

# Removal of Zn (II) from Wastewater by Adsorbent derived from **Ficus racemosa Bark**

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Abstract: The present study deals with the removal of Zn (II) from wastewater by batch process onto activated carbon derived from Ficus racemosa bark (ACFRB). This paper incorporates the effects of contact time, adsorbent dosage and pH. The adsorption behavior of the Zn (II) has been studied using Freundlich and Langmuir adsorption isotherm models. Based on the results and discussions, it can be concluded that the adsorbent prepared from Ficus racemosa bark has a significant capacity for adsorption of Zn (II) ions from aqueous solution and can be employed effectively as a low cost adsorbent. The present findings suggest that activated carbon derived from Ficus racemosa bark is environmentally friendly, efficient and low-cost adsorbent which is useful for the removal of Zn (II) from aqueous media.

Key words: Activated carbon, Ficus racemosa bark, Freundlich and Langmuir adsorption isotherm, Zn (II) ions.

# I. INTRODUCTION:

Today, the world is facing the problem of water pollution due to rapid development and industrialization. Heavy metals are one of the major pollutants in the environment. Excessive release of heavy metals into the environment due to industrialization and urbanization has posed a great problem worldwide. The pollution of water with toxic heavy metals is considered dangerous because of their great toxicity and their nonbiodegradability. These heavy metal ions can be accumulated through the food chain even at low concentrations, leading to serious problems on aquatic life as well as to animal, plant life and human health<sup>1</sup>.

Heavy metal contamination exists in aqueous wastes of many industries, such as metal plating, mining operations. tanneries, chloralkali, radiator manufacturing, smelting, alloy industries and storage batteries industries, etc.<sup>2</sup>. Discharge of treated industrial wastewater containing metal ions such as nickel, lead, copper, zinc and chromium are common in nearby water sources like river and lake. This may result in affecting the quality of aquatic and human life. Therefore, the removal of heavy metals from wastewater is essential  $^{3,4}$ . Almost all the heavy metal elements are highly toxic when their concentration exceeds their permissible limit in the ecosystem. Heavy metal pollutants are very difficult to eliminate naturally from the environment<sup>5</sup>.

Zinc is one of the trace elements essential for human health especially to protect against premature aging of the skin and muscles of the body, important for the physiological functions of living tissue and regulate many biochemical processes. The maximum allowable level of zinc in drinking water considered safe by the World Health Organization is 5 ppm<sup>6,7</sup>. Zinc is present in high concentration in wastewater of various industries like galvanizing, metallurgical, electroplating, mining, paints and pigments, pharmaceuticals, fiber production, ground wood pulp, newsprint paper, batteries, petroleum and petrochemical<sup>8,9</sup>. The excessive ingestion of zinc may lead to toxic effects such as stomach cramps, skin irritations, vomiting, nausea and anemia <sup>10</sup>. Hence, it is essential to remove zinc from industrial wastewaters before transport and cycling into the natural environment.

Various conventional treatments have been applied for removing heavy metals such as chemical precipitation, ion exchange, filtration and electrochemical treatment, but most of these methods are only suitable for large scale treatments and incur high cost to be practiced. Generally, all these treatments lead to certain disadvantages such as incomplete removal of heavy metals, high-energy requirements and production of toxic sludge. Numerous approaches have been studied for the development of more effective methods in removing metal pollution and the adsorption process is found to be more practicable over other techniques. Adsorption process is one of the easiest, safest and more cost-effective methods for heavy metal removal from industrial effluents and this process is already established as a simple operation and an easy-handling process<sup>11-16</sup>.

The objective of the present study is to find out the effectiveness of less expensive material that could be used as adsorbent for the removal of Zn (II) ions from wastewater. In this work, the adsorption behavior was studied by a set of experiments at various conditions, including pH, contact time and adsorbent dosage. The adsorption capacity of adsorbent was investigated using batch experiments.

# II. MATERIALS AND METHODS:

### **Preparation of Adsorbent:**

Bark of Ficus racemosa used in this work was collected from the nearby local forest area and it was cut into small pieces. It was washed with distilled water and dried in sunlight to remove the moisture. Then it was treated with formaldehyde to avoid the release of color by bark into the aqueous solution during the adsorption process. The above treated bark was carbonized by slow heating over a wide range of temperature (400-700°C) in the absence of air in a muffle furnace. The char obtained was subjected to thermal activation in the absence of air at elevated temperature 900°C and held at that temperature for 1½ hours. The adsorbent so obtained was ground and sieved through 200 mesh sieves. The dried sample was stored in airtight bottles for further use.

### **Preparation of stock solution:**

A stock aqueous solution of Zn(II) was obtained by dissolving 0.4404 g of AR grade Zinc Sulphate in 1000ml of double distilled water to give 100 ppm solution.

# **III. RESULTS AND DISCUSSION**

### Effect of contact time

For a fixed concentration of heavy metals and a fixed adsorbent mass, the retention of heavy metals increased with increasing contact time before equilibrium is reached. It can be seen that Zn (II) removal efficiency of activated carbon derived from Ficus racemosa bark increased from 21.77% to 87.87 %, when contact time was increased from 10 min to 110 min. Thus optimum contact time was found to be 110 min.



#### Fig.1 Effect of Contact time on Zn(II) removal by ACFRB

# Effect of pH

The pH of the aqueous solution is one of the key factors that control the adsorption process of Zn (II) ion because it controls the electrostatic interactions between the adsorbents and the adsorbate. Zn (II) ion removal efficiency was found to be 86.07% at pH 6. Maximum adsorption of Zn (II) ion was observed at the acidic pH. This is because, at lower pH there is increase in concentration of  $H^+$  ions on the carbon surface.





# Effect of adsorbent dosage

The obtained results reveal that the percentage removal of Zn (II) ions increased with an increase in the adsorbents dose because of more availability of number of active sites and more surface area. Maximum adsorption was observed at 7gm/lit i.e. 83.06%. But after 7gm/lit of dose, it remains constant.



# Fig.3 Effect of adsorbent doses on Zn(II) removal by ACFRB

### **Adsorption Isotherm**

Adsorption isotherms can be generated based on numerous theoretical models where Langmuir and Freundlich models are the most commonly used.

### Langmuir Isotherm

The Langmuir model is given by following eq (1)

### Ce / Qe = 1/Qm b+ Ce/ QM ------ (1)

Where, Ce is the equilibrium concentration in mg/lit, Qe is the amount of Zn(II) ion adsorbed at equilibrium (mg/g), Qm is the maximum adsorption capacity and b is the Langmuir constant (equilibrium constant). A plot of Ce/Qe versus Ce should indicate a straight line of slope 1/Qm and an intercept of 1/bQm<sup>18, 19</sup>. The value of  ${}^{\circ}Q_{m}$  was found to be 11.778 mg/g while value of 'b' is 0.077 respectively. The Langmuir parameters can be used to predict the affinity between the adsorbate and adsorbent using the dimensionless separation factor RL.

RL = 1 / (1 + bCe) - (2)

The value of RL lies between 0 and 1 for favorable adsorption, while RL> 1 represents unfavorable adsorption and RL=1 represents linear adsorption while the adsorption process is irreversible if RL=0. The dimensionless parameter RL value lies between 0.19332 and 0.85853 which is consistent with the requirement for favorable adsorption<sup>17</sup>.



### Fig. 4: Langmuir Isotherm for the adsorption of Zn (II) ion on activated carbon derived from Ficus racemosa bark

### **Freundlich Isotherm**

Freundlich isotherm model was also used to explain the observed phenomenon<sup>20</sup>. The Freundlich isotherm is represented by Eq. (3)

# LogQe = log Kf + 1/n log Ce -----(3)

Kf and n are constants incorporating all factors affecting the adsorption process such as adsorption capacity and intensity. A plot of log Qe vs log Ce gives a linear trace with a slope of 1/n and intercept of log Kf. Kf and n calculated from the intercept and slope of the plots were found to be 1.297 and 1.851 respectively.





# **IV. CONCLUSION**

The results indicated that activated carbon derived from Ficus racemosa bark is a promising new low cost adsorbent for removal of Zn (II) ions from aqueous solutions. From the experiments, it can be concluded that all operational parameters studied such as contact time, solution of pH and adsorbent dosage affect the Zn (II) ion removal efficiency of adsorbent. The pH selected for an optimal rate of adsorption for Zn (II) is 6. The experimental data for the adsorption process were well fitted by the Langmuir adsorption isotherm model and Freundlich adsorption isotherm model too. Thus the newly generated activated carbon derived from Ficus racemosa bark (ACFRB) has been proved to be an excellent eco-friendly and low-cost adsorbent material which can be successfully used for elimination of Zn (II) from contaminated water.

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