

NICKEL (II) REMOVAL FROM AQUEOUS SOLUTION USING ACTIVATED CARBON PREPARED FROM CASTER SEED HULL

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Abstract - Water is the important sources for all living things. Pollution of water source is one of the ecological crises to which the present world is subjected today. Now a day the water is mostly used in industrial and domestic purpose. It introduce the lot of impurities to the water. This is the major reason for water pollution. The heavy metal contamination becomes a serious problem in recent years. The heavy metal such as Cr, Ni, Cd, Hg, Co, As, Mn, Pb, and Zn Heavy metal toxicity can have several health effects in the body; Heavy metals can damage and alter the functioning of organs such as the brain, kidney, lungs, liver, and blood. So the heavy metal removal is essential from the water and waste water. Adsorptions of Nickel (ii) ion from its aqueous solution by castor seed hull (CSH) by activated carbon have been investigated using batch adsorption experiments. It has been found that the amount of nickel adsorbed per unit mass of the hull increases with the initial metal ion concentration, contact time, solution pH and with the amount of the adsorbent. Isotherm study will be conducted to easily understand the capacity of carbon. The experimental results were analyzed by the Langmuir, and Freundlich isotherms. The absorption capacity (Q₀) calculated from the Langmuir isotherm was 32.15 mg/g of activated carbon at initial pH of 5.0 ± 0.2 for the partial size 125-250µm.

Key Words: Carbon, Nickel (Ii) Removal, Castor Seed, Water

1. INTRODUCTION

Water is nature's wonderful, abundant and useful compound. It is also used for industrial purposes. Some of the major industries such as textiles, chemicals, pharmaceuticals, paper, food processing, leather and confectionaries are using enormous quantity of water. It is also used in irrigation for agricultural purposes and fore fighting. Pollution of the water source is one of the ecological crisis to which the present world is subjected today. Because of various activities by industrial and domestic sector a lot of impurities are introduced in the natural aqueous system. The heavy metal contamination becomes a serious problem in recent years. Traces of heavy metal such as Hg, Cd, Pt, As, Co, Mn, Fe and Ni have been identified as deleterious to aquatic eco-system and human health. These heavy metals are extremely toxic to all organisms. In this project specifically we are going to see about the removal of Nickel (II) from aqueous solution using activated carbon prepared from castor seed hull.

A number of process methods have been developed for the removal of heavy metals from wastewater. These unit operations include

1. Coagulation, Flocculation
2. Ion exchange
3. Precipitation
4. Complexion
5. Solvent extraction
6. Adsorption
7. Electro chemical operation
8. Flotation

Chemical precipitation uses lime or NaOH as precipitating agent. This method is used to formation of a separable solid substance from a solution, either by converting the substance into an insoluble form. Ion exchange process is expensive and careful control of P^H is required for maximum removal. Electrochemical dialysis suffers due to choking of the membranes. In reverse Osmosis, the heavy metal removal is very effective and easily. However cost of the membrane is a limiting factor. But the maintenance of the membrane and operating cost is very high.

Many materials have been tried for adsorption of heavy metals like orange peel. Guva seed, Banana peel, coffee husk, citrus fruits etc., and activated carbon treatment is very simple method for removal of heavy metals. For liquid phase application, the activated carbon is expected to possess high surface area and pore volume. It should also have sufficient hardness and abrasion resistance. Both pulverized and granular activated carbon has been used in liquid phase application. Many coal based activated carbon have been applied for inorganic trace metals such as Cd, Ni and Cr. Hence by examining the presently used clear up methods adsorption using activated carbon appears to have the least adverse effects. Not only are the trace elements removed, but also capable of producing an effluent which is free from suspended solids and organics.

However activated carbon has the disadvantage of being relatively high in cost and it's not possible easily. Therefore do not find wide spread use for water treatment purposes. Hence it becomes necessary to develop alternate materials

which are cheaper and process properties comparable to that commercially available granular carbon.

1.2 Aim and Scope of the work

The present study is aimed at preparing carbon from castor seed hull powder by pyrolysis and thermal activation procedure and will be tested for the removal of Nickel (II) from aqueous system.

1. The castor seed hull powder will be washed thoroughly with water and dried.
2. The hull powder will be subjected to pyrolysis procedure at 450 – 6000 C in the electrical furnace and then it will be activated under the temperature of 750 – 8000C in the same furnace.
3. The activated castor seed hull will be grow well and the particle size 200-250 mesh will be considered for adsorption activities for the removal of nickel from water.
4. Batch studies will be performed to understand the optimum time, optimum PH and optimum dosage required for preliminary examination.
5. Carbon characteristics & CSH will be found out to understand the potential of the carbon using ISI procedure 877-1976.
6. Isotherm studies will be conducted to understand the capacity of carbon.
7. A synthetically prepared nickel wastewater will be checked out for the removal of Nickel in batch reactor.

2. LITRATURE REVIEW

Vishal R et al., Guava seeds are economically cheaper and natural materials containing cellulose. The present investigation was carried out with the aim to exploit guava seeds obtained from the waste of guava processing industry for the development of metal adsorbent and to assess its ability for nickel adsorption from its aqueous solutions. The adsorbent from guava seeds was prepared by heating at 600 OCfor 1 hour, followed by shaking with 1N KOH solution at 200 rpm, 500C for 4 hours. The prepared adsorbent was then characterized for various physic-chemical parameters and morphological structure. Equilibrium isotherm data for removing Ni ions by developed adsorbent was analyzed using the Langmuir, Freundlich and Temkin isotherms. It was found that Langmuir isotherms fitted well to the data than Freundlich and temkin model. In order to investigate the mechanism of sorption, kinetic data was also modeled using the pseudo first order and pseudo second order kinetic equations. It was establish that, the pseudo second order equation was the best applicable model to describe the sorption process. Thermodynamic study showed values of standard change in Gibb's free energy (ΔG°) to be negative and standard change in enthalpy (ΔH°) and entropy change

(ΔS°) to be positive confirming the nature of adsorption to be endothermic, spontaneous and process to be feasible. The results revealed considerable adsorption of nickel on prepared Guava seed adsorbent and it could be economic method for the removal of nickel from aqueous solutions.

Mohamed H.H. Ali et al., The adsorption of heavy metals by various types of activated carbon originated from natural wastes is an effective, low-cost and innovative method for their removal from aquatic environments. This study aims to determine the applicability of adsorption isotherms models during the adsorbent activity of orange peel activated carbon for removal of Pb^{+2} , Ni^{+2} , Cr^{+3} and Cd^{+2} ions. The specific surface area, microspore area, and the effects of pH value, soaking time and dosage of orange peel activated carbon were investigated in this study. The optimum pH values for adsorption capacity and removal efficiency of heavy metal ions were 5 – 6. The optimum soaking time was 120 min for Pb^{+2} , 210 min for Ni^{+2} and Cr^{+3} and 240 min for Cd^{+2} . The optimum adsorbent dosage for removal of the studied was 2 gm. The isotherm equilibrium studies confirmed that both Langmuir and Freundlich adsorption isotherms well fitted models and revealed that adsorption of metals ions is one layer adsorption and confirmed highly efficient orange peel activated carbon in the removal of heavy metals. The environmentally friendly origin of orange peel indicates that could use in many broad-scale, low cost-effective and alternative applications.

Momna Khawaja et al., Presence of toxic heavy metals in air, soil, and water are growing threats to the environment. In this study, removal of divalent nickel from aqueous solutions has been investigated by utilizing a low cost pomegranate peel activated charcoal (PPAC) adsorbent. Adsorption capacity of the prepared charcoal at various parameters such as pH, contact time, metal ion concentration and adsorbent dose has been studied. Batch equilibrium experiments showed that maximum nickel adsorption takes place at neutral pH, while the maximum adsorption capacity for PPAC was 10.82 mg g^{-1} . It was also found that percentage removal of nickel is directly proportional to the adsorbent dose with maximum adsorption at an adsorbent dose of 0.5g/50 ml for various concentrations (10-150 ppm) and contact time of 50 minutes. Experimental equilibrium data was verified for *Langmuir* and *Freundlich* isotherm models to establish the adsorb ate-adsorbent interaction phenomena.

K. Periasamy et al., Activated carbon prepared from peanut hulls (PHC), an agricultural waste by-product, has been used for the adsorption of Ni (II) from aqueous solution. The process of uptake obeys both Freundlich and Langmuir adsorption isotherms. The applicability of Lagergren kinetic model has also been investigated. Quantitative removal of Ni (II) from 100 mL aqueous solution containing 20 mg/L Ni (II) by 85 mg PHC was observed over a pH range of 4.0 to 10.0. The suitability of

PHC for treating nickel plating industry wastewater was also tested. A comparative study with a commercial granular activated carbon (GAC) showed that PHC is 36 times more efficient compared to GAC based on Langmuir adsorption capacity (Q_0).

3. METHODOLOGY



Fig -1: Methodology

4. MATERIALS AND METHODS

4.1 Determination of Carbon Characteristics

Activated Carbon:

Activated carbon, also called activated charcoal, is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption or chemical reactions.



Fig -2: Castor Seed Washing & Sun Drying

Uses of activated carbon

Activated carbon is used to purify liquids and gases in a variety of applications, including municipal drinking water, food and beverage processing, odor removal, industrial pollution control. Activated carbon is produced from

carbonaceous source materials, such as coconuts, nutshells, coal, peat and wood.



Fig -3: Activated carbon prepared from castor seed hull

4.2 Methods for the Determination of Carbon Characteristics

1. Moisture

About 10g of the material was weighed in a petridish. The dish was placed in an electric oven maintained at $110 \pm 5^\circ\text{C}$ for about 4 hours. The dish was covered, cooled in a desiccators and weighed heating, cooling and weighing was repeated at 30 minutes intervals until the difference between the two consecutive weighing was less than 5mg.

2. Ash Content

2g of the carbon variety under examination was weighed accurately into a tared porcelain crucible. The crucible and its content were placed in an electric oven at $110 \pm 5^\circ\text{C}$ for about 4 hours. The crucible was removed from the oven and the contents were ignited in an electric muffle furnace at a temperature of 1000°C for about 3 hours. The process of heating and cooling was repeated until the difference between two consecutive weighing was less than 1mg (the ash was preserved for the determination of iron).

3. Apparent Density Test

A 10ml graduated cylinder was weighed accurately. For the determination of apparent density a trip balance was used to fill the carbon in the cylinder. Sufficient amounts of the carbon was poured with constant tapping and filled to the 7ml mark. The shaker attached to the balance should be adjusted, so that the carbon filled the graduated cylinder at approximately 1ml per second. After filling the graduated

cylinder with the carbon, it was weighed accurately. The apparent density was calculated by dividing the weight of carbon by 7.

4. Matter Soluble In Water

10g of the carbon material of known moisture content was weighed accurately and transferred into one litter beaker. About 300ml of distilled water was added and heated to boiling with continuous stirring. Stirring was continued for 5minutes after the flame was removed. The material was then allowed to settle and the supernatant liquid was filtered through a grouch crucible fitted with an asbestos mat. The procedure was repeated thrice with the residue in the beaker, using 300ml of water each time.

The combined filtrate was concentrated, to less than 100ml over a water bath, cooled and made up to 100ml mark in volumetric flask. Exactly 50ml of the concentrate was transferred to a china dish and evaporated to almost dryness on a boiling water bath and finally dried in an electric oven maintained at $110 \pm 5^\circ\text{C}$ cooled in desiccators and weighed. The procedure of drying and weighing was repeated at 30 minutes intervals, until the difference between two consecutive weighing was less than 5mg.

5. Matter Soluble In Acid

10g of the carbon under study was weighed accurately and transferred into a tall form of one litter beaker. 300ml of 0.25HCL was added and heated to boiling with continuous stirring. Stirring was continued for about 5 minutes after the flame was removed. The material was then allowed to settle and the supernatant liquid was filtered through a good crucible, fitted with an asbestos mat into a 2-litre beaker. The procedure was repeated thrice with residue in the beaker using 300ml of acid each time.

After fourth treatment the combined filtrate was concentrated to less than 100ml and made up in a 100ml volumetric flask. Exactly 50ml of the concentrate was transferred to a china dish and evaporated to dryness on water bath. The residue was finally dried in an electric oven maintained at $110 \pm 5^\circ\text{C}$. The dish then covered, cooled in a desiccators and weighed. The above procedure of drying, cooling and weighing was repeated at 30minutes intervals until the difference between two consecutive weightings was less than 5mg. Acid soluble matter was calculated using the same expression as in the case of matter soluble in water.

5. RESULTS AND DISCUSSION

5.1 Effect of agitation time on Nickel (II) adsorption

The effect of agitation time on the percent removal of Ni (II) by CSH carbon is shown in Figure 1. The percent removal increases with increase in agitation time and attains equilibrium within 65 mts for all the concentrations studied (10 to 40 mg/L). The curves were single, smooth and continuous till the saturation of Ni (II) on activated carbon surface.

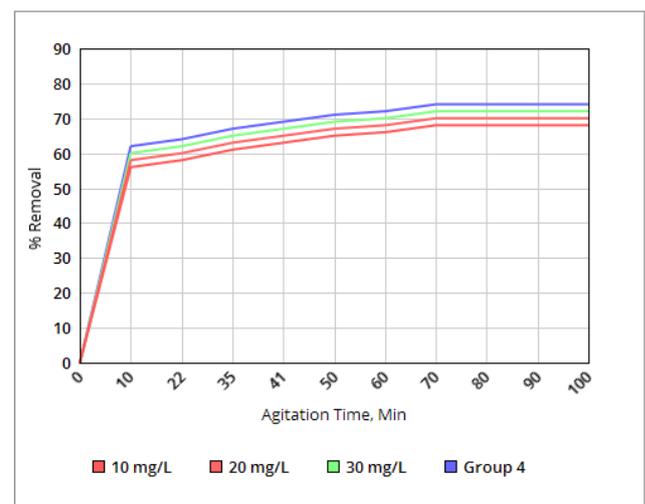


Chart -1: Effect of agitation time and initial Ni (II) concentration on Ni (II) adsorption

Adsorption kinetics

The adsorption kinetics of Ni (II) on adsorbent follows first order rate expression given by Lagergren.

$$\log_{10} (q_e - q) = \log_{10} q_e - K_{ad} t / 2.402$$

Where, K_{ad} (1/min) is the rate constant of adsorbent, q and q_e are the amount of Ni (II) adsorbed (mg/g) at time t (min) and equilibrium time. Linear plots of $\log_{10}(q_e - q)$ versus t (Figure) shows the applicability of above equation. The K_{ad} values for different Ni (II) ion concentrations of 10, 20, 30 and 40 mg/L calculated from the slope of the plots were 0.0505, 0.0514, 0.0735 and 0.0568 1/min respectively.

Effect of adsorbent dosage on nickel (II) adsorption

The effect of carbon dosage on percent removal of Ni (II) is shown in Figure 3. When the carbon dosage increases, the percent removal also increases. It was found that for the removal of Ni (II) of 30 mg/L, the maximum adsorbent dosage of 70 mg/40 mL was required. Increasing adsorbent dosage increases the removal because of availability of more surface area and functional group.

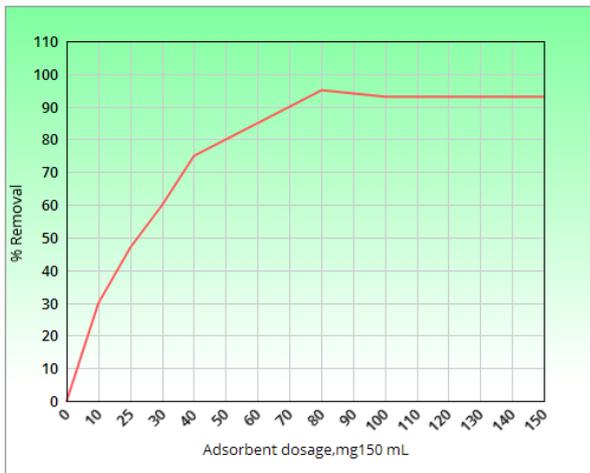


Chart -2: Effect of carbon dosage on Ni (II) adsorption

Adsorption isotherms

The Langmuir isotherm can be applied for adsorption equilibrium of Ni (II) onto CSH carbon¹³

$$C_e / q_e = 1/Q_{ob} + C_c Q_o$$

Where, C_e is the equilibrium concentration (mg/L), q_e is the amount of Ni (II) adsorbed (mg/g), Q_o and b are Langmuir constants related to adsorption capacity and energy of adsorption respectively. The linear plot of C_e / q_e versus C_e (Figure 5) shows that the adsorption follows Langmuir isotherm where $Q_o = 32.15$ mg/g and $b = 1.6153$ for 5- 40 mg /L concentration. Langmuir isotherm can be expressed in terms of dimensionless separation factor of equilibrium parameter.

$$R_L = (1 / 1+bC_o)$$

Where, C_o is the initial Ni (II) concentration (mg/L) and b is the Langmuir constant (L/mg). R_L values for different Ni (II) ion concentration (Table 4.3) was found to be between 0 to 2 indicate favorable adsorption of Ni (II) on to CSH carbon. The linear form of Freundlich equation can be given by, $\log_{10} (X/m) = \log_{10} K_f + 1/n \log_{10} C_e$

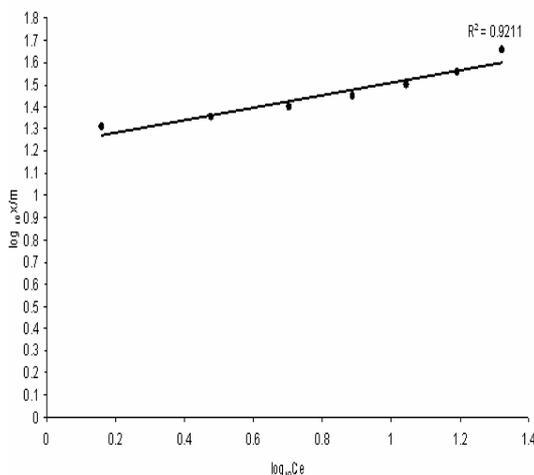


Chart -3: Freundlich plot for Ni (II) adsorption

Effect of pH on Nickel (II) adsorption

The effect of pH from 2.0 to 10.0 was studied to remove nickel (ii) ions from the aqueous solution with adsorbent (Figure). The precipitation was observed from the results at pH 8.0 onwards and the intensity of precipitation increases with the increase in pH from 8.0 to 10.0. Similar observations were reported for coir pith carbon¹⁴. The removal of metal ions increases with increase in pH from 8.0 to 10.0 even without adsorbent, this may be due to the formation of metal hydroxide precipitation.

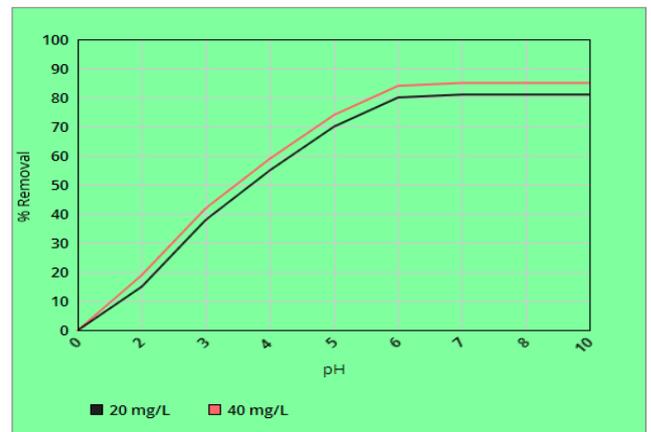


Chart -4: Effect of pH on Ni (II) adsorption

Desorption studies

Desorption studies were carried out to confirm the adsorption mechanism proposed above and to recover the metals from the adsorbent. The quantitative recovery of metal ion indicated that regeneration of carbon was possible. This is further evidence that ion exchange is involved in the adsorption mechanism. Desorption was carried out at different concentrations of hydrochloric acid (0.035-0.355M). The results are shown in Figure 8. Maximum desorption occurs at the strength of 0.320 M.

6. CONCLUSION

The current investigation shows that *Castor seed hull* carbon is a very effective adsorbent in the removal of Ni (II) ions from an aqueous solution. Increase in adsorbent dosage and agitation time increases Ni (II) ion removal at the optimum pH of 5 ± 0.2 . The adsorption followed both Langmuir and Freundlich isotherm models. The desorption studies reveal that recovery of Ni (II) ions from the adsorbent is possible.

REFERENCES

[1]. AlagesanKannan(2014) Removal of cadmium from aqueous solution using carbon derived from Palmyra palm fruit seed, International Journal of Hazardous Material, Vol.2, No.1, pp.1-6.

[2]. Bernard(2003) Heavy Metals Removal from Industrial Wastewater by Activated Carbon prepared from Coconut Shell, Research Journal of Chemical Sciences, Vol.3, No.8, pp.3-9.

[3]. Huang(1983), Activated Carbon Process for the Treatment of Cadmium (II)-Containing Wastewaters, Industrial Environmental Research Laboratory, Vol.600, No.2, pp.83-061.

[4]. Chin-paoHaung(1978) Removal of Cadmium (II) by Activated Carbon, Journal of the Environmental Engineering Division, Vol.104, No.5, pp.863-878.

[5]. Cristina Quintelas(2009)Removal of Cd(II), Cr(VI), Fe(III) and Ni(II) from aqueous solutions by an E. coli biofilm supported on kaolin, Chemical Engineering Journal, Vol.149, pp.319-324.

BIOGRAPHIES



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