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Removal of Cd^{2+} and Cr^{3+} ions from aqueous solution using modified polypropylene plastic waste

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Abstract

Heavy metals pollution of water poses a major environmental challenge due to its antagonistic effects. They are not biodegraded and tend to accumulate in human body to toxic levels linked to some health effects. Therefore, there is need for their removal in water. Technologies that exist such as membrane filtration are limited by their high operation cost. However, adsorption is a cheap, efficient, and easy technique of removal of pollutants from wastewater. There is limited information available on value

addition of plastic waste for application as adsorbents. Application of modified polypropylene plastic waste was explored in this study for remediation of Cd^{2+} and Cr^{3+} ions from model solution. This was achieved by first chemically modifying the plastic by use of hydrogen peroxide and hydrochloric acid to create adsorption sites. The chemically modified plastic waste was characterized using Scanning Electron Microscopy (SEM) and Fourier Transform Infrared Spectroscopy (FTIR). The images obtained confirmed availability of pores in the adsorbent which are critical for Cd^{2+} and Cr^{3+} ions adsorption. The FTIR results confirmed the presence of hydroxyl groups on the adsorbent which are vital for adsorption. Effect of adsorbent dosage, contact time, solution pH and initial metal ion concentration were investigated and the concentration of the resulting filtrate after adsorption determined using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). The results from optimization experiments showed that Cd^{2+} and Cr^{3+} ions adsorption was optimal at initial metal ion concentration of 15 mg/L and 20 mg/L respectively, contact time of 45 mins and 60 mins respectively and optimum adsorbent mass of 0.1 g. Optimal pH values of 4.5 and 5.5 respectively were also observed. Equilibrium experimental results showed adsorption capacities of 7.395 mg/g (Cd^{2+}) and 6.225 mg/g (Cr^{3+}) for Langmuir isotherm model with R^2>0.99 indicating chemisorption process. This study shows the good performance of the modified plastic waste in adsorbing the metal ions and also value addition for the plastic waste. Polypropylene plastic waste can therefore be applied in wastewater treatment to bring the concentration levels of heavy metals to the required limits.

Keywords: polypropylene, adsorption, heavy metals, equilibrium, adsorption capacity, adsorption isotherms