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Sequestration of Toxic Metal Ions from Industrial Effluent Using the Novel Chelating Resin Tamarind Triazine Amino Propanoic Acid (TTAPA)

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Abstract: Due to higher levels of industrial activity, the concentrations of toxic substances in natural water bodies are increasing. One of the most dangerous groups of toxic compounds is heavy metals, with even trace amounts of most heavy metals being harmful to aquatic life. This is why purifying water has become an urgent priority. In this context, ion-exchange resins have become more widely used in water treatment processes. However, to reduce the costs and improve the sustainability of this strategy, natural resins are favored over synthetic versions. Therefore, in the present study, a natural tamarind-based chelating resin was developed. The tamarind triazine amino propanoic acid (TTAPA) resin was synthesized and characterized using Fourier-transform infrared spectroscopy, thermogravimetry analysis, scanning electron microscopy, elemental analysis, and physicochemical analysis of the moisture content, total ion-exchange capacity, bulk volume, bulk density, and percentage nitrogen content. The biological oxygen demand and chemical oxygen demand of the industrial effluent before and after treatment were also analyzed. The batch analysis was used to determine the distribution coefficient and percentage removal of the metal ions Fe(II), Zn(II), Pb(II), Cu(II), and Cd(II). The removal efficiency of the prepared TTAPA resin was highest for Fe(II), followed by Cu(II), Zn(II), Pb(II), and Cd(II) in order. The chelating ion-exchange resin also had a metal ion recovery of more than 95%, thus demonstrating great promise for the sequestration of heavy metal ions from industrial wastewater. The proposed TTAPA resin is biodegradable, non-toxic, cost-effective, reproducible, and eco-friendly.

Keywords: water; water treatment; chelating; toxic; eco-friendly; adsorption

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1. Introduction

One of the major threats to natural ecosystems is the environmental pollution arising from urbanization and industrialization [1–3]. In particular, metal ions are released as a result of various human activities, causing a variety of negative environmental consequences [4–6]. In recent decades, there has been a significant increase in the use of toxic heavy metals in various industries, many of which enter the natural environment and damage flora and fauna [7]. These heavy metals are non-biodegradable [8] and damaging to human health when present above certain levels, including raising the risk of