International Scholars Journals

African Journal of Physics ISSN 9821-5213 Vol. 8 (3), pp. 001-004, March, 2021. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Biosorption of lead ions from aqueous solution by maize leaf

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Accepted 24 August, 2020

The removal of lead ions from dilute aqueous solution using maize (*Zea mays*) leaf as the adsorbent is reported in this paper. The effects of pH, initial metal ion concentration and contact time were studied at 27ºC. The analysis of residual Pb(II) ions was determined using atomic absorption spectrophotometer. Maximum adsorption occurred at pH 3. The adsorption isotherms obtained at 27ºC and optimum pH fitted well into both the Freundlich and Langmuir isotherms. The Freundlich and Langmuir equations are log =0.504 log C_e+0.6939 and 1/ = 0.176/C_e–0.03, respectively. The correlation factors are 0.9959 and 0.9939. The result of the pH experiment shows that the initial pH would play a vital role in the removal of the lead ions from solution. The kinetic studies show that uptake of lead ions increases with time and that maximum adsorption was obtained within the first 30 min of the process. These results indicate that maize leaf has potential for removing lead ions from industrial wastewater.

Key words: Adsorption, Pb(II), Freundlich isotherm, Langmuir isotherm, maize leaf.

INTRODUCTION

The increase in industrial activity during recent years is greatly contributing to the increase of heavy metals in the environment, mainly in the aquatic systems (Marques et al., 2000). Water pollution due to heavy metals is an issue of great environmental concern (Vasuderan et al., 2003). Heavy metal ions such as cobalt, copper, nickel, chromium, lead and zinc are detected in the waste streams from mining operations, tanneries, electronics, electroplating, batteries and petrochemical industries as well as textile mill products. Major lead pollution is through automobiles and battery manufacturers.

Heavy metals have a harmful effect on human physiology and other biological systems when they exceed the tolerance levels (Kobya et al., 2005). Exposure to lead can cause anaemia, diseases of the liver and kidneys, brain damage and ultimately death (Jain et al., 1989). Besides, chronic exposure to these contaminants present even at low concentrations in the environment can prove to be harmful to the human health. For these reasons, heavy metals must be removed as much as possible from industrial effluents.

The conventional methods used to remove heavy metals include chemical precipitation, ion exchange, electrodialysis, membrane separations, reverse osmosis, and solvent extraction (Matlock et. al., 2002; Feng et al., 2000, Mohammadi et al., 2004). The search for new, effective and economical technologies involving the removal of toxic metals from wastewaters has directed attention to biosorption based on metal binding capacities of various biological materials at little or no cost (Abia, et al., 2003; Ajmal et al., 2005; Aksu, 2002; Annadurai, et al., 2002; Babarinde and Oyedipe, 2001; Babarinde et al., 2002; Babarinde, 2002; Bansode, et al., 2003; Cimino, et al., 2000; Demirbas, 2003;Feng and Aldrich, 2004; Fourest and Roux, 1992). Of interest in this project work is the removal of lead ion from aqueous solution.

METHODS

Materials

The maize leaves (*Zea mays*) used as the adsorbent were obtained from a farm in Ijebu-Imusin, Ogun State, Nigeria. The dry leaves were rinsed with distilled water, sun-dried and cut into pieces. The salt used for the preparation of aqueous solutions was analytical grade.

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Biosorption experiments

Experiments were conducted at 27ºC to study the effect of initial solution pH, ion concentration and contact time on the adsorption of lead ions. Each experiment was conducted in a thermostated water bath (Haake Wia model) and the residual metal ions analysed using Atomic Absorption Spectrophotometer (Buck Scientific model 210 VGP), at wavelengths of 283.3 nm for lead. The detection limit of 0.05 was used while air/acetylene mixture was used as the oxidant.

Effect of pH

The procedure used is similar to those earlier reported (Vasudevan et. al., 2003; Xu et. al., 2006). Experiments were conducted at 27ºC to study the effect of initial solution pH on the adsorption of the metal ions by contacting 0.5 g of the maize leaf with 50 ml of 100 mg/l lead salt solution in a boiling tube. The pH of each of the metal solutions was adjusted to the desired value with 0.1 M sodium hydroxide and /or 0.1 M nitric acid (Lodeiro, et al., 2005).

The studies were conducted at pH values of 2, 3, 4, 5, 6 and 7. The boiling tubes containing the mixture were left in a water bath for 24 h. The sorbent was removed from the solution by filtration and the residual lead ion concentration in the solution was analysed by Atomic Absorption Spectrophotometer. All experiments were conducted in triplicates and the mean value was determined for each.

Effect of concentration

Batch adsorption study was carried out using a concentration range of 10–100 mg/l. 0.5 g of the maize leaf was weighed into each of the 30 boiling tubes employed and 50 ml of the metal ion solution was measured into each boiling tube containing the maize leaf. Three boiling tubes were used for a particular concentration. The adsorption mixture was then left in a water bath to maintain the temperature (27ºC) for 24 h. The maize leaf was removed from the mixture by filtration and the concentration of the residual ions in the solution was determined using Atomic Absorption Spectrophotometer. The amount of metal ions adsorbed from solution was determined by difference. The mean value was also calculated.

The results obtained were analysed using both Freundlich (Freundlich, 1907) and Langmuir (Langmuir, 1918) isotherms. The Freundlich isotherm in linearised form is log =1/n log C_e + log K, where K and n are Freundlich constants. The Langmuir isotherm in a linear form is 1/ = $(1/b_m)(1/C_e)$ + 1/ $_m$ wWhere b_m is a coefficient related to the affinity between the sorbent and sorbate, and $_m$ is the maximum sorbate uptake under the given condition.

Effect of contact time

The adsorption of the metal ions by maize leaf was studied at various time intervals (0-120 min) . A constant concentration of 100 mg/l was used. 0.5 g of maize leaf was weighed into thirty-six boiling tubes and 50 ml of each metal ion solution (100 mg/l) was added into each tube. The maize leaf in the thirty six tubes was then filtered at different time intervals of 5, 10, 15, 20, 25, 30, 45, 60, 75, 90, 105 and 120 min. The filtrates were then analyzed using Atomic Absorption Spectrophotometer. The amount of metal ions adsorbed was calculated for each sample. The mean of the three results for a particular time was then calculated and plotted against time.

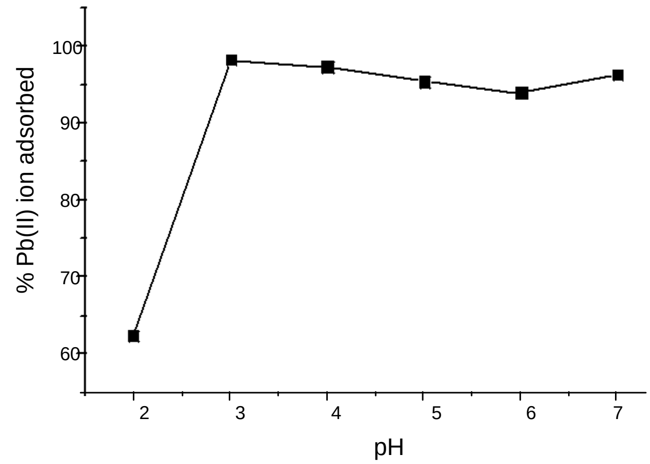

Figure 1. Effect of pH on sorption behaviour of Pb(II) sorption by maize leaf.

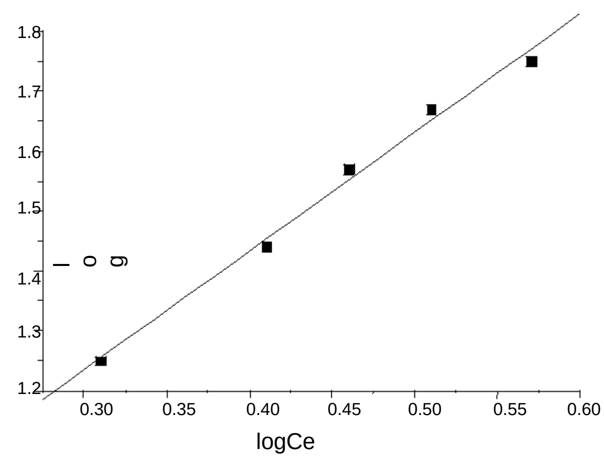

Figure 2. The linearized Freundlich adsorption isotherm of Pb(II) using maize leaf.

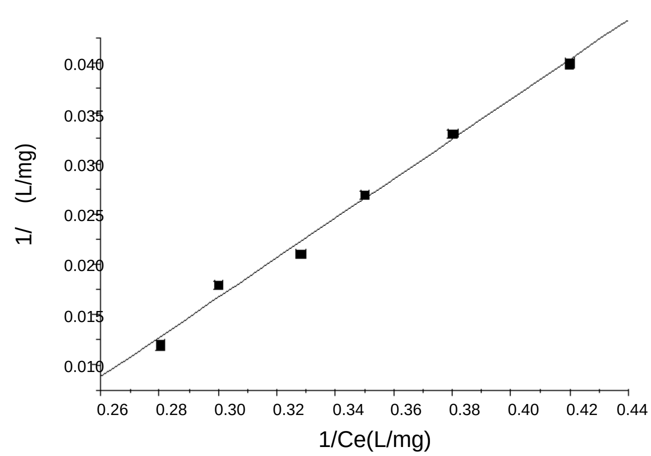

Figure 3. The linearized Langmuir adsorption isotherm of Pb(II) using maize leaf.

Table 1. Freundlich and Langmuir isothermal adsorption parameters for the adsorption of Pb^{2+} ions at 27ºC.

Freundlich parameters			Langmuir parameters		
1/n	**K**	**R**	**$1/b_m$**	**1/ $_m$**	**R**
0.504	4.356	0.9959	0.176	-0.03	0.9939

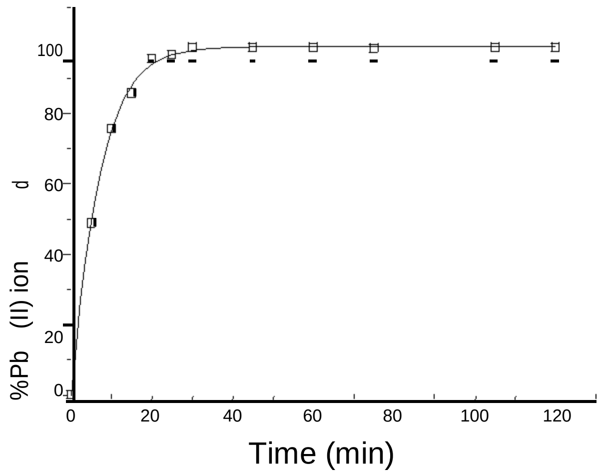

Figure 4. Time courses of Pb(II) ion removal by maize leaf.

RESULTS AND DISCUSSION

The results of the three different studies are shown in Figures 1 - 4. The result of the pH study shows that maximum sorption occurred at pH 3. The percentage Pb(II) adsorbed is slightly lower at higher pH. This suggests that optimum adsorption is obtained at pH 3. This implies that the initial pH would play a vital role in the removal of the Pb(II) ions from solution. The effect of metal ion concentration on adsorption capacity showed that maize leaf biomass adsorbed the lead ions from solution. The amount of Pb(II) ions adsorbed increased with increase in initial metal ion concentration. The data fitted well into both the Freundlich and Langmuir isotherms. The Freundlich and Langmuir parameters obtained (Table 1) compare well with those of other adsorbents that have been reported (J nior, et al., 2003; Lodeiro, et al., 2005) . The values of the parameters show that maize leaf is a good adsorbent for the removal of lead from wastewaters.

In conclusion, maize leaf, an agricultural waste, could be used as potential adsorbent for the removal of lead from aqueous solutions. The batch adsorption studies have shown that the adsorption of lead is pH dependent and the optimum pH for the removal is 3. The amount of lead ions adsorbed increased with increase in initial metal ion concentration. Maximum adsorption was obtained within the first 30 min.

ACKNOWLEDGEMENTS

The authors are grateful to J. O. A. Adegoke and T. Olayiwola of the Department of Chemical Sciences, Olabisi Onabanjo University, Ago-Iwoye for technical assistance.

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