Adsorptive Removal of Zinc by Using Neem Powder and Saw Dust

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ABSTRACT

The work concerns the studies on batch adsorption of zinc from waste water using adsorbents such as Neem powder and saw dust. Neem leaves adsorbent developed from locally available tree leaves to assess suitability remediates zinc contaminated water. Factors affecting the adsorption characteristics such as contact time, adsorbent dosage, pH on zinc efficiency were studied and best values for maximum removal were found. It was observed that the percentage removal of zinc increases with increase in adsorbent dosage, reaches equilibrium value and also with increase in agitation time, removal percentage was increased. All the experiments were performed at room temperature and at a stirring rate of 120 rpm. The maximum removal was observed for neem powder compared with saw dust.

Keywords: natural adsorbents, saw dust, Neem, zinc, adsorption isotherm and waste water

INTRODUCTION

Mostly zinc enters the environment as a result of mining, zinc purification, burning of coal and wastes. It is found in almost 100 enzymes and proteins which plays major role in DNA replication. Its deficiency causes malfunctioning and disorders in metabolism and functioning of human organs. If large doses of zinc (10–15 times higher than the RDA) are taken by mouth even for a short time, stomach cramps, nausea, and vomiting may occur. Levels of zinc in excess of 500 ppm in soil interfere with the ability of plants to absorb other essential metals, such as iron and manganese.

Hence due to its adverse effects on biological systems waste waters containing zinc have to be treated before releasing into the environment. The conventional methods used to remove chromium from aqueous include high capital and regeneration costs of the materials; these are not suitable for the small-scale industries. Therefore, there is currently a need for new, innovative and cost effective methods for the removal of toxic substances from wastewaters. Among these processes Adsorption with the selection of suitable adsorbent can be an effective and versatile method and can be easily adopted in low cost to remove heavy metals from large amount of industrial wastewaters.

The adsorbents are neem leaves powder and saw dust which generally has high metal adsorption capacity. A novel adsorbent was developed from mature leaves of natural Neem trees for removing toxic substances from water. The adsorbent, in the form of fine powder was found to be very effective in removing traces of zinc in waste waters.

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The Neem tree (*Azadirachta indica*) of family *Meliaceae* is native to the Indian sub-continent and its seed and leaves have been in use since ancient times to treat a number of human ailments and also as a household pesticide. Leaves of the tree are used as anti-inflammatory, anxiolytic, anti-androgenic, anti-stress, humoral and cell-mediated immune stimulant, anti-hyperglycemic, liver-stimulant, anti-viral and anti-malarial activities. The aim of the present investigation is to detect the performance of neem leaves powder and saw dust on zinc removal from aqueous solutions by varying contact time, pH and adsorbent dosage. Langmuir and Freundlich isotherms were applied to fit the experimental data.

MATERIALS AND METHODS

ADSORBENT PREPARATION

Saw Dust

The saw dust collected from local saw mill. Firstly the adsorbent washed and dried at room temperature to avoid the release of color by adsorbent in to the aqueous solution. The activation of adsorbents is carried out by treating it with concentrated sulphuric acid 0.1 N and is kept in an oven maintained at a temperature range of 20°C for 24 hours. Again is washed with distilled water to remove the free acid.

It has a variety of practical uses, including serving as mulch, or as an alternative to clay cat litter, or as a fuel, or for the manufacture of particleboard. It has also been used in artistic displays and as scatter.

Neem

The matured neem leaves are collected from neem trees. They are washed, dried and powdered. Then the fine particles are collected by sieving by 200 mesh. Then it is washed with hydrochloric acid and dried. Then again it is washed with distilled water. Then it is dried at 20°C in an oven for 24 hours to activate and cool to room temperature. It is in fine powder form. The powder is in thick green colour which enhances the bio adsorption rate. The colour of this adsorbent adsorbs the traces of toxic substances effectively. The powdered neem is then soaked in hydrochloric acid for few hours. Then solution is filtered using Whatman filter paper. After that it is dried again and washed with distilled water. Then it is filtered with Whatman filter paper. It is dried and stored in moisture free container.

Adsorbent Preparation

The processed neem powder as mentioned earlier is sieved using 150-200 mesh. Undersize particles were collected.

A stock solution of zinc was prepared by dissolving 1g of zinc in 1000 ml. This solution was diluted as required to obtain standard solutions containing 1000mg/l of zinc.

Preparation of Adsorbate solution

A stock solution of zinc was prepared by dissolving 1g of zinc in 1000 ml. This solution was diluted as required to obtain standard solution containing 1000mg/l of zinc.

Batch adsorption experiments

Batch adsorption experiments were conducted by agitating the standard flasks (250ml) at room temperature in a mechanical shaker. The effect of time and pH was studied with a zinc concentration of 1000 mg/l and an adsorbent dosage of 20 g/l the aqueous solution pH was adjusted in the range of 1-14 by using dilute HCl and NaOH solutions. Experiments were carried out by varying the adsorbent amount

from 20 to 100 g with a zinc concentration of 1000mg/ l. Finally, Zinc concentrations were analyzed spectrophotometrically.

Effect of agitation time

The effect of agitation time on zinc removal was observed at zinc concentration of 1000 mg/l and adsorbent dosage of 20g. The adsorbent dosage of 1g was added to the 10 different standard flasks containing 50 ml of adsorbent solution concentration 1000 mg/l. Flasks numbered 1,2,3....., were placed in mechanical shaker at 120rpm for 30min, 60min,150 min respectively. Final zinc concentration in the adsorbate solution was found spectrophotometrically at 310 nm. And percentage removal of zinc was calculated.

Effect of Adsorbent dosage

The effect of adsorbent dosage on zinc removal was observed at zinc concentration of 1000 mg/l at agitation time of 90 min. The prepared adsorbate solution was diluted to 1000mg/l. Adsorbent solution was transferred into 100ml standard flasks. the adsorbent dosage of 1g, 2g, 3g, 4g and 5g were added to the flasks numbered 1,2,3... respectively. Then the flasks were placed in a mechanical shaker at room temperature. The speed of the shaker is maintained at 120rpm and for a contact time of 90min. then the flasks were taken out and liquid in the flasks were filtered by what man filter paper. The filtered solution was analyzed in UV spectrophotometer at a wavelength of 310 nm. The percentage removal of phenol was found using standard calibration chart

Effect of pH

effect pH on zinc removal is observed at zinc concentration of 1000 mg/l and at agitation time of 90min. The prepared adsorbate solution diluted to 1000 mg/l and pH of the solution was found using PH meter. Then the pH of the solution was made to 5,6,8,10,12 by using NaOH and HCl of appropriate concentrations and solutions of different pH were taken in different flasks. Then the adsorbent made of 1g was added to the above solutions. These standard flasks were placed in mechanical shaker for 90 min. The speed of the shaker was maintained at 120rpm. After the completion of above mentioned agitation flasks were taken out and solutions were filtered using whatman filter paper. The filtered solution was analyzed using UV spectrophotometer at a wavelength of 310 nm. Similarly the percentage removal of zinc was found using standard calibration. The equilibrium amount of metal ion adsorbed per liter was calculated from the difference between the initial (C_i) and final (equilibrium) concentration (C_{eq}) in the solution. Respectively

$$X = C_i - C_{eq} \quad \text{mg/L}$$

The adsorption percentage was calculated by using from the following equation:

$$\text{Percentage of adsorption} = ((C_i - C_t)/C_i) \times 100$$

Where, C_i and C_t are the initial and at time (t) of the adsorbate concentration, respectively. The final concentration is determined by correlating adsorbance and concentration from standard calibration chart.

RESULTS AND DISCUSSION

All the experiments were carried out at a room temperature 305k and speed of the shaker was maintained at 120rpm and adsorbate solution of concentration 1000ppm.

Table: Comparison of percentage removal of zinc using different adsorbents

Agitation time (min)	% removal of Zinc		Adsorbent dosage (g/l)	% Removal of Zinc		pH	% removal of Zinc	
	Neem	Saw dust		Neem	Saw dust		Neem	Saw dust
30	45	33	1	65	63	4	61	65
60	55	49	2	70	65	6	67	71
90	72	56	3	72	70	8	72	78
120	80	70	4	74	74	10	79	81
150	83	75	5	82	77	12	77	79

Effect of agitation time

The effect of agitation time on the adsorption of zinc using neem powder and Saw dust was studied at adsorbent dosage of 20g/l.

The effect of agitation time using two adsorbents was compared in the graph as shown in Fig. 1. It is inferred that from the graph neem powder had shown better results. About 83.6% removal of zinc was reported for neem powder and the next best results were observed for saw dust (about 80% removal).

Fig.1 Effect of agitation time on % removal of zinc using two adsorbents

Effect of adsorbent dosage

The effect of adsorbent dosage on the percentage removal of zinc was studied at 120 rpm and agitation time of 90 min using neem powder and Saw dust the values are tabulated. From the graph shown in Fig.2 it is observed that the best results were shown by neem powder and then saw dust.

Fig.2 Effect of adsorbent dosage on % removal of zinc using two adsorbents

Effect of pH

Effect of solution pH on removal of zinc was studied using neem powder as adsorbent at adsorbent dosage of 20 g/l and agitation time of 90min. the values are tabulated below in Table. P^H of the solution is adjusted by using HCl and NaOH solutions.

Fig. 3 Effect of pH of two adsorbents

From the graph shown in Fig.3 it was observed that neem powder and saw dust almost same result in % removal of zinc at different pH levels of adsorbate solution. But the neem powder showed better result than saw dust to some extent. The variation in the sorption capacity between the various adsorbents could be related to the nature and concentration of surface groups responsible for interaction with the metal ions.

CONCLUSION

The utilization of waste material such as saw dust and neem powder for the removal of zinc from industrial waste water streams was investigated. The following conclusions could be drawn based on investigation. Neem powder and Saw dust are found to be better adsorbents for the removal of zinc compared to other low cost and commercially available adsorbents. The maximum adsorption of zinc for saw dust (72%) and neem powder (82.2%) was observed at pH 12.24 respectively. Langmuir isotherm better fitted the experimental data since the correlation coefficients for Langmuir isotherm was higher than the Freundlich isotherms. After fitted the data, the Langmuir constant (n) was lower than the Freundlich constant.

The present adsorbents such as saw dust and neem powder are used at an industrial scale to remove zinc ions from the effluents before discharging in to the water bodies. With the increase of adsorbent amount the percentage removal of zinc increases and the adsorption capacity of saw dust to adsorb zinc decreases because of availability of more unsaturated adsorption sites. Most of the electroplating effluents contain chromium as one of the contaminant, which can be removed in a cost effective and efficient manner by these adsorbents. Neem biosorbent exhibited highest zinc removal efficiency 82.2% at pH of 12.24, initial zinc concentration of 1000(mg/l), contact time of 90 min, adsorbent dosage of 5g/100ml and maintaining temperature of 307K. Zinc removal for a given adsorbent increases with time, attaining equilibrium within 90 min.

The optimum sorbent dosage was found at 5g/100l for both neem powder and saw dust. Enhanced adsorption was obtained at 150 min. It could be seen that the neem powder is more efficient in removing zinc from effluent streams as compared to saw dust. The Langmuir adsorption is found to be more suitable than freundlich isotherm. As the adsorbents used in this work are natural, they are economically cheap and eco-friendly.

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