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Removal of Lead Ion Using Maize Cob as a Bioadsorbent

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ABSTRACT
The intensification of industrial activity and environmental stress greatly contributes to the significant rise of heavy metal pollution in water resources making threats on terrestrial and aquatic life. The toxicity of metal pollution is slow and interminable, as these metal ions are non bio-degradable. The most appropriate solution for controlling the biogeochemistry of metal contaminants is sorption technique, to produce high quality treated effluents from polluted wastewater. Maize cob readily available was used as sorbent for the removal of lead ions from aqueous media. Adsorption studies were performed by batch experiments as a function of process parameters such as sorption 500ppm,2.5g, 400minutes, 400 rpm and 5 PH. Concentration, Dosage, time, rpm, and pH. I have found that the optimized parameters are Freundlich model fits best with the experimental equilibrium data among the three tested adsorption isotherm models. The kinetic data correlated well with the Lagergren first order kinetic model for the adsorption studies of lead using maize cob. It was concluded that adsorbent prepared from maize cob as to be a favorable adsorbent and easily available to remove the heavy metal lead (II) is 95 % and can be used for the treatment of heavy metals in wastewater.
Keywords: Heavy metal adsorption, isotherms, maize cob, leads ions.

I. INTRODUCTION

An increased use of metals and chemicals in the process industries has resulted in the generation of large quantities of aqueous effluents that contain high levels of heavy metals, thereby creating serious environmental disposal problems (Holan et al. [1]). Also exponential growth of the world's population over the past 20 years has resulted in environmental build up of waste products, of which heavy metals are of particular concern (Volesky et al. [2]). The need of finding alternative inexpensive and effective methods for heavy metals abatement from waters becomes inevitable. Biosorption is an emerging field in this regard and has great potentials for application in developing economies. It involves the use of living or non-living biological materials for pollutants' removal from aqueous solutions and industrial effluents. Heavy metals such as zinc are micro nutrients though essential in small amounts for plant and animal life, can however be harmful if taken up by plants or animals in large amounts, like other heavy metals not known to be essential nutrients There are at least 20 metals which cannot be degraded or destroyed. The important toxic metals are Cd, Zn, Pb and Ni. These heavy toxic metals enter into the water bodies through waste water from metal plating industries and industries of Cd- Ni batteries, phosphate fertilizer, mining, pigments, stabilizers,alloys etc.

Heavy metals accumulate in the food chain and because of their persistent nature, it is necessary to remove them from wastewater (Holan et al. [1], Vole sky et al. [2], Chong & Vole sky [3]).Removing heavy metals from waste water has therefore resulted in the search for other materials that may be useful in reducing the levels of heavy metals in the environment (Chong &Volesky [3]). In Nigeria, (Okieimen et al.1991, Horsfall and Spiff (2004) and Horsfall et al. (2003)) have used groundnut husk, fluted pumpkin and wild cocoyam respectively for removal of heavy metals from aqueous solutions. 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. It is very toxic in nature Environ. 1995). Lead (Pb) and its compounds are widely used in the industries, hence they are commonly found in air, water, soil and food. Pb may get into the aquatic environment through sources like smelters, industrial effluents from battery, paint, plastic, textiles, microelectronics, Among the various resources of biological wastes, agricultural wastes (e.g., stems, peels, husks, leaves, fruit shells, ...etc) have been demonstrated to remove metal ions in aqueous solutions (Tee & Khan [10]; Scott11], McKay & Porter [12], Sun & Shi [13], Al-Ashes & Duvnjak [14], Meunier etal. [15], Sekhar et al. [16], Özer et al. [17], Wang & Qin [18]).

Pb is a heavy metal of great environmental concern and poses threat to plants, animal and human health due to its bio accumulative tendency and toxicity. Pb has known beneficial biochemical attribute and it is known to have toxic effect on the nervous system, kidney and liver Pb, being a heavy metal, tends to accumulate in the food chain because of its persistent nature, and it is therefore necessary to remove it from waste water Thus realizing the effectiveness of lead and their toxicity the present work is framed in such a way to develop efficient bioadsorbents. The bioadsorbents chosen here is Maize cob which is an inexpensive source used for the removal of lead.

II. EXPERIMENTAL METHODS

2.1 Materials used

The maize cob used for the analysis was collected from markets in Coimbatore which are disposed as wastes. All the chemicals used were of analytical grade and they were used without further purification. All the chemicals (AR) were purchased from Precision Scientific Company, Coimbatore.

2.2 Preparation of bioadsorbents:

The collected maize cob was washed with double distilled water. The Maize Cob was dried in the hot air oven at 100 °C for 24 hrs. It is then taken out, crushed and put into a mechanical sieve to separate the particles based on their size. The samples of particular size were separated (mesh no-240-300) and was washed with distilled water thoroughly. It is then filtered using ordinary filter paper. The washed samples were then drenched in 1N conc. nitric acid solution for 12 hours. After 12 hrs the drenched samples were washed with distilled water until the soluble and colored components were removed. The washed samples were dried under the sun light for few hours. The samples were then soaked in 1N NaOH for 12 hours. Samples were then washed with de-ionized water and were oven dried for 12 hours at 100°C.

2.3 Sample storage

The separated samples were weighed and sealed within polythene bags for the analysis of adsorption studies.

2.4 Adsorption isotherms

In order to successfully represent the equilibrium adsorptive behavior, it is important to have a satisfactory description of the equation state between the two phases composing the adsorption system. Several isotherm models are available to describe this equilibrium adsorption distribution. The Langmuir equation is used to estimate the maximum adsorption capacity corresponding to complete monolayer coverage on the adsorbent surface and is expressed by **Langmuir Adsorption Isotherm Equation** $Ce / qe = 1/(b.\Theta) + Ce / \Theta$

Where *q*e is the amount adsorbed at equilibrium (mg/g) and *C*e is the equilibrium concentration of metal ions in solution (mg/L). The Freundlich model is an empirical equation used to estimate the adsorption intensity of the sorbent towards the adsorbate and is given by

Freundlich equation $= \ln qe = \ln k = 1/n\ Ce$

The adsorbing species–adsorbate interactions can be explained using the Tempkin isotherm equation. It is based on the assumption that the heat of adsorption of all the molecules in the layer decreases linearly with coverage due to adsorbate– adsorbate repulsions, and the adsorption is a uniform distribution of maximum binding energy

Temkin equation $q_e = a + b \ln Ce$

The other parameters are different isotherm constants, which can be determined by regression of the experimental data. In the Langmuir equation, θ (mg/g) is the measure of adsorption capacity under the experimental conditions and *b* is a constant related to the energy of adsorption. Freundlich treatment gives the parameters, *n*, indicative of bond energies between metal ion and the adsorbent and *K*, related to bond strength.

2.4 Characteristics of adsorbing material

A scanning electron microscope (SEM) and X-ray diffraction (XRD) was used to examine the surface of the adsorbent and the SEM photographs shows changes in the surface of the particle.A scanning electron microscope (SEM) is a type of electron microscope that images a sample by scanning it with a high-energy beam of electrons in a faster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography, composition, and other properties such as electrical conductivity. X-ray scattering techniques are a family of non-destructive analytical techniques which reveal information about the crystallographic structure, chemical composition, and physical properties of materials and thin films. These techniques are based on observing the scattered intensity of an X-ray beam hitting a sample as a function of incident and scattered angle, polarization, and wavelength.

III. RESULTS AND DISCUSSION

1.1 (a) Scanning Electron Microscopy

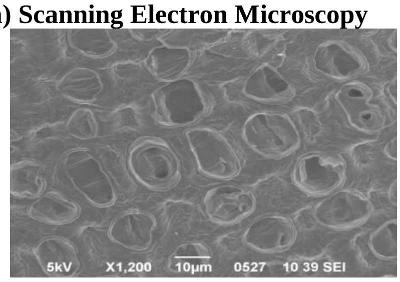


Figure 1.1 – Image of a sample of maize cob under the scanning electron microscopy

3.1(b) X- Ray Crystallography

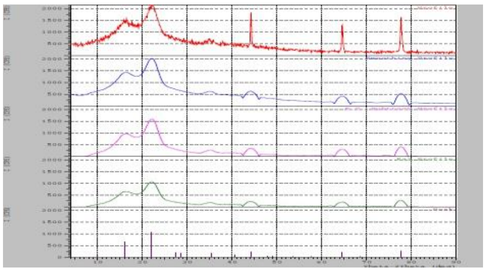
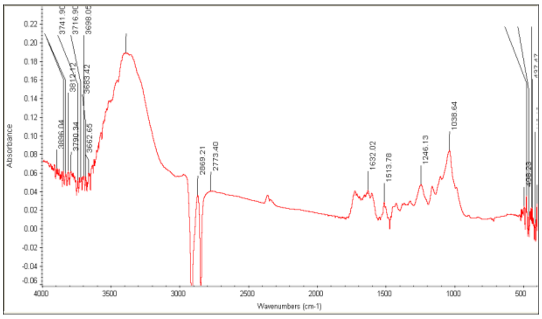


Figure 1.2 – X - ray crystallography graph

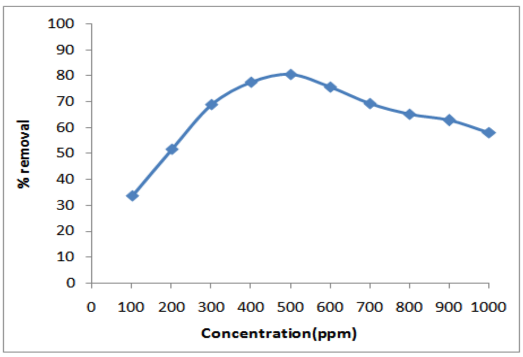
3.2(c) FTIR ANALYSIS OF BIOADSORBENT:

The FTRI analysis of biosorbent using FTRI shinadzn-8400 was carried out at PSG College of Arts and Science, Coimbatore, South India. For the identification of functional group that may be responsible of adsorption of metal ions on bio sorbent surface .The pure bio sorbent (acid treated was prepared and stored the dry samples were then diluted to 5% in KBR and last into disk before FTRI analysis



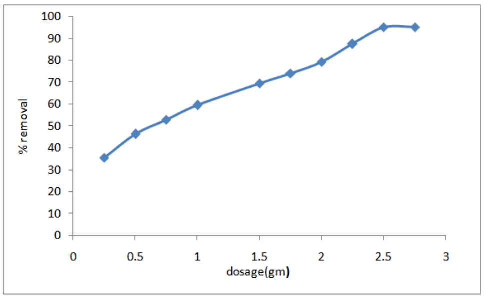
3.2 (a) Effect of lead concentration

At lower concentration all lead ions present in the solution could interact with the binding sites and thus the percentage of adsorption was higher than the higher initial copper ion concentration. At higher concentration, lower adsorption may be due to the saturation of biosorption sites. The decrease in percentage of biosorption may be caused by the lack of sufficient surface area to accommodate much more lead ions available in the solution.



3.2 (b) Effect of Biosorbent dosage

In this study, the biosorbent dosage is changed from 0.5 to 2.5 g and there is no change in other parameters are const like concentration, time, rpm and pH. The contact time half an hours, concentrations is 500ppm for lead as stated in the earlier section. The figure shows an increase in the biosorption percentage as dosage of biosorbent increases. This is because of the availability of more binding sites in the surface of the biosorbent for complexation of lead ions.The optimum dosage was found that 2.5g/lit



3.2 (c) Effect of contact time (Minutes)

Contact time profile for the Biosorption of lead for a solution of 100 mg/L is shown in the above graph. The data obtained from the Biosorption of lead ions on the maize cob sample showed that a contact time of two hours is needed to achieve equilibrium and the biosorption did not change significantly with further increase in contact time. Therefore, the uptake and unabsorbed copper concentrations at the end of two hours are given as equilibrium values (Qe, mg/g; Ceq, mg/L) respectively and decided to conduct further Biosorption experiments at this contact time of two hours.

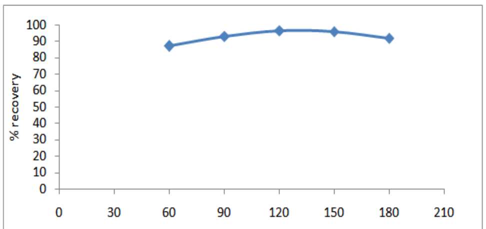
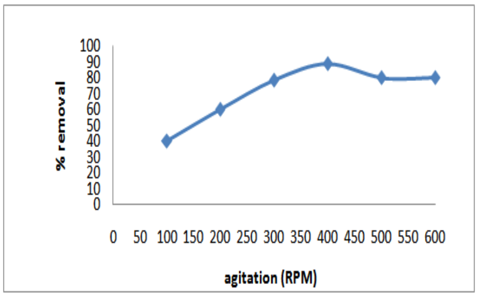


Figure 2.3 - Effect of contact time on the lead by adsorbtion using maize cob

3.2 (c) Effect of Agitation (Rpm)

Contact time profile for the Biosorption of lead for a solution of 100 mg/L is shown in the above graph. The data obtained from the Biosorption of lead ions on the maize cob sample showed that a agitation 400 rpm is needed to achieve equilibrium and the biosorption did not change significantly with further increase in speed.. Therefore, the uptake and unabsorbed copper concentrations at the end of 400rpm are given as equilibrium values (Qe, mg/g; Ceq, mg/L) respectively and decided to conduct further Biosorption experiments at this agitation speed of 400 rpm.



3.3 ADSORPTION ISOTHERMS

(a) Langmuir Isotherm **(b) Temkin Isotherm** **(C) Temkin adsorption isotherm**

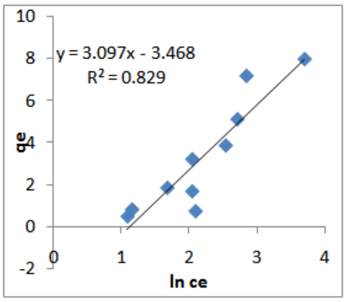


Figure 3.1

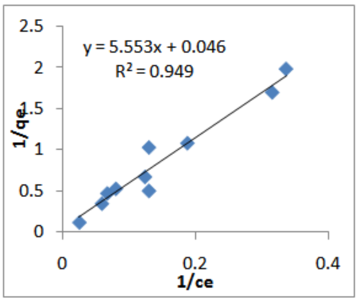


Figure 3.2

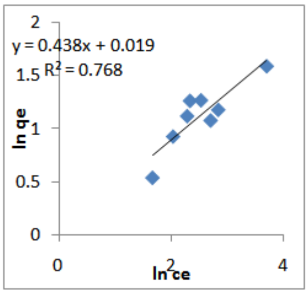


Figure 3.3

Table I – Adsorption studies

Adsorption Isotherm	Parameters		
Langmuir	q_{max} (mg/g)	b (l/mg)	R^2
	21.413	0.0084	0.8295
Tempkin	a	b	R^2
	0.7786	2.4911	0.9545
Freundlich	K_F	N	R^2
	1.900	4.566	0.7689

IV. CONCLUSION

Present study shows that chemically treated maize cob is an effective adsorbent for the removal of lead ions from aqueous solutions. The adsorption process is a function of the adsorbent and adsorbent concentrations, dosage, time, rpm and temperature. The maximum percentage removal was increased from 50 to 95%. Equilibrium was achieved practically in 2h. The equilibrium adsorption data are satisfactorily fitted in the order: Langmuir > Temkin > Freundlich, in the case of lead ions.

The adsorbent proved to be very effective on industrial waste water. Waste water from a leather industry in Vellore, Tamil Nadu was collected and was tested for the presence of lead. It was found to contain 0.96mg/liter of lead. And after treating the effluent with the bioadsorbant, it was found to remove 95% of lead from the waste water.

The economic feasibility of low cost adsorbents over activated carbon is estimated in the present study. It is found that maize cob which is cheap and available in abundance locally is the most economical among all the developed low cost adsorbents, and much cheaper than activated carbon. The result is not only important for the industries but also to the planet earth in general due to the resultant social and environmental benefits.

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