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# TAMARIND FRUIT SHELL ADSORBENT SYNTHESIS, CHARACTERIZATION AND ADSORPTION STUDIES FOR REMOVAL OF CR(VI) & NI(II) IONS FROM AQUEOUS SOLUTION

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### ABSTRACT

*Waste water treatment has gained an importance over the years due to rise in concentration levels of toxins leaving the industrial effluents. There are number of heavy metallic ions discharged from processes & putting burden on waste water management. Adsorption is one of the effective methods in the removal of metallic ions present in waste water. The present work deals with the removal of Cr (VI) & Ni (II) ions by the adsorbent synthesized from the Tamarind fruit shell. The synthesis of adsorbent is carried out using thermal method. The specific surface area of the adsorbent is estimated to be 2.1274± 0.0246 m/g as in BET method. The synthesized adsorbent is studied for the effect of ion concentration & adsorbent dosage on the removal of Cr (VI) and Ni (II) from aqueous solution. Based on the results & discussions, it can be concluded that the adsorbent prepared from tamarind fruit shell has a significant capacity for adsorption of Chromium (VI) & Nickel (II) ions from aqueous solution & can be employed effectively as a low cost adsorbent.*

***KEYWORDS:*** *Adsorption, heavy metals removal, Ni(II), Cr(VI), Tamarind fruit shell adsorbent.*

## I. INTRODUCTION

The increase in concentration levels of heavy metals in the environment particularly in water is a cause for concern. The major contributor for this rise in the concentration level is in the extensive development of heavy & manufacturing industries that use metals & related compounds.

Discharge of treated industrial wastewater containing metal ions such as nickel, lead, copper, zinc, chromium and aluminium are common in nearby water sources like river. This may result in affecting the quality of aquatic & human life. Therefore, the removal of heavy metals from wastewater is essential. [1, 2]

Adsorption is the one of the possible methods in removal of heavy metals from industrial waste water. The highly porous nature of adsorbent provides large surface area for deposition of adsorbate present in the liquid or gaseous mixture. Wide range of adsorbents are synthesized that show different characteristics depending upon their chemical constituents and the synthesis techniques adopted [1, 2, 3, 4 ,5 ].

Removal of Ni(II) & Cr(VI) is studied by many researches using adsorbents synthesized from agricultural waste material [6, 7 , 8, 9]

The objective of the present work is to synthesize an adsorbent from Tamarind fruit shell using thermal method and study its effectiveness in removal of Ni (II) & Cr (VI) ions from aqueous solution as a function of various process parameters.

The paper unfolds itself through sections that include materials & methods adopted in synthesizing adsorbent from Tamarind fruit shell, characterisation of adsorbent using BET method & details of the batch experiments with methods of analysis, Based on the results & discussion the paper concludes with suitability & effectiveness of Tamarind fruit shell adsorbent in removal of Ni(II) & Cr(VI) ions present in aqueous solution.

# II. MATERIAL & METHODS

## 2.1 Material for Adsorbent

Naturally and abundantly available material such as Tamarind fruit shell is used in the present work to develop low cost adsorbent & is procured locally. The flow chart in synthesis of Tamarind fruit shell into adsorbent using thermal method is given in Figure 1.

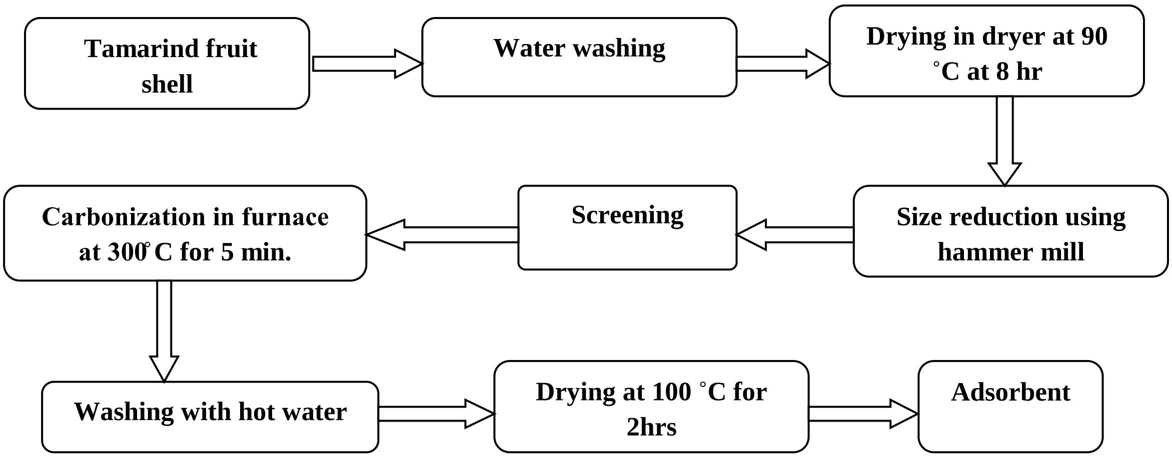


**Figure 1.** Flow chart for the preparation of adsorbent from tamarind fruit shell

Tamarind fruit shell is washed repeatedly with water to remove dust and soluble impurities. The contents are sun dried followed by oven drying at 90ºC. The dried tamarind fruit shell is converted into powder using a hammer mill, and sieved to obtain powder with average size of 1205 µ. The powder is then put in a furnace at a temperature of 90ºC for 5 min. The remains are washed with hot water for several times to remove the colour followed by drying at a temperature range of 90-100ºC for a period of 2 hr. The dried powder is tamarind fruit shell adsorbent & is stored in an air tight container for further usage.

## 2.2 Characterization of the adsorbent synthesized from Tamarind fruit shell by BET method

The surface area of a sample of Tamarind fruit shell adsorbent obtained is determined by Brunauer, Emmett and Teller (BET) $N_2$ sorption procedure with liquid $N_2$ at -195.679ºC. The specific surface area is found to be 2.1274$\pm$ 0.0246 $m^2/g$.

## 2.3 Synthetic feed solution preparation

In this work commercial grade metallic compounds, $NiCl_2 \cdot (H_2O)_6$ and $K_2Cr_2O_7$ are used. A stock solution of chromium (VI) is prepared by dissolving 0.5 gm of $K_2Cr_2O_7$ (Potassium dichromate) in 50ml of distilled water .This solution is diluted as required for batch adsorption experiments. Another stock solution of Nickel (II) is prepared by dissolving 2gm of $NiCl_2$ $(H_2O)_6$ (Nickel chloride-hexahydrate) in 50ml of distilled water. This solution is diluted as required for batch adsorption experiments.

## 2.4 Analysis methodology

The concentration of $NiCl_2\,(H_2O)_6$ & $K_2Cr_2O_7$ in the aqueous solution is determined by using digital colorimeter. The standardization of colorimeter is carried out by correlating the optical density of aqueous solution samples with the known concentrations of $NiCl_2 \cdot (H_2O)_6$ & $K_2Cr_2O_7$ present in theses samples[10]. Figure 2 shows a sample graph plotted between concentrations of $NiCl_2 \cdot (H_2O)_6$ in solution with optical density as obtained using digital colorimeter. This graph can be used for determination of concentration of ions present in aqueous solution by determining the optical density of the solution and reading the corresponding value of concentration.

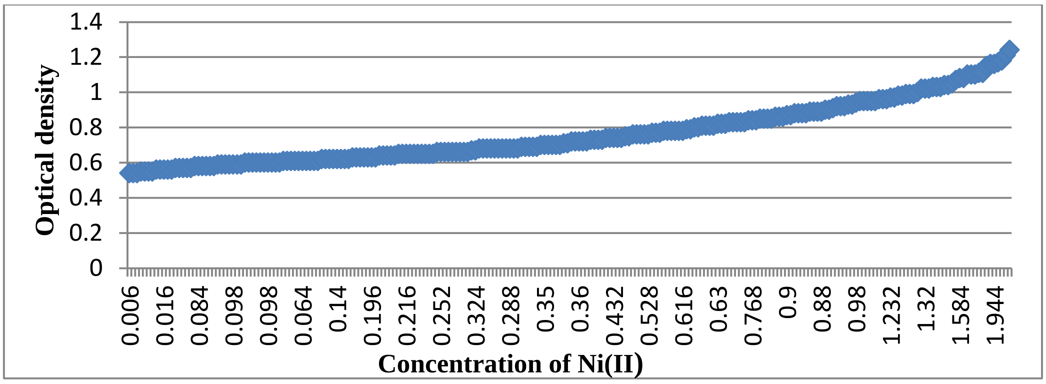


**Figure 2.** Optical density Vs Concentration of $NiCl_2\,(H_2O)_6$

## III. Adsorption Experiments

For the batch adsorption experiments, the effect of amount of adsorbent on the adsorption of the heavy metal ions such as Ni (II) & Cr (VI) is investigated. Adsorbent of 1-4 gm is added to a vessel containing 50ml of aqueous solution with known metal ion concentration. The mixture is stirred for 60 min & then filtered out. The concentration of final solution Ce, is estimated by determination of optical density & referring to the respective standardized graphs. Finally the % of adsorption is calculated as follows.

$$\%\text{ adsorption efficiency} = (Co - Ce) \times 100/Co$$

Where, Co and Ce are the initial and equilibrium Ni (II) & Cr (VI) concentration of the Nickel & Chromium solution, respectively.

## IV. Result & Discussion

### 4.1 Effect of adsorbent dosage on the adsorption of Ni (II) & Cr (VI) ion

The effect of adsorbent dosage on % removal of Cr (VI) & Ni (II) ions from waste water can be seen from the graphs plotted as shown in figure 3 & 4 respectively. It can be inferred that percentage adsorption of Ni (II) & Cr (VI) ions increases with increasing adsorbent dosage. It varies between 50-55%, 70-75%, 80-85% for initial concentration of Cr (VI) as 0.0025, 0.005 & 0.01 gm/10ml respectively and 20-25%, 70-80% & 75-90% for initial concentration of Ni (II) as 0.01, 0.04 & 0.08 gm/10ml respectively. It can also be said that tamarind fruit shell adsorbent is more effective in removal of Cr (VI) as compared to Ni (II) for lower value of adsorbent dosage. Similarly the % adsorption is a function of initial concentration of ions in the feed mixture also & increases with it for the same value of adsorbent dosage.
Figure 5 & 6 shows the equilibrium relationship correlating concentration expressed as gm/10 ml of Cr (VI) & Ni (II) ions in liquid phase with the concentration of adsorbate in solid phase expressed as amount of adsorbate per unit amount of adsorbent, gm/gm, respectively.

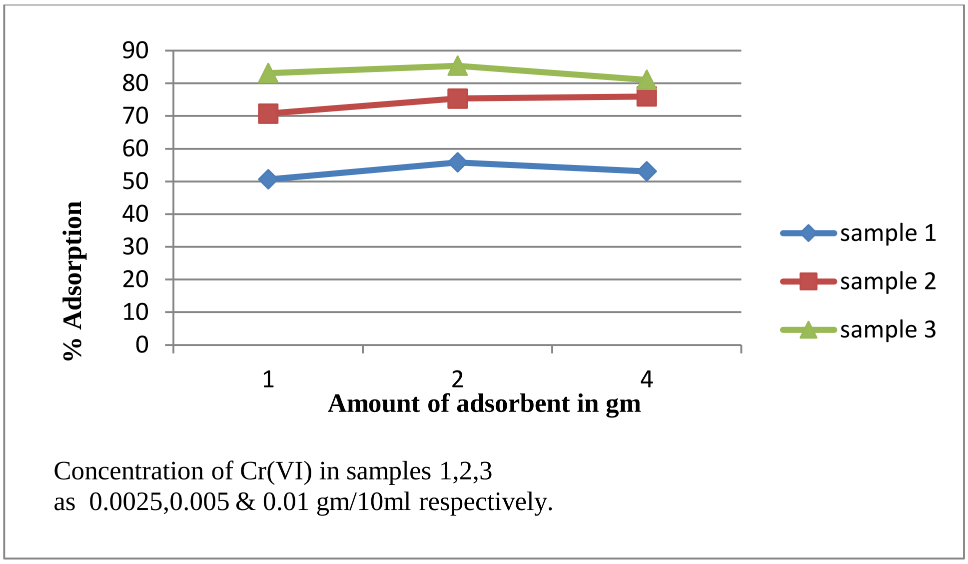


**Figure 3.** Effect of adsorbent dosage on Cr (VI) ion removal

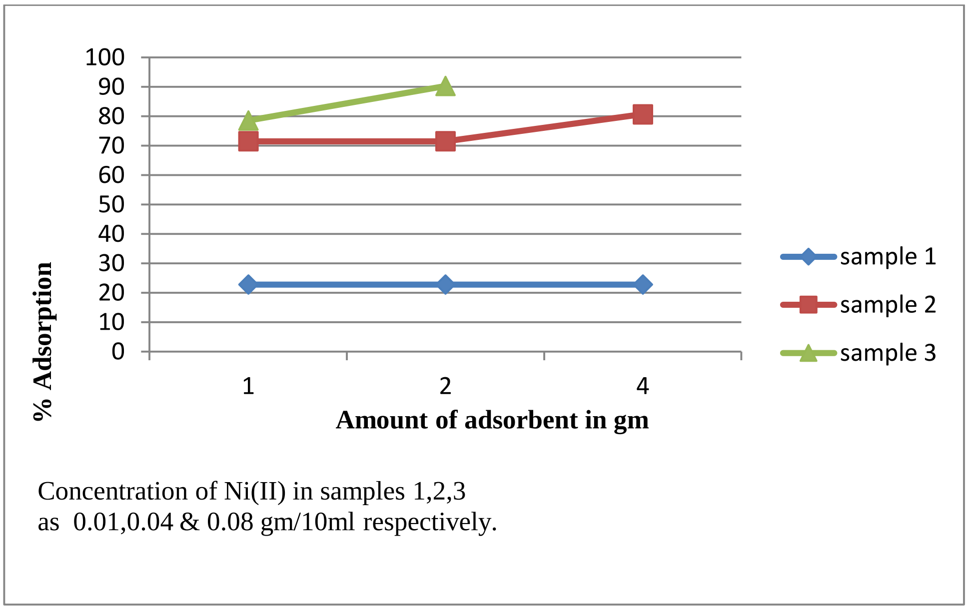


**Figure 4.** Effect of adsorbent dosage on Ni (II) ion removal

Figure 5 & 6 show the graphs plotted depicting equilibrium relationship expressed as concentration of Cr (VI) & Ni (II) ion in solid and liquid phases as q1, q2 &c1, c2 expressed as gm/gm & gm/10 ml respectively.

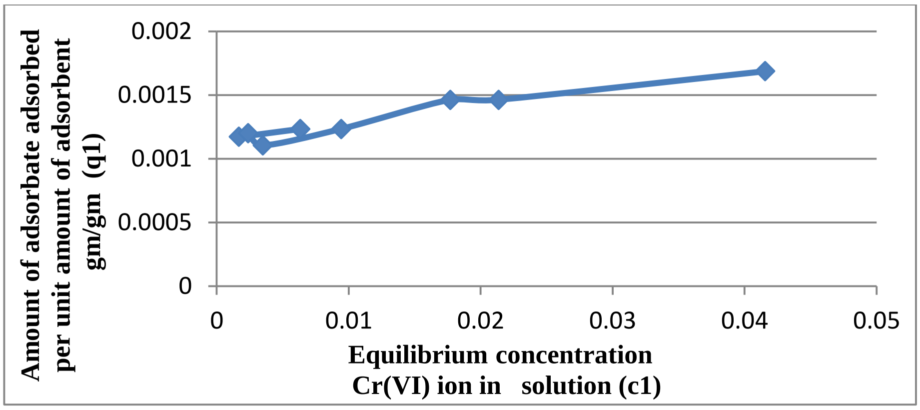


**Figure 5.** Equilibrium relationship between the concentrations of Cr (VI) ion in solution with the amount of adsorbate adsorbed per unit amount of adsorbent gm/gm.

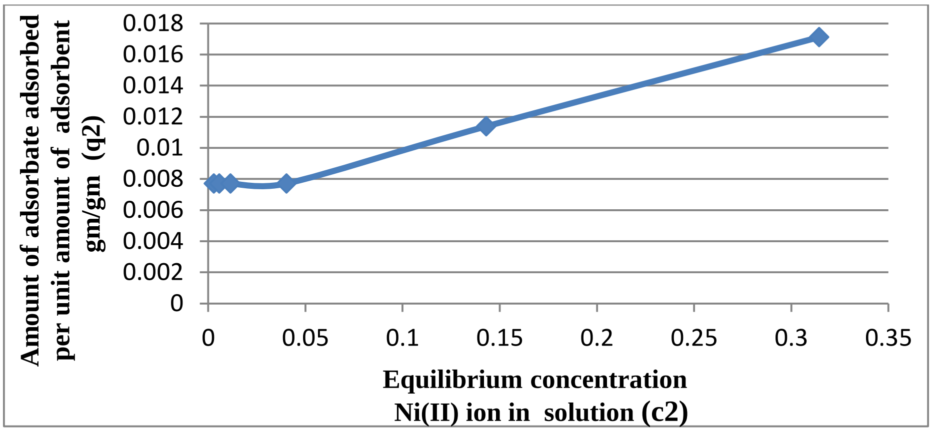


**Figure 6.** Equilibrium relationship between the concentrations of Ni (II) ion in solution with respect to the amount of adsorbate adsorbed per unit amount of adsorbent gm/gm.

As can be seen from the non-linear nature of these graphs, these are not following the typical linear adsorption isotherm criterion & hence for testing its fitness for the Freundlich adsorption isotherm, two log-log graphs between log $q^1 1$ & log $c^1 1$ and log $q^1 2$ & log $c^1 2$ have been plotted as shown in figure no 7 & 8 expressed as mg/gm & gm/lit respectively.

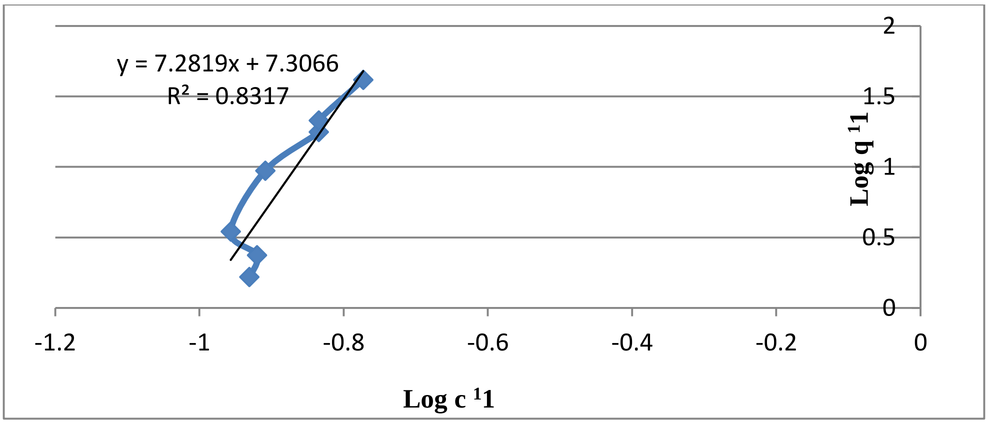


**Figure 7.** Freundlich adsorption isotherm of Cr (VI) adsorption on Tamarind fruit shell adsorbent

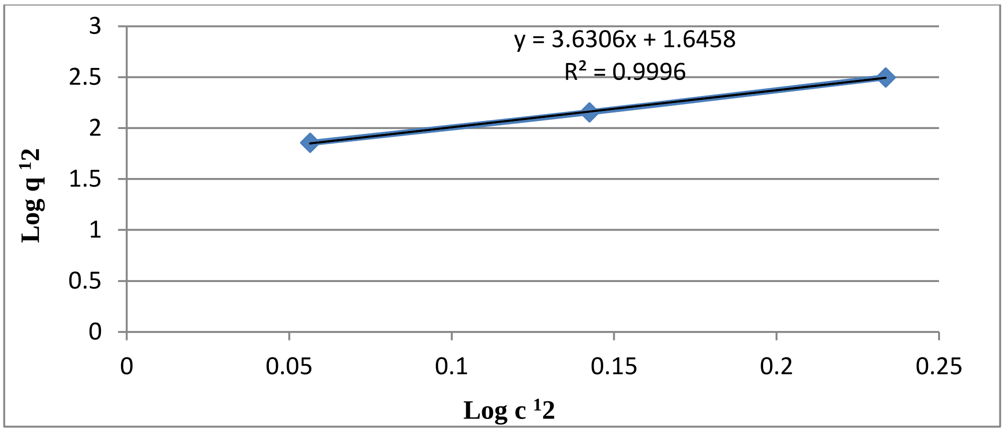


**Figure 8.** Freundlich adsorption isotherm for Ni (II) ion adsorption on Tamarind fruit shell adsorbent

It can be seen from these figures that the adsorption isotherms do fit into the criterion of Freundlich adsorption isotherms for the adsorption of Cr (VI) & Ni (II) ions from aqueous solution using Tamarind fruit shell adsorbent. The Freundlich adsorption Isotherm equation for Cr (VI) & Ni (II) ions can be expressed as follows.

$\log q^1 1 = 7.281 \log c^1 1 + 7.306$..................................................................................(1)

$\log q^1 2 = 3.630 \log c^1 2 + 1.645$..................................................................................(2)

The equation (1) & (2) are transformed into the $y = (m)\, x^{(1/n)}$ form as follows.

- $q^1 1 = (7.306)\, c^1 1^{(1/0.1373)}$ ........................................................................ (3)
- $q^1 2 = (1.645)\, c^1 2^{(1/0.2754)}$ ........................................................................ (4)

Where

q1 & q2 = amount of adsorbate adsorbed per unit amount of adsorbent, gm/gm.

c1 & c2 = equilibrium concentration of Cr (VI) & Ni (II) ion.

K & n= specific constants

Table 1. shows the values of ‘K’ & 1/n constant for Cr (VI) & Ni (II) ions adsorption using Tamarind fruit shell adsorbent. ’R’ is the correlation coefficient. The values of constants and coefficients are acceptable & are in accordance with the literature values. They are indicative of the effectiveness of adsorbent synthesized in the present work.

**Table 1.** Freundlich Isotherm Parameters

| Adsorbent | Adsorbate | K | n | $R^2$ |
|---|---|---|---|---|
| Tamarind fruit shell | Cr (VI) | 7.306 | 0.1373 | 0.831 |
| | Ni (II) | 1.645 | 0.2754 | 0.999 |

## V. CONCLUSION

The adsorbent synthesized from Tamarind fruit shell is observed to have surface area of 2.1274± 0.0246 $m^2/g$ as determined by (BET) method. This is acceptable & is close to the reported literature values of adsorbents synthesized from various agricultural waste materials. The removal of Ni (II) & Cr (VI) ions from aqueous solutions increases with increase in adsorbent dosage & varies in between 50-85.36% & 22-90.35% respectively depending upon the adsorbent dosage. Thus it can also concluded that tamarind fruit shell adsorbent can be used as an alternative low cost adsorbent for removal of Ni (II) & Cr (VI) ions in remediation of wastewater. However it is felt necessary that there is need for further development of adsorption process in the direction of modification of the adsorbent structure so as to improve the adsorption efficiency further by adopting a combination of chemical & thermal methods of synthesis.

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