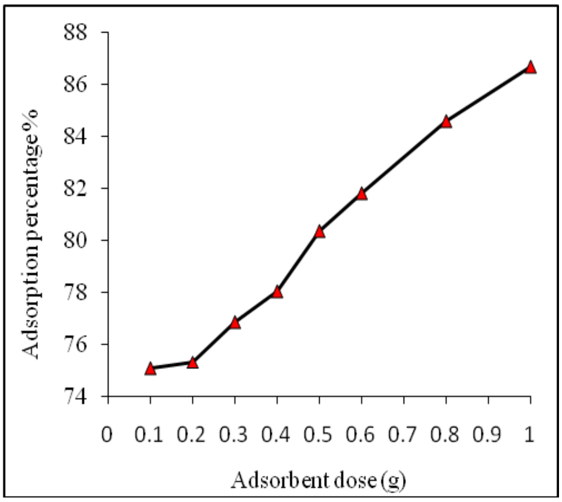

Fig. 4 Effect of dose on adsorption of Pb(II)

IV. ADSORPTION ISOTHERM

The adsorption of Pb(II) ions concentration ranging from 25 mg/L to 200 mg/L were studied and the data obtained was analyzed with both the Langmuir [12] and Freundlich [13] adsorption isotherm equations. In order to evaluate the fitness of the experimental data on Langmuir model, C_e /q_e were plotted against C_e as shown in "Fig. 5" and on Freundlich model, log q_e were plotted against log C_e as shown in "Fig. 6", respectively. The linearity of the graph and values of the correlation coefficient (R^2) revealed that the experimental data were more appropriately fitted on Freundlich isotherm model than Langmuir isotherm. Moreover the values of the correlation coefficients i.e $R^2 \approx 0.9918$ for Langmuir model and $R^2 \approx 0.7908$ for Freundlich model, respectively, suggested that adsorption of Pb(II) ions on coconut shell occurs by the formation of homogeneous monolayer followed by multilayer formation.

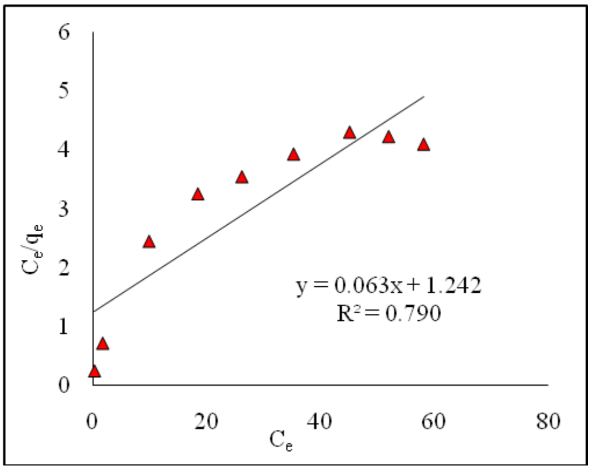

Fig. 5 Langmuir adsorption isotherm

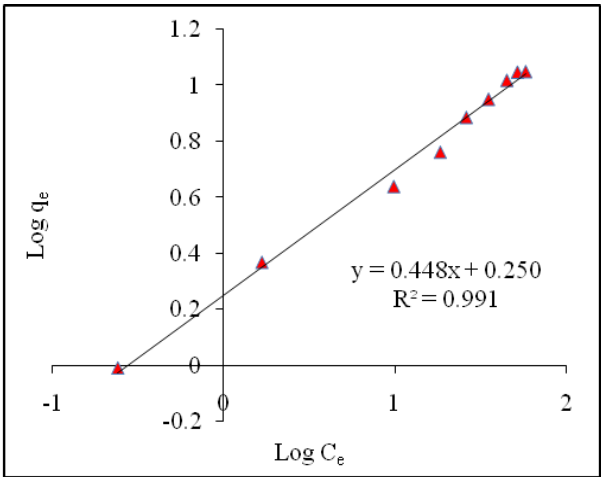

Fig. 6 Freundlich adsorption isotherm

V. CONCLUSIONS

The aim of the present study was to evaluate coconut shell as possible potential adsorbent for removal of lead from tannery effluent by batch process. It was found that the adsorption of Pb(II) ions by coconut shell was pH dependent and the optimum pH for the maximum removal (81.66%) of lead from was 4. The equilibrium data was found to be obeyed Freundlich model more appropriately than Langmuir model. It is also important to remark that the coconut shell is economically and easily available material. After treatment with heavy metals a very low amount of sludge is produced which may be disposed off without causing any harm to the environment. The results showed that the coconut shell has been found very effective and environment friendly adsorbent which can remove sufficient amount of lead from tannery effluent in very small period of contact time (20 minutes). Hence, coconut shell can be utilized in wastewater treatment containing Pb(II) as pollutants without any chemical treatment.

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