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Removal of Nickel ion from Industrial Waste Water using Maize Cob

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Abstract

The adsorption of Nickel (II) on Maioze cob has been studied using atomic absorption spectroscopy for metal estimation. Parameters like Heavy metal concentration, adsorbent dose, contact time and agitation speed were studied. Langmuir and Freundlich isotherms were employed to describe adsorption equilibrium. Maximum amount of nickel adsorbed as evaluated by Freundlich isotherm. Study concluded that Maize cob, a waste material, have good potential as an adsorbent to remove toxic heavy metal like nickel from industrial waste water.

Keywords: Adsorption, maiize cob, heavy metal, atomic absorption spectroscopy, isotherm.

Introduction

Corn or Maize, common name for the cereal grass widely grown for food and livestock fodder. Corn ranks with wheat and rice as one of the world's chief grain crops. Corncobs are an important source of furfural, a liquid used in manufacturing nylon fibers and phenol-formaldehyde plastics, refining wood resin, making lubricating oils from petroleum and purifying butadiene in the production of synthetic rubber. Ground corncobs are used as a soft-grit abrasive. Large, whole cobs from a special type of corn, "cob pipe" corn, are used for pipes for smoking tobacco. Corn oil, extracted from the germ of the corn kernel, is used as a cooking and salad oil and, in solidified form, as margarine; it is also used in the manufacture of paints, soaps, and linoleum. The search for alternate sources of energy has brought attention to corn as a fuel source. High in sugar content, corn is processed to produce alcohol for use with gasoline as gasohol, and the dry stalk is a potentially important fuel biomass. Maize cob is also gaining grounds due to its potential to overcome heavy metal pollutants. Insoluble cell walls of maize are largely made up of cellulose and hemicelluloses, lignin, condensed tannins and structural proteins.

The problems of our ecosystem are increasing with the advancement in technology. Heavy metal pollution is one of these problems. Contamination of water by heavy metals through the discharge of industrial waste water is a worldwide environmental problem. The elevated level of lead and other heavy metals, e.g. cadmium, chromium and mercury, in the local water streams is a major concern to public health. Mining, electroplating, metal processing, textile industry, and battery industry are the main sources of heavy metal ion contamination. Metals like lead, cadmium, copper, arsenic, nickel, chromium, zinc and mercury have been recognized as hazardous heavy metals. Heavy metals are toxic and have the tendency to bio-accumulate. It has been consistently desired that their levels be reduced in industrial and municipal effluents before ultimate repository in the ecosystem. Techniques used for removal of heavy metals, like chemical precipitation, lime coagulation, ion exchange, reverse osmosis and solvent extraction are expensive and non-environmental friendly, as compared to adsorption. It is therefore, essential to search agricultural by-products and to transform such materials to adsorbents. The purpose of present study is to evaluate the efficiency of Maize cobs as adsorbent for nickel. Maximum adsorption capacity of adsorbent, adsorption intensity of the adsorbate on adsorbent surface and adsorption potentials of adsorbent were estimated by Langmuir and Freundlich isotherms, respectively.

Material and Methods

Adsorbent: Maize Cob was collected from shops in Coimbatore and was washed with double distilled water. The washed samples were then drenched in 1N conc sulphuric acid solution for 12 hrs. After 12 hrs the drenched samples were washed with distilled water until the soluble and coloured components were removed and were dried in sun light for few hrs. The samples were then soaked in 1N NaOH for 12 hrs and washed with de-ionized water. The Maize Cob was dried in the hot air oven at 100 °C for 24 hrs. It is taken out, crushed and put into a mechanical sieve to separate the particles based on their size.

Stock solutions and Standards: 4.47g of Nickel sulphate was weighed and transferred to a 1000 ml standard flask. Distilled water was added to the standard flask to dissolve the salt and is further added up to the mark to obtain a 1000 mg/L of Nickel stock solution. The pH of the aqueous solution is varied by adding the required amounts of 1N HCl and 1N NaOH. Different concentrations of metal solutions were prepared by dissolving required amount of stock solution.

Equipment and Apparatus: pH adjustments were made with digital pH-meter using HCl (0.1 mol L_1) and NaOH (0.1 mol L_1). Nickel content in each experiment was determined with atomic absorption spectrophotometer. The absorbance of Nickel was recorded at 232.0 nm.

Study of Process Parameters: Effect of four parameters: heavy metal concentration, adsorbent dosage, contact time and agitation speed were studied. To study the effect of certain parameter, that parameter has been changed progressively keeping the other three constant. After adsorption, contents of the flasks were filtered and filtrates were subjected to atomic absorption.

Study of Adsorption Isotherms: Four solutions with concentrations 30, 50, 60 and 90 µgmL_1 were made by proper dilution of stock solutions of nickel. pH was adjusted to 4. 1.5 g of biosorbent was added to 50 ml of each metal solution and was agitated for half an hour. At the end, it is filtered and the filterate was analyzed for metal ions by atomic absorption spectroscopy.

Data Evaluation: Langmuir, (equation 1), Freundlich, (equation 2) isotherms were plotted by using standard straight-line equations and corresponding two parameters for nickel ion was calculated from their respective graphs.

$$1/qe = 1/qmax + (1/qmax.b)\,(1/Ce) \qquad (1)$$

$$\ln qe = \ln kf + (1/n) \ln Ce \qquad (2)$$

qe (mg g_1) is the amount of metal adsorbed and Ce (lg mL_1) is concentration at equilibrium. qm (mg g_1) and b (L g_1) are Langmuir isotherm parameters. KF and n are Freundlich isotherm parameters.

Results and Discussion

Effect of Nickel Concentration: Effect of initial concentration was studied by varying the heavy metal concentration, from 1 to 10 mg/L with 0.5g of adsorbant, at contact time of 30 mins. There is an increase in the adsorption and then it was stable (figure 1). The decrease in percentage biosorption may be caused by the lack of sufficient surface area to accommodate much more nickel ions available in the solution.

Effect of adsorbent dosage: Effect of adsorbant dosage on adsorption of nickel is studied by changing the biosorbent dosage from 0.5 to 5g and there is no change in other parameters like initial concentration. The contact time was 30 mins for nickel as stated earlier. The graph shows an increase in the biosorption percentage as dosage of biosorbent increases to certain level and then decreases (figure 2). This is because of the availability of more binding sites in the surface of the biosorbent for complexation of nickel ions.

Effect of contact time: Contact time profile for the biosorption of nickel for a solution of 90 mg/L is shown in the data obtained from the biosorption of nickel ions on the maize cob showed that a contact time of 90 mins is needed to achieve equilibrium and the biosorption decreases significantly with further increase in contact time (figure 3).

Effect of agitation speed: The agitation speed varied from 100 to 400 rpm is carried out with a magnetic shaker. As agitating rate on adsorption increased from 100 to 400 rpm, adsorption capacity of maize cob increases and then decreases (figure 4). The effect of increasing the agitating rate was to decrease the film resistance to mass transfer surrounding the adsorbent particles.

Adsorption isotherms: Freundlich isotherm than Langmuir, holds good in explaining the adsorption of nickel to maize cob more effectively. Correlation coefficient is more in freundlich isotherm compared to the Langmuir isotherm (figure 5 and 6).

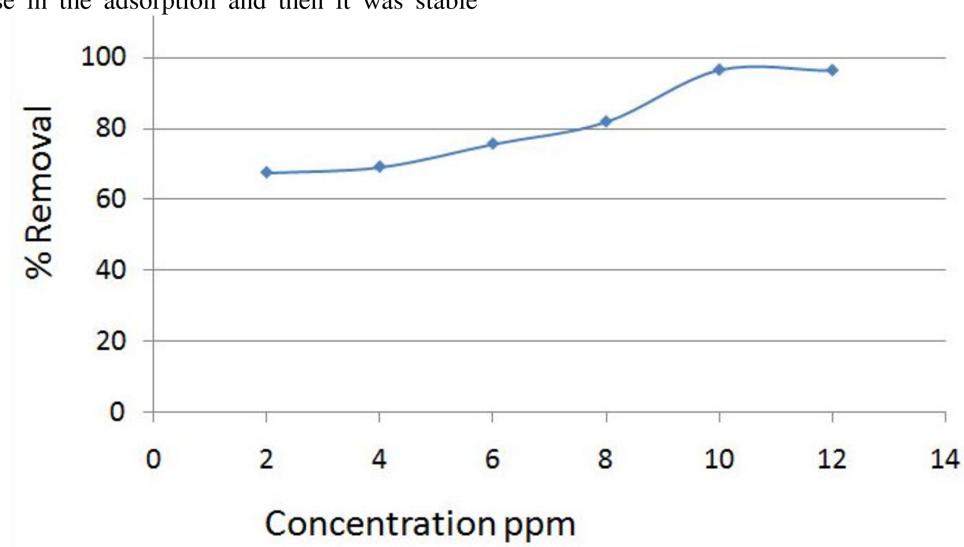

Figure-1
Effect of concentration on the adsorption of Ni by Maize cob

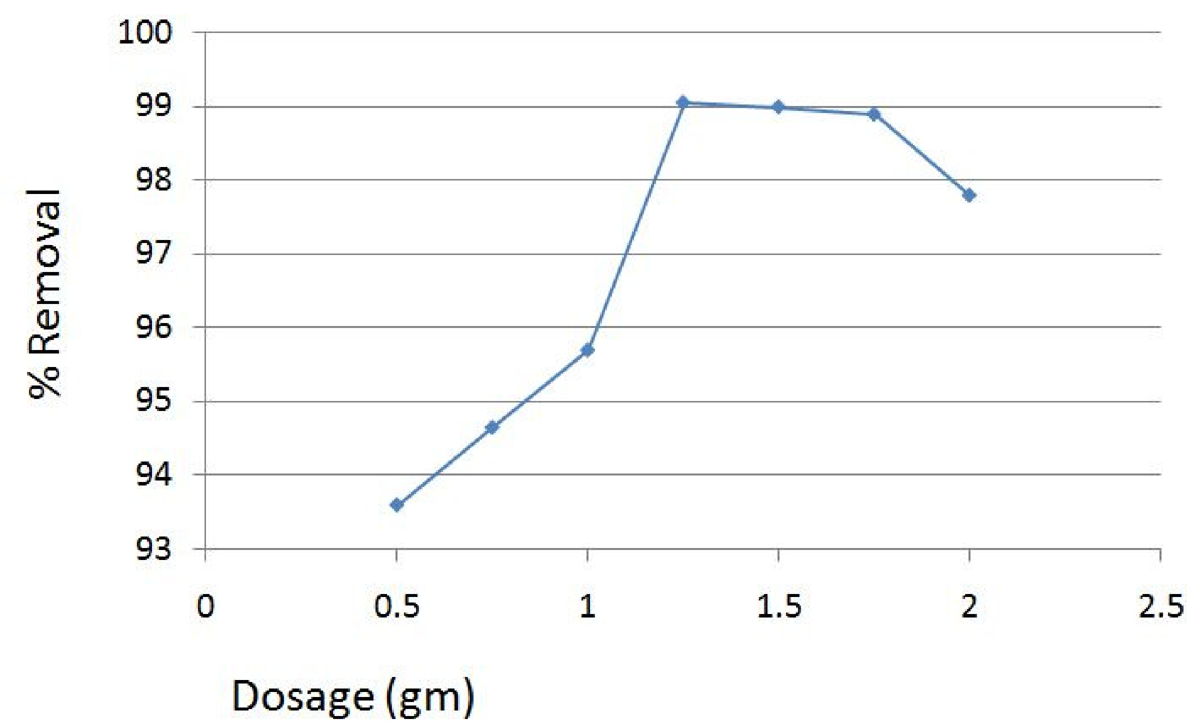

Figure-2
Effect of dosage on the adsorption of Ni by Maize cob

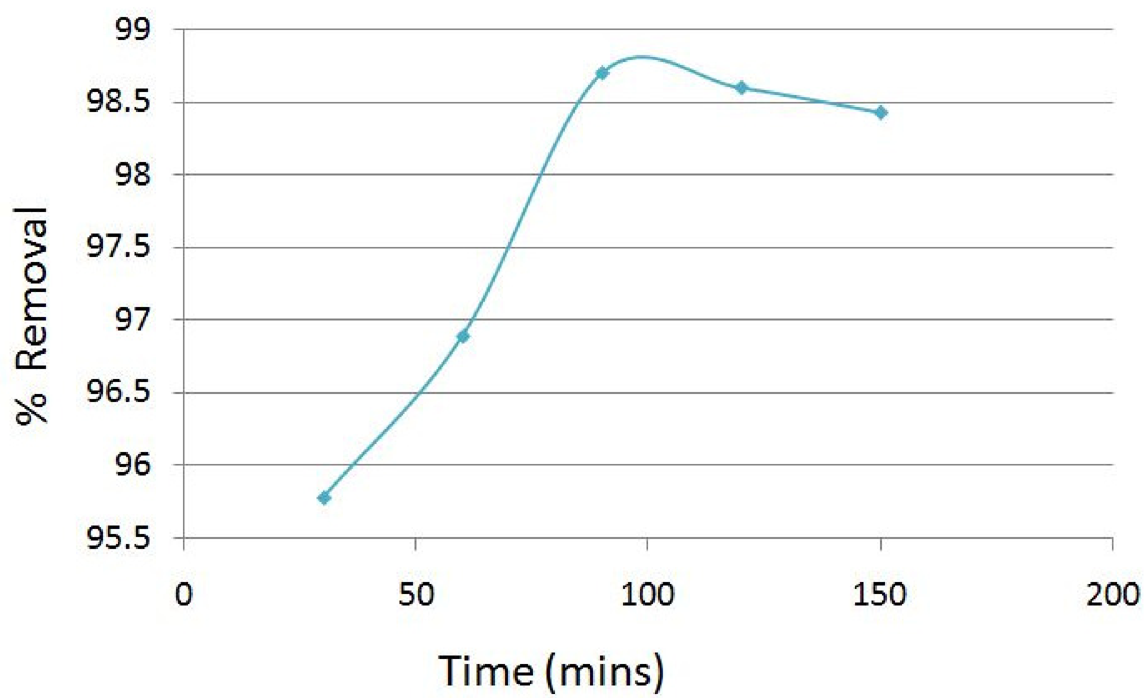

Figure-3
Effect of time on the adsorption of Ni by Maize cob

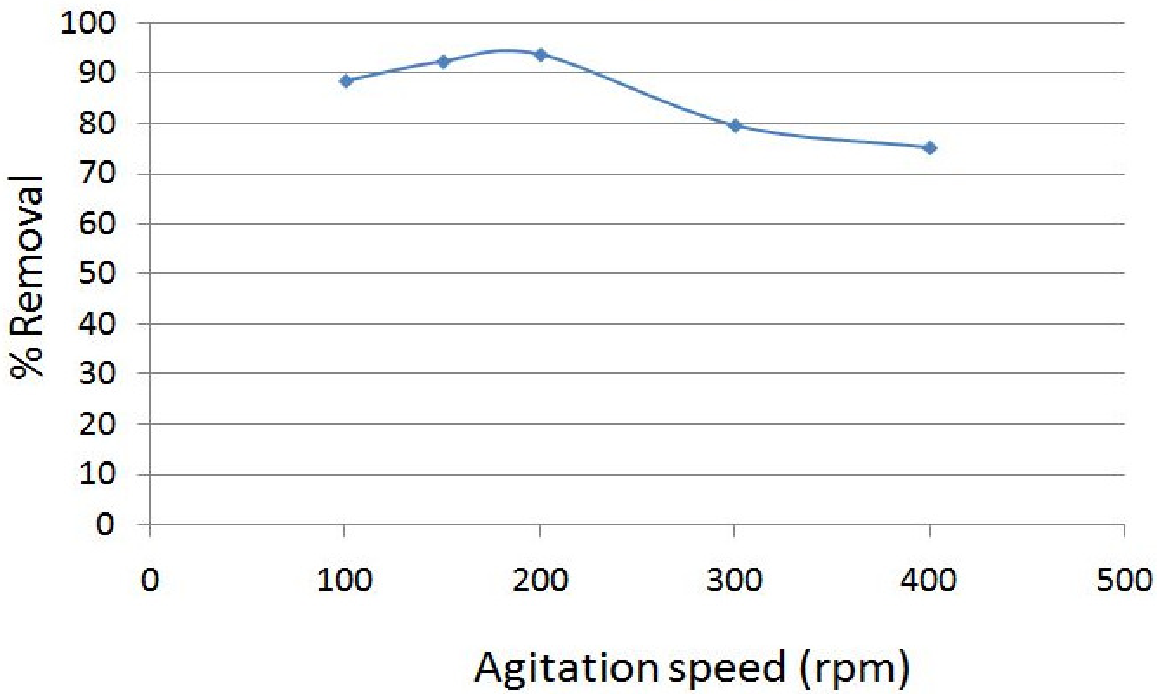

Figure-4
Effect of agitation speed on the adsorption of Ni by Maize cob

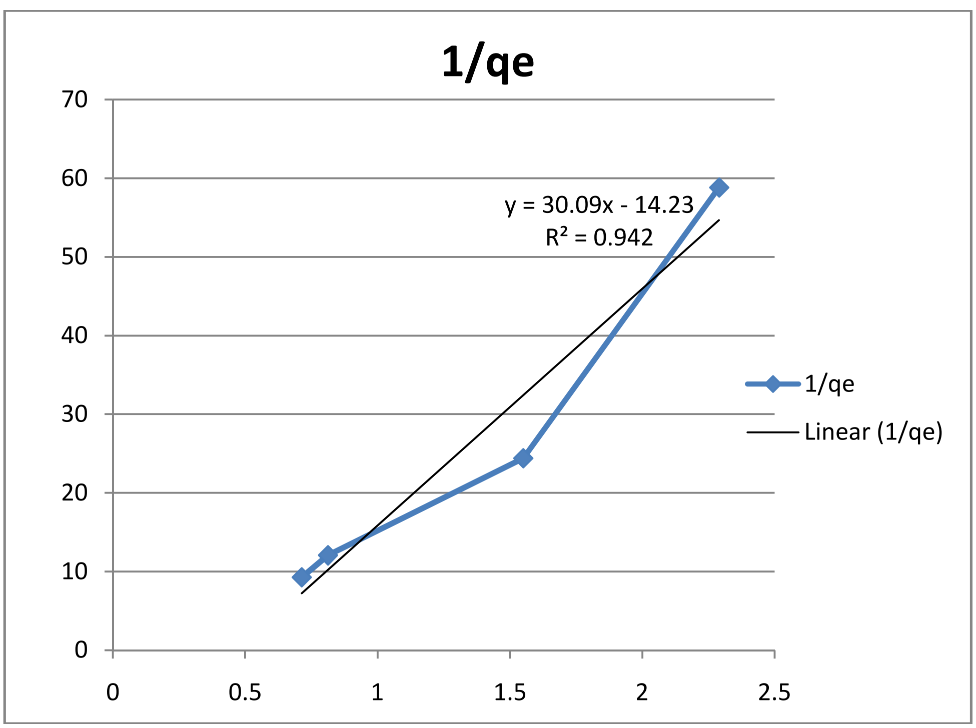

Figure-5
Langmuir Isotherm

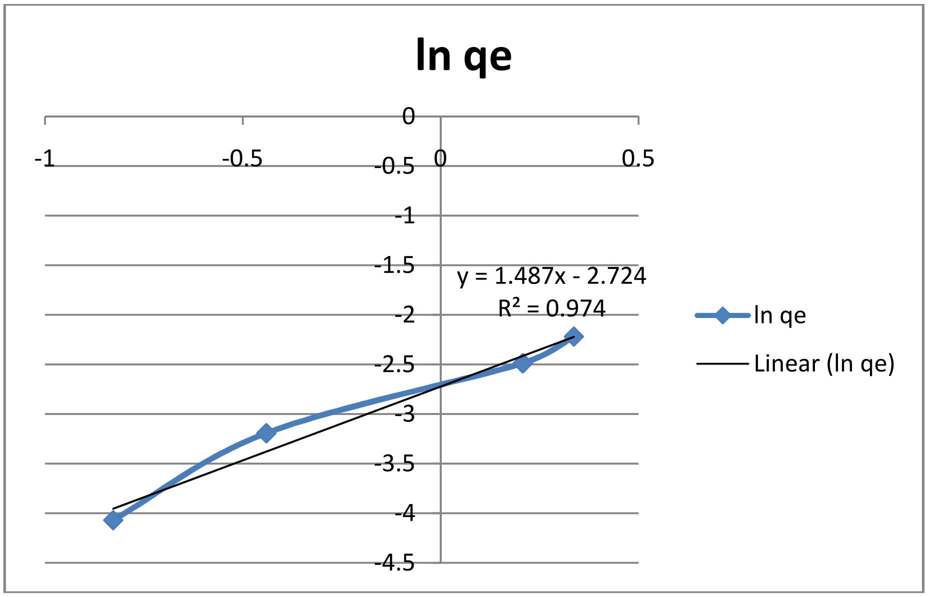

Figure-6
Freundlich Isotherm

Conclusion

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. To conclude, instead of chemicals, non-hazardous agro-waste materials like maize cobs can be used as heavy metal removers from wastewaters and industrial effluents to overcome water pollution.

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