

The adsorption characteristics of Cd²⁺ on PP and HDPE microplastics based on various particle sizes

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Microplastics smaller than 5 mm can serve as carriers for pollutants like heavy metals, drawing attention due to their non-biodegradable nature. Polypropylene (PP) and high-density polyethylene (HDPE), accounting for 31.8% of global plastic production, are widely dispersed in aquatic environments, potentially adsorbing heavy metals and posing a risk of human exposure through the food chain. This study evaluates the cadmium (Cd²⁺) adsorption characteristics of microplastics based on particle size and polymer type. PP and HDPE were categorized into three size groups (Group 1: 2.5 – 1.0 mm; Group 2: 1.0 – 0.3 mm; Group 3: < 0.3 mm). Adsorption experiments with Cd²⁺ solutions (0.5, 1, 5, 10, and 30 mg/L) were conducted and the supernatant was analyzed using ICP-OES at the Integrated Analytical Center for Earth and Environmental Sciences. The analysis results were evaluated using adsorption isotherm models (Langmuir, Freundlich, and Sips models). Both the Langmuir model ($R^2 > 0.99$) and the Sips model ($R^2 > 0.99$) were suitable for describing the Cd²⁺ adsorption processes of PP and HDPE, indicating that monolayer adsorption predominates. In Group 3, the affinity coefficient (K_L), adsorption intensity (n^{-1}), and maximum adsorption capacity (Q_m) for Cd²⁺ were highest, confirming that smaller particle sizes showed greater adsorption superiority. Based on Group 3 criteria, the Cd²⁺ adsorption capacity of PP (0.42 mg/g) was 8.48 times higher than that of HDPE (0.05 mg/g). In this study, we confirmed the differences in heavy metal adsorption characteristics of microplastics based on particle size and polymer type, with monolayer adsorption predominating over multilayer adsorption. Our findings suggest the potential of microplastics, particularly PP, to act as mediators for heavy metals in aquatic environments, indicating that PP may pose a greater risk by adsorbing heavy metals compared to HDPE.

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