REMOVAL OF CADMIUM (II) & NICKEL (II) USING ACTIVATED CARBON FROM PALMTREE WOOD POWDER

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Abstract— Water is nature's wonderful, abundant and useful compound. It is also used for industrial purposes. 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. It becomes essential to remove heavy metals from water and wastewater. The present study is aimed at preparing carbon from palm tree wood powder by pyrolysis and thermal activation procedure and will be tested for the removal of cadmium (II) and Nickel (II) from aqueous system. Carbon characteristics of PTPC will be found out to understand the potential of the carbon using ISI procedure 877-1976. Isotherm studies will be conducted to understand the capacity of carbon. Batch studies will be performed to understand the optimum time, optimum P^H and optimum dosage required for preliminary examination. Isotherm studies showed that this carbon derivative (PTPC) followed Freundlich adsorption both in distilled and tap water. The removal of Ni (II) was found to be 2.6 times more in distilled water than tap water and the removal of Cd (II) was found to be more in distilled water than tap water. This shows that common cations in tap water is able to interfere with the adsorption of Cd(II) & Ni(II).Thus it can be concluded that PTPC can effectively be used for the removal of Cd(II) & Ni(II) from aqueous system

Index Terms—. Freundlich adsorption , pyrolysis , thermal activation, optimum time, optimum P^H and optimum dosage, Heav y metal removal.

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Chapter 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.

Trace metals in water act as cumulative poison and accumulate in bodies of living organisms thereby causing chronic diseases. Metallic contamination destroys bacteria and self – purification of rivers. Heavy metals have a good affinity to attack sulfur bonds, proteins thereby disrupting cell metabolism. It also gives chromosome damage and interfere with the process of heredity in man. Majority of the toxic metals are usually found in water from battery viscous rayon, electroplating, pickling, galvanizing, rubber process industries are contributing considerable amount of heavy metal toxicity to the aqueous system.

Therefore it becomes essential to remove heavy metals from water and wastewater. This project work aims at preparing a suitable material for the removal of heavy metals.

1.2 Aim and Scope of the work

The present study is aimed at preparing carbon from palm tree wood powder by pyrolysis and thermal activation procedure and will be tested for the removal of cadmium (II) & Ni (II) from aqueous system.

1. The palm tree wood powder will be washed thoroughly with water and dried.

2. The wood powder will be subjected to pyrolysis procedure at 400 – 500^0 C in the electrical furnace and then it will be activated under the temperature of 800 – 850^0C in the same furnace.
3. The activated palm tree powder carbon will be grow well and the particle size 200-250 mesh will be considered for adsorption activities for the removal of Cadmium from water.
4. Batch studies will be performed to understand the optimum time, optimum P^H and optimum dosage required for preliminary examination.
5. Carbon characteristics & PTPC 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 cadmium wastewater will be checked out for the removal of cadmium & Nickel in batch reactor.

CHAPTER 2

MATERIALS AND METHODS

2.1 MATERIALS FOR Cd (II) REMOVAL

1. Apparatus
   - Systronics spectrophotometer with 0.1cm quartz cells for colour measurement.
   - P^H meter (systronics) with combined glass electrodes for the P^H measurement.
   - Horizontal mechanical shaker for equilibrium studies
2. Reagents for Cd (II) determination

Unless, otherwise specified, all reagents used were of analytical grade and distilled water was used for dilution purposes.

Cd(II) solution (500 mg/l) : It is prepared by dissolving 0.2854g of cadmium sulphate ($3CdSo4.8H_2O$) in water and diluted to 250 ml. Appropriate volume of stock solution were suitably diluted with water to obtain a concentrating 20 mg/l for batch experiments.

1. Cd (II) Determination: For the preparation of standard graph, the stock solution was diluted with distilled water to obtain a concentration of 50 mg/l.
2. Potassium Iodide solution (10%): 10g of potassium Iodide were dissolved in 50 ml water. A few crystals of sodium thio sulphate were added and diluted to 100ml.
3. Pyronine G solution (0.024 %): 0.06g of pyronine G dye was dissolved in water and diluted to 250ml.
4. Gelatin (1 %): 1g of gelatin was dissolved in boiling water, cooled and diluted to 100ml.
5. Citrate Buffer (P^H 4.0): 29.4g of sodium citrate and 19.2g of citric acid were dissolved in 200ml of water. The $P^{H\ of}$ the solution was adjusted to 4.0 using P^H meter and then diluted to 250ml.
6. Determination of Cadmium: A suitable aliquot of (up to 15 ml) containing not more than 15kg of cadmium was transferred to 25ml standard flask. 2.5 ml each of citrate buffer, KI and pyronine G solution were added with mixing followed by 1ml of gelatin. The solution was diluted to mark with distilled water and mixed well. The intensity of color was measured at 575nm with reference to a reagent blank. A graph for 1.40 mg of Cd (II) was prepared by following the procedure. The unknown concentration of the sample liquid was finding out by referring to the calibration graph.

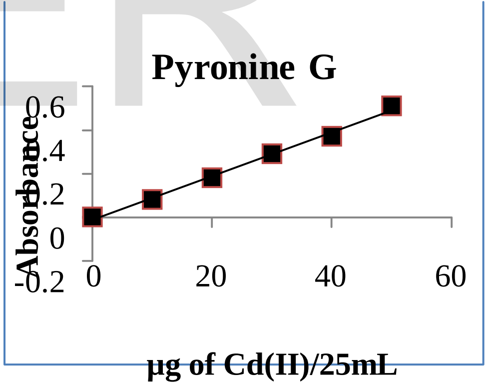

Fig 2.1 pyronine G graph

METHOD OF BATCH EXPERIMENTS

Batch experiments were conducted in polythene bottles of 300ml capacity proved with screw caps. The polythene bottles were washed well with chromic acid before and after use.

100ml of the solution containing 10mg/L of ions under investigation were taken in the bottle. After the addition of carbon, the bottles were equilibrated for specific periods of time in a rotary mechanical shaker. At the end of the equilibration period, the solutions were filtered; using G-3 crucibles if necessary and the concentration of respective ions were established by spectrophotometer.

2.2 MATERIALS FOR Ni (II) REMOVAL

1. APPARATUS
   a. Systronics digital spectrophotometer with 1cm quartz cells for color measurements.
   b. Elico digital pH meter with combined glass electrodes for pH measurements.
   c. Rotary mechanical shaker for equilibrium studies.
2. REAGENTS

   Unless otherwise specified, all reagents used were of analytical grade and distilled water was used for dilution purposes.
3. REAGENTS FOR BATCH STUDIES

   Stock solution of Nickel Ion was prepared as follows:

   Nickel Solution (1000mg/L) : 3.55gm of $NiSO_4.3H_2O$ was dissolved in water and diluted to 1000ml.

   Appropriate volume of stock solution was suitably diluted with water to obtain a concentration of 20mg/L for batch experiments. For column studies, 200mg/l of Nickel were prepared, diluting suitable volumes of respective stock solution.

REAGENTS FOR NICKEL DETERMINATION

1. STOCK SOLUTION

   Dissolve 447.9mg of Nickel sulphate ($NiSO_4.6H_2O$) in distilled water and make upto 1000ml in a volumetric flask (100mg/l).
2. STANDARD SOLUTION

   Pippete out 10ml of stock solution into a 100ml flask and make upto the volume.
3. HCL (0.5N)

   Dilute 43ml of concentrated HCL to 1000 ml with distilled water.
4. SODIUM CITRATE SOLUTION

   Dissolve 125gm of sodium citrate dehydrate in 500ml distilled water.
5. IODINE SOLUTION

   Dissolve 20gm of potassium iodide in 50ml water. Dissolve 6.4gm of iodine inthis iodide solution and dilute to 1000ml (0.05N).
6. DIMETHYL GLYOXIME SOLUTION

   Dissolve 1gm of DMG in 100ml concentrated ammonia solution, Add 10ml distilled water, and filter if necessary.

METHODS OF EXPERIMENTS

Batch experiments were conducted in polythene bottles of 300ml capacity provided with screw caps. The polythene bottles were washed well with chromic acid before and after use.

100ml of the solution containing 20mg/l of ions under investigation were taken in the bottles. After the addition of carbon (PTPC), the bottles were equilibrated for specific periods of time in a rotary mechanical shaker. At the end of equilibration period the solutions were filtered using G-3 crucible if necessary and the concentration were established by spectrophotometric.

DETERMINATION OF Ni (II) IONS

Place appropriate volumes of Nickel working solution covering the range upto 100mg into a series of 50ml volumetric flask (or 50ml nessler tubes) include a 50ml volumetric flask containing none as the blank. Place a suitable aliquot of the sample containing not more than 100mg in 50ml nesslers tube. If the samples contain organic matter it must first be destroyed by acid digestion. Then, aliquot of the digested sample has to be neutralized and taken in the volumetric flask. If the sample contains small amounts of iron, manganese and copper, it may be determined directly. If it contains excessive amounts, a separate has to be adopted.

To the blank and standards and sample add 20ml of 0.5N Hcl. Then add the following reagents in order with mixing after each addition.

(i) 10ml sodium citrate solution
(ii) 2ml iodine solution
(iii) 4ml dimethyl glyoxime solution (DMG)

Make up to 50ml with distilled water and allowed to stand for 20 minutes. Compare the color visually or photo metrically using a spectrophotometer at 470nm or filter photometer with a suitable blue filter taking water as the reference. Prepare a calibration curve and find out the mg Nickel equivalent to the observed optical density. The standard graph for Ni(II) estimation is given in Figure 2.2.

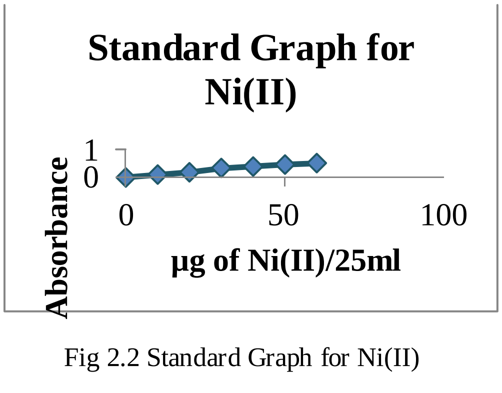

Fig 2.2 Standard Graph for Ni(II)

CHAPTER-3

EXPERIMENTS AND RESULTS

3.1 IMPORTANCE OF CARBON CHARACTERISTICS

The use of carbon in wastewater treatment applications is primarily due to the enormous capacity for removal of contaminants by adsorption process. Consequently high surface area is desirable. Hardness or Abrasion resistance is also important in the case of regenerable carbon, as it must undergo alternate cycles of exhaustion and reactivation with minimum material loss.

Moisture content though does not affect adsorptive power, dilutes the carbon and therefore necessitates the use of additional weight of carbon to provide the required weight. Ash content generally gives idea about inorganic constituent associated with carbon. In any case, the actual amount of individual inorganic constituent will vary from one grade to another as they are mainly derived from source materials or from activating agents during its preparation.

The apparent density may be regarded as a measure of the activity of the carbon. In the case of granular activated carbon, it also gives an idea about the space that would be occupied by the material in the column. When the carbon is contacted with water or wastewater or acidic wastewater, leaching impurities from the carbon should not be significant, so that the desired quality of the effluent is not altered. Consequently, tests pertaining to matter soluble in water and acid present in carbon assumes important.

The PH of the most commercial carbon is due to inorganic ingredients originating in the source materials and the actual value of PH will be determined by conditions under which the carbon is subjected to use. The capacity of carbons with respects to removal of color and organics are generallyrevealed by methylene blue and phenol number tests. The determination of iron is considered important only in those instances where release of iron is objectionable.

3.2 PREPARATION OF CARBON

The palm tree wood powder obtained from wood industries was washed with water and sun dried. This dried powder was taken in a crucible and heated in an electrical furnace maintain the oven temperature range 400-4500c. The wood powder was subjected to slow pyrolysis process so that a char is produced. This char was further activated at 800-8500c using the same electrical furnace, for a period of 15 minutes in a closed container. This thermally activated material was transferred to a beaker, cooled to room temperature and powdered well using electrical motor and sieved to size range 200 – 250 mesh (ASTM). This powdered carbon materials (PTPC) was subjected to carbon characteristics tests for cadmium (II) removal in batch studies. The characteristics of the carbon are given in Table 4.1.

Table 3.1
Characteristics of Palm Tree Powder Carbon

S.No	Control tests	Results
1	Bulk Density (gm/ml)	0.61
2	Moisture (%)	9.20
3	Ash (%)	3.73
4	Solubility in water (%)	3.61
5	Solubility in (0.25M) HCL (%)	11.81
6	PH	8.92
7	Decolorizing power	125
8	Phenol number	27
9	Ion exchange (meq)	NIL
10	Surface area (m2/g)	290
11	Iron (%)	1.25

3.3 BATCH STUDIES FOR THE REMOVAL OF Cd (II)

Batch experiments were done to establish various parameters for the removal of Cd (II) from aqueous solutions. Experiments were carried out using 100ml of solutions containing 20mg of Cd (II) adjusted to a P^H of 5.0 contained in 300ml polythene containers. After adding 0.1g of carbon the solutions were equilibrated in a rotary mechanical shaker for specific periods of time. The equilibrated solutions were filtered in using G3 crucible if necessary and the amount of Cd(II) present in the solutions were determined using pyronine G spectro-photometric method as described under the section materials and methods.

Batch experiments were done with palm tree wood powder carbon (PTPC) which has been activated under the temperature range 800- 850^0C, using 200 – 250 mesh size (ASTM). Initial studies were done with distilled water carbon potential.

3.3.1 EFFECT OF EQUILIBRATION TIME IN Cd (II) REMOVAL

In order to find out the optimum equilibration time for adsorption process a series of experiments were conducted with 20mg/l of Cd (II) solutions and 0.1g of PTPC was added in 300ml polythene containers. The solutions were withdrawn at periodic intervals of 30 minutes and the Cd (II) contents were determined using pyronine G method. The results are shown in figure 4.1. It is seen from the figure that a minimum of 5 hours of equilibration time is required for the maximum removal of Cd (II) for this carbon (PTPC). Therefore further experiments were carried out with 5 hours of equilibration time. The extend of removal was found to be 85% only when 0.1g of carbon was used at a P^H 5.0.

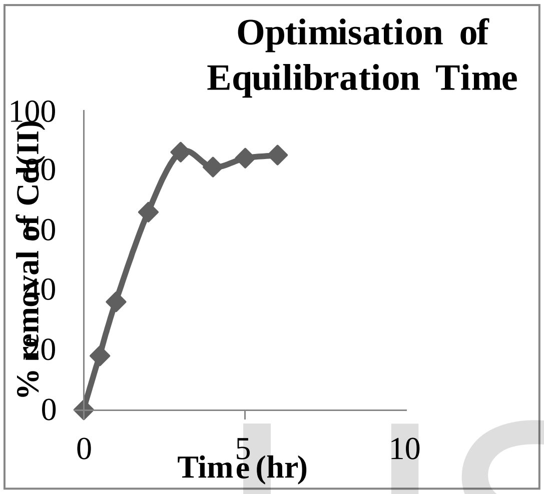

Fig 3.1 Effect of Equilibration time in Cd (II) removal

3.3.2 EFFECT OF P^H IN REMOVAL OF Cd (II)

In order to determine the effect of P^H on the adsorption of Cd(II) removal, experiments were carried out with 20mg/l of Cd(II) solutions initially was the P^H range 1.0 – 11.0 and using 0.1g of carbon. The solutions were equilibrated for 5 hours and analysed for Cd (II) content. The results are shown in figure 4.2 from which it is evident that the carbon was able to remove 83-85% of Cd (II) under the P^H range 4.0 – 7.0. At low P^H conditions, the removal of Cd (II) was, due to the positive nature of the surface as well as due to competition of H^+ ions for Cd(II) ions. However as the P^H rises, the quantity of H^+ ions are decreased and the removal of Cd (II) increases. However at high P^H conditions the removal process decreases, due to the formation of Cd $(OH)_2$ precipitates. However for further experiments, a P^H of 5.0 was maintained.

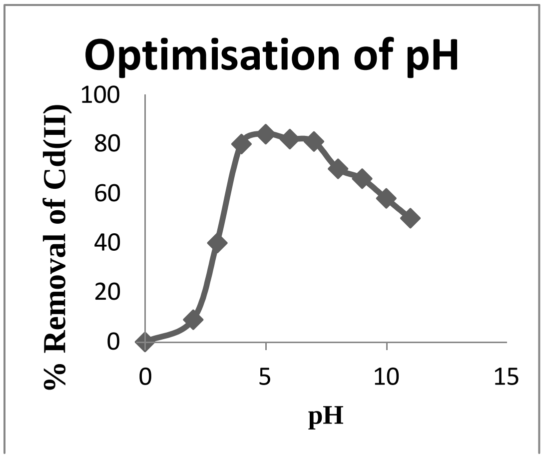

Fig 3.2 Effect of P^H in Cd (II) removal

3.3.3 EFFECT OF CARBON DOSAGE IN REMOVAL OF Cd (II)

In order to find out the minimum carbon dosage required for the maximum removal of Cd (II), experiments were conducted with 20mg/l of Cd (II) in 300ml bottles. Carbon dosage of 50 – 350mg/100ml were added and equilibrated for 5 hours. The results are given in figure 4.3. It could be seen from the figure, that a maximum carbon dosage of 200mg/100ml was required to achieve a maximum removal of 90.0 %. The optimum dosage was fixed around 200mg per 100ml of the solution.

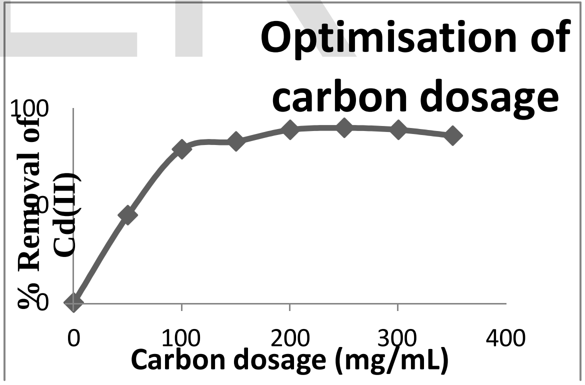

Fig 3.3 Carbon dosage in Cd (II) removal

3.3.4 FREUNDLICH ADSORPTION ISOTHERM

Freundlich adsorption isotherm is the most widely used mathematical form to explain the adsorption process in aqueous system. The equation is represented as

$$X/m = K^*C_e^{1/x}$$

Where, x = amount of Cd (II) adsorbed
m = weight of adsorbent

C_e = equilibrium concentration of the solute

K, 1/x = constants characteristics of the system

The above equation is an empirical expression that explains the heterogenecity of the surface and the exponential distribution of sector and energies. The above equation may be written in log form

$$\text{Log } (x/m) = \text{Log } K + 1/x \text{ Log } C_e$$

Plotting Log x/m Vs Log C_e a straight line is expected with a slope of 1/x and Log K is the intercept of Log x/m at Log $C_e = 0$. The value of 1/x obtained for adsorption of most organic compounds on activated carbon is 41. Steep slope of 1/x close to 1 indicates adsorption capacity at high equilibrium concentration that rapidly diminishes at lower equilibrium concentrations covered by isotherm. Relatively at flat slopes if 1/x <c<1 indicate that the adsorption capacity is only slightly reached at lower equilibrium concentrations. As the freundlich equation indicates the adsorption capacity factor on the carbon, x/m is a function of the equilibrium concentration of the solute. Therefore higher capacities are obtained at high equilibrium concentration.

The freundlich equation can be used for calculating the amount of activated carbon required to reduce any initial concentration (C_0) to a predetermined final concentration (C_e). By substituting (C_0 - C_e) for x in equation, where C_0 is the initial concentration

$$\text{Log } [(C_0 - C_e) / m] = \text{Log } K + 1/x \log C_e$$

Comparison of different activated carbon, for the removal of different compounds or removal by the same carbon, can be made using the above equation.

In order to establish the absorption capacity of carbon, employing isotherm studies, experiments have been done by taking Cd (II) concentration under the range 10 to 100mg/l. The solution was adjusted to pH 5.0 and (PTPC) was added so that 100mg of carbon /100ml was maintained. The solution were equilibrated for 24hours.At the end of the equilibration period, Cd (II) solutions were filtered if necessary and analysed for Cd (II) removal. The concentration of Cd (II) remaining in solutions was subtracted from the respective initial concentration. The values were divided by carbon dosage to get x/m values. The Log values of these data were plotted against Log values of Cd (II) remaining in the solution. A straight line curve can be noticed in the case of Cd (II) solution prepared with in distilled water and tap water. These results are shown in figure 4.4.

These corresponding Freundlich equations can be written as follows:

For distilled water: $x/m = 6.310\, C_e^{0.65}$

For Tap water: $x/m = 2.344\, C_e^{0.38}$

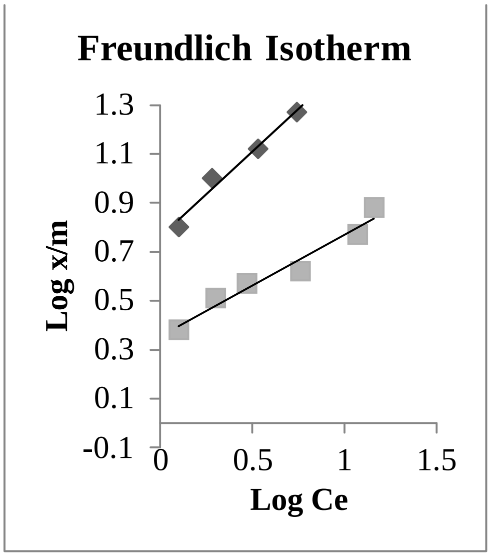

Fig 3.4 Freundlich Isotherm in Cd(II) removal

It could be seen that the adsorption capacity is much higher to the distilled water than tap water. This is mainly due to competition of cations and anions available with water for adsorption sites.

3.4 WASTEWATER CHARACTERIZATION STUDY

Preliminary studies have clearly establish that the palm tree powder carbon (PTPC) prepared from pyrolysis followed by activated at 800 – 850^0C has produced a carbon derivative, which is capable of running cadmium (II) from distilled water and tap water solution. In order to find out the efficiency of this material in the application of wastewater, experiments were done with synthetic Cd (II) wastewater solution.

In this connection a Cd (II) wastewater was prepared in line with electroplating waste of cadmium, for the experiment. The characteristic of the effluent is follows:

1. Cadmium (II) mg/L - 20.0
2. p^H value -7.0 – 8.0
3. Suspended solids - 20 mg/l
4. Cyanide (as CN mg/l - 0.2

The above wastewater was adjusted to a p^H condition of 5.0 using HCL. About 1L of wastewater was taken in a 2 litre beaker and sufficient quantities of palm tree powder carbon (PTPC) was added and stirred for sufficient time of 5 hours using magnetic stirrer equipment. About 3 – 4gms of PTPC was added and stirrer well for a period of 5 hours. After the characterization study, the wastewater was analysed for Cd (II) content, after filtering through a sand filter bed created on a funnel, under gravity condition the percentage removal of Cd (II) was found to be 96 – 97%.

3.5 BATCH STUDIES FOR THE REMOVAL OF NI(II) IONS

Batch experiments were performed to establish various parameters for the removal of Ni (II) from aqueous solution. The experiments were carried out using 100ml of solution containing 20mg/l of Ni (II). The p^H was adjusted to 4.5 and the solutions were taken in polythene bottles containing 300ml capacity. After adding 0.1gm of carbon (PTPC), the solutions were equilibrated in a rotary mechanical shaker. The equilibrated solution were filtered using G-3 crucible if necessary and the amount of Ni(II) present in the solution were determined using Dimethyl glyoxime method (DMG) as described in materials and methods.

Batch experiments were performed with PTPC using 250-300 mesh powder. Initial testing were done with distilled water solutions and finally synthetically prepared Ni(II) wastewater, to assess the potential of the carbon.

3.5.1 EFFECT OF EQUILIBRATION TIME IN NI(II) REMOVAL

In order to find out the Optimum equilibration time for adsorption process, a series of experiments were conducted with 20mg/l of Ni(II) solution and 0.1g of PTPC taken in 300ml bottles. The solutions were withdrawn at periodic intervals of 30 minutes and the Ni (II) content was determined, using DMG method. The results are shown in Fig3.1. It is seen from the figure, minimum of 4.5 hours of equilibration time is needed for the maximum removal of Ni (II) for PTPC (80%). However further experiments were done with 5hours of equilibration time. The extend of removal was found to be 80-82%.

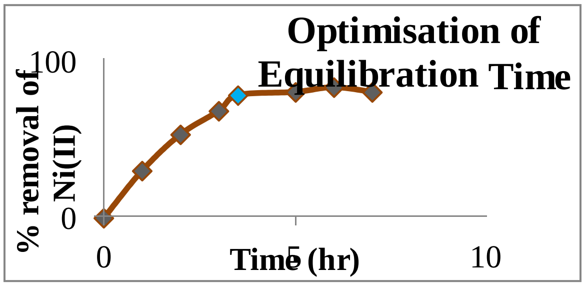

Fig 3.5 Effect of Equilibration time in Ni (II) removal

3.5.2 EFFECT OF P^H IN NI (II) REMOVAL

In order to determine the effect of p^H for Ni (II) removal, experiments were conducted with 20mg/l of Ni (II), initially taken the p^H range 1-12.0 and using 0.1g of PTPC carbon. The solution were equilibrated for 5hours and analysed for Ni (II) removal. The results are shown in figure3.2, from which it is evident that the Ni(II) removal was maximum over the p^H range 5.0 – 8.0. Hence further experiments were done at a $p^H$of 6.0. At lower p^H condition, the proton concentration is more and under the influence of acidic conditions Ni (II) removal was lower. It could be seen that as the p^H is lower, the proton to Ni (II) concentration decreases and over the p^H range 5.0 – 8.0 the maximum removal of Ni (II) occurred. However, at p^H condition greater than 8.0, Ni (II) is getting precipitated as Ni $(OH)_2$ by which, again a fall in the Ni (II) adsorption takes place. Hence the optimum p^H is fixed over the range of 5.0-8.0.

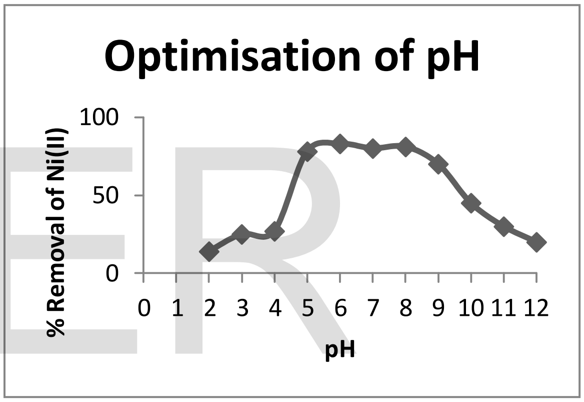

Fig 3.6 Effect of P^H in Ni (II) removal

3.5.3 EFFECT OF CARBON DOSAGE IN NI (II) REMOVAL

In order to find out the maximum carbon dosage required for the maximum removal of Ni(II) experiment were done with 20mg\L of Ni(II) with PTPC . The carbon dosages were varied over the range 100-700mg\100ml and the results are shown in figure 4.It could be seen from the figure 3.3, minimum carbon dosage of 600 mg\100ml is required to give a maximum removal of 86-89%. Therefore the optimum dosage is fixed a round 600mg\100ml for an initial concentration of 20mg\l.

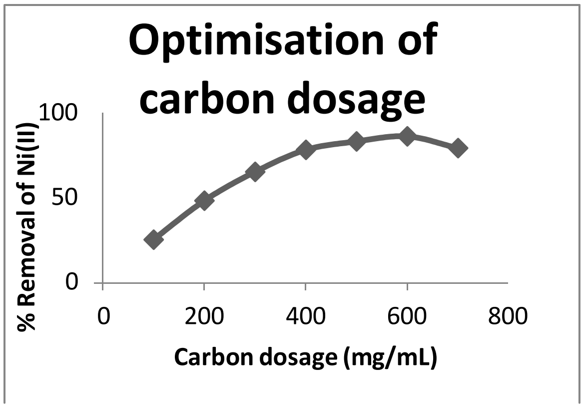

Fig 3.7 Carbon dosage in Ni (II) removal

3.5.4 FREUNDLICH ADSORPTION ISOTHERM

Freundlich adsorption isotherm is widely used mathematical form to explain the adsorption process in aqueous system. The equilibrium is represented as

$$x/m = K*C_e^{1/x}$$

Where, x = amount of solute adsorbed
m = weight of adsorbent
C_e= equilibrium concentration of the solute
K,1/x = constants characteristics of the system

The above equation is an empirical expression that explains the heterogenecity of the surface and the exponential distribution of sector and energies. The above equation may be written in log form

$$\text{Log}\ (x/m) = \text{Log}\ K + 1/x\ \text{Log}\ C_e$$

Plotting Log x/m Vs Log C_ea straight line is obtained with a slope of 1/x and Log K is the intercept of Log x/m at Log C_e = 0. The value of 1/x obtained for adsorption of most organic compounds on activated carbon is less than 1. Steep slope of 1/x close to 1 indicates adsorption capacity at high equilibrium concentration that rapidly diminishes at lower equilibrium concentrations covered by isotherm. Relatively at flat slopes if 1/x <1 indicate that the adsorption capacity is only slightly reduced at lower equilibrium concentrations. As the freundlich equation indicates the adsorption capacity of loading factor on the carbon, x/m is a function of the equilibrium concentration of the solute. Therefore higher capacities are obtained at high equilibrium concentration.

The freundlich equation can be used for calculating the amount of activated carbon required to reduce any initial concentration (C_0) to a predetermined final concentration (C_e). By substituting (C_0 - C_e) for x in equation, where C_0 is the initial concentration

$$\text{Log}\ [\ (C_0 - C_e) / m] = \text{Log}\ K + 1/x\ \log C_e$$

Comparison of different activated carbon, for the removal of different compounds or removal by the same carbon, can be made using the above equation.

In order to establish the adsorption capacity of carbon using isotherm equation experiments were done by taking Ni (II) concentration over the range 10-60mg/l. The solutions were adjusted to a p^H of 6.0 and the PTPC was adsorbed to an extent of 0.1g per 100ml for each solution.

The solutions were equilibrated for 24hours. At the end of equilibration period, Ni (II) solution were filtered if necessary, and analyzed for Ni (II) removal by DMG method. The concentrations of Ni (II) remaining in solution were substrate from the respective initial concentration. The substrate values were divided by carbon dosage to get x/m values. The log values of these data were plotted against the log values of concentration of Ni (II) remaining in solution. A straight line curve can be noticed in the case of Ni (II) solution prepared in distilled and tap water. The results are shown in figure 3.4.

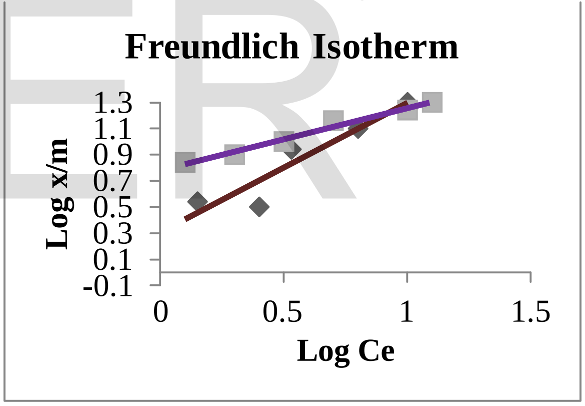

Fig 3.8 Freundlich Isotherm in Ni (II) removal

It could be seen from the figure, the removal capacity was found to be much higher in the case of distilled water than tap water. The decrease in the adsorption capacity of the tap water might be due to the competition of calcium and magnesium ions for the sites available in the carbon surface. The corresponding freundlich equations can be written as follows:

For distilled water $x/m = 0.60\ Ce^{0.42}$
Tap water $x/m = 0.23\ Ce^{0.94}$

It could be seen that in distilled water, Ni (II) removal was 2.6 times greater than tap water.

3.6 Experiments with wastewater

Preliminary studies have clearly established that the PTPC carbon prepared from palm tree powder with cleaning and followed by thermal activation at 800^0C is capable of removing Ni (II) from aqueous solution. In order to find out the efficiency of the carbon in the application of wastewater, experiments were done with synthetically prepared Ni (II) wastewater.

In the connection, a plating wastewater was synthetically prepared and used for the experiments. The characteristics of the final effluent are given below:

Table 3.2Characterization of wastewater

S.No	Particulars	Amount present
1	P^H value	3.0
2	Total suspended solids	125mg/l
3	Sulphates	300mg/l
4	Chlorides	425mg/l
5	Iron salts	22mg/l

The above wastewater was adjusted to p^H 5.5 – 6.5 using sodium hydroxide. About 1 litre of the wastewater was taken in a 2 litre beaker and sufficient quantity of PTPC carbon was added and stirred for sufficient time over the range of 5 – 6 hours using magnetic stirrer. About 6 – 7 grams of PTPC was added initially and stirred well. At the end of the equilibration time the effluent filtered through a sand filter bed created on a funnel. Under gravity condition, the filtered effluent was analysed for Ni(II) content. The removal of Ni(II) was found to be 95.0%.

CHAPTER – 4
CONCLUSION

In the present project study, a waste organic source material such as palm tree wood powder was used and subjected to carbon preparation. By doing pyrolysis follow by thermal activation, a carbon derivative was prepared. This carbon derivative (PTPC) was used to examine the removal of Cd (II) & Ni (II) from distilled water and wastewater. The following conclusions are states as follows:

1. The yield of the carbon was found to be 63%. This when 100g of palm tree powder was used, the resulting weight of the carbon was found to be 63g.
2. The PTPC carbon has a good bulk density and sufficient surface area.
3. The carbon was able to remove Cd (II) & Ni (II) by adsorption mechanism.
4. Preliminary studies indicated that the PTPC carbon required about 5 hour's equilibration time to achieve about 80% to 85% removal of Cd (II) and Ni (II).
5. The optimum P^H for the removal was found to be over the range 4.0 – 8.0.
6. The optimum carbon dosage was found to be 200mg/100ml of solutions under optimum p^H condition for Cd (II) removal.
7. The Optimum Carbon dosage was found to be 500mg/100ml for an initial concentration of 20mg/l of Ni (II).
8. Experiments were conducted to know the potential of this PTPC using synthetically prepared electroplating wastewater in which the concentration of Cd(II) was kept around 20mg/l. Proportionate quantities of carbon were added using isotherm studies (4 g/l) to the wastewater. After adjusting the p^H of this water over the range 4.5 – 5.5, the adsorption studies indicated a removal of 96 – 97%.
9. Experiments with synthetic wastewater indicate that 6.7g/L of PTPC required to remove about 85% of Ni (II), over a period of 5 – 6 hours. The remaining liquid requires final polishing stage of filtration through sand filters to achieve aboutb94% removal.
10. The Cd (II) & Ni (II) follows freundlich adsorption isotherm. The removal of Cd (II) & Ni (II) in distilled water was found to be greater than tap water. The lower adsorption capacity in tap water may be due to competition of common cations available in tap water.

Thus it can be concluded that PTPC can effectively be used for the removal of Cd (II) & Ni (II) from aqueous system.

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