A novel ion exchange resin as an alternative for conventional chelates for separation and removal of toxic metal ions from industrial wastewater

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Abstract

Tamarind Kernel-Power (TKP), a naturally occurring polysaccharide, has been used for the synthesis of a novel ion exchange resin, namely Tamarind triazine methyl sulphamic acid (TTMSA). The resin acts as a scavenger for toxic metal ions from the effluents of various industries. Characterization of resin has been done by FTIR, TGA and elemental analysis. Various physico- chemical properties of resin were analyzed including ion-exchange capacity, % nitrogen content, bulk density, bulk volume and moisture content. The resin was found to be stable with good reproducibility, good ion exchange capacity and selectivity for toxic metal ions.

The partition coefficient values and percentage adsorption of various metal ions on the newly synthesized resins were determined by batch method with the help of Atomic Absorption spectrophotometer. The efficiency of resin was studied for up to 10 cycles. Analysis has shown that the adsorption of different metal ions on TTMSA resin followed the order $Fe^{+2} > Cu^{+2} > Zn^{+2} > Pb^{+2} > Cd^{+2}$. *A suitable and cost-effective method was employed to reach the result of this experiment.*

Keywords: Ion exchange resin, heavy metals, AAS, Industrial effluents, partition coefficient.

Introduction

With extensive damage to the mother earth due to urbanization and industrialization, chelating ion-exchange resins provide a solution for the cleaning of water and soil and hence contribute to healthy living. The contamination of water and soil with various kinds of metal ions is due to uncontrolled disposal which includes industrial effluents, mining processes, military installation, e-wastes, drugs etc. into water bodies and landfill sites. Pollution may also result due to weathering of natural geologicalmaterials[17,27].

These tend to increase the metal ion concentration in soil and water. The increasing concentration of metal ions beyond the permissible limit leads to toxic levels giving tremendous harm to humans, flora and fauna of land as well as of aquatic life. Chemical fertilizers, pesticides and effluents from industries are a potential source of increasing toxic metal ions in the agricultural field.

Toxic metal ions are taken up by the plants and enter the food chain, thus adversely affecting human and animal life. The anthropogenic activities deeply contaminate the soil and water, leaving the water unfit for drinking and the land unfit for dwelling. Though several government and non – government organizations are taking care to restrict the discharge of untreated loads to rivers, seas and lands, strict laws are being imposed for its control. Curbing environmental pollution is one of the major challenges of the present times.

Various methods have therefore been developed from time to time to remove toxic metal ions from sewage water, industrial effluents and wastewater to make it suitable for drinking, washing, bathing, as well as for irrigation purposes. These methods include ultrafiltration, reverse osmosis[1], solvent extraction, precipitation, chemical and electrochemical techniques[4], advanced oxidation process[13,21] and ion-exchange methods[15,24]. Activated carbon is also being used for the removal of toxic metal ions such as Cu[18], Cr[20] and Ni[23]. Apart from zeolites[30], polymers[7-10,12], fly ashes[6], graphene oxides[26,32,35] and biomasses[2,16,29,31,33,34] are also used for the removal of heavy metal ions from industrial wastewater.

Ion exchange resins are useful for metal ion removal and separation from industrial effluents. This is because of its greater selectivity, chemical stability, ease of operation as well as cost-effectiveness. Ion exchangers have varied applications in the field of medicine (Kidney dialysis), food and beverage industry, pharmaceutical technology petrochemical, hydrometallurgy, metal finishing, chemical, petrochemical, sugar and sweetener production, ground and portable water treatment, industrial waste treatment and many others. In the last few years, ion exchange has gained a lot of significance in wastewater treatment and has become a pioneering technique for the removal of toxic metal ions from industrial effluents.[3,11,28]

Naturally occurring polysaccharides having stable insoluble matrix and characterized with various chelating functionalities have been used as effective means for the removal of heavy metal ions from wastewater.[5] Tamarind, a naturally occurring polysaccharide (Figure 1) has been studied for its application in the field of ion exchange