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Adsorption Study on Zinc (II) ions from Aqueous solution using Chemically Activated Fruit of *Kigelia Pinnata* (JACQ) DC carbon

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Abstract

In recent years, the preparation of low cost adsorbents as an alternative for the removal of toxic heavy metals from the waste water. Now a days, various natural adsorbent have been used by many researchers as a cheaper method for the treatment of water. The toxic heavy metals are released in the environment; due to rapid industrialization and urbanization possess a great threat to environment. Adsorption is an effective technique for the removal of heavy metals from the aqueous solutions. In this work adsorbent is prepared chemically from the fruit of Kigelia pinnata as a measure to control the environmental pollution. The studies are carried out to remove the Zinc (II) ions from the aqueous solutions The chemically activated carbon was characterized using standard American Standard Testing Methods. (ASTM). Adsorption studies were performed by batch experiments showed that the adsorbent prepared from the fruit of Kigelia pinnata (KP) has a good capacity of adsorption of Zinc (II) ions from aqueous solution. The parameters study includes contact time, adsorbent dosage, initial concentration, and pH. The adsorption of zinc ions was tested with Langmuir and Freundlich isotherm models.

Keywords: Zinc, Kigelia pinnata, adsorbent, adsorption, adsorption isotherms.

Introduction

Many industries releases Heavy metals into the environment indiscriminately, affect the entire living organism. The toxic heavy metals accumulate in the living organism which are non-biodegradable causes various disorders[1,2]. Zinc is an essential element for the living beings when it is in micro levels, if it exceeds the permissible limit it causes a serious threat to human beings like vomiting, fever, cough, fatigue, dehydration anemia, and even causes damage to lungs, pancreas etc[3]. The World Health Organization stated a legal limit of Zinc in drinking water is 5 mg /L[4].

The heavy metals removal from the waste water is an important global issue[5]. Adsorption is the effective method for the removal of heavy metals even in very low concentration present in the water[6]. In this study low cost chemically activated carbon was used as an adsorbent prepared from the fruit of Kigelia pinnata to remove the Zinc from the aqueous solution by adsorption. The percentage removal of Zinc using activated carbon was studied by batch mode experiments at different contact time, adsorbent dosage, initial concentration, and pH. Langmuir and Freundlich adsorption Isotherms were used to study the adsorption capacity.

Material and Methods

Adsorbent: Preparation of activated carbon: In this present study, Kigelia pinnata fruit (figure-1) was used as a adsorbent for the removal of Zn (II) ions from aqueous solutions. Kigelia pinnata fruits were collected and washed with distilled water. The fruit was cut into small pieces and dried in sunlight for two weeks. The dried pieces were grounded into a very fine powder in a machine to increase the surface area. The finely powdered material was chemically activated by treating with the calculated amount of 98% concentrated Sulphuric acid and kept aside for 12 hours until all the fumes escapes. The acid treated material was kept in a hot air oven for 5 hrs, and then cooled. The carbonized material obtained was washed with double distilled water for several times until the excess of acid is removed. The chemically activated carbon was dried in hot air oven for 8 hours at 105°C until it dried. The prepared activated carbon was grounded well and sieved. The chemically activated carbon, of less than 0.5 mm (mesh size of 250 µm) were put in an air tight bottle for further use as an adsorbent in batch studies.

Figure-1
***Kigellia pinnate powder* (fruit)**

Figure-2
***Kigellia pinnate Activated Carbon* (fruit)**

Adsorbate: Synthetic solutions of 1000ppm were prepared by dissolving 0.4404 g of analytical grade (Merck) $ZnSO_4.7H_2O$ and 5ml of 1:1 HNO_3 using distilled water. The required concentrations of the solution for experiments were made from the synthetic stock solution. It was mixed with required amount of activated carbon for the study.

Adsorbent characterization: Scanning electron microscope (SEM) machine was employed to check the surface morphology of activated carbon.

Table-1
Characteristics of Adsorbent

Characteristics	Values
Moisture content (%)	7.9
Ash content (%)	1.60
Volatile matter (%)	25.14
Fixed carbon (%)	65.36
pH	4.05 (ASTM D 3838-80)
Conductivity(200µs)	175.

Adsorption experiment: The adsorption process was taken place in a magnetic stirrer, at regular interval of time after equilibrium was achieved the solution was filtered with what man paper No 42. The filtrate was analyzed complexo metrically, to evaluate the concentration of Zinc (II) ions in the supernatant solution.

The calculation for the percentage removal of Zinc from the aqueous solution was done according to the equation:

% removal = $Ci - Cf/\ Ci \times 100$ Where C_i (mg/L) the initial concentration (before adsorption), Cf (mg/L) the final concentration (after adsorption).

The l adsorption of metal was calculated according to the following equation:
$qe\ =\ (Ci - Cf)V\ /\ 1000\ W$.

Where qe (mg/g) is the adsorption capacity. V(L) is the volume of solution taken at time t, and W(g) is the adsorbent dosage, C*i* and *Cf* are the initial and final equilibrium concentration.

To study the extent of adsorption by adsorbent dosage, the experiments were conducted in different dosages from 0.05 to 0 .5 g. the effect of initial concentration of zinc(II) from 10 to 60 mg/L and the pH of the solution various from 2 to 8 solution, pH was adjusted using 0.1M HCl and 0.01M NaOH solutions. The adsorption isotherm experiments were conducted at room temperature with the concentration of 50mg/L[6]. and pH 6.0and dosage of 500mg.

Adsorption isotherms: Adsorption isotherms give the study of adsorption capacity of the adsorbent and describe the relationships between adsorbent and adsorbate concentration at the fixed temperature. Langmuir and Freundlich adsorption isotherms are used to describes the relationships of adsorption equation, it is used to assess the correlation of the experimental data[7].

Langmuir Model: The Langmuir equation is the simplest isotherm model. This model based on the formation of monolayer of adsorb ate on the adsorbent surface, and thereafter adsorption does not take place because of saturation is achieved[8].The Langmuir equation represented by the expression

$$Ce/qe\ =1/Qob\ +Ce/Qo\ .$$

Where, Ce = equilibrium concentration (mg/L), qe = the equilibrium amount at time per unit adsorbent (mg/g). b and Qo are Langmuir constants. The graph is plotted between Ce/Qe Vs Ce from the slope and intercept, constants are calculated.

Freundlich Model: The data has been used for analyzing the Freundlich isotherm an empirical method by the following equation[9].

$$\log qe\ =\ \log K\ \ +\ \ 1/n \log Ce\ .$$

Where *qe* = amount of metal ion adsorbed, (mg/g) *Ce* = equilibrium concentration of adsorb ate (L).The graph is plotted between *log qe* Vs *log Ce* from the intercept and slope K and n was found out. K is the Freundlich adsorption capacity constant and n is the Freundlich adsorption intensity constant are calculated.

Results and Discussion

Effect of contact time: The effect of contact time plays an important role irrespective of the other experimental parameters in adsorption system. Figure-4 depicts that there was an appreciable increase in percentage removal of Zinc up to 60 min. thereafter further increase in contact time the removal of zinc was very small (at 75 min)represented the formation of monolayer of Zinc on adsorbent and equilibrium was achieved. Thus the effective contact time (equilibrium time) taken as 60 min under the particular condition is 78% and it is independent of initial concentration (60ppm). The adsorption of heavy metal ion increases as time increases the same is recorded[10, 11].

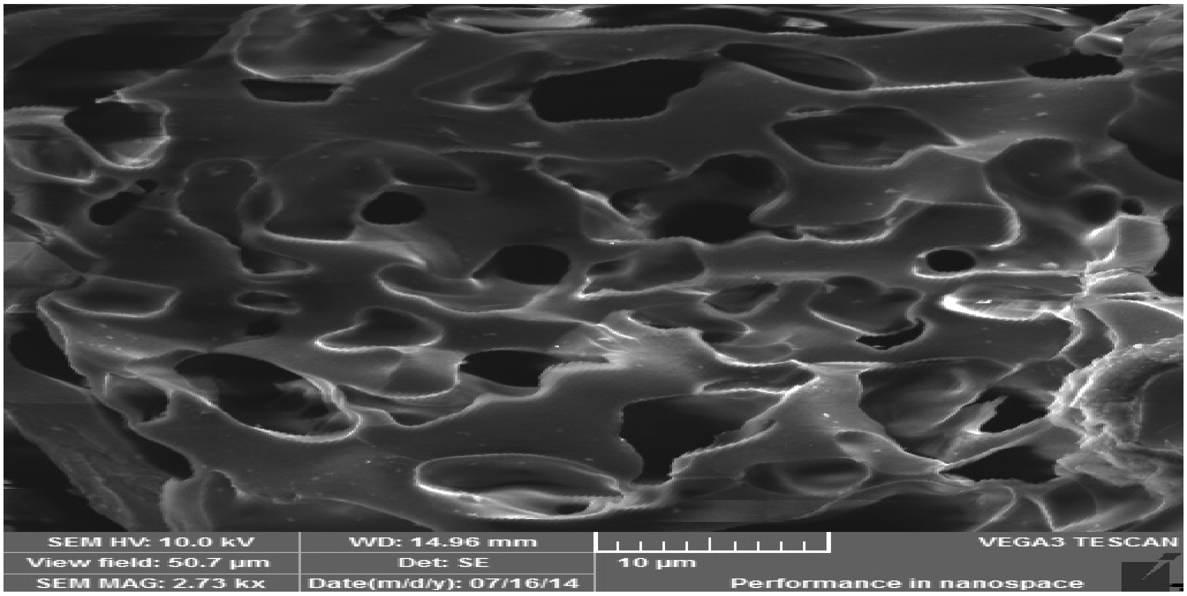

Figure-3
The SEM image shows that the activated carbon surfaces are porous

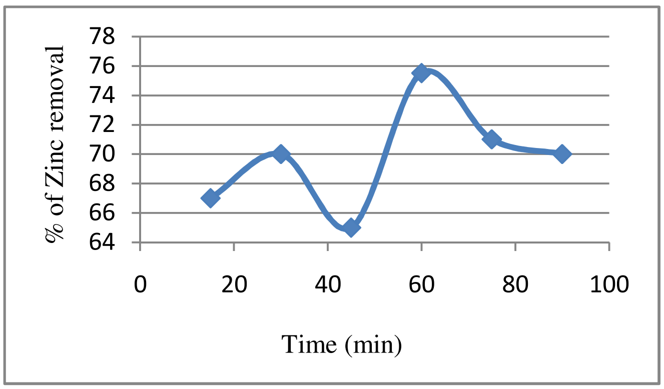

Figure-4
Effect of contact time

Effect of adsorbent dosage: the adsorption of Zinc by activated carbon at different dosages 50mg to 600 mg for the zinc concentration is investigated. The figure-5 showed that the removal of zinc increases due to the greater availability of adsorbent with the increase in dosage of adsorbent up to 500mg. The removal percentage from 60 –84% acquired by the increase of adsorbent dosage up to 500mg and thereafter increase of dosage, the removal of zinc is very small, due to the saturation of adsorption sites. Thus the effective dosage is taken as 500mg. The adsorbent dosage increases the adsorption capacity because of more surface area; the report was same[12,13].

Effect of initial concentration: The initial concentration of zinc provides and important forces to overcome all mass transfer resistance of metal ions between the aqueous and solid phases[14] (figure-6). The concentration of zinc (II) increases from 5mg/l to 300 mg/L, the removal of zinc adsorption decreased from 95% to 45.5%.The curve was constant after 50mg/L shown that the availability of adsorption sites were saturated. Increasing uptake of zinc ion in the solution by the chemically activated carbon is mainly due to the availability of adsorbent sites up to 50mg/L by increasing the concentration above 300mg/L there is no increase in uptake of zinc by adsorbent. It forms a layer there is no sites existing further[15].

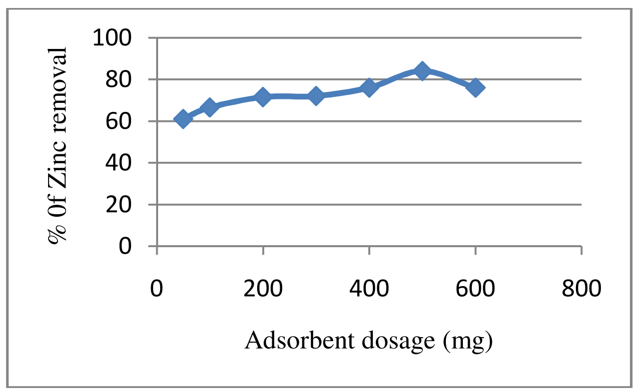

Figure-5
Adsorbent dosage

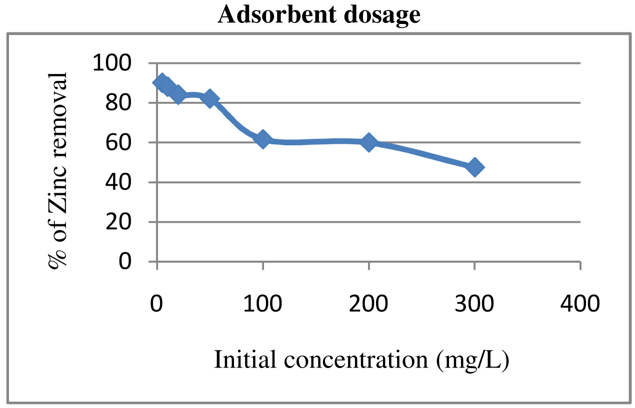

Figure-6
Effect of initial concentration

Effect of pH: The pH of the solutions is greatly affected for the removal of Zinc (II) from the aqueous solutions. The removal of Zinc (II) increases from 60% at pH2 to 75.6% at pH6. Figure-7 Zinc adsorption is noted to be maximum at pH 6 with 7 5.6% respectively. After that the adsorption capacity decreases from 6 to 9. The adsorption at pH2 observed low due to the higher concentration and mobility of [H^+] ions present, therefore Zinc (II) ions adsorption is less at lower pH the presence of hydronium ions on the surface of adsorbent prevents the metal ion binding[16,17]. At lower pH the adsorbent surface becomes more positively charged and the electrostatic force of attraction between the adsorbent and metal ion reduced. At pH6 there is a decrease in the adsorption capacity .This is due to the precipitation of zinc .The pH has significant effect on metal adsorption from the aqueous solution[13].

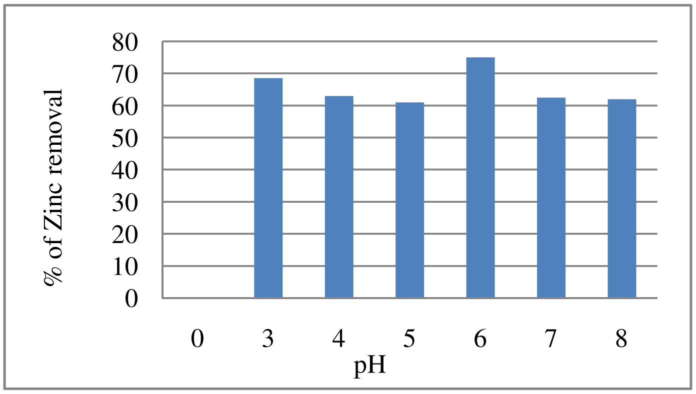

Figure-7
Effect of pH

Adsorption isotherm Models: Isotherms models give the mathematical relationship used to describe the adsorbent and adsorb ate adsorption behaviors and adsorption capacity[18]. Langmuir adsorption isotherm linear form equation were applied and the graph was plotted between values Ce/Qe Vs Ce shows the capacity and energy of adsorption. Figure-8 shows that the linearity is due to the monolayer formation of metal ion on the adsorbent surface[19]. The linearity can be seen from the graph the zinc adsorption is best represented by Langmuir isotherm (highest R^2 value). The Freundlich isotherm is empirical and heterogeneous layer is formed by plotting the graph the values log Qe Vs log Ce. Figure-9 gives the slope and intercept. The correlation coefficient for Freundllich isotherm R^2= 0.965 and Langmuir isotherm R^2=0.993 are nearly equal Therefore present investigation found to be fitted well with these equations[20].

Conclusion

The chemically prepared activated carbon from kigelia pinnata is used as a potential adsorbent for the adsorption of Zn (II) from the industrial waste water. The condition for the removal of Zinc obtained from this study are the required contact time is maximum of 60 minutes, at the concentration of 50 mg/L and the dosage of adsorbent is 500 mg/L. at pH 6. The adsorption capacity of prepared carbon is found to be maximum 84 % of Zinc .Langmuir and Freundlich isotherms models were significant correlation with adsorption equilibrium data.

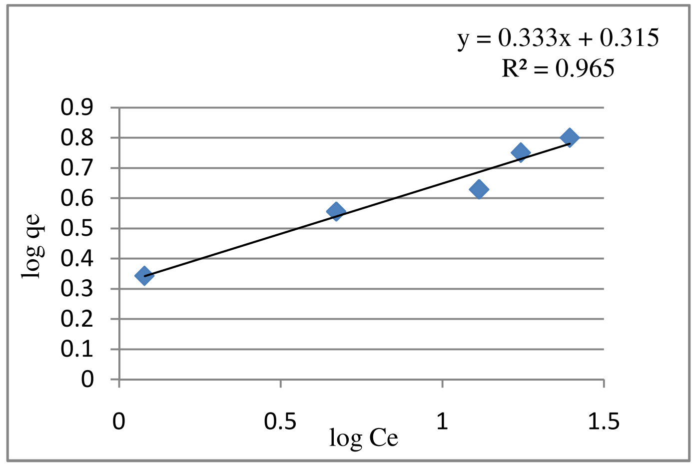

Figure-8
Freundlich isotherm

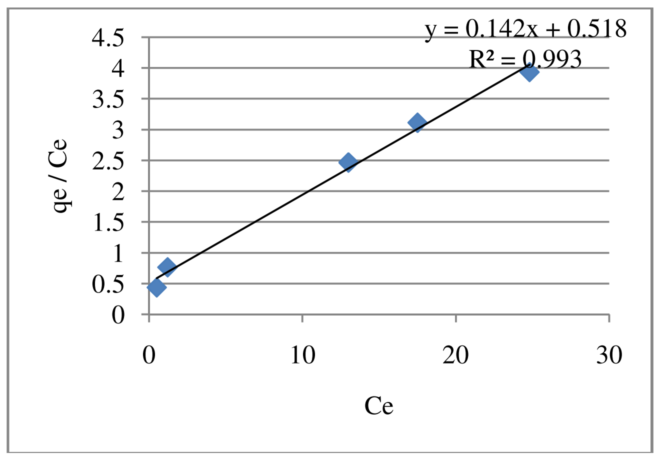

Figure-9
Langmuir isotherm

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