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Adsorption isotherm and kinetic studies of Nickel (II) ions removal using Neem bark charcoal and commercially activated Carbon: A comparative study

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Abstract
This paper describes the adsorption of Ni (II) ions from aqueous solution by using neem bark charcoal (NBC) and commercially activated carbon (CAC) and its comparison. The effect of concentration, contact time, adsorbent dosage and its pH. In this study it obeys a Lagergran kinetics rather than Natarajan- Kalaf kinetic studies. This study shows that Neem bark charcoal is eco-friendly adsorbent for the removal of Ni (II) ions.

Keywords: NBC, CAC, kinetics

1. Introduction

The increasing awareness of the environmental consequences arising from heavy metal contamination of the aquatic environment has led to the demand for the treatment of industrial waste water before discharge into the aquatic environment [1]. Heavy metals are not biodegradable and have become an ecotoxicological hazard, and increasing significance owing to their harmful effect on human beings and other biological systems when they the tolerance level. A number of technologies for the removal of heavy metals from aqueous solutions have been developed [2]. Biosorption of heavy metals from aqueous solution is a relatively new technology for the removal of heavy metals from industrial waste water [3]. The main advantage of using biosorption method is due to cost effectiveness, availability and eco-friendly. The removal of heavy metals from sewage and from industrial effluents has been widely studied [4].

Activated carbon adsorption is widely employed for the removal of trace inorganic [5]. Activated carbons, with their high surface area, micro porous character, and chemical nature of their surface, have made them potential adsorbents for the removal of heavy metals from industrial waste water [6]. Over the last few years number of investigations has been conducted to test low cost adsorbent to remove the heavy metals from solution [7]. Electroplating is a process in which metal finishing and metal deposition takes place [8]. Nickel is one of the metal released during electroplating. Nickel is present in waste water from chemical industries, metal processing [9]. Heavy metal deposition in body causes oral ulcer, cancer, renal failure. The exposure of Nickel affect skin and causes irritation, damage the nervous system [10, 11]. The ground water in India was contaminated by these metals. There was a need of removing this metals from ground water [12]. The awareness of environmental problem arising from heavy metal contamination in water needs several methods [13], and the adsorption method is given in this study.

1.1 Experimental Section

2. Materials and Methods

The adsorbent materials used were commercially activated carbon (CAC) and neem bark charcoal (NBC) powder, which is a low cost adsorbent. Neem barks are collected, washed with water and dried over sunlight grounded to powder. The adsorbate sample used is AR grade nickel sulphate. All the reagents are prepared by using distilled water. The neem bark was cleaned using tap water in order to remove unwanted materials. The washed sample material was sun dried for 2-5 days. Then it was carbonized by using muffle furnace for an hour at 500° C. Then it was cooled, and then grounded in a laboratory blender and made it into fine powder. A stock solution of Ni (II) was prepared by dissolving Analar grade $NiSO_4$ in deionized water. The experimental solutions of the desired concentrations were obtained by successive dilutions. The experiment was carried out at room temperature. The absorbances were measured in UV spectrophotometer at 320 nm.

2.1 Batch adsorption studies

In the present study commercially activated carbon (CAC) and Neem Bark Charcoal (NBC) were used as an adsorbent for the removal of Ni (II) ions from an aqueous solutions. The results and data presented in these batch adsorption studies helps, to suggest the usage of low cost adsorbent Neem Bark Carbon as an alternative to Commercial Activated Carbon for the effective removal of metal ion from the industrial effluents.

The present investigation also helps to understand the effect of various experimental parameters like concentration, pH, contact time, and the dose of adsorbent for the removal of metal ions by adsorption over the adsorbents like Neem Bark Charcoal (NBC) a low cost adsorbent, and the Commercially Activated Charcoal (NBC). Batch type adsorptions were carried out by keeping anyone of the parameters constant at room temperature.

3. Result and Discussion

3.1 Effect of initial concentration

The effect of initial concentration of Ni (II) by the adsorbents (CAC and NBC) was studied with the constant dose of adsorbent in all the bottles and the different concentrations of

the solutions were maintained. The bottles were then kept in the mechanical shaker and shaken vigorously for an hour. The solutions were then filtered. Then the absorbance of the filtrates was measured by using UV spectrophotometer.

The effect of initial concentration of Ni (II) on the removal of metal adsorbed on the CAC and NBC was studied with fixed dose of adsorbent and constant contact time by varying the initial concentration of metal ion. Analysis reveals that the amount of metal ions adsorbed increases while the percentage removal decreases with increase in initial concentration of metal ion. This might be due to lack of available active sites on the adsorbent surface compared to the relatively large number of active sites required for the high initial concentration.

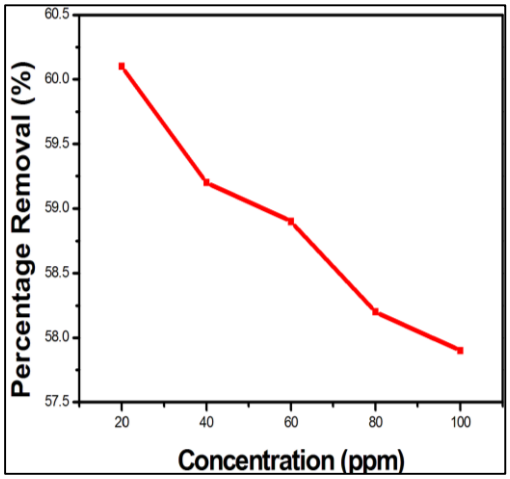

Fig 1

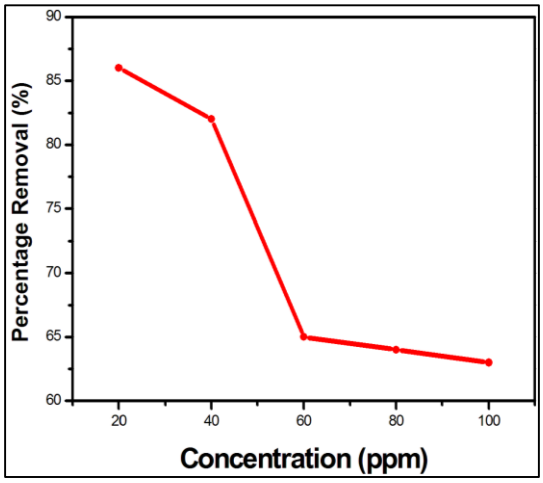

Fig 2

The fig (i) represents adsorption of Ni (II) ion by using NBC as adsorbent and fig (ii) represents the adsorption of Ni (II) ion by using CAC as adsorbent. Here in both cases the adsorbent decreases when the concentration of Ni (II) ions increases. But when comparing CAC and NBC the percentage removal will be more for CAC. This is because the surface area of the activated charcoal will be high. The maximum removal of metal ion by NBC and CAC was found at an optimum initial concentration of 50ppm.

3.2 Effect of contact time on the removal of ni (ii) ion

The batch adsorption experiments were carried out at different contact time with constant initial concentration, pH and the dose of adsorbent at room temperature. The bottles had adsorbent, pH and concentration of Ni (II) solution were shaken for in a mechanical shaker at different contact times (10, 20, 30, 40, 50, 60) minutes and then the solution were filtered. The equilibrium concentration of the Ni solution was obtained by its absorbance value the result were analyzed.

In the adsorption studies, the effect of contact time plays a vital role irrespective of the other experimental parameters affecting adsorption kinetics. The adsorption studies were carried out at different contact time (10-50) at constant initial concentration of Ni (II) ion over NBC and CAC and constant adsorbent dosage.

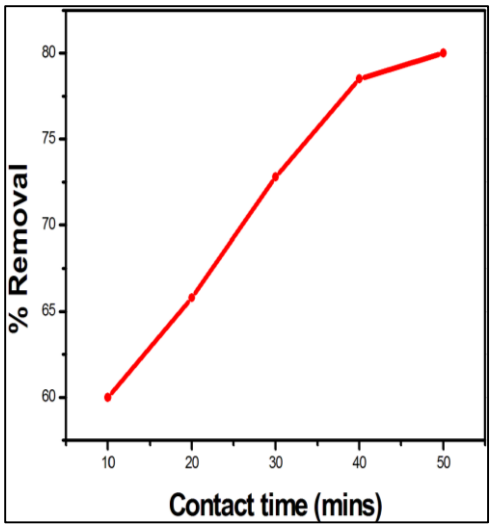

Fig 3

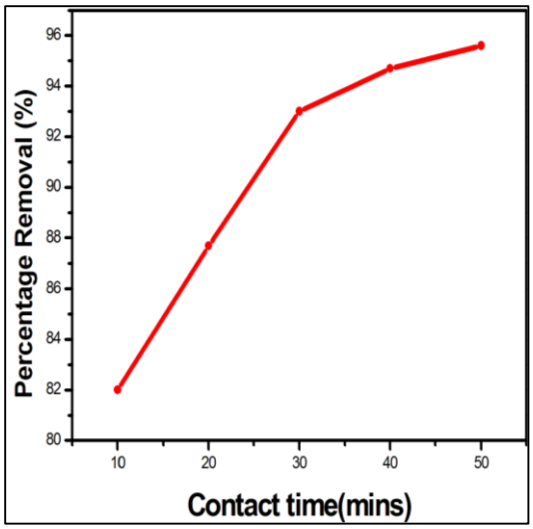

Fig 4

Fig (iii) and (iv) represents the effect of contact time on the removal of Ni2+ by using NBC and CAC as an adsorbent. The percentage removal of Ni2+ is higher in CAC as adsorbent than NBC as adsorbent. The percentage removal

increased with increase in contact time. Hence complete removal of the metal ion from the aqueous solution can be achieved by increasing the contact time.

3.3 Effect of adsorbent dosage for the removal of ni (ii) solution

The effect of dose of adsorbent studied by keeping the concentration and pH of the solution constant. The dose of adsorbent (CAC and NBC) were varied. The batch adsorption studies at constant initial concentration for each adsorbent were carried out from the spectrophotometrical analysis of filtrates the equilibrium concentration can be determined. The results were tabulated and minimum amount of adsorbent required for the maximum removal of Ni were determined and fixed as the optimum dose of adsorbent.

Effect of adsorbent dosage on adsorption of Ni (II) on CAC and NBC was studied by changing the mass of adsorbent at fixed dose of adsorbate, with a constant initial concentration and optimum pH. The adsorption increases within the increase in dose of adsorbent. This may be due to the increase in availability of active sites to the increase in the effective surface area resulting from the increase in dose of adsorbent. From this study, it was observed that increase in mass of adsorbent the surface area available increases. Due to this percentage removal increases.

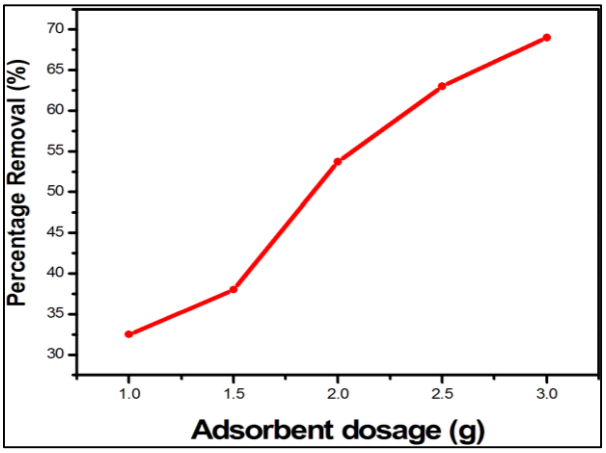

Fig 5

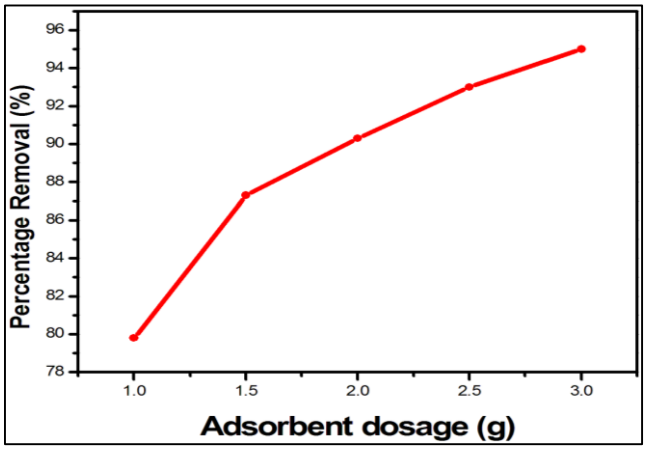

Fig 6

Fig (v) Fig (vi) represents the effect of adsorbent dosage on the removal of Ni2+ by using NBC and CAC as adsorbent. The percentage removal increased with increase in dose of adsorbent. Hence complete removal of the metal ion from the aqueous solution can be achieved by increasing the mass of adsorbent.

3.4 Effect of PH for the removal of NI (ii) solution

The effect of initial pH on the extent of Ni solution from the adsorbent the initial pH of the solution was varied by adding required volume of 1N per chloric acid. The pH was measured and the solution kept in bottles. The solution were shaken for an hour, it was filtered. The filtrate solution was used to the % removal of metal ion and the amount of metal adsorbed was calculated by using the absorbance.

The percentage removal of metal ion is pH dependent. pH plays the significant role in adsorption process.by changing pH value the effect of initial pH increase in initial pH decreases the percentage removal of metal ion on both CAC and NBC as shown in graph. The initial pH affects the charge on the surface of the adsorbent by changing its capability to adsorb metal ion.

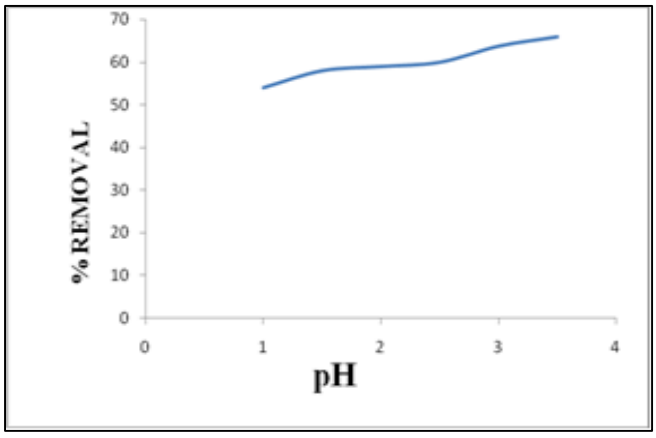

Fig 7

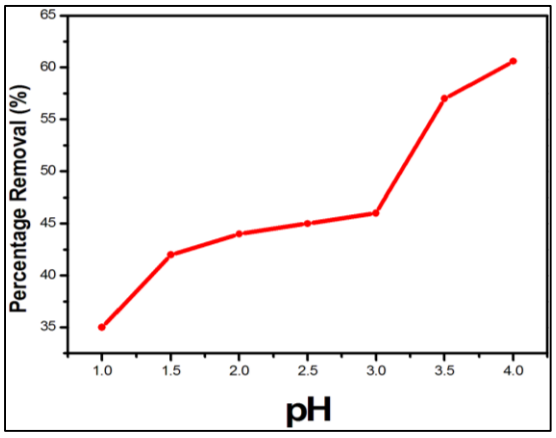

Fig 8

Fig (vii) and (viii) represents the effect of NBC and CAC on the removal of Ni2+ ions. At acidic condition the removal will be high than basic condition. At low pH the removal of H+ is easier than OH- ions. At basic condition precipitation begins to happen.

3.5 Adsorption isotherm

In the batch adsorption technique used for waste water treatment, the adsorption process plays a significant role. The adsorption equilibrium is well correlated by Langmuir adsorption isotherm.

3.6 Langmuir isotherm for the removal of ni^{2+}

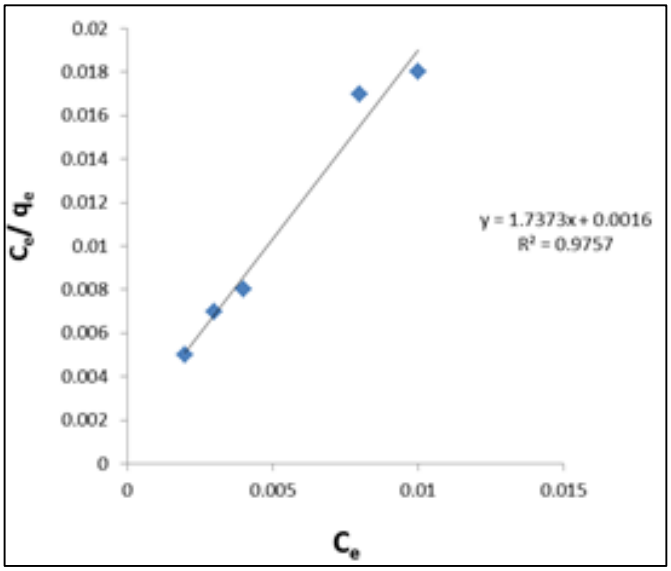

Fig 9

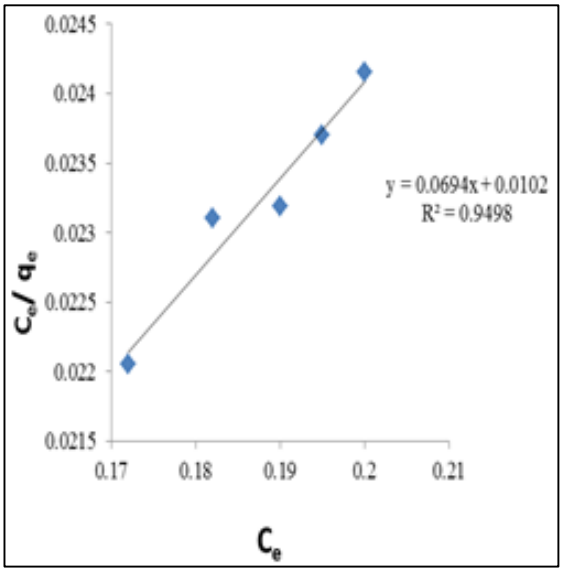

Fig 10

Fig (ix) and (x) represents the Langmuir adsorption isotherm. The correlation coefficient value of NBC is more when compared with NBC. The linear plot of C_e/q_e Vs C_e shows that the adsorption obeys Langmuir model. The two isotherm plots for the adsorbent systems are found to be linear with correlation coefficient close to unity. On the basis of correlation coefficient, the system obeys Langmuir isotherm.

3.7 Kinetics of adsorption

Kinetics of adsorption is significant to decide the solid solution interphase and helps to determine the rate of adsorption process. There is found to be linear for Ni solution on CAC and NBC under different condition.

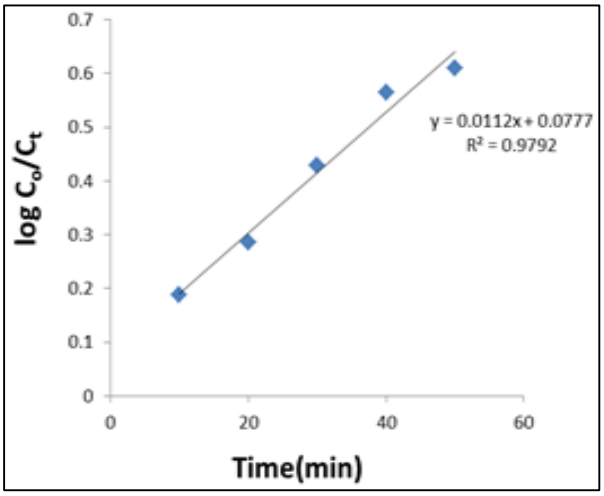

Fig 11

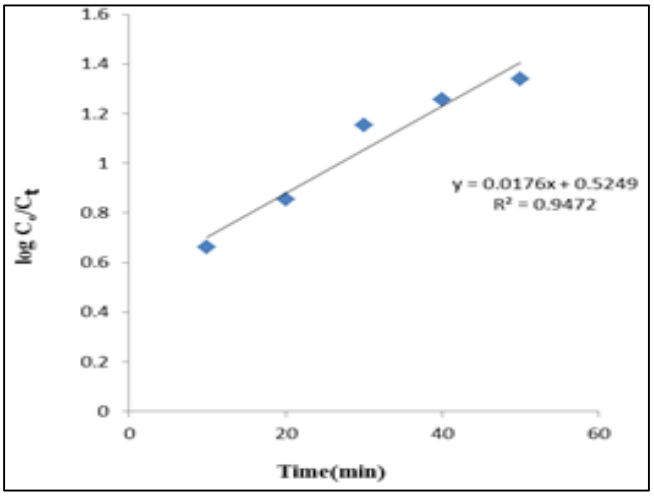

Fig 12

The correlation coefficient values for Natarajan- Khalaf equation for the adsorption of metal ion over CAC and NBC are close to unity.

3.8 Lagergran equation for the removal of ni (ii) ions

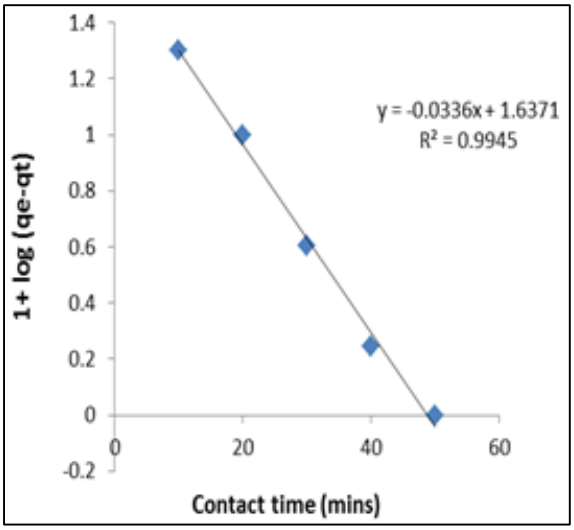

Fig 13

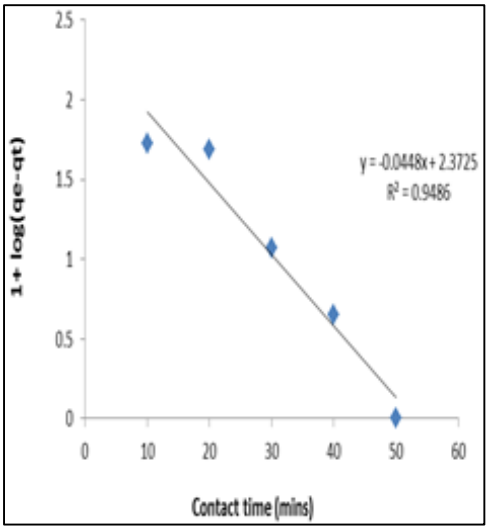

Fig 14

Among the two kinetics, on the basis of correlation coefficient values it is clear that Lagergran equation is followed by the NBC system.

4. Conclusion

Bio-sorption is an effective and versatile method and can be easily adopted in low cost to remove heavy metals from waste water.

In the present study an attempt has been made to study the feasibility of Azadiracta indica barks waste, a cheap, locally and easily available for the adsorption of metal ions. The data shows the maximum removal of Ni (II) metal ions from its aqueous solution.

The experimental data reveals the following features of Azadiracta indica barks waste in adsorbing Ni (II) metal ions. The activated carbon of neem bark powder was capable of removing Ni (II) ion from the aqueous solution. pH plays a significant role in the adsorption of metal ions. This indicates the adsorption process is pH dependent. The percentage removal of Ni (II) increased with the decreased in initial concentration and pH, increase in dose of adsorbent and contact time. Adsorption data obeyed Langmuir adsorption isotherms. On the basis of correlation coefficient values it is clear that Lagergran equation is followed by the NBC system. The low cost adsorbent performance is well in removing heavy metals and also environment.

5. References

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