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Adsorption of Nickel (II) Ions from Aqueous Solution by using Terminaliachebula seed carbon

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Rapid industrialization has resulted in accelerating the flux of heavy metals which are posing a serious threat to the environment. The present investigation was carried out to sudy the removal of Ni(II) from aqueous solution using sulphuric acid treated Terminaliachebula seed. The effect of contact time, adsorbent dosage, pH on the adsorption of Ni(II) ions using Terminaliachebula seed carbon (TCSC) was determined. A steady trend was observed for all variables. The optimum contact time for the maximum adsorption of the Ni(II) using TCSC was found to be 4 h. The removal of Ni (II) from aqueous solution using TCSC was found to be maximum at the adsorbent dosage of 200 mg, The optimum pH value for adsorption of Ni(II) was determined to be 5 and this pH was used in subsequent studies. The adsorption data fitted well into Freundlich adsorption isotherm. From the Freundlich Adsorption isotherm The adsorbent capacity K and the adsorption intensity 1/n values are found to be 1 and 0.5 respectively shows that the natural adsorbent Terminaliachebula seed carbon (TCSC) is efficient in removing Ni (II) from an aqueous solution.

INTRODUCTION

Environmental Pollution

Pollution of the environment is one of the most horrible ecological crisis. The three basic amenities for living organisms are air, land and waters. Today the environment has become foul, contaminated, undesirable and therefore harmful for the health of living organisms including man.

WATER POLLUTION

Today water resources have been the exploited natural system since man strode the earth. Deterioration of the aesthetic and life supporting qualities of water is caused due to rapid population growth, industrial proliferation, urbanizations, excess fertilization, increasing living standard and wide spheres of human activities, thus water pollution is defined as alteration in physical, chemical and biological characteristics of water. This may cause harmful effect on human beings.

MAJOR EFFECTS OF WATER POLLUTION

The food chain is damaged. When toxins are in the water, the toxic travel from the water, the animals drink to humans when the animal's meat is eaten.

Diseases can spread via polluted water infectious diseases such as typhoid and cholera can be contracted from drinking contaminate water. The human heart and kidneys can be adversely affected. Other health problems are poor blood circulation, vomiting and damage to the nervous system.

Marine food sources are contaminated or eliminated.

Pollutants in the water will affect the overall chemistry of the water, causing changes in acidity, temperature and conductivity. These factors have an effect on the marine life.

Acid rain contains surface particles, which can have fish or plant life in lakes and rivers.

Altered water temperature can kill the marine life and about the ecological balance in water boils, especially lakes and rivers.

Nickel:

Nickel is a metal, commonly used to make coins, magnets, jewellery, stainless steel, electronics, and components of industrial machines and its salt also used in several industrial applications such as electroplating, storage batteries, and automobiles and aircraft parts, etc. Most people are familiar with the attractive mirror-finish that can be achieved by nickel plating. However, despite the beautiful appearance, nickel exposure, especially in industrial and occupational settings, can present significant health hazards.

Sources of Nickel:

Although today it is not profitable to mine nickel in the USA, small amounts of by-product nickel are being recovered from copper and palladium-platinum ores in the western United States.

Approximately 87,000 tons of nickel is recovered annually by recycling stainless steel and other nickel-iron alloys. This represents about 39% of the nickel used each year.

It is estimated the there is about 140 million tons of nickel available in identified deposits. Eighty-four million tons or 60% of the total available nickel is in laterite deposits. A deposite in which rain and surface water leached Ni-rich rock and concentrated the nickel at or near the surface of the earth is the laterite deposit. Nickel sulphide deposits contain the remaining 40 % (56 million tons).

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Exposure to Nickel:

Nickel is one of many carcinogenic metals known to be an environmental and occupational pollutant. The New York University school of Medicine warns that chronic exposure has been connected with increased risk of lung cancer, cardiovascular diseases, neurological defects, developmental deficits in childhood, and high blood pressure.

Nickel exposure introduces free radicals which lead to oxidative damage and may also affect the kidneys and liver. In 2012, Egypt's ministry of agriculture administered liver function tests to 25 nickel-plating workers. Results showed they overwhelmingly suffered from compromised liver function.

2. MATERIALS AND METHODS

2.1 Preparation of sulphuric acid treated Terminalia chebula seed Carbon (TCSC)

In order to have sufficient amount of carbon for the systematic adsorption studies of nickel removal **Terminalia chebula seed powder (50 g)** were carbonized using 20ml of concentrated sulphuric acid in each instance. After mixing thoroughly, the samples were let to stand in an oven at 140^0C -160^0C for 24 hours to facilitate charring of the material. They were then washed with tap water. Finally they were washed with distilled water and dried in an air oven at 110^0C for 8 hours.

2.2 CHARACTERIZATION OF TERMIALIA CHEBULA SEED CARBON (TCSC)

The characteristics of Termialia chebula seed carbon such as moisture content, ash content apparent density, matter soluble in water, matter soluble in acid, pH, decolorizing power, iron content and ion exchange capacity were estimated by standard procedures.

2.3 BATCH MODE STUDIES

STANDARD CALIBRATION CURVE FOR Ni (II)

From the stock solution, 10 ppm of Nickel Sulphate solution was prepared. Various volumes of this solution were pipetted out into a series of 50ml standard flasks. To each flask added 20ml of HCl,10ml of sodium citrate,2ml of iodine solution and 4ml Dimethyl glyoxime and the solution were made up to the mark. The flasks were kept for 20 minutes. Required amount of solution were taken in the cuvette. Using spectronic-200 spectrophotometer absorbance for each solution were noted.

A graph was drawn between concentration of Nickel Sulphate solution taken along X-axis and absorbance along Y-axis. Thus a standard calibration curve for was obtained.

2.4 EFFECT OF EQULIBRIUM TIME

Effect of contact time of Nickel adsorption was studied by varying the contact time between the adsorbate and adsorbent in the range 1 to 10 h. Adsorption of nickel at different contact time was studied for initial nickel concentration 10 ppm, while the dose was 0.5 g/100 ml and the solution pH was kept unchanged in all bottles.3.2. The percentage of Nickel adsorbed was obtained from the standard calibration curve. A graph was drawn between equilibrium time along the x axis and percentage of Ni adsorbed along y axis.

2.5 EFFECT OF pH

Solution pH is an important variable which controls the adsorption of the heavy metal from wastewater. The effect of pH on the removal of nickel ions by TCSC was investigated. The adsorption of nickel was studied in the pH range 1–10 with a constant TCSC amount of 0.5 g/100 ml of nickel solution, shaking time of 5 h and nickel concentration of 10 ppm.

Different buffer solutions with 1,2,3,4,5,6,7,8,9 and 10 were prepared from 10 ppm of Nickel sulphate solution. About 0.5 g of TCSC transferred into 10 different stoppered bottles. To this added 100 ml of each of these pH solutions and the bottles were kept in an electric shaker for 5 hours.

A graph was plotted using percentage of nickel adsorbed against pH of the solution for both adsorbents. The maximum adsorption took place at particular pH that was considered as the selected pH for both the adsorbents at which maximum adsorption takes place.

2.6 EFFECT OF CARBON DOSAGE

100 ml of 10ppm nickelsulphate solutionwhich was adjusted to the pH 8 was taken in ten stoppered bottles. Various carbon dosage such as 0.5g, 1.0g. 1.5g, 2.0g, 2.5 g, 3.0g, 3.5g, 4.0g, 4.5g, 5.0g of TCSC were separately weighed and transferred into 10 different stoppered bottles. The bottles were kept in an electric shaker for 5 hours to attain equilibrium. Then absorbance of each solution were noted using spectronic-200 spectrophotometer for the corresponding weight of carbon dosage. The amount of adsorbent for which maximum adsorption took place was found out from the graph. A graph was plotted using percentage of nickel adsorbed against carbon dosage of the solution for the both adsorbents.

2.6 FREUNDLICH ADSOPRTION ISOTHERM

A series of 5ppm, 10ppm, 15ppm, 20ppm, 25ppm, 30ppm, 35ppm, 40ppm, 45ppm, 50ppm, nickel solution were prepared in 100ml standard flask. 200mg of TCSC was weighed and transferred into 10 separate stoppered bottles. To this added

100ml of the above series of solution. These bottles were kept in the shaker for 5 hours. After 5 hours all the bottles taken out, allowed to stand for few minutes, filtered and first few ml of the filtered were discarded from each bottle. Then 14 ml of the filtrate was pipetted out into a 50 ml standard flasks. To this solution 20ml of 0.5 N HCl, 10 ml of sodium citrate, 2 ml iodine solution and 4ml of dimethyl glyoxime were added and kept for 20 minutes. Similar procedure was repeated for other concentration of solutions. The instrument spectronic-200 spectrophotometer was standardized using blank solution. Then the absorbance of experimental solution were noted.

2.7 DESORPTION OF NICKEL

200 mg of TCSC mixed with 100ml of 10 ppm nickel solutions in each of the 10 stoppered bottles and kept in the electric shaker for 7 hours. The bottles were taken out allowed to stand for few minutes. The residue were washed thrice with distilled water and mixed with a series of 100ml of 0.01 N, 0.02 N, 0.03 N,0.04 N ,0.05 N, 0.06 N, 0.07 N, 0.08 N, 0.09 N and 0.1 N HCl solutions in separate stoppered bottles and kept in the shaker for 4 hours. Then all the bottles were taken out, allowed to stand for few minutes, filtered and first few ml of the filtrate were discarded from each bottle. Then 20 ml of 0.5 N HCl, 10 ml of sodium citrate solution, 2 ml of iodine solution, and 4 ml of Dimethyl glyoxime were added and kept for few minutes. Then absorbance of each solution were measured using spectronic - 200 spectrophotometer.

3. RESULTS AND DISCUSSION

3.1 DETERMINATION OF TERMINALIA CHEBULA SEED CARBON CHARACTERISTICS

The various characteristics of Terminalia Chebula Seed carbon such as Moisture content , Ash content, Apparent density, Matter soluble in water, , Matter soluble in acid, pH, Decolorising power , Iron content, Ion exchange capacity were determined and the results were tabulated in Table 1

Table 1 Characterisation of Termialia Chebula Seed Carbon (TCSC)

S.No	**Characteristics**	**Terminalia chebula seed carbon (TCSC) %**
1.	Moisture content	**17.22**
2.	Ash content	**6.13**
3.	Apparent density	**0.69 g/cc**
4.	Matter soluble in water	**2.64**
5.	Matter soluble in acid	**12.5**
6.	pH	**2.64**
7.	Decolorizing power	**135**
8.	Iron content	**15.80**
9.	Ion exchange capacity	**0.02**

3.2 Determination of Equilibrium Time

TABLE -2 Effect of Equlibration Time

Time in hours	**Absor bance**	**Final concentration**	**Percentage of Ni(II) adsorbed**
1	0.314	2.6	74
2	0.270	2.3	77
3	0.309	2.6	75
4	0.275	2.3	77
5	0.269	2.2	78
6	0.263	2.2	78
7	0.233	1.9	78
8	0.232	2.0	78
9	0.227	1.9	79
10	0.224	1.8	79

Table 1 show the equilibration time and the percentage of Ni adsorbed for 10 ppm of $NiSO_4.6H_2O$ solution. The removal increases with time and attains equilibrium at fourth hour for TCSC

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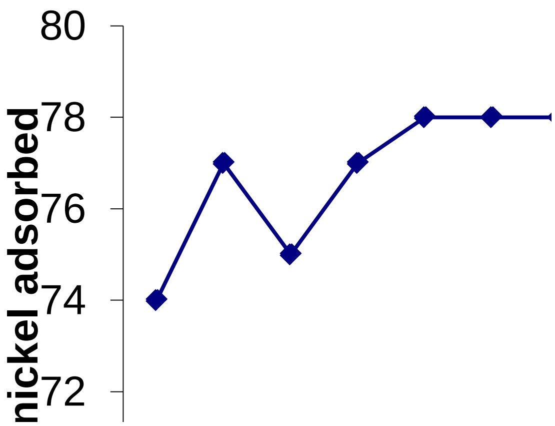
Figure 1 Effect of Equilibrium Time



3.3 EFFECT OF pH

Table – 3 Determination of optimum pH

pH	Absorbance	Final concentration	Percentage of Ni(II) adsorbed
1	0.273	2.3	77
2	0.346	2.9	71
3	0.279	2.3	77
4	0.329	2.7	73
5	0.309	2.6	77
6	0.338	2.8	72
7	0.299	2.5	75
8	0.280	2.4	76
9	0.288	2.4	76
10	0.290	2.2	78

Table 3 shows the effect of pH on the removal of Ni (II) by TCSC

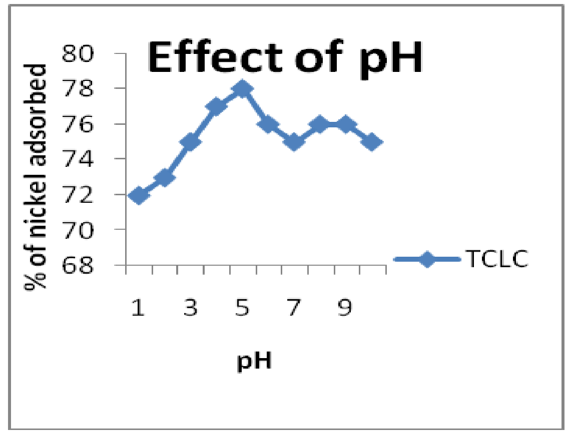


Figure 2 Effect of pH

3.4 EFFECT OF CARBON DOSAGE

Table – 4 Determination of optimum carbon dosage

Carbon dosage g	Absorbance	Final concentration	Percentage of Ni(II) adsorbed
0.5	0.148	1.6	78
1.0	0.168	1.7	72
1.5	0.274	2.7	73
2.0	0.284	2.6	74
2.5	0.280	2.6	74
3.0	0.321	2.9	71
3.5	0.255	2.4	76
4.0	0.239	2.3	74
4.5	0.286	2.6	74
5.0	0.288	2.6	74

Table 4 shows the effect of carbon dosage on the removal of Ni (II) by TCSC

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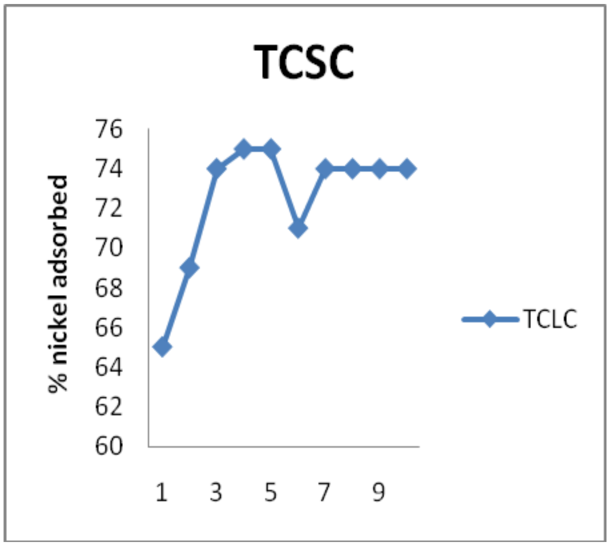
3.4 EFFECT OF CARBON DOSAGE

Figure 3 Effect of Carbon dosage



3.5 FREUNDLICH ADSORPTION ISOTHERM FOR TCSC

Table 5 shows that the freundlich equation is used to check the effect of adsorption. This equation is basically empirical but is often useful as a means for data description. Freundlich adsorption isotherm which is of the form

Log_{10} (x/m) = log_{10}K+1/n $log_{10}C_{eq}$

K = Equilibrium constant

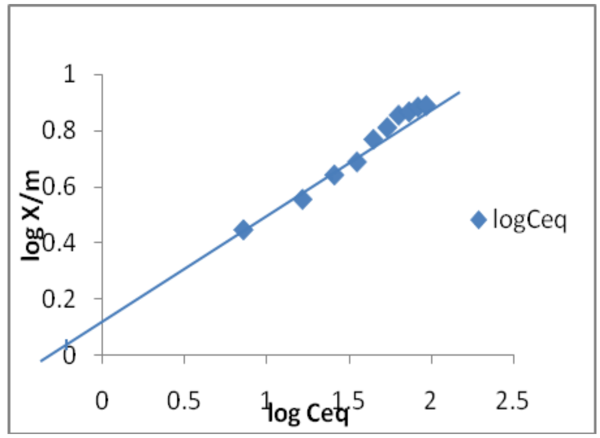
C_{eq}= Equilibrium concentration (mg/L)

x/m = Amount adsorbed per unit mass of TCSC

Table – 5 FREUNDLICH ADSORPTION ISOTHERM FOR TCSC

Concentration of solution in ppm	Absorbance	Final concentration	TCSC		
			x/m	log x/m	log C_{eq}
10	0.234	2.1	7.9	0.8976	0.3424
20	0.527	2.5	17.5	1.2479	0.3979
30	0.889	2.7	27.3	1.4361	0.4471
40	1.20	2.9	37.1	1.5693	0.4913
50	1.41	3.6	46.4	1.6665	0.5563
60	1.68	3.9	56.8	1.7489	0.6020
70	1.80	4.2	65.5	1.8182	0.6435
80	1.86	4.6	75.4	1.8773	0.6627
90	2.50	5.8	84.2	1.9253	0.7634
100	1.95	7.4	92.6	1.9666	0.8692

FIGURE-5



3.6 DESORPTION OF Ni (II)

Desorption helps to elucidate the nature of adsorption and help to remove the metals from water and the adsorbent. Attempts were made to regenerate Ni(II) from the spent carbons using HCl of various strengths ranging from 0.01N to 0.1N.

TABLE 3.6

Concentration of HCl (N)	Absorbance	Final Concentration	Percentage of Ni(II) regenerated
0.01	0.741	5.9	41
0.02	0.563	5.0	50
0.03	**0.552**	**4.5**	**55**
0.04	**0.492**	**4.1**	**59**
0.05	**0.332**	**3.2**	**68**
0.06	**0.317**	**2.7**	**73**
0.07	**0.249**	**2.2**	**78**
0.08	**0.226**	**2.0**	**80**
0.09	**0.187**	**1.7**	**83**
0.10	**0.114**	**1.3**	**87**

It has been found that a concentration of 0.1N of HCl is required to re cover 87% TCSC

CONCLUSION:

In this work, the following significant conclusions could be drawn be from the investigation on the removal Ni (ll) using Terminaliachebula seed carbon.

By batch mode studies, the removal is found to increase with time and attains equilibrium at 5^{th} hour for TCSC. The percentage of removal has reached a maximum at pH for 8 The removal of Ni (II) is taken as a function of carbon dosage. For the quantitative removal of Ni (II) from 100 ml of solution containing 10mg/L a minimum carbon dosage of 200mg of TCSC From Freundlich adsorption isotherm study, .

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