Removal of Lead from Aqueous Solution by using Low Cost Adsorbent

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ABSTRACT

Industrial uses of metals and other domestic processes have introduced substantial amounts of potentially toxic heavy metals into the atmosphere. High concentrations of heavy metals are known to produce a range of toxic effects and also have a potentially damaging effect on human physiology and other biological systems. One of these heavy metals being produced is, lead, which is highly toxic to human body systems. It was investigated that the adsorption process is being widely used by various researchers for the removal of heavy metals from waste streams. Activated carbon has frequently been used as an adsorbent but it is an expensive material. In recent years, more attention has been gained by the biomaterials which are by-products or the wastes of large-scale industrial processes and agricultural waste materials because of their negligible cost and easy availability. The aim of the paper is to examine the removal of lead by using a low cost adsorbent. The influence of various factors such as pH, adsorbent dosage, contact time and initial metal ion concentration is to be studied to identify the adsorption capacity of the adsorbent. The future scope of the research is various modifications and mode of operation to improve the adsorption capacity.

Keywords: Adsorption, Heavy metals, Lead, Adsorbent, Tea leaves, Removal, Pb (II)

1. INTRODUCTION

As an outcome of rapid development in agriculture, industries and health-care facilities, significant amounts of toxic chemicals are being used by various activities which generate large amounts of hazardous wastes. Heavy metals are one of the most predominant hazardous pollutants in the environment. Heavy metal ions and dyes are often found in the environment as a result of their wide industrial applications. They are the common contaminants of wastewater and most of them are known to be toxic or carcinogenic. In addition, they are not biodegradable and tend to accumulate in living organisms, causing various diseases and disorders[1]. They enter the food chain through water and bio-accumulate and cause toxicity problems. The toxicity of heavy metals to aquatic organisms has been a subject of interest to biologist for many years. Therefore, their presence in the environment, in particular in water, should be controlled.

One of the heavy metals which is highly toxic and is attracting wide attention of environmentalists due to its acute and chronic toxic effects on animals and human health is lead. Lead ion is introduced into natural waters through various industrial applications such as those from the insecticide, storage battery manufacturing, paint and metal plating/finishing industries. Lead poisoning can cause cognitive impairment, behavioural disturbances, kidney damage, anaemia, and toxicity to the reproductive system and nervous system. Assimilation in the human body of relatively small amounts of Pb (II) over a long period of time can lead to malfunctioning of certain organs and chronic toxicity [2]. It can damage nearly all tissues, particularly the kidneys as well as the immune and nervous system. There is a need to treat the wastewater to bring the concentration of toxic elements below the recommended release limit. As per IS: 10500, the permissible limit of lead in drinking water is upto 0.01mg/L.

Different technologies and processes are currently being used for removing metals and organic compounds from wastewater such as Biological treatments, Membrane processes, Advanced oxidation processes, Chemical and Electrochemical techniques and Adsorption [3]. Amongst all the treatments proposed, adsorption is one of the most popular and extensively used methods. Adsorption is the adhesion of a chemical species onto the surface of particles. It has been proved to be an excellent way to treat industrial waste effluents, offering significant advantages like the low-cost, availability, profitability, ease of operation and efficiency, in comparison with conventional methods especially from economical and environmental points of view. The efficacy of adsorption relies on the capability of the adsorbent to adsorb metal ions from the solutions onto its surface. Activated carbon has undoubtedly been the most popular and widely used adsorbent in wastewater treatment throughout the world. In spite of the abundant uses of activated carbon, its applications are sometimes restricted due to their high cost. Thus, many researchers are interested in the production of safe and low cost alternatives which has attracted them towards the low cost agro and industrial wastes and by-products for the removal of heavy metals from wastewater and it has been investigated successfully.

2. LITERATURE REVIEW

Many adsorption studies are done by researchers using low cost adsorbents [4]. Biosorption of lead (II), copper (II) and cadmium (II) ions from aqueous solutions onto olive leaves powder has been investigated by Akl M.Awwad et al. indicating that olive leaves powder is an effective adsorbent[5]. Removal of lead (II) and copper (II) from aqueous solutions were studied by N.K. Amin et al. using pomegranate peel (raw), activated carbon prepared from pomegranate peel and activated carbon prepared from chemically treated pomegranate peel. The results showed that activated carbon prepared from chemically treated pomegranate peel is an effective adsorbent for the removal of lead and copper ions[6]. The removal of poisonous Pb (II) from wastewater by different low-cost abundant adsorbents was investigated by Ghani et al. Rice husks, maize cobs and sawdust, were used at different adsorbent/metal ion ratios. Removal of the poisonous lead ions from solutions was possible using rice husk, maize cobs and sawdust as adsorbents and rice husk was the most effective one[7]. Yasemin et al. studied the adsorption of lead, cadmium and nickel from aqueous solution by sawdust of walnut. The effect of contact time, initial metal ion concentration and temperature on metal ions removal had been studied. It was found that sawdust appears to be a promising adsorbent for removal of heavy metals from wastewater and this process is potentially more economical than any other current process technology. Also, adsorption of heavy metal ions depends on their initial concentrations, temperature and contact time[8]. The ability of converting a waste product, rice husk, into an economically cheap adsorbents have been investigated for Pb(II) and NO^{3-} removal from aqueous solution through adsorption by Adediran et al. The results from this study showed that the chemically modified rice husk has considerable potentials for the removal of nitrate and Pb (II) ions from aqueous solutions over a wide range of experimental conditions through adsorption[9].

3. EXPERIMENTAL

The aim of this study was to find out the effectiveness of less expensive material that could be used as an adsorbent for the removal of Pb^{2+} ions from wastewater. The adsorbent taken under consideration for this study is spent tea leaves powder.

Sample preparation- Synthetic wastewater samples were prepared by using analytical grade lead nitrate by using double distilled water. A 1M stock solution was prepared having a lead concentration of 1000 mg/L. The solutions of various concentrations under study were made from stock solution by making appropriate dilutions.

Adsorbent Preparation- Spent tea leaves were recovered and repeatedly washed with distilled water in order to remove soluble and coloured compounds. Then the solid was rinsed with distilled water and oven dried in oven at 60°C for 24 hours. After that, it was crushed and sieved to a ground size into a fine powder.

Method- The batch experiments were conducted in 250 mL conical flasks. The volume of the test solution was maintained as 100 mL. All the samples were mechanically agitated in low speed. The experiments were conducted at room temperature. The duration of the experiments was 150 minutes. The amount of Pb(II) adsorbed on the raw adsorbent was recorded titrimetrically by using EDTA solution as the titrant, xylenol orange as the indicator and hexamine buffer to maintain the pH as per the standard method given in Vogel (1978) [10]. The experiments were carried out to study the effect of pH (2-6), effect of Adsorbent dose (0.4-1.2g/100 mL), effect of contact time (30-150 min) and effect of initial metal ion concentration (20-100 mg/L).

The amount of metal ion adsorbed was calculated as:

$$\% \text{ Adsorption} = \frac{(C_o - C_e)}{C_o} X \, 100$$

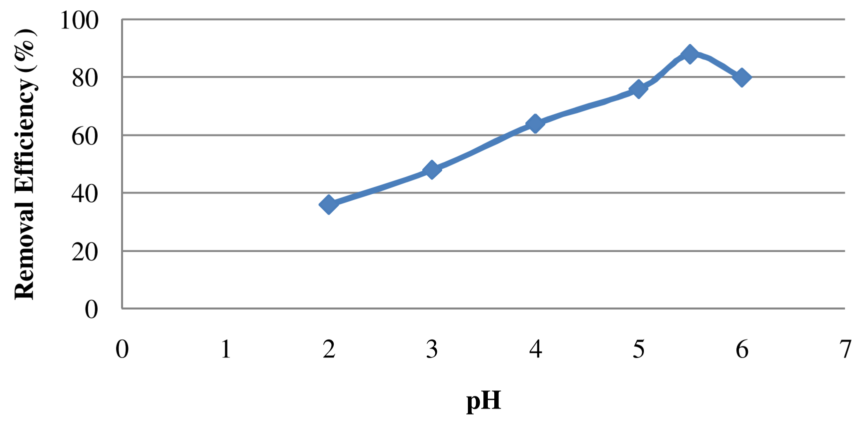
Where, C_o and C_e are the initial and final concentration of adsorbate, respectively.

4. RESULTS AND DISCUSSION

4.1 Effect of pH on the adsorption

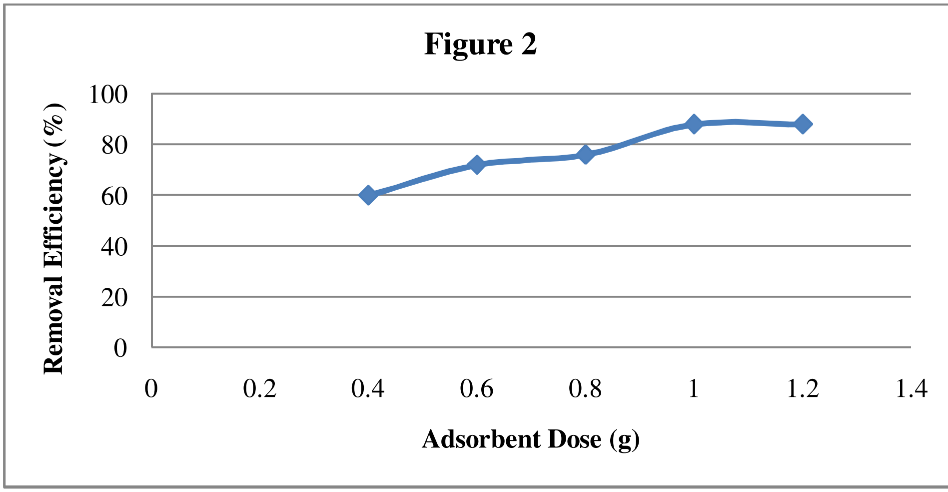
In these studies, the effect of pH on the adsorption of Pb (II) ions on tea waste was studied by using the initial concentration of the experimental solution as 25 ppm. The adsorbent dose was optimized and fixed as 1g/100 mL. The optimum contact time was 150 min. The maximum adsorption of Pb (II) on the surface of the adsorbent was 88%. The analytical results are presented in Figure 1.

Figure 1



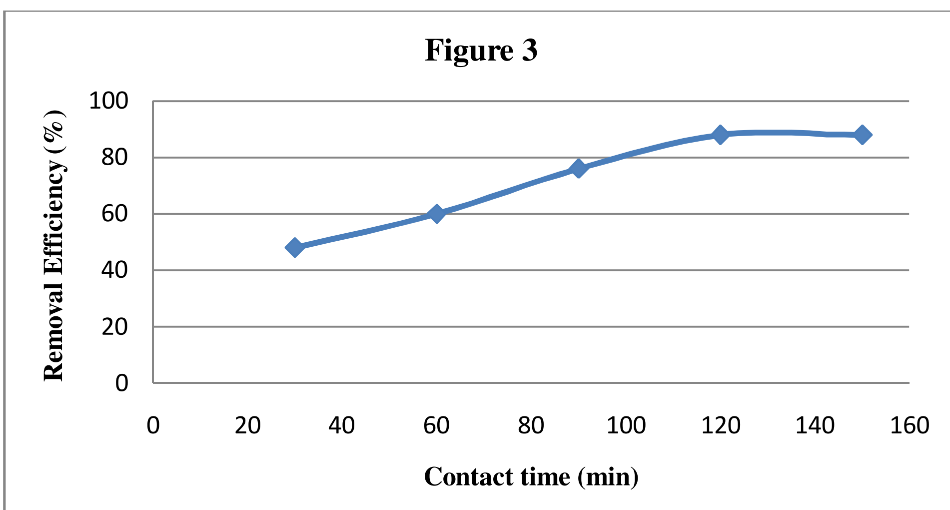
4.2 Effect of amount of adsorbent on the adsorption

The effect of adsorbent dose was studied by maintaining the pH at 5.5, metal ion concentration at 25 ppm and a contact time of 150 minutes was observed. To achieve this aim, five batch experiments were conducted with the adsorbent dose as 0.4, 0.6, 0.8, 1, 1.2 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 of 88% at 1 g of the adsorbent. From the results, it is clearly observed that 1g of the adsorbent was sufficient for the effective removal of Pb (II) in aqueous solutions. A further increase in the quantity of adsorbent has no effect on the quantity of lead ions adsorbed. The results are presented in Figure 2.



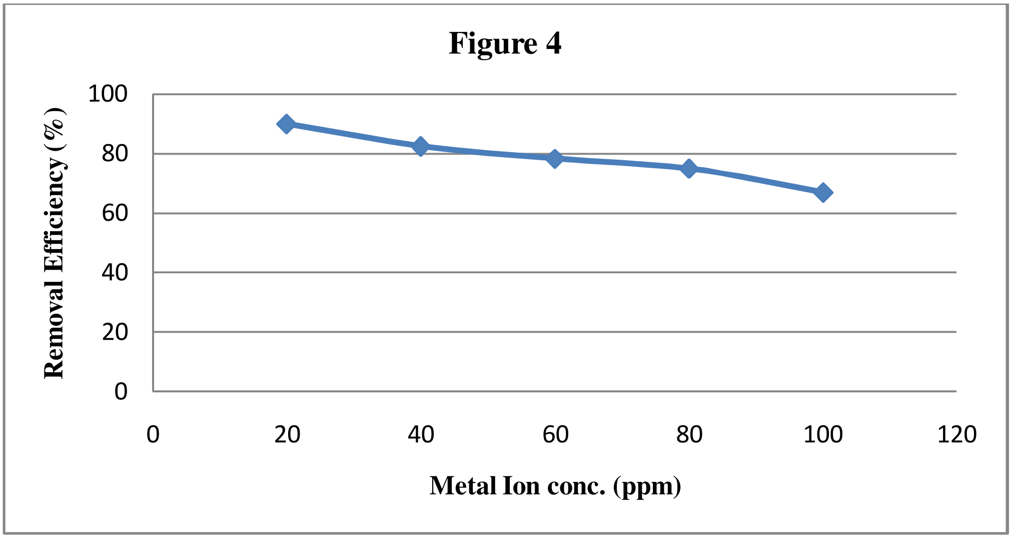
4.3 Effect of contact time on the adsorption

By fixing the amount of adsorbent at 1 g per 100 mL test solution and the pH at 5.5, 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, a maximum of 88 % removal was achieved at 120 minutes. Further, on increasing the contact time, no significant changes were observed in the removal of Pb (II) ions from the solution. The analytical results are presented in Figure 3.



4.4 Effect of concentration of Pb (II) ions

In the present study, we have selected 20, 40, 60, 80 and 100 ppm as the initial concentration for the comparative study for the removal of Pb (II). Fixing the amount of adsorbent as 1 g, the effect of the concentration of Pb (II) on the removal of Pb from solution was tested. The removal of Pb (II) was maximum for the lowest concentration of 20 ppm. However, the results presented in figure 4, show that the percentage of removal decreases with increasing the initial lead concentration. This can be explained by the fact that all the adsorbents have a limited number of active sites, which become saturated at a certain concentration.



5. CONCLUSIONS

The removal of Pb (II) in synthetic wastewater by using adsorption technology was studied in batch experimental systems. Based on the results, the following conclusions can be drawn. Spent tea leaves is an efficient biomaterial for the removal of lead from industrial wastewater. The maximum percent removal of Pb (II) under the conditions employed here, is 88 with an effective dose of 1g of the adsorbent at a pH of 5.5. The handling of the material is very easy and harmless. This process can be effectively used in Pb (II) and other heavy metals removal in industrial wastewater.

REFERENCES

[1] from *http://en.wikipedia.org/wiki/Adsorption http://www.chemvironcarbon.com*

[2] S. J. Khurshid and I. H. Qureshi, *Nucleus*, 21 (1984) 3.

[3] Zahra.A .*Lead removal from water by low cost adsorbents:A Review.* Pak. J. Anal. Environ. Chem. (2012) 13(1):01-08.

[4] Sud, D., Mahajan, G. and Kaur, M.P. *Agriculture waste material as potential adsorbent for sequestering heavy metal ions from aqueous solutions - a review*. Bioresource Technology. (2008) 99:6017-6027.

[5] Awwad.A, Farhan.A .*Equilibrium, Kinetic and Thermodynamics of Biosorption of Lead (II) Copper (II) and Cadmium (II) Ions from Aqueous Solutions onto Olive Leaves Powder.* American journal of chemistry(2012) 2(4):238-244.

[6] Adediran.G, Owalude.S, Tella.A, Olaremu.A .*Equilibrium sorption of Pb(II) and nitrate ions from aqueous solution using chemically modified rice husk*.

[7] Ghani.M, Hefny.M, Chaghaby.G .*Removal of lead from aqueous solution using low cost abundantly available adsorbents.* International journal of environmental science and technology(2007) 4(1):67-73.

[8] Bulut.Y, Zeki.T .*Removal of heavy metals from aqueous solution by sawdust adsorption.* Journal of Environmental Sciences (2007) (19):160–166.

[9] Ashtoukhya.E, Amina.N, Abdelwahabb.O .*Removal of lead (II) and copper (II) from aqueous solution using pomegranate peel as a new adsorbent*. Elsevier Desalination 223(2008):162–173.

[10] Vogel. A.I .*Textbook of quantitative inorganic analysis.* 4th Ed., ELBS publishers, Great Britain, (1978): 330.