Adsorption of Chromium from Industrial Waste Water By Using Neem Leaves as a Low Cost Adsorbent

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Abstract

The present work is aimed at exploring Neem Leaves as low cost adsorbent for removal of Chromium (VI) from Industrial Waste Water. Adsorption is one of the important industrial processes used for removal of color, odor, turbidity, metal ions and reduction of COD. In adsorption, the solute present in dilute concentration in liquid or gas phase is removed by contacting with suitable solid adsorbent so that the transfer of the component first takes place on the surface of solid and then into the pore of the solid. Neem Leaves carbon Adsorbent used in present study is prepared at Laboratory scale is observed to be very effective for removal of chromium from its aqueous solution. This study describes the various methods of investigation and the detailed experimental procedure to obtain the adsorption kinetics, Adsorption Equilibrium and the Effect of various parameters on batch Adsorption and Column adsorption system. It is revealed that the maximum removal efficiency is observed up to 85% for bio sorbent prepared from Neem Leaves.

Keywords: Adsorption, Chromium, Neem Leaves, adsorbent, Efficiency.

Introduction

Pure water is not easily available to all. Deprived section of the society consumes contaminated water and takes ill periodically. The water may be contaminated by natural sources or by industrial effluents [1]. There are various source of industrial waste water such as from iron and steel Industry, mining, chemical industry and electroplating industry. Chromium is one of the metal ions from electroplating industry present in water effect the human health. Chromium is a metallic element in the periodic table. Chromium is found naturally in rocks, plants, soil and volcanic dust, humans and animals. The most common forms of chromium in the environment are trivalent (chromium-3), hexavalent (chromium-6). Chromium-3 occurs naturally in many vegetables, fruits, meats, grains and yeast. Chromium-6 is generally produced by industrial processes. Major sources of chromium-6 in drinking

water are discharges from steel and pulp mills, and erosion of natural deposits of chromium-3. At many locations, chromium compounds have been released to the environment via leakage, poor storage, or improper disposal practices [2]. In the draft human health assessment for chromium-6 that was released in September 2010 by EPA for independent expert peer review and public comment, EPA is proposing to classify hexavalent chromium (or chromium-6) as likely to cause cancer in humans when ingested over a lifetime. It becomes necessity to serve clean water to the society.

We can say healthy environment is the cost of healthy life [3]. The proposed work is concern with the removal of chromium ions by using low cost adsorbent. There are various methods for water treatment, and now a day, adsorption operations employing solids such as activated carbon and synthetic resins are used widely in industrial applications for purification of waters and wastewaters. Adsorption phenomena are operative in most natural physical, biological, and chemical systems. Adsorption is the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface. This process creates a film of the adsorbate on the surface of the adsorbent.

Methods And Materials

In this study the adsorbent is prepared from Neem Leaves to remove Chromium from Industrial waste water. The pretreatment of adsorbent and analytical techniques for preparation of chromium ion solution and investigation of various parameters are presented.

Preparation of Adsorbent

The neem Leaves washed with water and then dried the leaves in tray dryer for complete removal of moisture. It takes nearly 2-3 hrs at 110$_o$C. Then the dried leaves crushed and kept in muffle Furnace for 3 hrs at 250$_o$C. The Heating period depends on the atmospheric temp. After Heating, a black colored adsorbent in a powder form obtained.

Determination of Maximum wavelength for operation

The stock solution of 1000 mg / ltr of chromium prepared by dissolving 1 gm of chromium chloride in 1000 ml of distilled water. Then their absorbance was recorded at different wavelength by using UV Spectrophotometer. Up to certain wavelength % absorption increases and then decreases, at the point where the % absorption is maximum that point is considered as maximum wavelength of operation.

Construction of standard calibration curve for chromium

For this purpose, solution of chromium chloride of different concentration was prepared and their absorbance was recorded by using UV Spectrophotometer. The Spectrophotometer is set to Zero absorbance with the reference solution (Distilled water) and then the absorbance of standard

solution was measured. With the help of these Reading standard calibration curve plotted between % absorption and standard chromium chloride solution of various concentrations.

Table 1. The Standard Calibration Curve For Chromium

Concentration (ppm)	Absorbance
1	0.1
2	0.19
3	0.32
4	0.38
5	0.48
6	0.5
7	0.64
8	0.7
9	0.87
10	0.99

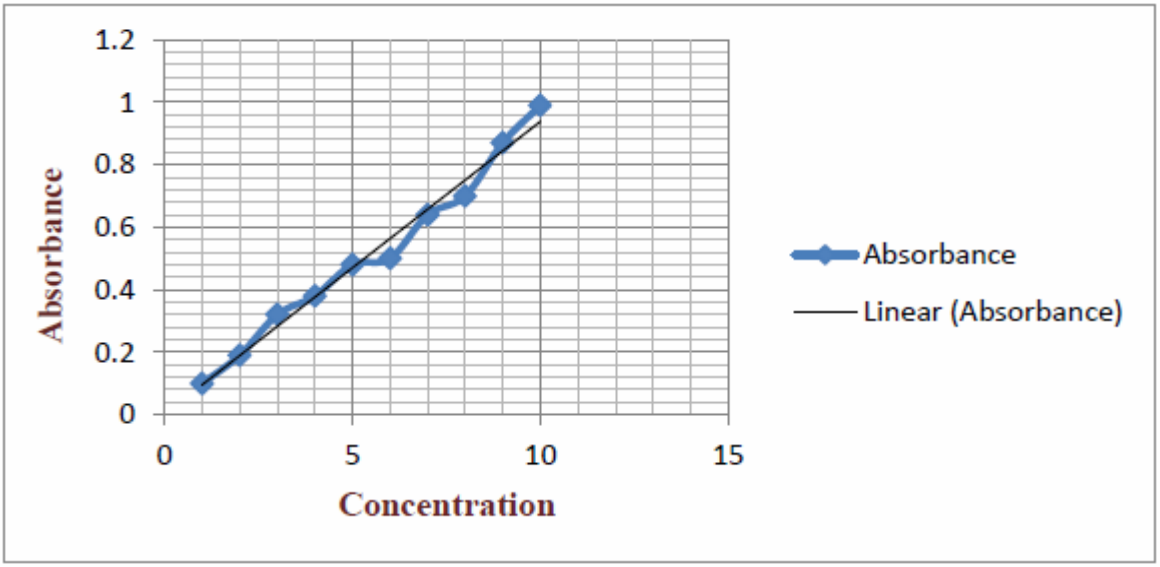

Figure 1. The Standard Calibration Curve For Chromium

Result And Discussion

Adsorption studies were performed by Batch Technique to obtain the rate and Equilibrium data. The removal efficiencies of Low cost Adsorbents during the investigation of batch adsorption process had been studied.

Removal of chromium ion by Batch study

The Effect of pH on removal of Cr (VI) ion

The pH affects the solubility of chromium ion to a great extent. The pH of the aqueous solution is the controlling factor in the adsorption process; hence it become necessary to determine at what pH aloes, max adsorption will takes place. The max removal efficiency was 67.5% at 4.1 pH value.

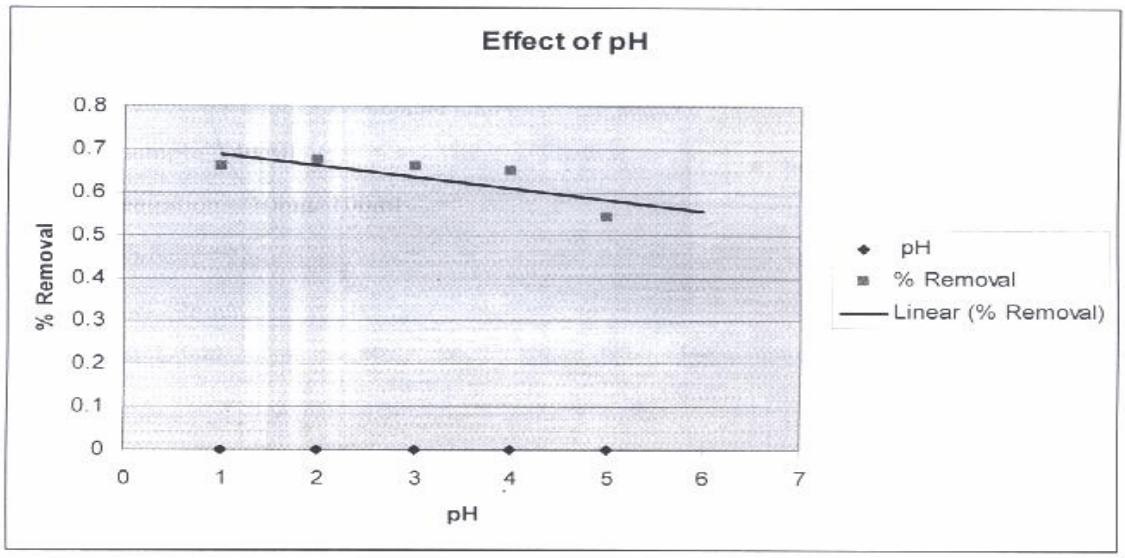

Figure 2. The effect of ph on removal of cr (vi) ion

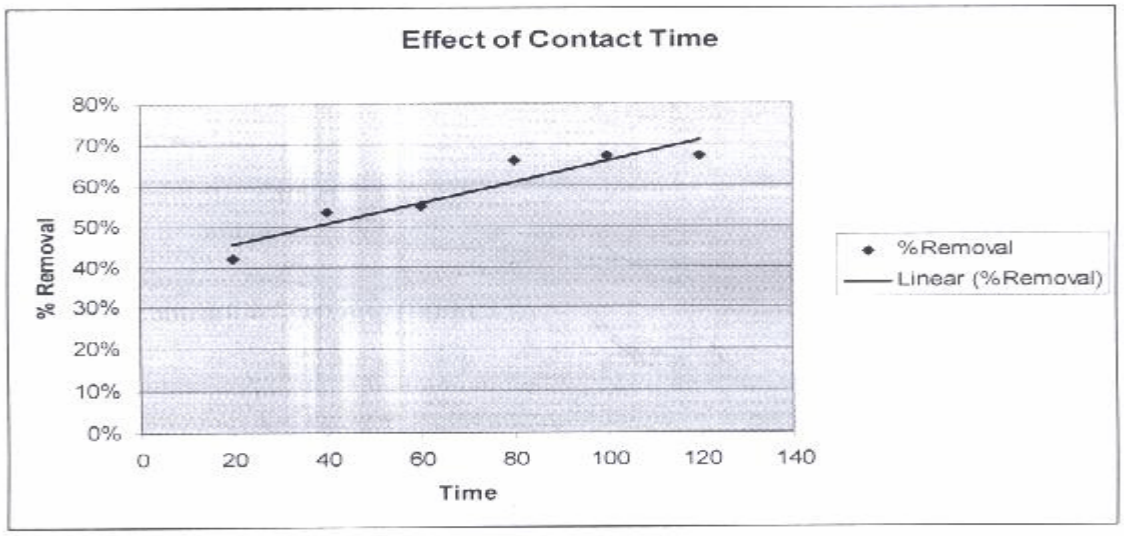

Figure 3. The effect of contact time on removal of cr (vi) ion

The Effect of Initial Concentration on removal of Cr (VI) ion

The effect of Initial concentration of Cr ion on the adsorption efficiency by adsorbent material was investigated by varying the initial concentration as shown in Fig 4. It was observed that the activities of all the adsorbent material falls sharply with an increase in initial concentration of chromium ion. The max Cr removal efficiency for the set of all optimized parameter was found for 98% for Neem Leaves at initial concentration of 30mg/100ml.

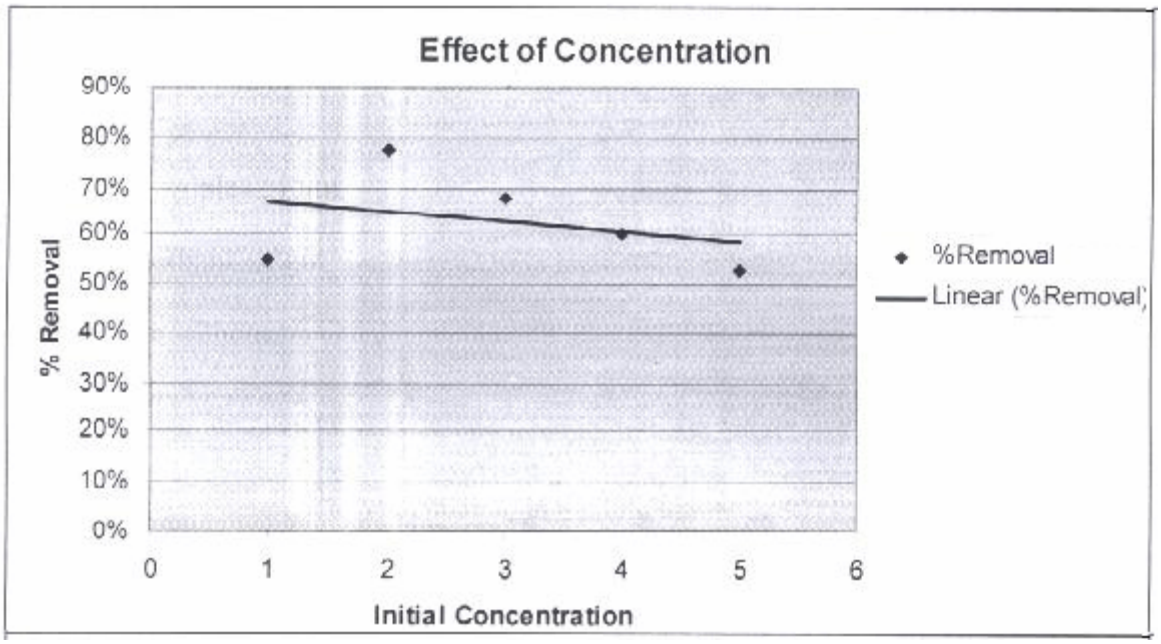

Figure 4. The effect of initial concentration on removal of cr (vi) ion

The Effect of Adsorbent Dose on removal of Cr (VI) ion

The effect of the amount of adsorbent on the rate of uptake of chromium ions is shown in Fig.5. It can be seen that the rate of the removal of chromium ions increases with an increases in the amount of adsorbent dose. The amount of adsorbent dose varies from 2gm/100ml to 10gm/100ml. The result obtained for neem leaves, the removal efficiency is maximum at dose of 8gm/100ml which is up to 85%.

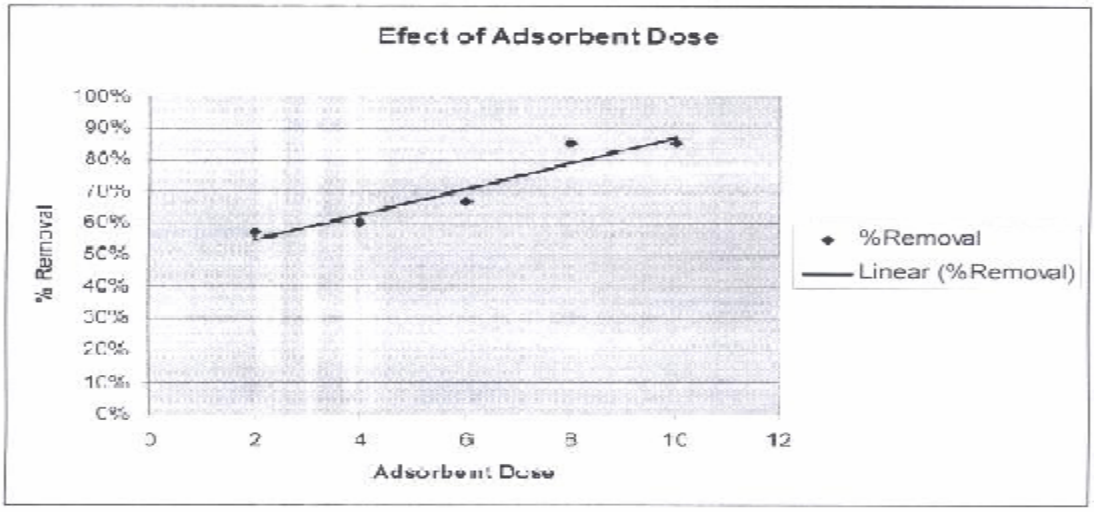

Figure 5. The effect of adsorbent dose on removal of cr (vi) ion

Adsorption Kinetics

The adsorption isotherm is a functional Expression for the variation of adsorption with concentration of adsorbent in bulk solution at constant Temperature. It is observed that the amount of adsorbed material per unit weight of adsorbent increases with increasing concentration but in direct proportion.

Table 2. R valuebased on isotherm

R Value	Type of Isotherm
R > 1	Unfavorable
R = 1	Linear
0 < R < 1	Favorable
R = 0	Irreversible

Langmuir Adsorption Isotherm

Langmuir Isotherm is based on the assumption that points of valence exists on the surface of the adsorbent and that each of these sites is capable of adsorbing one molecule, thus the adsorbed layer will be one molecule thick.

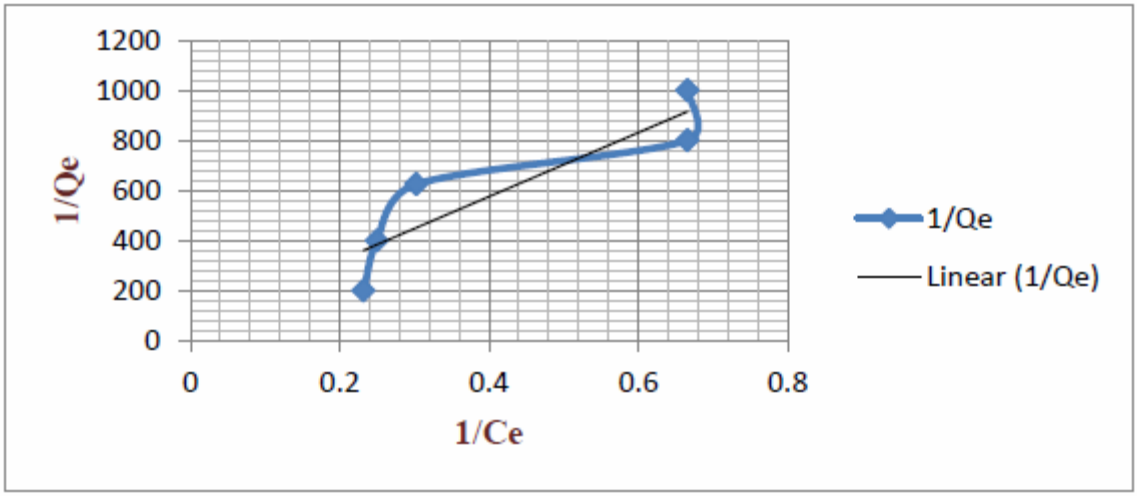

Figure 6. Langmuir Adsorption Isotherm

When 1/Qe is plotted against 1/Ce for neem leaves as shown in Fig.6, a straight line with the slope 1/bQo is obtained which shows that adsorption follows the Langmuir isotherm. The Langmuir constants b and Qo are calculated. The separation factor is define by

R2 = 1 / (1 + b*Co)

It is found that R2 value for Langmuir model follows the condition 0< R<1 and hence the process of removal of chromium using treated neem leaves follows the Langmuir isotherm in favorable manner.

Freundlich Adsorption Isotherm

Freundlich Adsorption Isotherm is based on the assumption that the adsorbent heterogeneous surface composed of different classes of sites with adsorption on each sites following the Langmuir Isotherm.

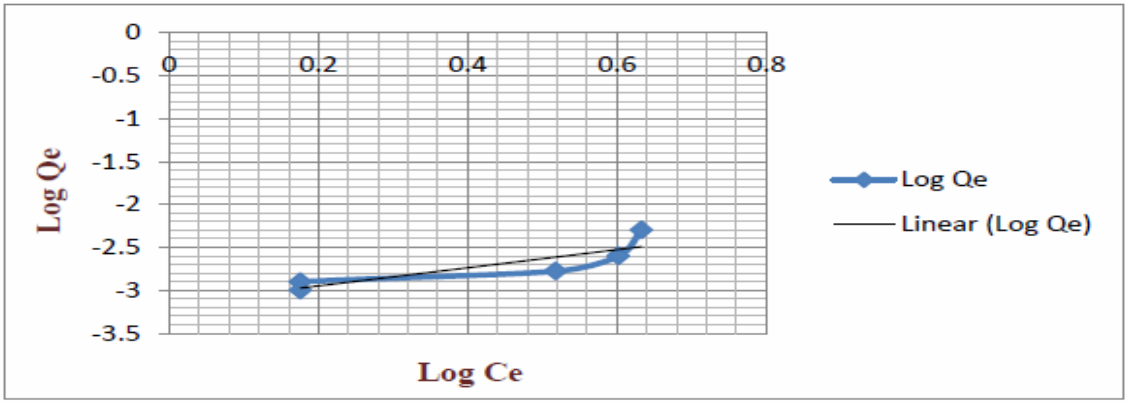

Figure 7. Freundlich Adsorption Isotherm

A plot of log Qe and Log Ce shown in Fig 7 yields a straight line for adsorption data which follows the Freundlich theory. The values of constants can be determined by plot and it confirms the applicability of Freundlich model.

Removal of Cr (VI) in Continuous Fixed Bed system

From fig 2 to 5, it is observed that initially the bed was giving 90 - 98 % of removal efficiency. After Break Through point, the decreasing pattern of percentage of chromium ions removal at break through time was observed from graphs shown in Fig.8 to Fig. 11[4].

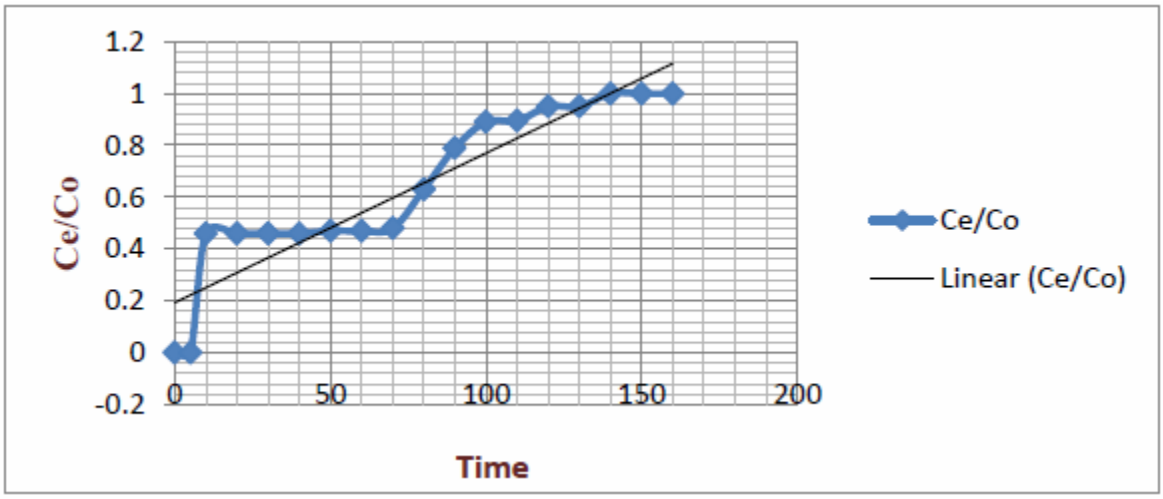

Figure 8. Effect of flow rate on break through time

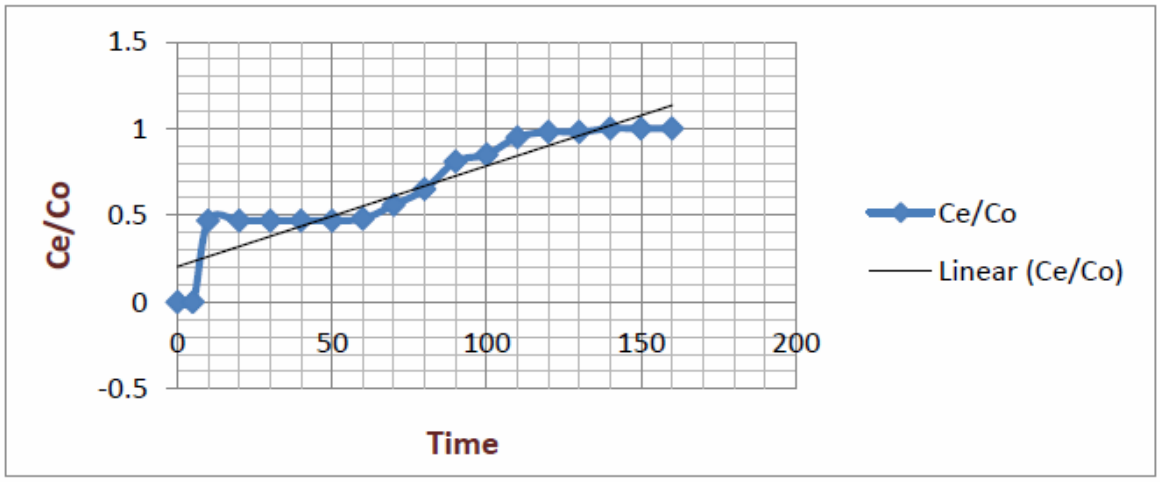

Figure 9. Effect of flow rate, initial concentration and height of adsorbent bed on break through time

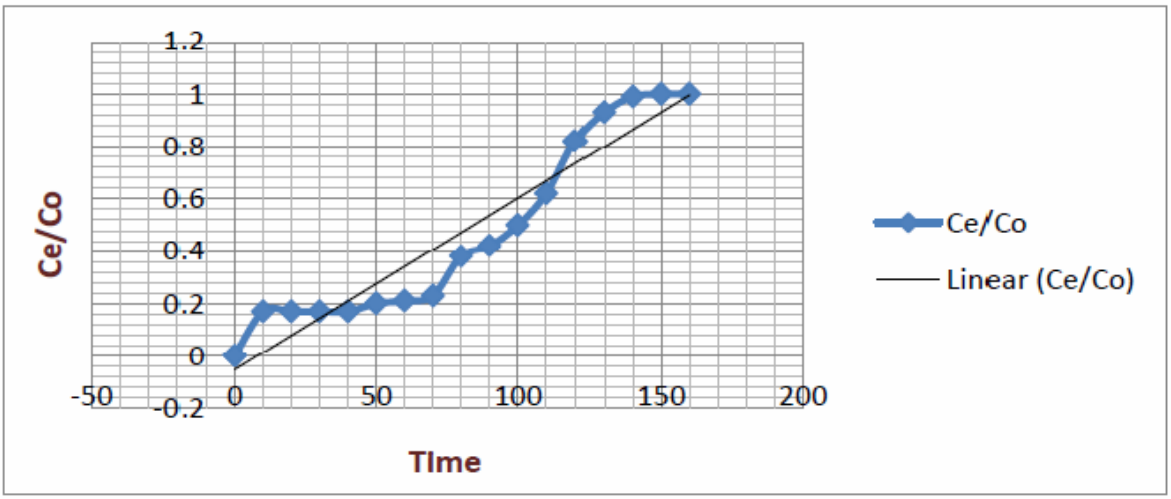

Figure 10. Effect of initial concentration on break through time

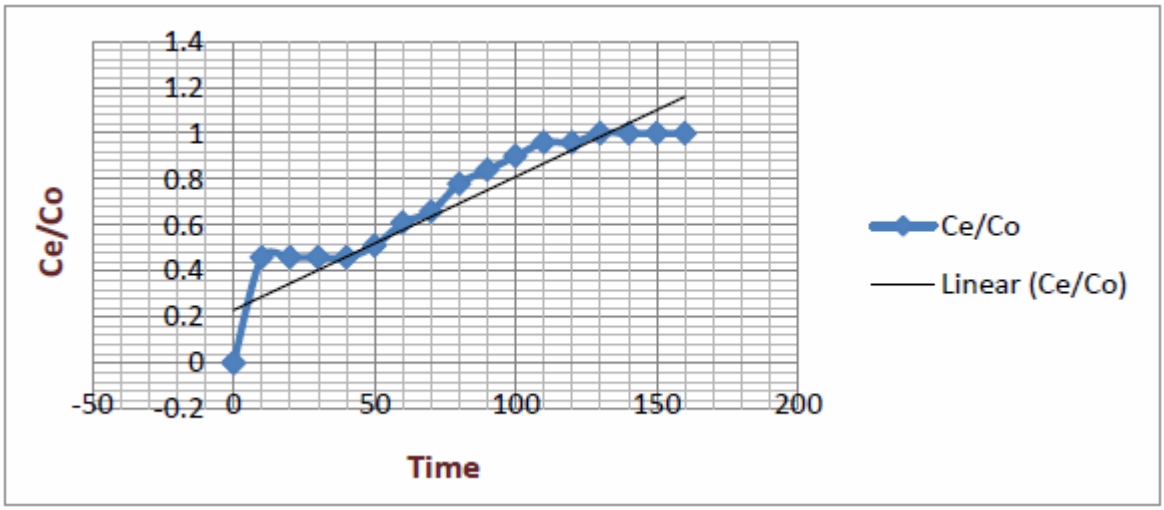

Figure 11. Effect of height of adsorbent bed on break through time

Figure 8 & 9. Effect of Flow Rate on Break through Time

This study was conducted to evaluate the influence of flow rate on the efficiency of adsorbent in continuous adsorption column for removal of chromium ions. The result obtained by varying the flow rate of chromium solution as 0.5 and 1.5ml/ 20sec and values of the break through time are noted. It is observed from Fig. 8 & 9, that the break through time decreases as the flow rate increases.

Figure 9 & 10. Effect of Initial Concentration on Break through Time

The effect of Initial concentration on the adsorption Efficiency of the adsorbent material was investigated by varying the concentration as 10 and 20mg/100ml as shown in Fig 9 and Fig.10. It is observed that due to increase in concentration, the break through time decreased that means the adsorbent bed reached at the exhaustion earlier.

Figure 9 & 11. Effect of Height of adsorbent Bed on Break through Time

The effect of Initial concentration on the adsorption Efficiency of the adsorbent material was investigated by varying the adsorbent amount as 10, 20 and 30gm as shown in fig 9 and Fig.11. It is observed that the rate of chromium ions increases with increase in the amount of adsorbent bed. In all condition, the Initial concentration of chromium ion was at 10mg/100ml.

Conclusion

The present work is attempt for the systematic studies of removal of chromium from waste water using low cost adsorbent prepared from Neem Leaves. From the Experimental Findings It has been observed that the adsorbent material can be used successfully for removal of chromium from waste water. The maximum removal efficiency was observed up to 85% for biosorbent prepared from Neem Leaves at the optimum values of parameters.

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