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The Use of Testa of Groundnut Shell *(Arachis hypogea)* for the Adsorption of Ni(II) from the Aqueous System

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This paper presents the use of testa of groundnut shell for the removal of nickel from dilute aqueous solutions at laboratory scale. The adsorption isotherm of Ni(II) on the testa of groundnut shell was carried out by the batch adsorption process. Various parameters such as initial concentration, pH and amount of the adsorbent doses were studied. The experimental adsorption data obtained followed both Langmuir as well as Freundlich isotherms. Maximum adsorption (85%) was observed at pH 6. The monolayer adsorption capacity was found to be 18.79 mg/g, which is greater than most of the low-cost adsorbents reported.

Key words : *Adsorbent, thermodynamic parameters, isotherm.*

Introduction

Wastewater containing nickel, originates primarily from metal industries, particularly during plating operations. Occurence of dermatitis in some workers engaged in electroplating, polishing paints and pigments may be attributed to nickel poisoning. To curtail metal pollution problems, many processes have been developed for the treatment and disposal of metal containing wastes including chemical precipitation of metals usually by lime setting of the metal precipitates in a pond. The other processes generally used include ion exchange, reverse osmosis, in flotation and evaporation etc. The major shortcomings of the conventional treatment are low efficiency at low concentration of heavy metals, expensive handling and safe disposal of toxic sludge.

The need of economical, effective and safe methods for removing heavy metals from wastewater has resulted in the search for unconventional materials that may be useful in reducing the levels or accumulation of heavy metals in the environment. Removal of metals by low cost and easily available materials like sawdust fly-ash[1], fruit peel of orange[2], kyanite[3], baker's yeast[4], bagasse fly ash[5], goethite[6] and sewage sludge[7] has been studied recently. The testa of groundnut shell, an economical and low cost material, was obtained from the local area and was found to have great potential to adsorb nickel from aqueous solutions.

Methodology

Preparation of adsorbent

The groundnut shell was used for the removal of Ni(II) from aqueous solution. It was dried, crushed and washed thoroughly with double distilled water to remove adhered particles from the surface and finally dried in an air oven at 100-105^{0}C for 24 h. After drying, the adsorbent was sieved through 150 mesh size and used as such.

Adsorbate solution

All the chemicals used were of analytical grade. Stock nickel nitrate and potassium dichromate solution containing 1000 mg/L of the metal were prepared in distilled water. All the working solutions were prepared by diluting the stock solution with distilled water.

Adsorption studies

Batch adsorption experiments were carried out at room temperature 30±1^{0}C. Known volume of the Nickel solution (50 mL) of known initial concentration was treated with a specified known weight (m) of groundnut shell and the solution was kept in stoppered conical flask. After the contact time of 24 h, the solution was filtered and the filtrate was subsequently analyzed for metal ion concentration by AAS model GBC 902 using air- acetylene flame, and then removal by adsorbent was calculated. The similar estimation was also carried out at various pH, temperature and dosages. The percentage removal of nickel and the amount of nickel adsorbed per unit mass of adsorbent were calculated by using the following relationship.

$$\% \text{ removal of nickel} = Ci - Ce/Ci * 100 \quad \text{———— (1)}$$

$$qe = (Ci - Ce/m) * V \quad \text{———— (2)}$$

The adsorption data were analyzed by employing the Freundlich and Langmuir isotherms.

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Result and disscusion

Effect of concentration

The effect of concentration on the adsorption is shown in **Fig.1**. It has been observed that the adsorption capacity of Ni (II) increased from 0.68 mg/g to 9.7 mg/g, whereas the % adsorption increased from 68% to 97%, as the concentration increased from 10 to 100 ppm.

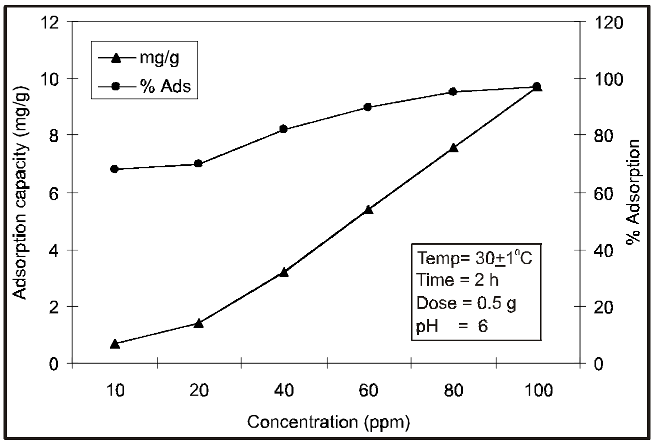

Fig.1: Effect of concentration

Effect of pH

The effect of pH on the adsorption of Ni(II) on groundnut shells was studied at room temperature by varying the pH of nickel solution- groundnut shell suspension from pH 1 to 8. The pH of the aqueous solution is an important controlling parameter in the adsorption process and thus the role of hydrogen ion concentration was examined in the solution at different pH. The plot of metal adsorption capacity (mg/g) as well as % adsorption versus pH is shown in **Fig. 2**. From the figure, it is observed that adsorption of nickel varies with pH and hence nickel adsorption on groundnut shell is highly pH dependent. With increase in pH, the extent of adsorption increases and reaches to maximum value 4.5 mg/g (85%) at pH 6. However, the adsorption capacity decreases, if pH is further

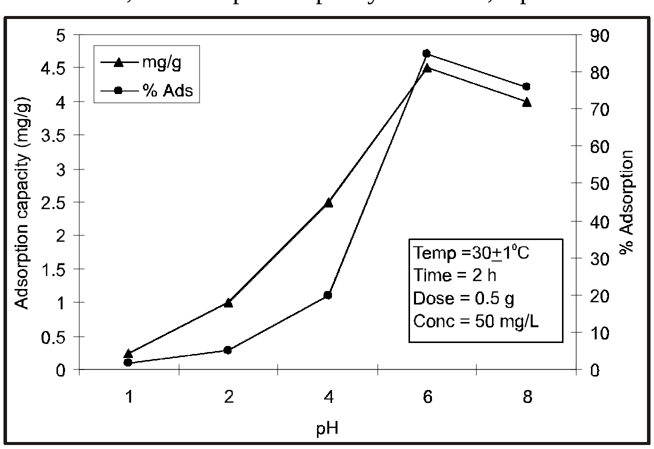

Fig. 2: Effect of pH

increased and reaches to 4 mg/g at pH 8. The similar results have also been observed on flyash[1]

Effect of doses

The adsorption capacity (mg/g) and percentage adsorption of Ni(II) at different doses of groundnut shell is shown in **Fig. 3**. The percentage of adsorption increased as the adsorbent dose is increased. It may be concluded that by increasing the adsorbent dose, the efficiency of groundnut shell increases, while adsorption density decreases with increase in adsorbent dose. The decrease in adsorption density may be due to the fact that some adsorption sites may have remained unsaturated during the adsorption process, whereas the number of sites for adsorption increased by increasing the adsorbent doses, and that resulted in the increase of removal efficiency.

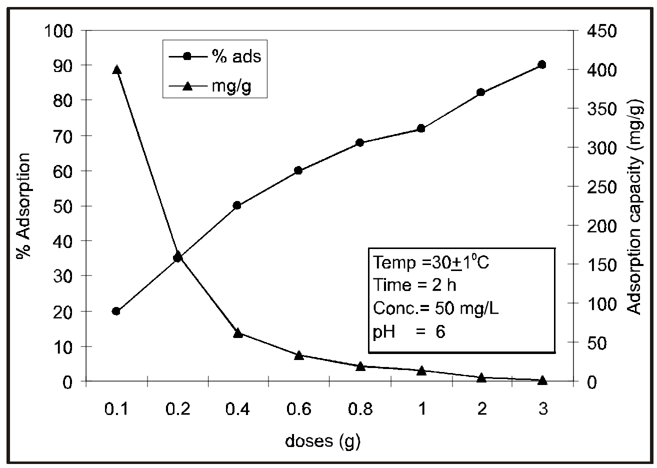

Fig.3: Effect of doses

Adsorption isotherms

The adsorption data has been analyzed in the light of Langmuir and Freundlich adsorption models. The Langmuir equation may be described as

$$\frac{1}{x/m} = \frac{1}{\theta^0 b} + \frac{1}{Ce} + \frac{1}{\theta^0 b}$$

Where x/m is metal uptake per unit weight of adsorbent, Ce is the equilibrium concentration of metal (mgL^{-1}), (q^0 and b are Langmuir constants relating to adsorption capacity and adsorption energy respectively. The Langmuir isotherm is valid for monolayer adsorption onto the surface of the adsorbent containing a finite number of identical sites. The plot of 1/x/m against 1/Ce gives straight line **(Fig. 4)**, showing the applicability of Langmuir isotherm. The values of Langmuir constants and regression coefficient (R^2) have been reported in **Table** 1 at different temperatures. The essential features of the Langmuir isotherm can be expressed in terms of a dimensionless constant separation factor or equilibrium

Table 1 : Langmuir and Freundlich constants at different temperatures

Temperature 0^0C	Langmuir Constants Q_0 (mg/g)	R^2	Freundlich Constants K_f	R^2	1/n
30	18.79	0.9927	1.2	0.9927	0.23
40	7.46	0.9797	1.4	0.9863	0.27
50	2.69	0.9996	2.1	0.9955	0.31

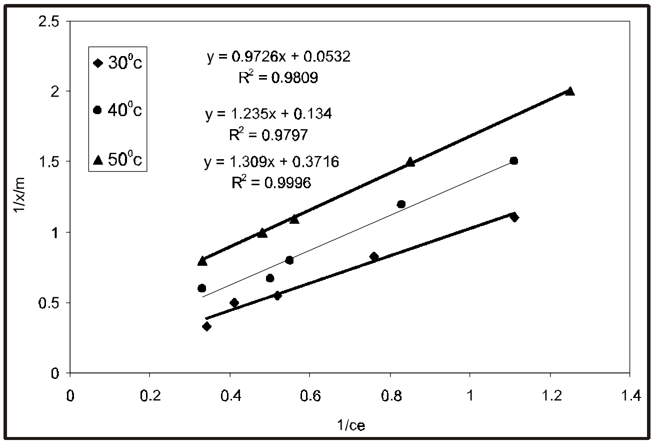

Fig.4: Langmuir Isotherms

parameter (R_L), which is defined by the following relation:

$$R_L = 1/ 1+b\ C_0$$

Where C_0 is the initial metal ion concentration (mg/L) and b is the Langmuir constant. The R_L values at 30^0, 40^0 and 50^0C are found to be 0.62, 0.63 and 0.60 respectively, showing favourable adsorption of Ni(II).

The Freundlich adsorption isotherm was also applied for the adsorption of Ni(II).

$$\log x/m = \log K_f + 1/n \log Ce$$

Where Ce is the equilibrium concentration (mgL^{-1}), x/m is the amount adsorbed per unit weight of adsorbent (mgL^{-1}), Kf and n are Freundlich constants. The linear plot of log x/m vs log Ce indicates that adsorption of Ni(II) also follows Freundlich isotherm **(Fig.5)**. The values of Freundlich constants and regression coefficient (R^2) have been reported in **Table 1** at different temperatures. The details pertaining to the extent of adsorption of Ni(II) by different adsorbents reported by various researchers, along with the result of the present study are included in **Table 2** in the form of monolayer adsorption capacity (Q_0). The data in the table indicate that groundnut shell has the maximum adsorption capacity compared to other adsorbents.

The testa of groundnut shell *(Arachis hypogea)* is cheaper than most of the other adsorbents, like activate carbons,

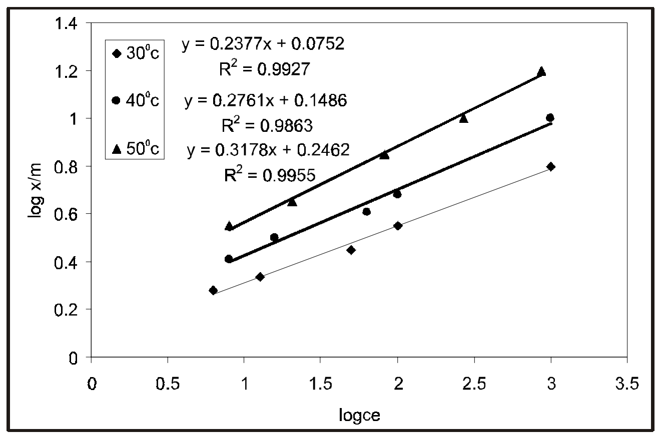

Fig.5 : Freundlich Isotherms

Table 2 : Maximum capacity, Q_0 (mg/g) for adsorption of Nickel by various adsorbents

Adsorbent	Q_0 (mg/g)	Reference
Anaerobically digested sludge	7.66	Gould & Genetelli[9]
Amorphous iron hydroxide	6.80	Mustafa & Haq[10]
Sphagnum moss peat	9.20	Ho et al.[11]
Calcium-alginate	10.50	Huang et al.[12]
Native sugar beet pulp	11.86	Reddad etal. [13]
Kaolinite	10.79	Yavuz et al. [14]
Spent animal bones	7.22	Al-Ashed et al.[15]
Chitosen acetate crown ether	6.4	Tan et al.[16]
Groundnut shell	18.79	present study

and hence the testa of groundnut shell can be burnt and used as a source of heat for steam generation. According to Coupal[8], the heat value of peat is related to the moisture content by the following eqation:

$$\text{Net heat (BTH)} = 100\,(x-10)$$

Where, x is the percentage of dry testa of groundnut shell in the wet mixture.

The use of testa of groundnut shell appears to be a very convenient method for the treatment of Ni(II) containing solution. The most attractive advantage of the adsorbent towards treatment is the simplicity of the system, lower cost and the ability to accept a rather wide variation of effluent composition.

Conclusion

In the present study, adsorption of Ni(II) on the testa of groundnut shell in synthetic solution has been studied. The data obtained through this work supports that the testa of groundnut shell is an effective low cost adsorbent for the removal of nickel in aqueous solution. The adsorption of Ni(II) ion is dependent on the amount of groundnut, concentration of metal ion and pH of the metal solution. Maximum removal of Ni(II) on testa of groundnut shell has been observed (85%) at pH 6. The equilibrium adsorption data are correlated by Langmuir and Freundlich isotherm equations. The maximum monolayer capacity of testa groundnut shell was found to be 18.79 mg/g at 30±1 ^{0}C, which is greater than that most of the low-cost adsorbents reported.

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