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Ferronia elefuntum Fruit Shell: A Carrier for Scavenging the Zinc from Aqueous Solution

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ABSTRACT

The studies on removal of Zinc were conducted using *Ferronia elefuntum* Fruit shell. Adsorption efficiency has been evaluated. The effect of pH, contact time adsorbent dose, concentration of metal, particle size and temperature were studied. The results reveals that Langmuir and Freundlich isotherms are followed during adsorption process. Thermodynamics parameter indicate the feasibility of the process. Kinetic studies have been performed to understand the mechanism of adsorption.

Key words: Pentavalent Zinc, Adsorption, Langmuir and Freundlich isotherm, *Ferronia elefuntum* Fruit Shell.

INTRODUCTION

The Twentieth century started with an extensive damage to the natural resources[1]. Unplanned industrialization, urbanization, pollution explosion change in life-style, over exploitation of natural resources, commercial establishment and modern agricultural practices have degraded the quality of environment. The main effects being faced are:

- Continental invasion of air and water
- Marine pollution through waste discharges.
- Release of variety of chemical and biological contaminants into the water bodies, on land and in air.
- Ground water pollution.
- Acid rains and nuclear fallout.

These effect are not only covering the pollution of environment but also are responsible in creating genetic erosion in plant, animals including human beings and microorganisms. Water is a prime natural resource and is a basic human need. The availability of adequate water supply in terms of its quality and quality is essential for the existence of life.

Water is available in nature as surface water and ground water through the self purification mechanisms like physicals, chemical and microbiological process at natural bodies, are carried out in nature. However, natural water is rarely suitable for direct consumption to human beings. Rapid industrilization and population growth resulted to generation of large quantities of wastewater and causing problem of their disposal. Industiral water consistutes the major source of various kinds of metal pollution in water. The presence of heavy metals in the environment has been of great concern because of their increased discharge, toxic nature and other adverse effects on the receiving streams. When the concentration of toxic metal ions exceed tolerance limit, they may become real health concern[2]. There is an immediate need to introduce cleaner technologies to minimize the pollution and to protect the degrading environment. It is not possible to achieve zero waste discharge but is is an essential to treat the waste.

Among the toxic heavy metal ion which present in potential health hazard to aquatic animals and human like Pb, Cd, Cr, V, Bi and Mn are important.

The maximum tolerance limit for Zinc (II) for public water supply are 10 mg/L. Toxicity of metal depends on the type of metal, does and the ionic form. Toxicity of Zinc[3] and its salt include rhinitis, blood dischards, an itching and burning sensations in the throat dry cough with small amount of vicid sputum, general weakness. The modrrate toxicity include respiratory tract infections bronchitic, bronchopneumonia, Disorder of the nervous system and tremor of the finger and hands. In animals, it affect the kidney nervous respiratory cordiovaschular and immune system.

Literature survey reveals that, there are many methods namely coagulation, precipitaiton, ion exchange and adsorption, for removal of Zinc (II) metal ions from aqueous medium. However, adsorption is an easy economical process for removal and retrieval of cation from aqueous medium. Efficiency of adsorption process mainly depends on nature of absorbent, absorbate, ph, concentration, temperature, time of agitation etc.

These cheap and efficient absorbents can carry to cater the need of population in the rural areas and the population in the idustrial area where safe drinking water is not available. In the present study, Zinc (II) is removed by using Ferronia Elefuntum.

Absorbent

The Ferronia Elefuntum Fruit Shell was first dried at a temperature of 160°C for 6 hours. After grinding it was sieved to obtain average particle size of 200 mesh. It was then washed several times with distilled water to remove dust and other impurities. Finally it was dried again in an oven at 50°C for 6 hours. The adsorbent was then stored in desiccator for final studies.

Batch Study

The dried amount of 0.5 gms of Ferronia Fruit Shell was taken in 250 ml reagent bottle and synthetic solution (200 ml) containing various concentration of Zinc (II) ion was added and system is equilibrated by shaking the contents of the flask at room temperature so that adequate time of contact between adsorbent and final concentration of metal ion. Zinc (II) was determined by spectrophotometry (9) using Xylenol Orange method. The spectrophotometer, systronic (model 104) was used to measure the concentration of Zinc (II) ions.

Adsorptions isotherm

Equilibrium adsorption for C_e verses q_e, plotted for Ferronia Elefuntum Fruit Shell are shown in figure 1. The adsorption capacity in mg/L was calculated then the equation.

$$q_e = (C_o - C_e)\ V/M$$

Where

C_o is the initial concentration of Zinc (V)

C_e is the concentration at equilibrium in mg/L

V is the volume of solution in litre and

M is the mass of adsorbent in grams.

Equilibrium isotherms was studied for both Langmuir and Freundlich isotherm. The results are shown in figure 2 and 3 which, illustrate the plot of Langmuir and Freundlich isotherms of Ferronia Elefuntum Fruit Shell of Zinc (II). The saturated monolayer can be represented by:

$$q_e = \frac{Q_o - bC_e}{1 + bC_e}$$

The linearised form of the Langmuir isotherms is

$$\frac{1}{q_e} = \frac{1}{Q_e b} \times \frac{1}{C_e} + \frac{1}{Q_o}$$

Where Q_o and b are Langmuir constants. The plot of $1/C_e$ Vs $1/q_e$ was found to be linear, indicating the applicability of Langmuir model. The parameters Q_o and b have been calculated and presented in Table 1. The langmuir constant Q_o is a measure of adsorption capacity and b is the measure of energy of adsorption is favourable or not, a dimentionless parameter 'R' obtained from Langmuir isotherm is.

$$R = (1+bx\ Cm)^{-1}$$

Where b is Langmuir constant and Cm is maximum concentration used in the Langmuir isotherm. The adsorption of Zinc (II) on Ferronia Elefuntum Fruit Shell is a favourable process as "R" values lie between zero to one. Coefficients of co-relation (R) are also shown in table 1. The applicability of Freundlich isotherm was also tried using the following general equation.

$$q_e = k.C_e^B$$

linearised form of this equation is

$$\log\ q_e = B.\log\ C_e + \log\ k$$

Where B and k are Freundlich constants. These constants represent the adsorption capacity and the adsorption intensity respectively.

Plot of log q_e Vs log C_e was also found to be linear. The values of B and k are presented in Table 1. Since the value of B are less than 1, it indicates favourable adsorption.

RESULTS AND DISCUSSION

Effect of concentration of metal ion and contact time

The response of Adsorbate dose and contact time on the remvoal of Zinc (II) is presented in figure (I). The observations reveal that an increase in the adsorbate dose, rate of adsorption increase up to certain level and then it become constant. Also at the time of contact increase, adsorption increase and then it become constants.

Effect of pH on the removal of Zinc (II)

The effect of pH on the removal of Zinc (II) is shown in figure 4. Experiment were conducted at the constant initial Zinc (II) concentration, adsorbent dose (Ferronia Elefuntum Fruit Shell) of 0.5 gm/100 ml and the contact time of 4 hours. The pH of the aqueous solution is an important controlling parameter in the adsorption process. It was observed that the percentage removal of Zinc (II) is higher at pH = 2 and then decrease with increase o pH.

Effect of particle size

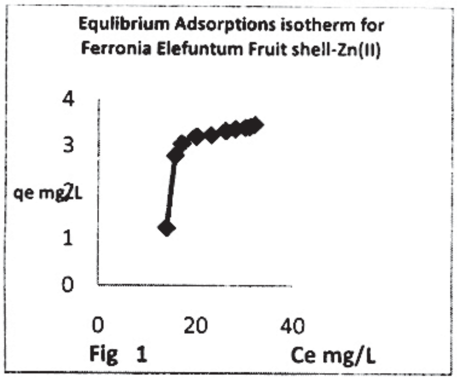
The adosrption particle size has significant influence on the kinetics of adsorption. The influence of particle size furnishes important information for achieving optimum utilization of adsorbent. Four particle size 50, 100, 150, 200 micron size (Indian Standard Services) under optimum condition. It is found that, as the particle size increase the rate of adsorption decrease.

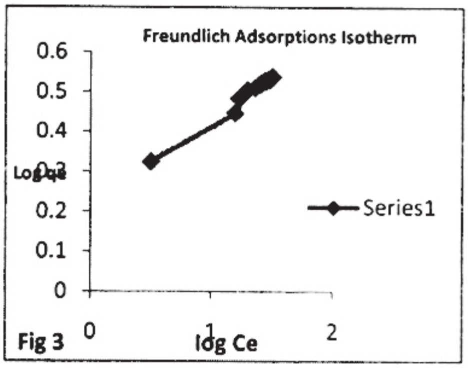
Kinetics of Adsorption

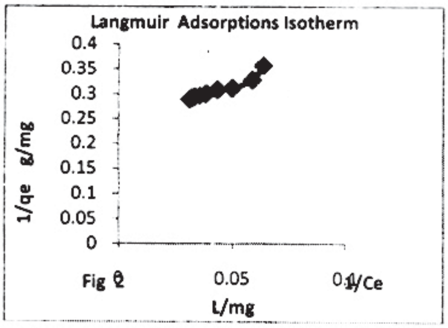
0.5 gm of Ferronia Elefuntum Fruit Shell and 200 ml Zn^{++} solution was taken in 1000 ml R.B. and shake vigorously for about four hours. After every 15 minutes, 5 ml sample of the solution was withdrawn for the first hour and subsequently the interval between the sample withdrawn and

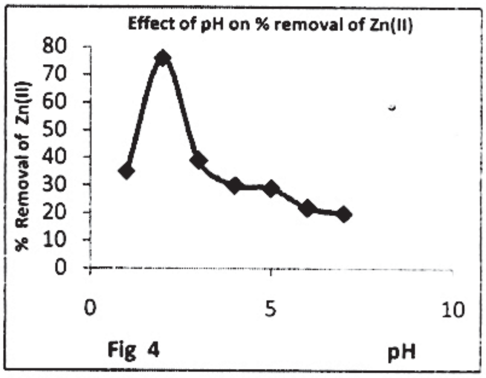
Table 1: Isothermal constants

Langmuir constants				Freundich constants		
Q_o	b	r	R^2	K	B	R^2
4.957	0.52	0.38	0.998	0.5348	0.4528	0.9878


Equlibrium Adsorptions isotherm for
Ferronia Elefuntum Fruit shell-Zn(II)
4
3
1
0
0
20
40
Fig 1
Ce mg/L


Freundlich Adsorptions Isotherm
0.6
0.5
0.4
0.2
0.1
0
Series1
Fig 3
0
2
log Ce


Langmuir Adsorptions Isotherm
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/qe g/mg
0.05
L/mg


Effect of pH on % removal of Zn(II)
80
70
60
50
40
30
20
10
0
% Removal of Zn(II)
0
5
10
Fig 4
pH

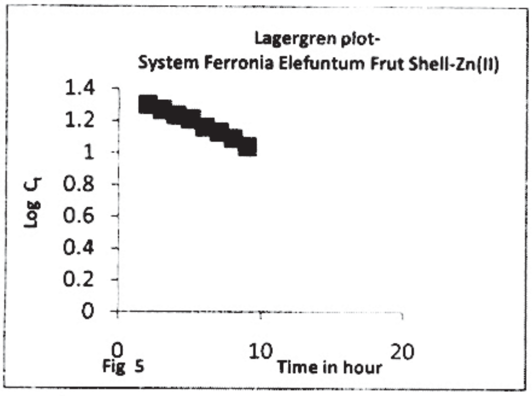

Lagergren plot-
System Ferronia Elefuntum Frut Shell-Zn(II)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
10
20
Fig 5
Time in hour

Fig.

increased to 30 minutes. The concentration of the metal ions in the sample, withdrawn were determined by the spectrophotometry and were designated as Ct and the value of the concentration of the metal ion on the Ferronia Elefuntum Fruit Shell at the same time interval estimated using the relation.

$$q=(C_o-C_t)V/W$$

The rate of adsorption of Zinc (II) on Ferronia Elefuntum Fruit Shell was studied by using the first order reate equation proposed by Lagergren (10).

$$\text{Log } C_t = \text{Log } C_o - \frac{K_{ad}}{2.303} t$$

$$K_{ad} = \frac{2.303}{T} \text{Log } C_o/C_t$$

Where, K_{ad} is the constant for adsorption.
The plot of log Ct Vs t is shown in figure 5.

CONCLUSION

The following conclusion have been drawn from the present study

1. The percentage retrievel of Zinc (II) is formed to be increase with decrease the intitial concentration of Zinc (II). The removal is found rapid in initial stages followed by slow adsorption upto saturation limit.
2. The developed technique of retrieval of Zinc (II) isons using Ferronia Elefuntum Fruit Shell appears to be a cheap and practically viable for the use of semiskilled worker in the villages.
3. The present work on adsorption process is in good agreenment with Langmuir isotherm indicating monolayer adsorption process.
4. The result on adsorption process reveal that at pH = 2.0, zinc (II) uptake capacity is better.
5. The straight lines plots of log C_t vs t for the adsorption show the validity of Lagergren equation and suggest the first order kinetics.
6. Regeneration studies are not necessary with the view that the cost of adsorbent is very low and it can be disposed of safely.

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