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ADSORPTION AND MODELING STUDIES OF HEAVY METAL Zn (II) USING FULLER'S EARTH, LATERITE SOIL AND BLACK COTTON SOIL AS ADSORBENTS

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Abstract - This work focuses on removal of Zinc (II) from its prepared synthetic sample using Fuller's earth, Laterite soil and Black cotton soil as Adsorbents. Effect of contact time, adsorbent dosage and pH on Zinc (II) removal was found out. All the three adsorbents were found to be very effective for Zinc (II) adsorption It was found that 70 min contact time at pH 4 and 800mg adsorbent dosage was sufficient for approximately 79 % removal by fuller's earth, similarly 70 % removal by laterite soil and 71 % by black cotton soil. At different contact time, dosage and pH, batch adsorption studies were conducted.

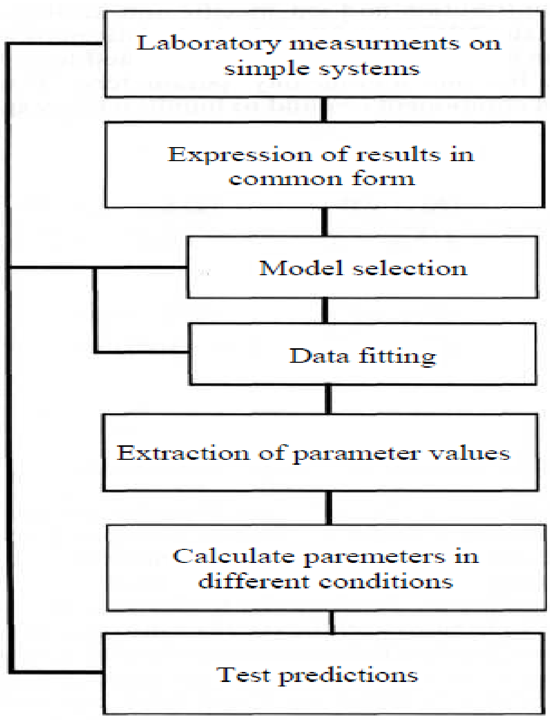
***Key Words*: Zinc (II) Fuller's earth, Laterite soil, Black Cotton soil and Adsorption**

1. INTRODUCTION

Clean environment and beautiful nature is a gift of god to mankind. But due to rapid growth of industrialization, urbanization, all over the world coupled with population explosion have resulted in pollution of environment. The air we breathe, the water we drink, the food we consume have been polluted remarkably by the heavy metals, which are the by product of various industries. Process waste streams from the mining operations, metal plating facilities, Basic non-ferrous metal waste foundries. Zinc is frequently used in industrial processes such as metal plating industries, galvanizing industries, mining operations and tanneries and are usually present in high concentrations in the liquid wastes which are released directly into the environment without any pre-treatment.

Zinc is an essential and beneficial element for human growth. Concentration above 5mg/L can cause a bitter astringent taste in water. The zinc concentration in water varies from 0.06 to 7.0 mg/L with a mean concentration of 1.33mg/L Zinc most commonly enters the domestic water supply from deterioration of galvanized iron and dezincification of brass. Zinc in water also may result from industrial waste pollution. The (Food and Agricultural Organization) FAO recommended maximum level for zinc in irrigation water is 2mg/L. The (United StatesEnvironmental Protection Agency) US EPA primary drinking water standard is 5 mg/L.

1.1 THE MODELLING CYCLE



1.2 ADSORPTION

Adsorption is one of the effective methods for removing heavy metals from waste water. But the standard adsorbents like silica gel etc are costly. So low cost adsorbents i.e. Fuller's earth, Laterite soil and Black cotton soil which are easily available and can serve as an economically available alternative. Adsorption is a separation process in which the molecules of a fluid phase, i.e. gas or liquid are transferred to a solid surface. Therefore, the composition of the system is heterogeneous consisting of two or more fluid phases including the solid adsorbent. Molecules that have been adsorbed onto solid surfaces are referred to as adsorbate, and the surfaces to which they are adsorbed are referred to as the substrate or adsorbent. Adsorption takes place in the boundary between the phases called the interface.

1.3 Objective of the study

To evaluate a feasible and economical low-cost treatment of heavy metal, as present in synthetic sample by Fuller's earth laterite soil and black cotton soil which are naturally available as an adsorbent.
The present study has been carried out according to the guidelines as follows
1) To study the physico-chemical characteristics of fuller's earth, laterite soil and black cotton soil
2) Removal efficiency of adsorbents as a function of contact time, adsorbent dosage and pH.
3) For predicting the dynamic response of the fixed-bed column, a mechanistic model will be developed. Determination of parameters in various models for adsorption/chemisorption of during purification water by curve fitting method.
4) The model will be solved on software and will allow the comparison of the experimental results with the simulation predictions.

2. Materials and Methodology

Fuller's Earth:
It is a clay material that has the capability to decolorize oil or other liquids without chemical treatment. Fuller's earth typically consists of Attapulgite or Bentonite. Modern uses of fuller's earth include absorbents for oil, grease, and animal waste (cat litter) and as a carrier for pesticides and fertilizers. Minor uses include filtering, clarifying, and decolorizing; active and inactive ingredient in beauty products; and as a filler in paint, plaster, adhesives, and pharmaceuticals as shown in the below fig1.

Fig1. Fuller's earth

Laterite soil: Laterites are soil rich in iron and aluminum, formed in hot and wet tropical areas. Naturally all laterites are rusty red as shown in the fig 2 in powdered form respectively. It's mainly because of iron oxides. They develop by intensive and long-lasting weathering of the underlying parent rock.

Tropical weathering (laterization) is a prolonged process of mechanical and chemical weathering which produces a wide variety in the thickness, grade, chemistry and ore mineralogy of the resulting soils.

Fig 2 Laterite soil

Black cotton soil:
Generally, black cotton soil is found in the central, western and southern states of India, including
Karnataka. Black cotton soil is one of major soil deposits of India. Black soil in India is rich in metals such as Iron, Magnesium and Aluminum. However, it is deficient in Nitrogen, Potassium, Phosphorous and Humus. As shown in the below fig 3 in powdered form respectively.

Fig 3 Black cotton soil

The Physico-chemical Characteristics of the adsorbents is described in the table 1

Table 1: Physico-chemical Characteristics of the adsorbents

Sl. No.	CHARACTERISTICS	UNITS	FULLER'S EARTH	LATERITE	BLACK COTTON SOIL
1	Moisture Content	%	2.22	3.44	5.86
2	Decolorizing Power	mL /g	13.5	18	21
3	pH values	- - -	7.8	7.6	7.1
4	Specific Gravity	- - -	1.88	2.40	2.54
5	Surface Area	m2 /g	750	453	520
6	Bulk Density	g/c	0.923	1.140	1.105

		c			
7	Color	- - -	Light gray	Red	Black

2.1 Preparation of Synthetic Zinc (II) Solution

A. Stock Zinc solution:

Dissolve 1000 mg (1g) zinc metal in 10mL 1 + 1HNO3. Dilute and boil to expel oxides of nitrogen. Dilute to 1000 mL; 1mL = 1mg Zn.

Standard zinc solution: Dilute 10mL stock zinc solution to 100 mL with water; 1 mL =10μg Zn.

B. Equipment's

All the glass wares used in the experimental work were soaked overnight in a 10mg/L of zinc (II) solution to minimize the possibility of zinc being adsorbed on glass surface during the experimental work. The excess of zinc is washed off with 1:3 HNO3 and distilled water prior to use. After completion of the experimental work the glassware is soaked in 1:3 HNO3 followed by distilled water for 4hrs to remove excess zinc and then washed with tap water before soaking in 10mg/L of zinc (II) solution.

C. Procedure

Determining the micrograms per liter of dissolved or total recoverable zinc in each sample from the digital display or printer output while aspirating each sample. Dilution of samples whose zinc concentrations exceed the working range of the method and multiplying by the proper dilution factor. The concentration of zinc present in the sample is directly displayed on computer's screen which is connected to AAS. Also, the results are compared by the calibration curve prepared.

D. Selection of Optimum Contact Time

The adsorption is strongly influenced by the contact time, for the study of effect of contact time 100mL of 10mg/L Zinc (II) solutions is mixed with 1gm of adsorbents and stirred on Gyro shaker for various time interval such as 10,20,30,40,50,60,70,80,90,100,110,120 min. The samples are filtered and analysed for remaining Zn (II) concentrations.

E. Determination of Optimum pH

To determine the optimum pH series of conical flasks were taken with 100 mL of 10 mg/L Zn (II) solutions. Optimum dosage of adsorbents is added to the respective flasks. The pH of the flasks is adjusted ranging from 2,3,4,5,6,7,8.

The flasks were shaken for optimum contact time. After stirring, the samples are filtered and analyzed for the residual Zn (II) concentration. The flask containing Zn (II), which gives minimum residual concentration, is selected as the optimum pH.

3. Results and Discussion

Zinc (II) removal study has been carried out with respect to the following parameters

a) Effect of contact time
b) Effect of dosage
c) Effect of pH

a) Effect of Contact time

Contact time has greater influence in the adsorption process. The effect of contact time on removal of Zinc (II) from synthetic sample's by using all the three adsorbents. The graph for contact time is plotted as shown in the fig 5.

From the fig 3.1 it is evident that the extent of Zinc (II) adsorption increases with increase in time. After equilibrium further increase in time, adsorption is not changing. Hence, the removal efficiency on 'Zinc (II)' by using Fuller's Earth, Laterite soil and Black cotton soil is found to be 75 %, 65 % and 64 % with an optimum contact time of 70 mins, 80 mins and 90 mins respectively.

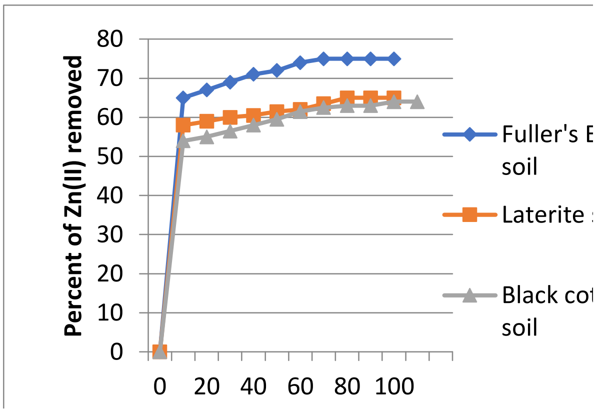


Chart 3.1: Effect Of Contact Time on Zn (II) Removal by Fuller's Earth, Laterite Soil and Black Cotton Soil

b) Effect of Adsorbent Dosage

Adsorption is a process in which continuous transfer of solute from solution to adsorbent occur, until residual concentration of solution maintains an equilibrium with that adsorbed by the surface of adsorbent at constant contact time. Effect of adsorbent dosage is studied and graph of percentage of Zinc(II) removed versus dosage is plotted as shown in fig.3.2. It is observed from the graph that as dosage increases amount of Zinc increases, sharply in the beginning and attains maximum latter. The point where maximum is attained is taken as optimum dosage. After attending optimum dosage, change in laterite soil dosage alter much in the beginning and remain constant after attending optimum dosage. Hence removal efficiency on 'Zinc (II)' by using Fuller's Earth, Laterite soil and Black cotton soil was found to be 76 %, 67.50 % and 71 % with an optimum dosage of 1000mg, 1200mg and 1200mg respectively.

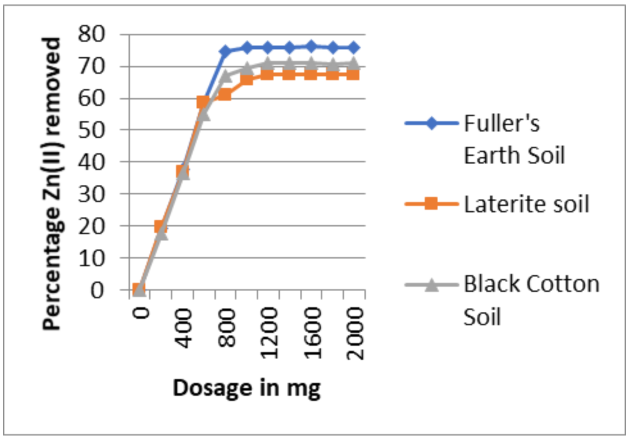


Chart 3.2 Effect of Adsorbent Dosage on Zn (II) Removal by Fuller's Earth, Laterite Soil and Black Cotton Soil.

Effect of pH

The pH of solution has influence on the extent of adsorption removal efficiencies of Zinc (II) by naturally available adsorbents at different pH values are shown in fig 3.3. The amount of Zn (II) removal not only depends on the surface area, optimum time and optimum dosage but also depends on pH. From the fig 3.3 it is observed that zinc (II) is removed more effectively in acidic range. The removal efficiency of zinc by using Fuller's earth, Laterite soil and Black cotton soil was found to be & 79%, and 70% & 71% with an optimum pH 4,5 and 5 respectively.

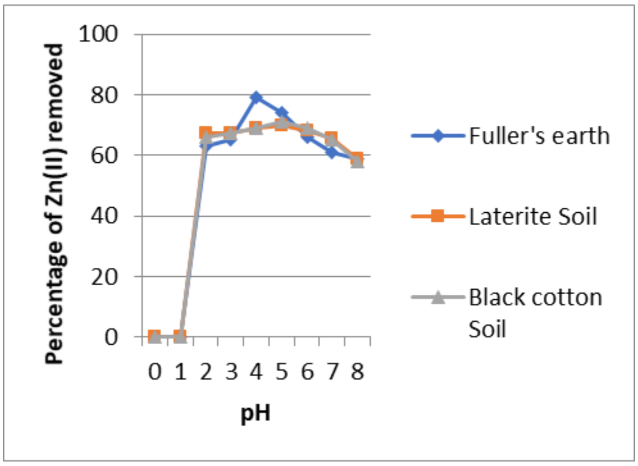


Chart 3.3 Effect Of pH On Zn (II) Removal by Fuller's Earth, Laterite Soil and Black Cotton Soil.

4. Conclusions:

Based on the experimental study following conclusions can be drawn

1) The statistical analysis by using fuller's earth shows good removal efficiency of Zinc (II) from synthetic solution compared with laterite soil and black cotton soil.

2) The adsorption of Zinc (II) is mainly pH dependent. The removal efficiency of adsorbent increases with decrease in pH value. It has been observed that maximum adsorption takes place in the acidic medium around pH 4.

3) The result of experiment on optimization of dosage of adsorbent reveals that, increase in amount of dosage added, increases the removal of Zinc (II) from the solution and almost becomes constant after saturation dose.

4) The adsorptive kinetics data were satisfactorily correlated with power function, simple Elovich and Olaofe's proposed equations using linear regression analysis. The Olaofe's proposed equation was found to have the best correlation with R^2 between 96-99% and the kinetics of Zn (II) adsorption on the local clays is the least when compared with other heavy metals.

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