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Investigation on the adsorption behavior of peanut shell for heavy metals in aqueous solution.

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Abstract:

In this study, agro-waste material were used as adsorbent for removal of lead, zinc, cadmium and nickel from aqueous solution. This work aims to optimize conditions for preparation of this materials to obtain maximum metals adsorption capacity. optimal conditions were determined in terms of removal of metals efficiency or energy consumption. The results indicate that maximum adsorption takes place at pH 7-8, contact time of 2 hours, adsorbent dose of 1.8 g, initial concentration of 60mg/L and at a temperature of 340 K. Peanut husk is a good adsorbent for the xenobiotic and non-xenobiotic heavy metal. The trend of uptake for peanut husk is in the order of Zn (II)> Ni (II)> Pb (II)> Cd (II).

Key Words: Adsorption, heavy metals, peanut shell

1. Introduction

The naturally available materials are the sustainable choice for the adsorptive removal of various pollutants from wastewater. The disposal and management of agriculture waste have been the concern of socioeconomic and environmental importance. Hence, agricultural wastes especially husks (originated from peanut, coconut, black gram etc.)have been frequently used as a natural source of biosorbents (7). Heavy metal are toxic and have the tendency to bioaccumulate. It has been consistently desired that their levels be reduced in industrial and municipal effluents before ultimate repository in the ecosystem. metal removal from aqueous solution can be reached by certain methods, such as oxidation/reduction, evaporative recovery, filtration, chemical precipitation, ion exchange and membrane technologies, electrochemical treatment, the most widely used adsorbent as activated carbon. It is found that the carbon always remains costly materials as adsorbent. Activated carbon also requires heterogeneous materials to upgrade the removal performance of inorganic matters and require a large capital investment and high operating costs (11). Therefore, this situation made it no longer attractive to be used in small scale industries because inefficient in cost inefficiency.

Nowadays, biological adsorbents are being used effectively and efficiently. The appropriated modification of the raw biosorbents by crown esters and Sulphur bearing groups like sulphides, thiols, dithiocarbamates and dithiophosphates can eliminate the drawbacks and improve their performances significantly. Biosorption is a process that utilizes low cost biosorbents to sequester toxic heavy metals. Biosorption has distinct advantages over the conventional methods which include: reusability of biomaterial, low operating cost, selectivity for specific metal, short operation time and no chemical sludge. This work includes the utilization of peanut husk which is a low cost biosorbent for the removal of heavy metals from aqueous solutions.

2. Materials

Peanut shell was collected from local market near by bus stand in Jhansi (India). After collection the husks were washed thoroughly to remove dust using distilled water then dried in an oven at 105^0C for 24 hours. Dried husks were grounded using a laboratory mill, sieved to obtain particle size of 0.4-0.6 mm and rinsed using 0.1 N HCl. Peanut husk was dried and stored in an oven at 80^0C to reduce the moisture content. Then these adsorbents were used for batch experiments.

3. Preparation of Stock Solution

For preparation of 1000 mg/L stock solution of xenobiotic Pb(II), Cd(II) and non- xenobiotic Zn(II), Ni(II) metal ion , salt of these metal ion were dissolved in one liter volumetric flask and final volumes were made up to the mark with deionized water. The standard solutions of metals were prepared before use by the appropriate dilution of the stock solutions. The prepared solution will be used in treating the peanut husk by soaking the peanut husk powder in the solution for the adsorption of heavy metals.

Adsorption capacity and % removal efficiency were calculated using the following equations respectively.

$$C\ C\ X\ V\ m$$

$$q \quad \overline{\qquad\qquad} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots .... 1$$

$$Removal\ efficiency\ \% \quad \frac{C\ C\ X\ 100}{C} \ldots \ldots \ldots \ldots \ldots \ldots \ldots 2$$

Where, q_e (mg/g) is the amount of metal ion adsorbed, Ci is the initial metal ion concentration, Ce is the concentration of metal ion at equilibrium, V is the volume of ions and m is the mass of adsorbent.

4. Results and discussion

The effect of various important physical parameters on the sorbent behavior of peanut husk is investigated experimentally in laboratory of host department. The effect of pH, adsorbent dose, contact time, temperature and initial metal ion concentration is presented below:

4.1 Effect of pH

The pH of solution is significantly influencing the removal of heavy metals hence it is an important condition for adsorption of xenobiotic and non-xenobiotic heavy metal ions. The effect of pH on the amount metal ion was analyzed on pH range from 2-9. The amount of metal ion adsorption increases with increase in pH as shown in Fig-1.

At lower pH, H^+ ions compete with metals ions for the exchange sites in the adsorbent material. The heavy metals are released in more amount in acidic conditions. The maximum adsorption occurs at pH 8 for peanut husk and after this precipitation of metal ion take place. Decreasing trend in uptake was observed above pH 8 due to formation of soluble hydroxyl complexes

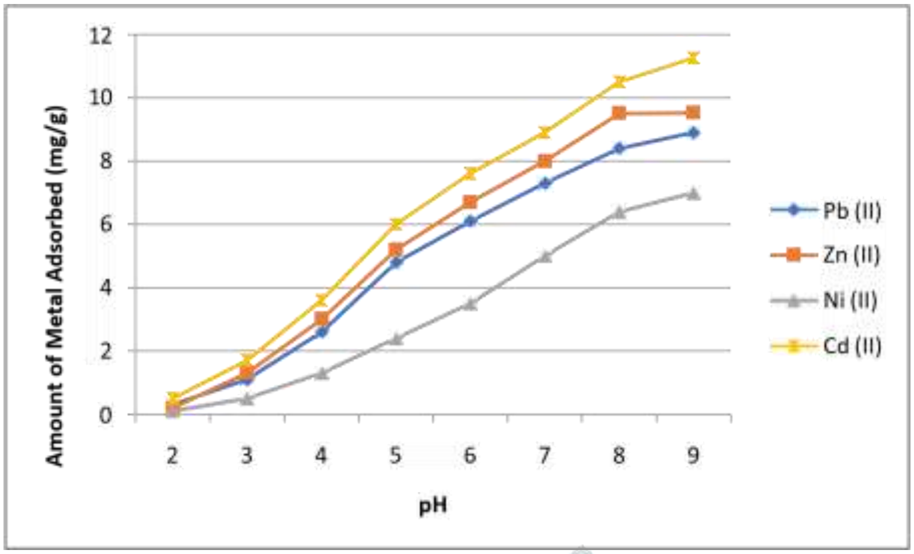

Figure 1: Effect of pH on Adsorption of Metal

4.2 Effect of Adsorbent Dose

Figure 2 illustrate the effect of peanut husk dose on metal ion removal from waste water. The experimental result showed that adsorption rate increase with increase in adsorbent dose for heavy metal and get saturation after 2g of peanut husk dose for Pb(II), Ni(II) ions and at an adsorbent dose of 1.6 g for Cd(II) ion. Adsorbent rate continuously increases with increase in adsorbent dose for Zn(II).

The removal efficiency and specific uptake of metals depend on type and quantity of the biosorbent. The increase in percentage removal of lead with increase in adsorbent dose was due to the availability of more and more adsorbent surfaces for the solutes to adsorb.

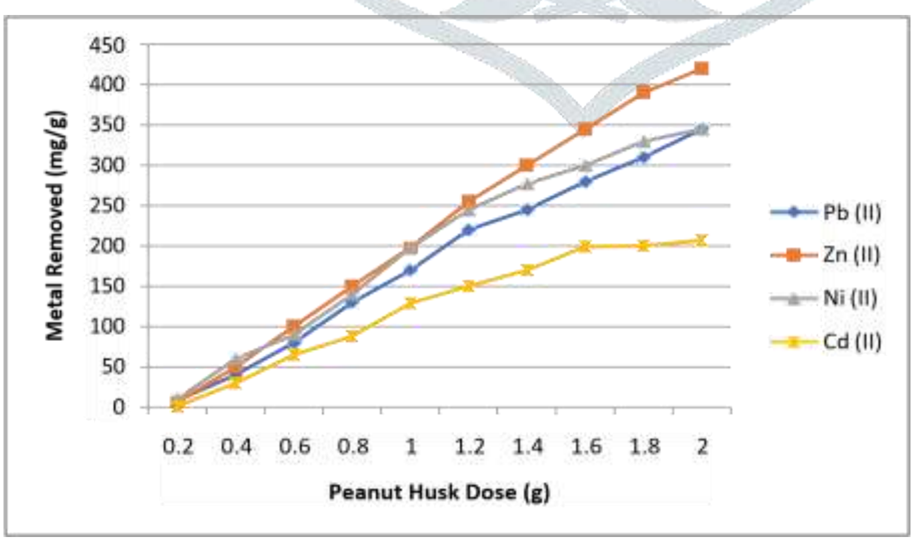

Figure 2 : Effect of Adsorbent Dose Adsorption of Metal

4.3 Effect of Initial Metal Ion Concentration

The adsorption experiments were carried out with metal ion concentrations of 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100, mg/L at pH 8. The effect of initial metal ion concentration of xenobiotic and xenobiotic heavy metal shown in Fig. 3.

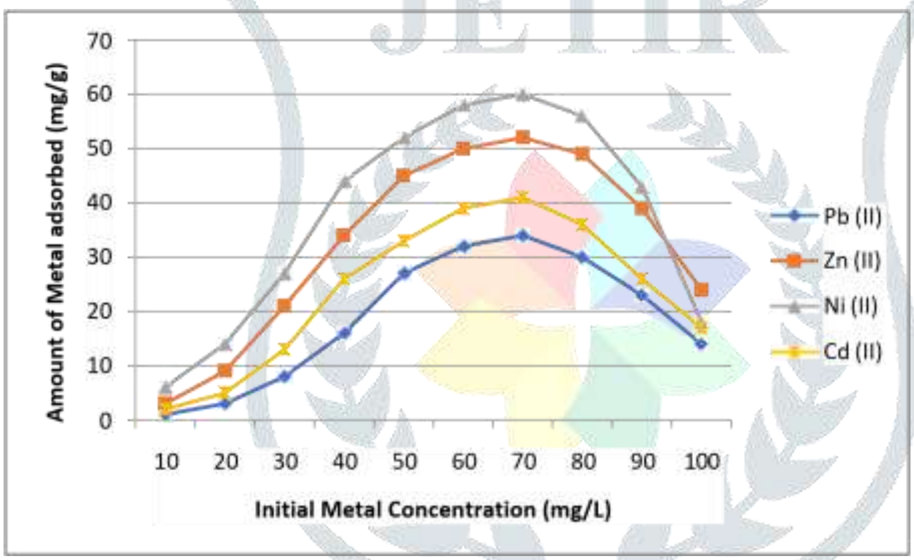

Figure 3: Effect of Initial Metal Ion Concentration

The result from the plot showed that adsorption increase as the initial metal ion concentration increase from 10-70 mg/L and further decrease with increase in metalion concentration. Such behavior can be because of the unchanging number of available active sites on the adsorbent here the amount of adsorbent was constant.

4.4 Effect of Contact Time

In the present study, effects of contact time (15 - 140 min) on the removal of xenobiotic and non-xenobiotic heavy metal ions have been carried out with initial concentration of 45 mg/L at pH 8. maximum uptake of metal ion was at 2 hours. After 2 hour the % removal of metal ion was negligible. Figure 4. showed the effect of contact time on adsorption of xenobiotic (Pb^{2+}, Cd^{2+}) and non-xenobiotic (Zn^{2+}, Ni^{2+}) heavy metals. The rapid initial biosorption may be attributed to the accumulation of metals on to the surface of biosorbent, due to its large surface area. With the progressive occupation of these sites, process became slower in the second stage.

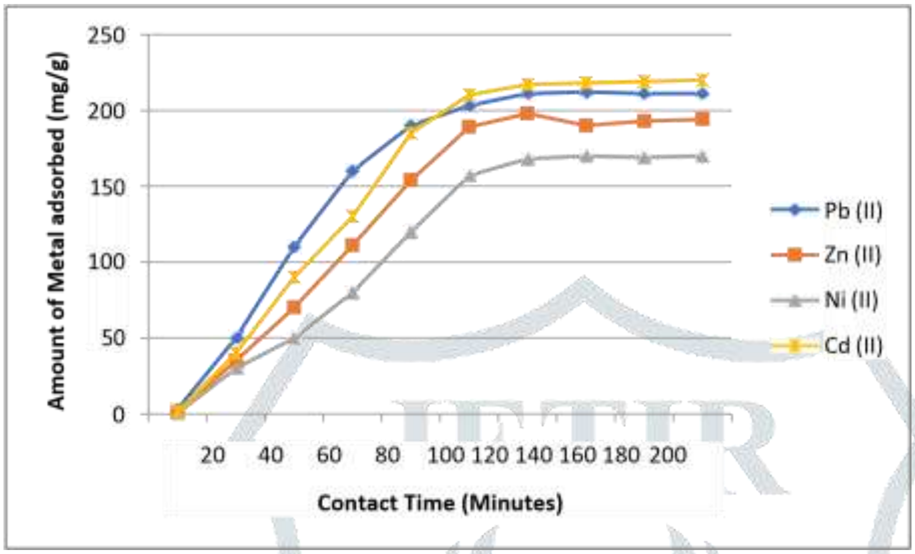

Figure 4 : Effect of Contact time on Adsorption of Metal Ion

4.5 Effect of Temperature

Temperature is key parameter to control the adsorption process. Figure 5. presents the effect of temperature on adsorption of all the four heavy metals under study at pH value of 8. It is observed that maximum adsorption of metal ions takes place at 340 K.

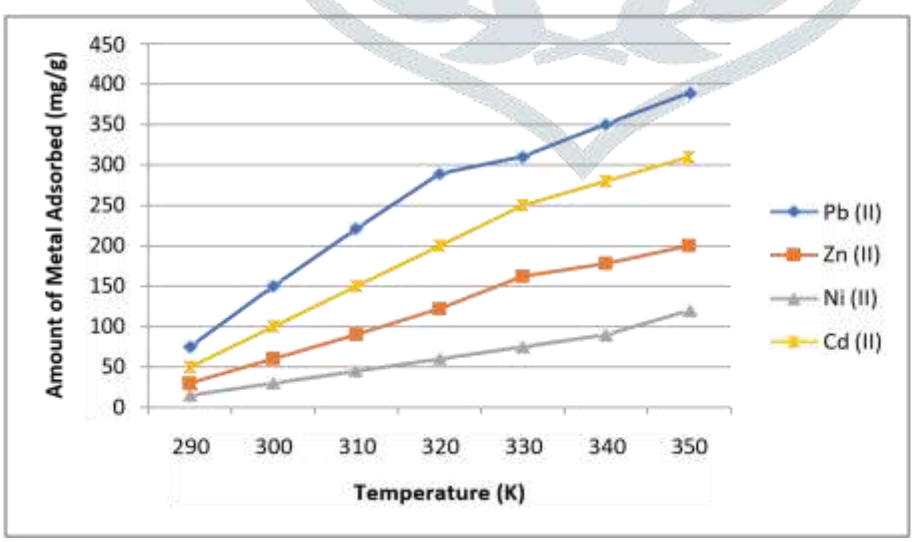

Figure 5: Effect of Temperature on Adsorption of Metal

5. Adsorption Isotherm

Adsorption isotherm are useful in finding out the adsorption capacity of adsorbent. In the present study, the adsorption of xenobiotic (Pb^{2+}, Cd^{2+}) and non-xenobiotic (Zn^{2+}, Ni^{2+}) on peanut husk was studied by Langmuir and Freundlich adsorption isotherm model. Experimental result of Langmuir isotherm has been shown in figure 6. According to Langmuir model uptake of metal ion occur at a homogeneous surface by monolayer adsorption. The linearized form of Langmuir isotherm is represented following equation:

$$C \qquad 1 \qquad C\,q \qquad K\,Q \qquad Q$$

$$\_\_ \qquad \_\_\_\_ \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . . \; 3$$

Where, qe (mg g^{-1}) is the maximum amount of metal ions adsorbed per specific amount of adsorbent, when all binding sites are occupied;

Ce (mg L^{-1} or mmol L^{-1}) is the equilibrium concentration;

Qm (mg g^{-1}) is the amount of metal ions required to form a monolayer;

K_l is the Langmuir equilibrium constant related to the energy of sorption (L mg^{-1} or L $mmol^{-1}$).

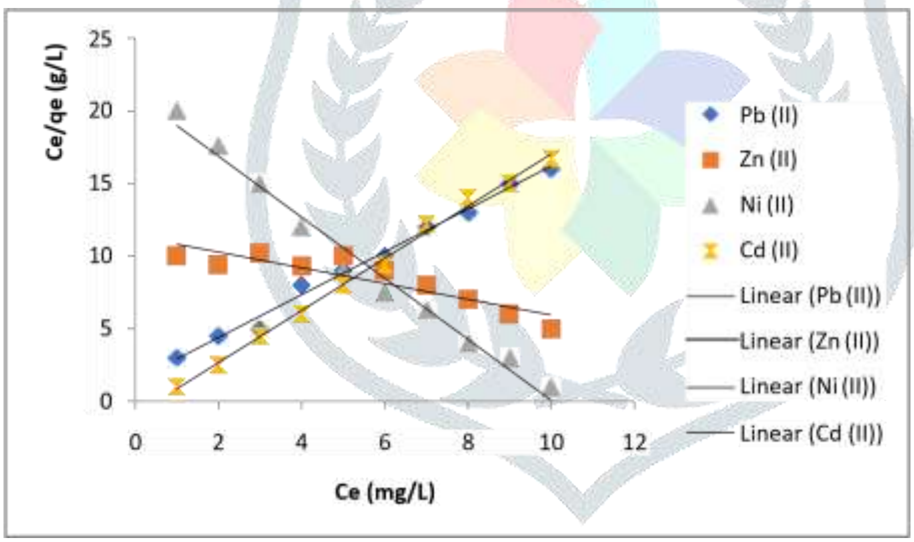

Figure 6: Langmuir Isotherm

For determination of the Langmuir parameters, Ce/qe can be plotted versus Ce. According to

Freundlich adsorption isotherm, uptake of metal ion occurs at heterogenous surface by multilayer adsorption. Linearized form of Freundlich isotherm is represented by following equation:

$$\ln qe \qquad \ln K \_ \frac{1}{n} \ln C \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \; 4$$

Where KF and 1/n are Freundlich constant related to adsorption capacity and intensity of adsorption. Freundlich parameter are obtained by plotting ln q_e versus ln C_e. The experimental result of Freundlich isotherm has been shown in Fig. 7.

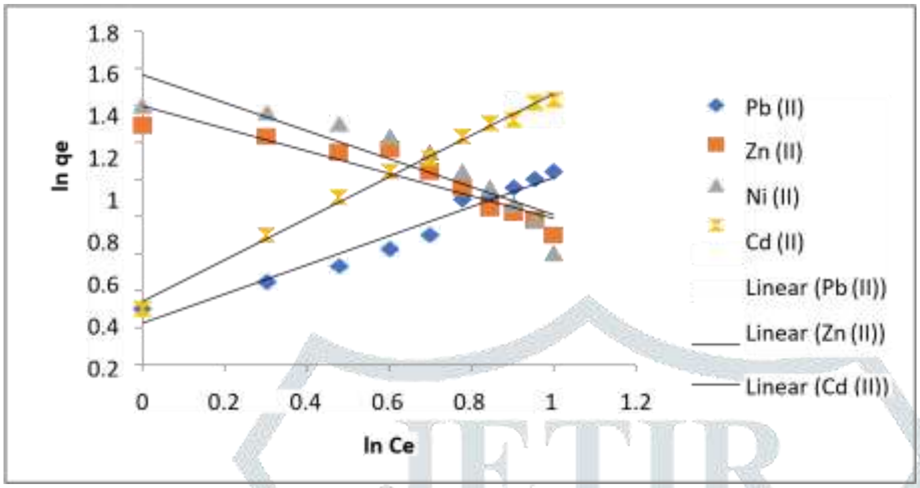

Figure 7: Freundlich Isotherm

Conclusion

Detailed analysis of experimental data was carried out by using adsorption isotherms, to explain adsorption of Pb (II), Cd (II), Zn (II) and Ni (II), on peanut husk has more tendency to absorb zinc and nickel as compare to lead and cadmium. This experiment forms the basis for the study of kinetics of adsorption capacity of peanut husk with the view of varying other parameters such as the pH, temperature, the adsorbent dosage, contact period and initial metal ion concentration in order to establish the level of its performance and adsorption isotherm parameter. The study show that maximum adsorption takes place at pH 7-8, contact time of 2 hours, adsorbent dose of 1.8 g, initial concentration of 60mg/L and at a temperature of 340 K.

Peanut husk is a good adsorbent for the heavy metal. The trend of uptake for peanut husk is in the order of Zn (II)> Ni (II)> Pb (II)> Cd (II).

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