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COMPARATIVE STUDY ON THE REMOVAL OF ZINC FROM SYNTHETIC WASTEWATER BY ACTIVATED SAW DUST AS AN ADSORBENT

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Abstract - *The present study was carried out to develop a cost effective adsorbent and to study the adsorption process for removal of heavy metal zinc. The industrial waste water contains highly toxic metal. The heavy metal such as zinc is of highly toxic and harmful for the living organisms. The adsorption is the one of the most popular method for the removal of zinc. The removal of zinc from waste water was investigated using sawdust as an adsorbent, was observed effects of various process parameters like adsorbent dosage, pH, contact time, initial zinc concentration was found. In these process two types of activation such as acid activation [H2SO4] and base activation [NaOH]. The present paper Optimum condition for removal of zinc was found adsorbent dosage 5 gm, pH 5, contact time 120 min with at 10ppm initial zinc concentration. The maximum removal efficiency of zinc ion by acid and base activated sawdust is 98.68% and 99.58%.*

Key Words: **Sawdust, Zinc, Adsorption, Freundlich isotherm model, Langmuir Isotherm Model.**

1.INTRODUCTION

The industrial wastewater is the one of the main source of environmental pollution and it contains different types of heavy metals can be found. The industries such as leather, textile, plating industry, tannery, petroleum refining industries, pigment and dyes, wood processing, paint (Neetesh Kumar Dehariya et al, 2018). Large amount of zinc exposures causes depression, lethargy, neurological sign and increased thirst, there are so many methods which is easily available for reducing the concentration of the heavy metal in the waste water. The different process of treating heavy metal such as precipitation with hydroxide, ion exchange, reverse osmosis, electro dialysis, oxidation, reduction and adsorption (Pragati et al, 2015).

The aim of this project is to optimize the zinc in the solution by adsorption process using naturally available low cost adsorbents. There are many low cost adsorbent materials available for the treatment of heavy metals. Myrtaceae Sawdust (Sadegh Ghasemi et al, 2014) for adsorption of Zn^+, Neem leaf (Reena Malik et al, 2012) for Biosorption of Zn^+, Mangifera Indica Peel (Thejeshwar Raju D et al, 2017) for adsorption of Zn^+, rice husk (Mohamed Hasnain Isa et al, 2014) for removal of Zn^+, rubber wood sawdust (C Raji et al, 2007) for removal of Pb, Hg, Zn, sawdust (Bulut Yasemin et al, 2007) for removal of Pb, Cd, Ni, Coconut shell (Jimoh A et al, 2007) for removal of Cu and Zn^+ from aqueous solution.

Sawdust is produce in large quantities and one of the important possible material produced at sawmill as a waste material. Sawdust is mainly consisting of primarily lignin, cellulose and hemicellulose, easily traps the impurities present in the waste water as a heavy metal ion. The main purpose in the use of sawdust as an adsorbent has been high removal efficiency of zinc in wastewater (Pragati et al, 2015).

Adsorption is the one of the best process of mass transfer operation and it is an essential process in physicochemical treatment of waste water. The 2 phase interface involves accumulation of substance like liquid-liquid, liquid-gas, liquid-solid is called process of adsorption. The substance which adsorbed in the adsorbate and the adsorbing material is termed adsorbent (Laxikant Pandey et al, 2015).

2. MATERIALS AND METHODOLOGY

2.1 Preparation of Adsorbents

A. Acid Activated Sawdust: [AASD]

Sawdust was collected and sun dried for 2 days. The collected sawdust was washed with tap water for 2-3 times to removal of dust and other pollution impurities, and finally washed with distilled water, later it was sun dried. The adsorbent was sieved to obtain a fraction of 150μm. activation of sawdust was carried out with concentrated sulphuric acid [H_2SO_4] and kept in a hot air oven, maintained at 105 °C for 24 hours. Later the char was washed a number of times to remove the acid content present in it. Then soaked overnight in 1% sodium bicarbonate to removal of residual acid, the soaked adsorbent washed with the distilled water. Finally, adsorbent was dried in a hot air oven at 150 °C for 24 hours before conducting the experiments.

B. Base Activated Sawdust: [BASD]

Sawdust was collected and sun dried for 2 days. The collected sawdust was washed with tap water for several times to removal of dust and other pollution impurities, and finally washed with distilled water, later it was sun dried. The adsorbent was sieved to obtain a fraction of 150μm.activation of sawdust was carried out with sodium hydroxide[NaOH] and kept in a hot air oven, maintained at 105 °C for 24 hours. Later the adsorbent was washed more than two times before using the experiments.

2.2 Preparation of Adsorbate

Zinc solution: - 4.40gm of $ZnSO4. 7H2O$ and dissolved it in 100ml water and mixed in 1 liter of volumetric flask and dissolved by shaking the solution. The concentration of the solution is 1000PPM.

2.3 Batch Adsorption Studies

The study of batch adsorption process on zinc removal was conducted considering four parameters. Parameters considered for the study were: adsorbent dosage, pH, contact time and initial concentration.in each trial one parameter was studied varying its values, while keeping other parameters kept constant. Detailed batch adsorption process as follows:

- In this experiment adsorbent dosage was varied as 1, 2, 3, 4 and 5gm. pH was varied as 1, 3, 5, 7 and 9. Contact time was varied as 30, 60, 90, 120 and 150 and initial zinc concentration of the solution was varied as 10, 50, 100, 250 and 500 mg/l. 100ml of diluted zinc sample was taken in 5 conical flasks and then labeled from 1 to 5 containing initial zinc concentration of 10 mg/l. Adsorbent is measured and then added to each beaker. The pH of sample was adjusted to optimum value of 5 using sulfuric acid and sodium hydroxide. All the samples were placed inside the rotary shaker were agitated 150rpm for 120 minutes. After the agitation samples from each conical flask were filtered to beaker using whatman filter paper. The filtered samples were then stored in bottle. Zinc concentrations of these filtered samples were find out using atomic absorption spectrophotometer.

3 RESULT AND DISCUSSIONS

3.1 Formula Used

The percentage of zinc ion removal from the sample is determined by using the formula is shown below.

$$\text{Metal Ion Removal (\%)} = \frac{Ci - Cf}{Ci} \times 100$$

Where, Ci (mg/l) = Initial Metal Ion Concentration in The Solution

Cf (mg/l) = Final Metal Ion Concentration in The Solution

3.2 Factor Effecting Adsorbent

3.2.1 Effect of Adsorbent dosage

The effect of adsorbent dosage on removal of zinc is shown in Fig. 1. The experiment is carried out by varying the adsorbent dosage from 1.0 to 5.0 gm by keeping pH, contact time, initial zinc concentration and also maintain 150 RPM constant. stirring the sample to mix the adsorbent correctly then sample is placed inside the shaker for 120minutes. The efficiency of zinc is increased on increasing adsorbent dosage. The maximum percentage of zinc removal was about 98.18% [AASD] and 98.96% [BASD] at adsorbent dosage of 5.0 gm.

3.2.2 Effect of pH

The above experiment shows that zinc was removed efficiently using 5.0 gm. Hence keeping adsorbent dosage, contact time, initial zinc concentration constant. pH of the sample is varying about 1, 3, 5, 7, 9 by using H_2SO_4 [Acid] and NaOH [Base] the pH of the sample is altered. From the graph fig. 2. Then 100ml of zinc solution is taken into a 250 ml of conical flask and adding of adsorbent into a conical flask. the conical flask is placed inside the shaker for mix at 150 RPM for 120 minutes. The solution is taken after agitation and sample is filtered using whatman filter paper. The results indicated that maximum efficiency of the zinc removal at pH 5 was about 98.10% [AASD] and 99.15% [BASD] at laboratory temperature.

3.2.3 Effect of contact time

In this case contact time was varies from 30, 60, 90, 120, and 150 minutes by keeping adsorbent dosage, pH, initial zinc concentration constant. From the graph fig 3. Take 100ml zinc solution is taken into a 250ml of five conical flasks and adding 5 gm of adsorbent for each conical flask and pH of the aqueous solution was adjusted to optimum value of 5 by adding 0.25N NaOH. Sample is placed in shaker for 150 rpm for 120 minutes. Then sample filtered using whatman filter paper. The percentage of zinc removal was more after 60 minutes due large surface area of the adsorbent. The maximum removal of zinc 98.60%[AASD] and 99.58%[BASD] at 120 minutes.

3.2.4 Effect of Zinc Concentration

The initial zinc concentration of the solution was varied as 10, 50, 100, 250, 500 mg/l, while keeping the adsorbent dosage, pH, contact time constant. From the graph fig 4. first we prepare all above concentration of stock solution and take 100ml of zinc solution and adding 5gm of adsorbent and adjusted the optimum value of 5 pH. Efficiency of zinc removal is more for 10 mg/l and decreased by increasing in concentration of the solution. The maximum removal efficiency of zinc was about 98.68%[AASD] and 97.66%[BASD] at 10 mg/l.

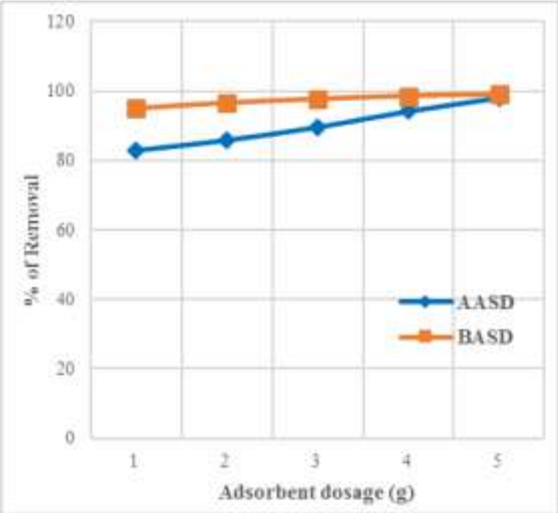

Fig-1: Effect of adsorbent dosage on adsorption of zinc

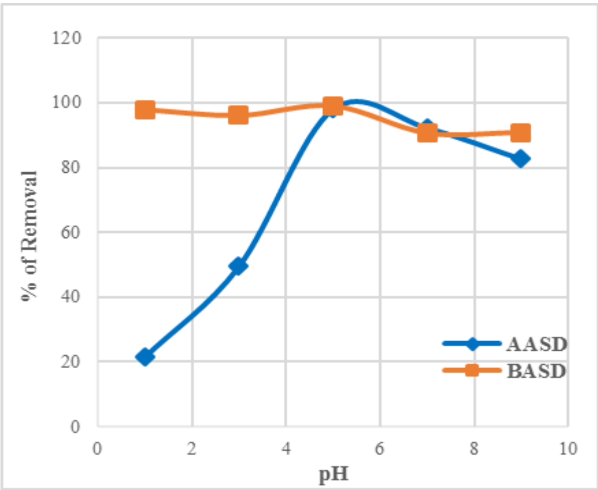

Fig-2: Effect of pH on adsorption of zinc

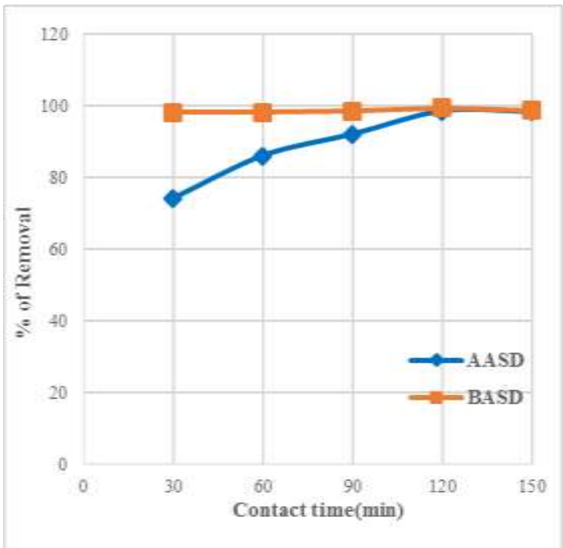

Fig-3: Effect of contact time on adsorption of zinc

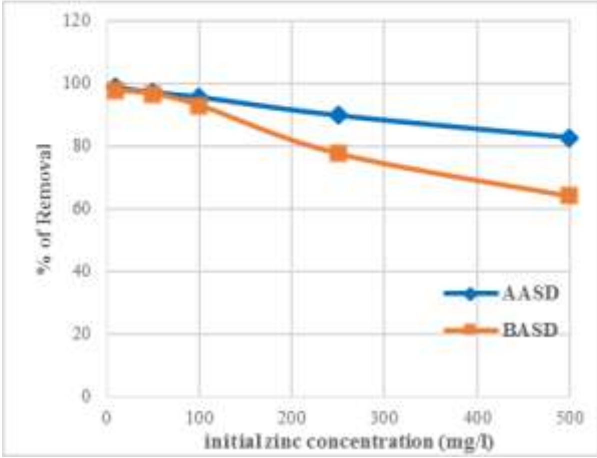

Fig-4: Effect of initial zinc concentration on adsorption of zinc

3.3 Adsorption Isotherms

The adsorption process is usually plotted and studied using a graphs known as adsorption isotherms. The graph between the amount of adsorbate (X) adsorbed on the surface of adsorbent (M) and the pressure is maintained at constant temperature.

Regularly used adsorption isotherm models are:

- Langmuir adsorption model
- Freundlich isotherm model

Langmuir adsorption isotherm model:

Langmuir adsorption isotherm model is valid for single-layer adsorption. It occurs between the number active sites of the surface undergoing adsorption and pressure.
The Langmuir equation is given by:

$$qe = \frac{Q^o.K.Ce}{1+K.C}$$

$$1/qe=1/Q^o+1/K\ Q^o*1/Ce$$

Where qe is the mass of materials adsorbed per mass of adsorbent, Q^o is the maximum adsorption capacity (monolayer), Ce is the equilibrium concentration in solution, K is the intercept value. Determine the constants from a plot of 1/qe versus 1/Ce.The adsorption experimental data for the adsorbents used in the study did not represent the best fit for the Langmuir adsorption model.

Freundlich adsorption isotherm model:

Freundlich adsorption isotherm is defined as the relationship between the amount of an adsorbate adsorbed per unit weight of adsorbent and the adsorbate equilibrium concentration in the fluid. Freundlich adsorption isotherm model is one of the most widely used mathematical models

which fit the experimental data over a wide range of concentration.
The Freundlich equation is given by:

$$qe = K_f C_e^{1/n}$$

Where qe is the mass of materials adsorbed per mass of adsorbent, Ce is the equilibrium concentration in solution, n and K_f = system specific constants, 1/n = slope, constants are determining from a plot graph between log qe versus log Ce. The adsorption experimental data for the adsorbents used in the study represent the best fit for the Freundlich adsorption isotherm model.

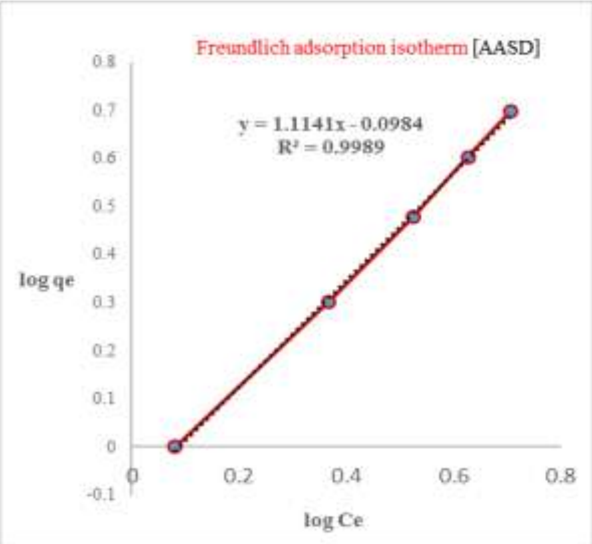

Fig-5: Freundlich Isotherm for Zinc adsorption on adsorbents

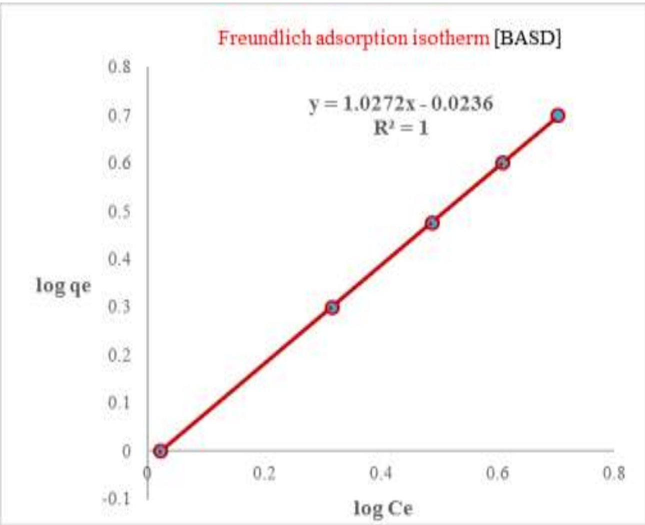

Fig-6: Freundlich Isotherm for Zinc adsorption on adsorbents

Table -1: Freundlich isotherm constants and regression coefficient for different adsorbents

Adsorbent	k_F	1/n	R^2
AASD	0.7972	0.8975	0.9989
BASD	0.8975	0.9735	1.0

4 CONCLUSION

Sawdust is very efficient and cost-effective. Various adsorbents which area available naturally proved their efficiency in removal of Zinc from the wastewater. Testing is carried out by using AASD and BASD at ideal condition (5gm/100 ml adsorbent dose, 5 pH, 120 min contact time and 10mg/l) is 98.68% and 99.58%. BASD removal efficiency of zinc is high compare to AASD. The Freundlich isotherm were fitted for AASD and BASD. The experimental data not suitable for Langmuir isotherm

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