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Use of Corn Cob as Low Cost Adsorbent for the Removal of Nickel (II) From Aqueous Solution

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ABSTRACT

The present study focuses on the use of Corn cob as an effective and efficient adsorbent for the removal of Ni (II) from aqueous solution. The influence of Physico-chemical parameters such as Adsorbent Dosage, Contact time, pH and Initial concentration has been examined in Batch studies. The initial and residual concentration of Ni (II) was analyzed using UV- Double Beam absorption spectrophotometer at 394 nm by which the percentage removal can be calculated. The equilibrium data onto the adsorption of Ni (II) was measured using Langmuir and Freundlich Isotherm model. The results revealed that Corn cob, a waste material have good potential as an adsorbent for the removal of toxic heavy metal like Ni (II) from Industrial waste waters.

KEYWORDS: Adsorption, Corn cob, Ni (II) Removal and Adsorption Isotherm.

INTRODUCTION

In recent years, Heavy metals are released into the environment due to rapid Industrialization and Urbanization causing a great problem worldwide [1]. The pollutant occurs to waste water is toxic and that contaminates the ground water and aquatic ecosystem [2]. One of the important toxic heavy metal Ni (II) finds its own way of the water bodies of Ni (II) mining and by industries [3, 4]. Due to the uptake of high concentration of Ni (II) from the groundwater that not only affects the aquatic life but also the Human beings causing Lung Cancer, Nose Cancer, Respiratory Failure, Allergic Reactions and so on [5, 6]. So it is necessary to remove the Ni (II) from the Industrial waste before being discharged into water streams. There are number of processes has been employed for the treatment of waste water such as Reverse Osmosis, Chemical Reduction, Ion- Exchange, Electro dialysis and Activated Carbon adsorption Hazardous and Environmentally unsuitable chemicals [7, 8]. The adsorption using Agro-based plant waste consists of lignocellulosic materials

that are found to be cost effective, eco-friendly and easy alternative in removing the heavy metals [9, 10, 11]. The present study is aimed for the adsorption on Agro industrial waste Corn cob as a function of Adsorbent Dosage, Contact time, pH and Initial concentration then the equilibrium data for adsorption studies is explained by Langmuir and Freundlich Isotherm model.

MATERIALS AND METHODS

Corn cob as an Adsorbent for Adsorption studies

Corn cob was collected from the local market of Tiruppur District, India and was washed with Distilled water. The collected sample was the oven dried at 80°C for 8 hours, then pulverized and sieved using various size sieves. Finally 250 micron size particles were used for further experiments.

Preparation and Analysis of Metal Ion solution

All the Chemicals were purchased from Hi-Media and used without modification. Distilled water is obtained from Milli–Q water system (Millipore Corporation) and filtered to remove any impurities. The stock solution to Ni (II) was prepared by dissolving 4.48 g for Anhydrous Nickel Sulphate in one liter of distilled water and the final concentration of Ni (II) solution was obtained as 1000 ppm from which the stock solution was diluted with distilled water to obtain the different concentration of Metal solutions. Using UV- Double Beam Adsorption Spectrophotometer (LAB INDIA- UV 3092) the initial and residual concentration of Ni (II) was analyzed at 394 nm.

Biosorption Studies

Biosorption studies were performed in rotary shaker at 200 rpm using 250 ml Erlenmeyer flasks containing the known quantity of Corn cob (Adsorbent) with 100 ml of Ni (II) solution. The various parameters for the adsorption of Ni (II) such as Adsorbent Dosage, Contact time, pH and Initial concentration has been examined in Batch studies and the kinetic studies using Langmuir and Freundlich Isotherm were also evaluated. The filtrate was removed from the adsorbent solution and filtered using Whatmann No.1 filter paper and the percentage removal of Ni (II) was determined by UV Spectrophotometer. The amount of Ni (II) adsorbed by the adsorbent and the percentage removal of Ni (II) was calculated using the following Equations:

$$Q = (C_0 - C_e)$$

Removal Percentage of Ni (II) = $C_0 - C_e / C_0 \times 100$

Where,

Q - Adsorption capacity of Corn cob

C_o-Initial concentration of Nickel

C_e-Residual concentration of Nickel

RESULTS AND DISCUSSION

Effect of Adsorbent Dosage on Biosorption of Ni (II)

The effect of Adsorbent dosage on Biosorption experiment was studied by varying the amount of adsorbent Corn cob from 1 to 7 g at pH 6 in a 250 ml conical flask and kept in orbital shaker for 120 min. The absorbance of the filtered solution was measured using UV Spectrophotometer at 394 nm and the graph was plotted between the Adsorbent Dosage VS Percentage removal of Ni (II) from the solution as shown in Figure 1. The percentage removal was obtained at 70.08 % to 6 g of Corn cob and further increase in the Biosorption dosage does not cause any change is due to the availability of more binding sites in the surface of Biosorbent at adsorption sites [6, 12, 13].

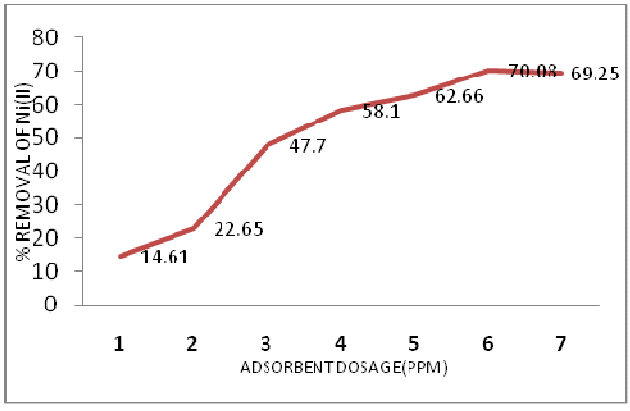

Figure 1 Effect of Adsorbent Dosage VS Percentage removal of Ni (II)

Effect of pH on Biosorption of Ni (II)

The effect of pH on the adsorption of Ni (II) in aqueous solution was carried out over the pH range of 1 to 9 by keeping all the parameters constant with an optimum Corn cob of 6g at pH 6 and 90min contact time. The graph was plotted between different concentrations of pH VS Percentage removal of Nickel as shown in Figure 2, which shows the maximum removal efficiency of Ni (II) at pH 6 as 71.01%. The percentage removal increases up to pH 6 after the removal ratio was decreased due to H^+ and OH^- ions present in the solution [14, 15, 16].

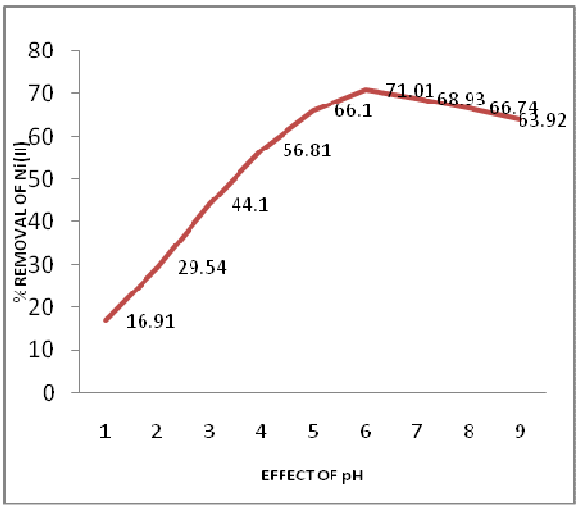

Figure 2 Effect of pH VS Percentage removal of Ni (II)

Effect of Agitation Time on Biosorption of Ni (II)

Biosorption studies on the effect of Agitation time was performed for the removal of Ni (II) with an optimum adsorbent of 6g at pH 6 by varying the contact time from 15 to 90 minutes. The percentage removal of Ni (II) was 70.9 % at 90 min was observed and the graph was plotted between Contact time VS Percentage removal of Ni (II) as shown in Figure 3. The rate on the removal of Ni (II) was higher at the initial stage is mainly due to the larger accessibility of active sites in the adsorbent and after 90 min it reaches to equilibrium due to the lesser availability of active sites [17, 18].

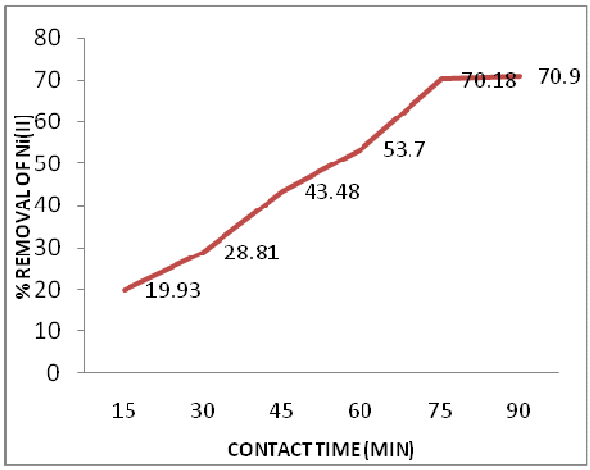

Figure 3 Effect of Contact time VS Percentage removal of Ni (II)

Effect of Initial Concentration on Biosorption of Ni (II)

The effect of Initial Concentration for the removal of Ni (II) were carried out by varying the Concentration from 25 ppm to 150 ppm per 100 ml solution with an adsorbent of 6g at pH 6 with a contact time of 90 min and the graph was plotted between the Initial Concentration VS Percentage removal as shown in Figure 4 from that the removal efficiency of Ni (II) was observed as 86.08 % for 25 ppm and 67% for 150 ppm. The percentage removal was higher with lower initial concentration, then the highest concentration was due to the availability of more binding sites at the initial stage of the Adsorbent [19, 20].

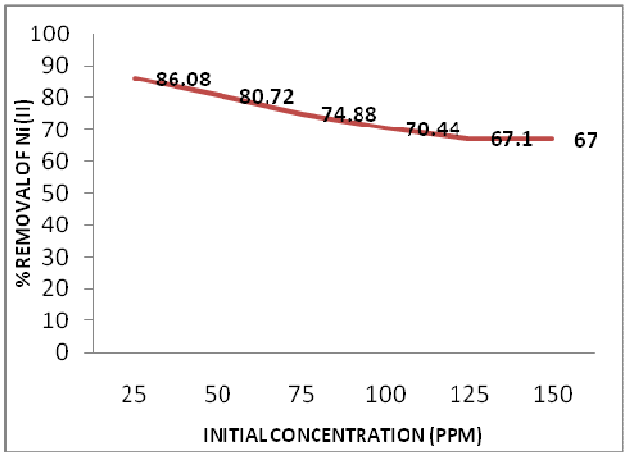

Figure 4: Effect of Initial Concentration on Biosorption of Ni (II)

Biosorption Isotherm

Adsorption Isotherms are the mathematical models used to identify the metal uptake per unit weight of the adsorbent to have an equilibrium concentration of the adsorbate [21].The results of the present study in the adsorption of Ni (II) on to Corn cob were analyzed using the known models such as Langmuir and Freundlich that are connected with the amount of adsorbate on the adsorbent.

Langmuir Isotherm

Langmuir model is the theoretical model describes the adsorption of Adsorbate (A) onto the surface of the Adsorbent (S) for the removal of Ni (II) in the aqueous solution [22]. The Langmuir isotherm equation is derived from rational consideration and is given by,

$$\mathbf{1/(X/m) = 1/q_m + 1/K_A . q_m (1/C_e)}$$

Where,

X/m - Amount adsorbed per unit weight of adsorbent Corn cob (mg/g)

K_A, q_m - Constants

K_A - Rate of adsorption

q_m - Adsorptive capacity of Corn cob,

C_e - Equilibrium concentration of the adsorbate in solution after adsorption (mg/l).

A graph was plotted between **1/Ce VS 1/(X/m)** as shown in Figure 5 and the value of K_A= 0.2942 and q_m= 0.0026 was calculated. The Langmuir isotherm can be expressed in terms of a dimensionless value R_L, is defined as

$$\mathbf{R_L = 1/ (1+ K_A . C_o)}$$

Where,

R_L - Indicates the Isotherm

C_o - Initial concentration (mg/l).

There are four probabilities for the values of R_L as shown in Table 1. The values of R_L is 0.007 for the studied system at different dosage were found to be in between 0 to 1 which indicate favorable adsorption of Ni (II) onto the adsorbent Corn cob [13, 23, 24].

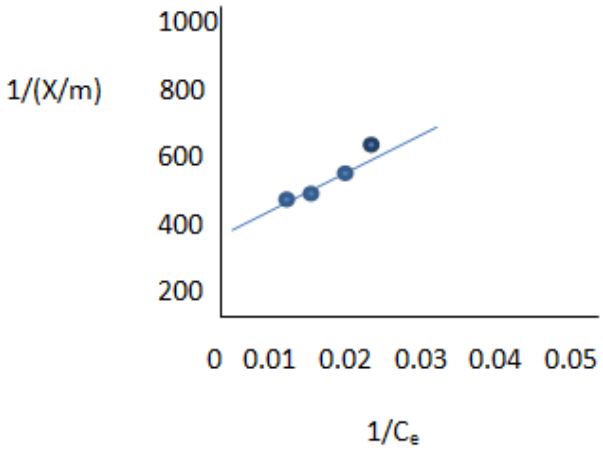

Figure 5 Langmuir Isotherm

R_L	Type of Isotherm
$R_L > 1$	Unfavorable
$R_L = 1$	Linear
$0 < R_L < 1$	Favorable
$R_L = 0$	Irreversible

Table 1: Comparison Ranges of R_L Values

Freundlich Isotherm

For heterogeneous surfaces the Freundlich isotherm model can be applied and the linearized Freundlich model isotherm can be applied for the adsorption of Ni (II) [25] and expressed as

$$\mathbf{Log\ (X/m) = Log\ K_F + 1/n\ (Log\ C_e)}$$

Where,

x/m - Amount of Nickel adsorbed at equilibrium (mg/g)

C_e - Equilibrium concentration of Nickel in solution (mg/l).

K_F – Adsorption Capacity

n – Adsorption Intensity.

The graph was plotted between the logarithmic plot of **C_e VS X/m** to evaluate the constants from which the value of the intercept Log K_F= 0.0289 was calculated as shown in Figure 6. The slope of the line will give the value of 1/n= 0.78. The result indicated that the adsorbent has several different types of adsorption sites and the calculated n value

1.28 indicates good adsorption of Ni (II) on Corn cob [26, 27, 28].

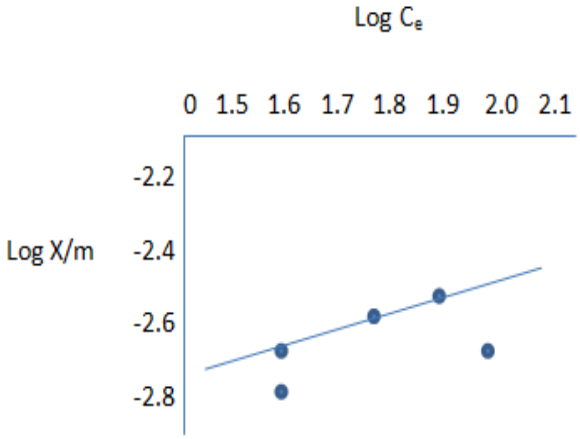

Figure 6 Freundlich Isotherm

CONCLUSION

The present study shows that Corn cob was an effectual Biosorbent for the adsorption of Ni (II) ions from the aqueous solution. The effect of Adsorbent Dosage, Contact time, pH and Initial concentration were studied. From the studies, the consumption of Ni (II) ions by the biomass was increased with increasing metal ion concentration. The maximum removal percentage was 70.08 % to 6 g of adsorbent and further addition of adsorbent did not cause any change in the removal efficiency. The higher percentage removal of Ni (II) at pH 6 was 71.01 % that shows the removal efficiency is minimized due to H^+ and OH^- ions present in the solution. The equilibrium agitation time for the percentage removal was 70.9 % at an optimum time of 90 min that reveals Ni (II) removal increases with an increase in the agitation time. On varying the concentration of the Ni (II), the maximum and minimum removal percentage of Ni (II) on to the adsorbent was 86.08 % for 25 ppm and 67% for 150 ppm which shows up the percentage removal is maximum at lower concentration. Adsorption Isotherms were studied using Langmuir and Freundlich model for the adsorption studies. This type of non- Hazardous Agro-waste materials like Corn cob appears to be low cost, eco- friendly and easy alternative instead of using chemicals for the removal of Heavy metals to overcome environmental pollution.

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