# Adsorption of Zn(II) from aqueous solution on mango leaves powder

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**Abstract**

Since ancient times, it's a common practice in India to use mango tree leaves when there is a large crowd of people to ensure free flow of oxygen, for their ability to absorb excess carbon dioxide. Owing to its purifying nature, it has been studied for waste water treatment also. In the present study, potential of mango tree leaves have been investigated in removing zinc ions from aqueous solution. Batch adsorption studies were conducted to determine the optimum values of solution pH, zinc ion concentration in the solution, adsorbent dose and contact time at 20ºC for maximum removal zinc ions from the synthetic solutions. It was observed that Zinc ion removal increased with increase in adsorbent dose and time. Optimum pH was 4. Equilibrium data was well described by the Langmuir, Freundlichand Temkin adsorption isotherm models.

## 1. Introduction

Increased population, urbanization and industrialization has caused a considerable damage to the environment due to accumulation of pollutants into the surroundings. Presence of heavy and toxic metal ions in water is a major concern today because of their non-biodegradability. Zinc is widely used in various industries such as automobile industry, rubber, paints, pigments and iron and steels, plastics, cosmetics, photocopier paper, wall paper, printing inks, pharmaceuticals and metal industries. Effluents coming out of these industries are contaminated with high amounts of zinc. Accumulation of high levels of zinc in body through contaminated water can result in various ailments such as stomach cramps, skin irritations, anemia, damage pancreas, disturbed metabolism, arteriosclerosis and respiratory disorders etc. Zinc also influences the activity of microorganisms and earthworms, slowing down the breakdown of organic matter, thus interrupting the characteristics of soil [1, 2]. Hence, removal of zinc from waste water is essential till it reaches the permissible levels. Conventional methods for treating effluents, such as precipitation, redox, membrane technologies, electrolysis etc., are costly and have problem of disposal of secondary waste such as toxic sludge [3]. In the light of these facts, adsorption has proven to be a better option as large varieties of adsorbents are available at a very low cost and the sludge formation and disposal is also not a problem of as many of these adsorbents are biodegradable [4]. Thus adsorbents such as activated carbon, zeolites, biosorbents,

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Agricultural waste [5,6,7,8,9,10,11,12,13,14,15,16,17,18] etc., are reported in literature for zinc, other heavy metals and pollutant removal from effluents. The present study was carried out to assess the potential of mango tree leaves as low cost agriculture adsorbents in adsorbing zinc from aqueous samples prepared in lab. The equilibrium data was analysed through adsorption isotherm.

### 2. Materials and Methods

#### A. Preparation of Adsorbent

Mango tree leaves were collected from the study area, GNDIT Rohini, Delhi, India. Leaves were Sun dried for 5 days, oven dried at 200ºC for six hours in hot air oven. Dried leaves were powdered in a grinder and washed several times with distilled water till the entire colored impurities removed, again dried in hot air oven at 200ºC for 8 hours. The powdered bark was sieved (Indian Standard Sieve) and various fractions of adsorbent was separately stored in air tight containers.

#### B. Preparation of stock solution

Stock solution was prepared by dissolving Zinc metal chips in a few drops of concentrated HCl and then diluting it to a solution of 1000 ml with distilled water. Solutions of required concentrations were prepared by further diluting the stock solution with distilled water. pH of the solutions was adjusted with the help of 0.1N HCl and 0.1N NaOH solutions.

#### C. Batch Adsorption Studies

Batch experiments were carried out to study the adsorption of zinc ions on mango tree leaves at 22 ºC. Aqueous solutions in the concentration range of 10 to 100 ppm with adsorbent dose of 2 to 20 g/L in the pH range from 3 to 8 were agitated at 200 rpm at 22 °C for 2 hours. The mixture was then filtered and analyzed for zinc ion concentration with the help of AA Susing air-acetylene flame. The amount of metal ions adsorbed on the surface of adsorbent was calculated from the difference between the initial and final concentrations of the solutions. Percentage removal of zinc from the solution after the batch adsorption was calculated as

$$\% \text{ Removal} = [(C_i - C_o)/C_i]*100 \quad (1)$$

Where $C_o$ represents the final zinc ion concentration and $C_i$ represents the initial zinc ion concentration in the solution.

The equilibrium adsorption capacity is calculated as

$$q_e = [(C_i - C_e)V]/m \quad (2)$$

Where V is the volume of the solution in litres and m is the mass of the adsorbent used [13].

## 3. Results and Discussions

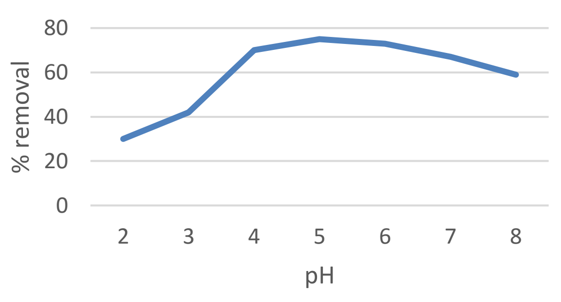
### 3.1 Effect of pH

Adsorption of zinc on mango tree leaves was investigated in the pH range between 3 and 8.The effect of initial pH on % removal of zinc ions is shown in Fig. 1.Chart suggests that the maximum removal was obtained at pH 5. A maximum of 75% zinc metal ions were removed at this pH at 22°C. % removal is sufficiently high at pH 4 and 6, but drops sharply at low pH values. Gradually, at higher pH values % removal is lowest at pH 3. % removal increased with increase in pH due to negative charges at active sites on the surface [6].

### 3.2 Effect of initial zinc ion concentration in the solution

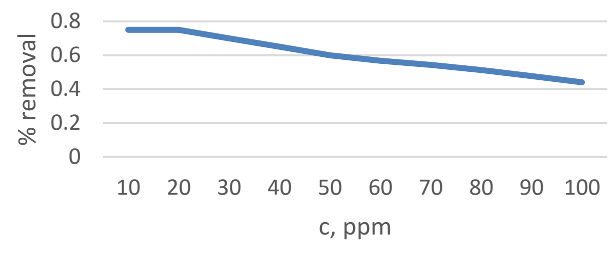
The amount of zinc removed by adsorption on to mango tree leaves depended largely on the initial metal ion concentration, as shown in the fig 2% removal decreased with increase in metal ion concentration. Lower initial

**Fig 1:** Adsorption of zinc on mango leaves powder: Effect of pH on % removal




concentration results in higher % removal due large number of available binding sites. As the total number of active sites on the adsorbent are occupied by the heavy metal ions with the course of time, % removal start to decrease.

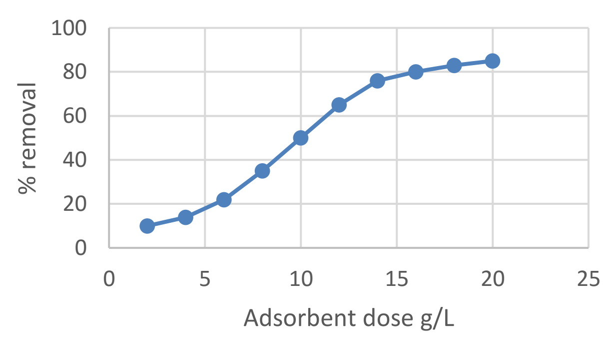
**Fig 2**: Adsorption of zinc on mango leaf powder: Metal ion concentration vs % removal




### 3.3 Effect of adsorbent dose

Results have shown that the amount of zinc adsorbed increased as the amount of adsorbent increased from 2 to 20 g/L, as shown in Fig. 3. This is because the surface area available for adsorption increases to a large extent with increase in adsorbent dose, hence increasing the availability of active sites for the metal ion to adsorb. As the adsorbent dose is increased, the time taken for adsorption also decreases as the metal ions come in contact with freely available active sites, thus increasing the efficiency of the process.

**Fig 3:** Adsorption of zinc on mango leaf powder: Adsorbent dose vs % removal




### 3.4 Effect of Contact Time

During the experiment, it was observed that the % removal increased with time till the equilibrium was reached. Equilibrium was reached in 80 minutes, after which the concentration of zinc ions in the solution became constant. The adsorption of zinc ions was rapid in the beginning, but became gradual with time. The effect of contact time on the amount of zinc ions on adsorbent surface is as shown in Fig.4.

**Fig. 4**: Adsorption of zinc on mango leaf powder:
Time vs % removal

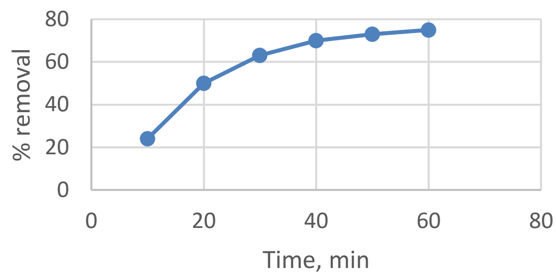



**Fig. 7**: Temkin isotherm: Adsorption of zinc on mango leaf powder

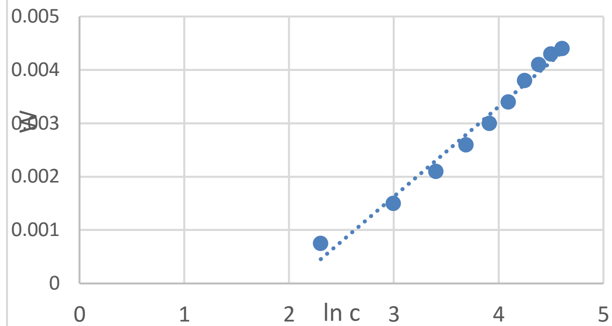



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**Fig.5**: Langmuir isotherm: Adsorption of zinc on mango leaf powder

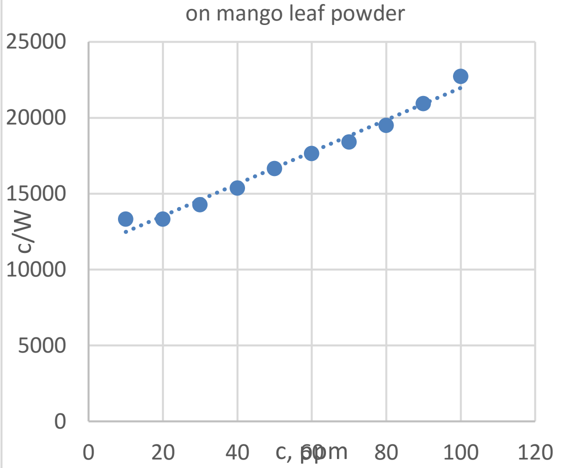
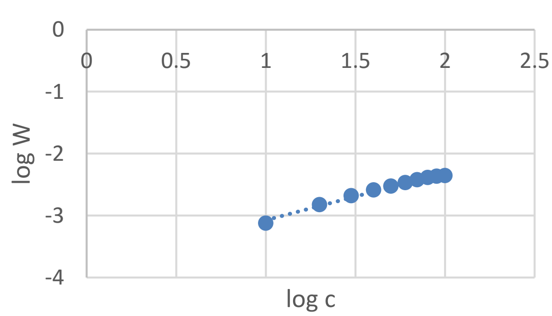



**Fig:6**: Freundlich Isotherm: Adsorption of Zinc on Mango leaf powder




### 3.5 Adsorption isotherms

The equilibrium data was tested with the help of adsorption isotherms, Langmuir, Freundlich and Temkin isotherms. The data fitted well into the isotherms. Langmuir and Freundlich isotherms gave very good fits as compared to the Temkin isotherm. The Karl Pearson correlation coefficients obtained were .998, .953 and .880 for Langmuir, Freundlich and Temkin isotherms respectively. The adsorption isotherms obtained are shown in fig. 5,6 and 7. The isotherms give a straight line, representing a good fit of the equilibrium data.

## 4 Conclusions

Mango tree leaves have shown a good potential towards removal of zinc, a heavy metal ion harmful for life when consumed in excess amount, from aqueous solution. The % removal of the zinc metal ion obtained was 75% even at very low temperature i.e. 20$^{o}$C. The adsorbent can be recommended for treatment of industrial waste water, as it can be a good solution to treat contaminated water when used at optimum conditions given its low cost and ready availability.

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