Ions Exchange Resin for the Removal of Zinc Metal from Industrial waste water in India

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Abstract:
There are many methods available to remove heavy metal ions from waste water and default water. Among all the available methods, ion exchange is considered to be the most simple and efficient one. A macro particular divinylpolystyrene based chelating ion exchange were used for the removal of zinc (II)from industrial waste water.The accumulated information of the comparison mentioned above was shown in column system as concentration zinc(II) 500mg/L , flow rate of 2.5 mL/min.The result obtained show that the strong cation exchange resin performed well for the adsorbed zinc(II) metal from industrial waste water of the various industries like electroplating, pain, fertilize, galvanizing, metallurgical, mining , pigments, pulp and paper and pharmaceuticals industries.

Keywords: *Chelating resin, Zinc (II), Waste water, Adsorption*

Introduction

Environmental pollution is one of the main problems of the society in the 21st century. The major pollutants include toxic metals, the quantity of which permanently increases in the environment as the result of increased industrial activity. In nature zinc occurs in the form of minerals. The degree of toxicity of zinc is not big, but it depends on the ionic form, and changes under the influence of water hardness and pH. The daily average download of zinc by an adult is estimated at about 10-50mg/day. The toxic dose is 150-500 mg. It is necessary for the proper functioning of living organisms and it is involved in the metabolism of proteins and carbohydrates. High doses of zinc cause damage to many biochemical processes followed by its deposition in the kidneys, liver, gonads. Zinc is one of these toxic metals and is present in high concentration in wastewater of various industries. Zinc metal ions do not degrade and thus are carried away to the food chain and finally get accumulated in the living organisms, causing several diseases and disorders. Waste water treatments would not only be economical but will also help to maintain the quality of the environment. The heavy metals, having hazardous effects on health, can be treated from natural environment has resulted in a number of environmental problems.

There are many process for removal of heavy metals such as electro dialysis, reverse osmosis, bio-adsorption, and ion exchange process are developed to removal of heavy metals from industrial waste water. Among the heavy metal removal processes is Zn^{+2} form industrial waste water with strong acid cation-exchange resins. Column system generally requires prediction of the break through curves for the effluents.

Ion exchange techniques for removal of heavy metal

Ion Exchange resins are insoluble granular substances which have in their molecular structure acidic or basic radicals that can be exchanged. The positive or negative ions fixed on these radicals are replaced by ions of the same sign in solution in the liquid in contact with them.

Ion exchange resins are polymers that are capable of exchanging particular ions within the polymer with ions in a solution that is passed through them. This ability is also seen in various natural systems such as soils and living cells. The synthetic resins are used primarily for purifying water, but also for various other applications including separating out some metals.

Ion exchange resins having cross linked hydrocarbon matrix and derivative with inorganic group are the most common ion exchange materials used in industrial applications. The majority of the commercial resins are based on the styrenedivinylbenzene structure because of its good resistance against chemical and physical stress. The structure is stable at relatively high temperatures and over the whole pH range. Styrene polymer chains are crosslinked with divinylbenzene (DVB) and the elasticity of resin can be adjusted by varying the amount of DVB it contains.The ion exchange properties of organic resins are mainly based on ionogenic groups which can be attached to practically all the styrene rings in the styrene-divinylbentzene co-polymer. Thus, resins with very low crosslinking (DVB portion 1-2%) can have the maximum theoretical concentration of the ionogenic groups of approximately 9mmol/g. Usually, commercial resins contain ionogenic groups at a concentration in the range of 2.5-5 mmol/g. The nature of ionogenic groups can vary from strong acidic cation exchangers (-SO3-) to strong basic anion exchangers (-N+(CH3)3) and to chelate forming exchangers. There are also active groups which have no electric charge but donor atoms attract cations by donating free electron pairs to form coordination bonds. Ionogenic, chelating, and complex forming active groups may be called functional groups.

Strong acid resins are so named because their chemical behavior is similar to that of a strong acid. The resins are highly ionized in both the acid ($R\text{-}SO_3H$) and salt ($R\text{-}SO_3Na$) form. They can convert a metal salt to the corresponding acid by the reaction:

$2(R\text{-}SO_3H)+Zn(OH)_2 \dashrightarrow (R\text{-}SO_3)_2Zn+ 2H_2O$

The hydrogen and sodium forms of strong acid resins are highly dissociated and the exchangeable Na+ and H+ are readily available for exchange over the entire pH range. (These resins would be used in the hydrogen form for complete deionization; they are used in the sodium form for water softening (calcium and magnesium removal). After exhaustion, the resin is converted back to the hydrogen form (regenerated) by contact with a strong acid solution, or the resin can be convened to the sodium form with a sodium chloride solution. For Equation 5. hydrochloric acid (HCl) regeneration would result in a concentrated zinc hydroxide ($Zn(OH)_2$)solution.

Properties of resin

Tabel 1 Properties of resin

Properties	Resin
Functional groups	- So_3
Ionic form as shipped	H^+ , Na^+
Total exchange capacity	≤ 1.8 eg/L
Bed depth	80 mm
Flow rate	3-4 BV/h
Concentration (%)	3-8
Contact time	8 min

Data analysis

In addition, the percentage of Zn(II) ions removed from the aqueous solution by resin were calculated using,

$$\% R = [(Ci - Ct)/Ci] \times 100$$

where , R = Percentage of removal metal from solution (%)

Ci = initial metal ions concentration (mg/L)

Ct = metal ion concentration in solution at time (mg/L)

Column operation

Compact glass column of ~35.0 cm length and 2.0 cm id was loaded with 70.0 g of the resin. The column was equilibrated at required pH using 0.2 M acetate buffer solution. The breakthrough capacities and interstitial volume were determined, according to the known methods. Effect of flow rate was studied and was optimized with a view to utilize the method for the preconcentration of ZN(II) from trace level samples.

Column loading experiments were conducted using a glass column with an inner diameter of 20 mm. A perforated glass disc at the bottom of the column allowed containment of the resin, while a rubber stopper at the top of the column prevented floating of the resin. The resin bed comprised 70 g of resin in the dry-tapped form. The feed solution was pumped, in top flow mode, through the column using a peristaltic pump with variable speed control. All experiments were conducted at ambient temperature (25°C). The zinc concentration of the feed was varied from 50 mg/L to 180 mg/L and the flow rate varied from 10 BV/h to 20 BV/h. Samples of the exiting solution were collected at intervals of 3 BV and assayed for residual metal content, from which breakthrough curves were plotted. The mass transfer zone length and resin capacity for zinc were calculated for each experiment.

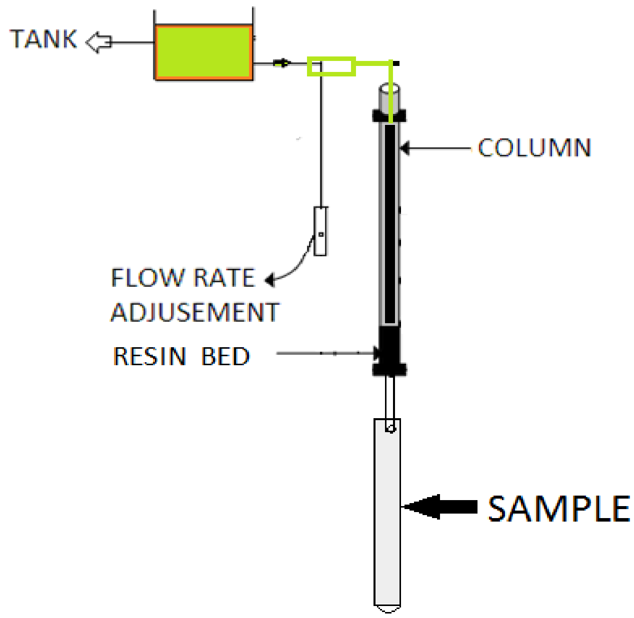

Fig: 1 Equipment for column adsorption experiment

Result and discussion

The resin beads of 40-60 mesh size were used throughout the work. In this study adsorption properties of zinc(II) on strong cationic resins has been studied by using column technique.

A.Effect of pH

The initial concentration of the solution was taken as 10 mg/L and the contact time given was 40 min, pH was varied from 0-12. The maximum adsorption was obtained at a pH of 6 and the adsorption decreased with an increase or decrease in pH 5. The results are shown in table and chart.

Table : 2 pH effect on adsorption of Zn

pH	Initial con. of Zn mg/L	Final con of Zn mg/L	Adsorption of Zn (%)
0	45 mg/L	0	0
2	45 mg/L	22	49
4	45 mg/L	30	67
6	45 mg/L	35	78
8	45 mg/L	32	71
10	45 mg/L	31	69
12	45 mg/L	30	67

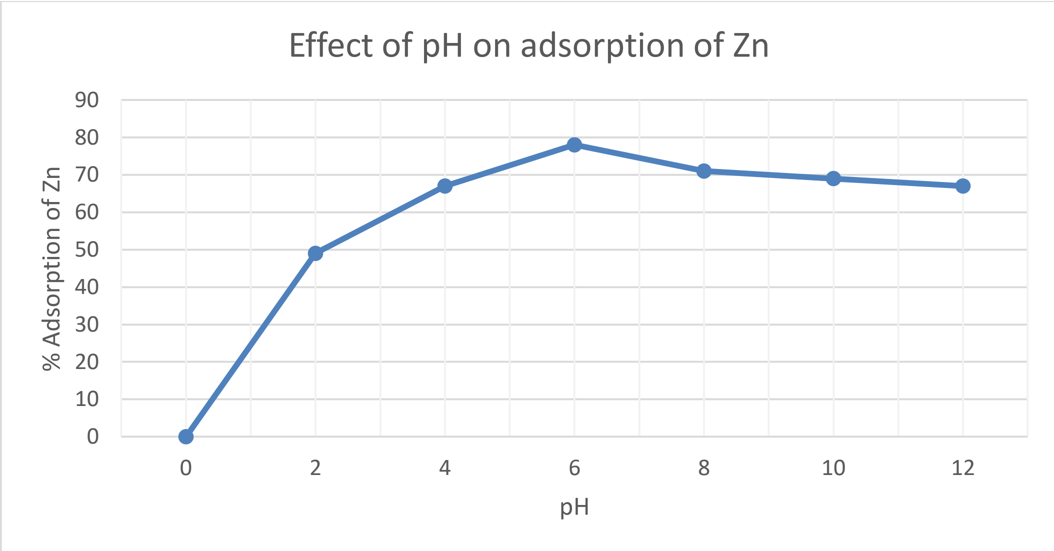

Fig : 2 Effect of pH on adsorption of Zn

B. Effect of contact time on adsorption

The effect of contact time was studied using an intial concentration of 10 mg/L of zinc and pH of 6. The maximum adsorption was found at a contact time of 70 minutes. Increase in contact time shows some variable change in the results.

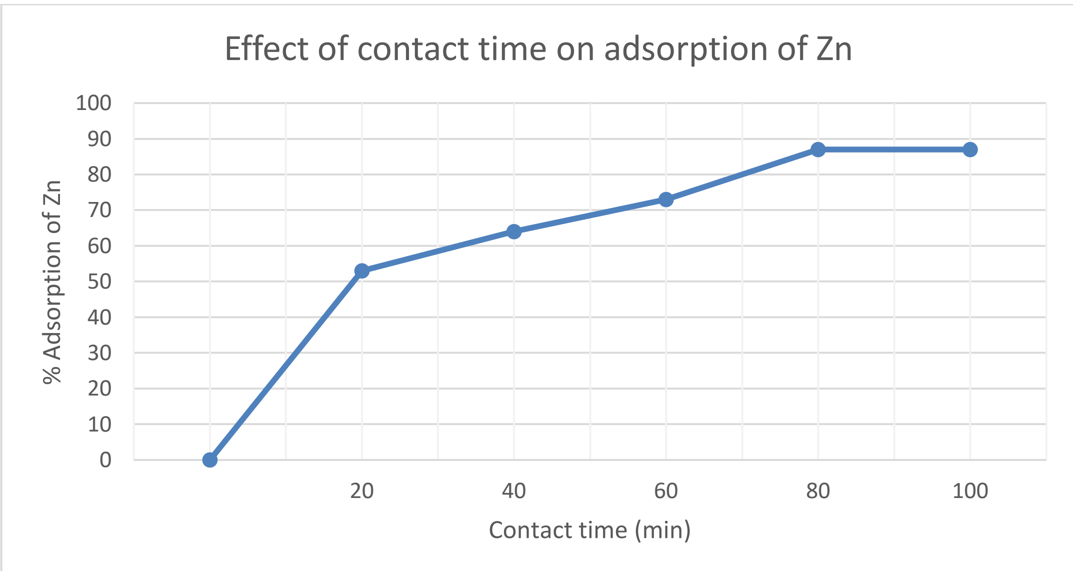

Fig : 3 Effect of contact time on adsorption of Zn

C.Effect of contact time on adsorption

The initial concentration of zinc was varied form 0-10 mg/L. A contact time of 80 min was provided and the obtained results are shown in table 3.

Table: 3 Effect of initial concentration of adsorption of Zn

Contact time	Initial con. of Zn mg/L	Final con of Zn mg/L	Adsorption of Zn (%)
80	2 mg/L	1.1	55
80	4 mg/L	2.52	63
80	6 mg/L	4.25	71
80	8 mg/L	6.25	78
80	10 mg/L	7.6	76

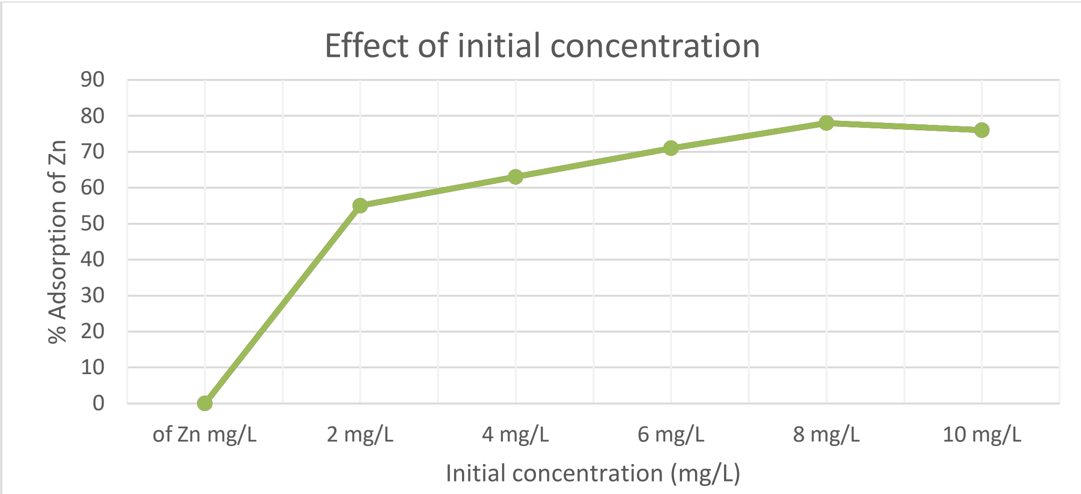

Fig : 4 Effect of initial concentration on adsorption of Zn

Conclusions

Synthesised strong cationic resin was found to be a good adsorbent for the removal of zinc from the wastewater. At optimum conditions of pH , contact time , and initial concentration .The removal of zinc was found to be 80% for industrial wastewater.

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