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Enhanced Vector Transport of Ciprofloxacin by Aged Polyethylene Microplastics in the Presence of Organic Matter

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Abstract

The comparative assessments of an emerging pollutant, ciprofloxacin (CPX) adsorption to both pristine and aged polyethylene (PE) microplastics and their desorption at different environmental factors and possible binding mechanisms are rarely discussed. This study evaluates the adsorption of CPX to pristine and aged PE microplastics (< 250 µm, 1 g L^{-1} at different pH (3 – 10), reaction time (72 h), and initial CPX (1 - 30 mg L^{-1}) in humic acid (HA)- mixed water (0.5 - 2.5 mg L^{-1}) to reveal the potential binding mechanisms. Desorption of microplastic-bound CPX was performed at stimulated human stomach and gut fluids through batch sorption studies. Fourier Transform Infrared (FTIR) spectroscopy was performed to characterize PE microplastics. The presence of O-containing functional groups in the resultant FTIR spectra of aged microplastics confirmed their photooxidation. Within the optimum pH 6.0 - 7.0, aged PE microplastics in 2.5 mg L^{-1} HA-mixed water showed higher adsorption (2.25 mg g^{-1}) than pristine microplastics (1.71 mg g^{-1}). Best-fitted Elovich and non-linear pseudo-second-order kinetic models indicated the chemical adsorption of CPX by pristine and aged microplastics, respectively. Non-linear corporative adsorption behaviour for CPX binding to both PE microplastics was well agreed with the Hill isotherm model. The companionship of intermolecular hydrogen bonds, nucleophilic, Van der Waals, and $\pi - \pi$ interactions was the leading CPX adsorption mechanism. The pH-dependent desorption of microplastic-bound CPX exhibited a higher bio accessibility in stomach (15.32%) than in gut fluid (9.56%). These findings suggest that PE microplastics are potential vectors of CPX migration in HA-mixed water, influenced by solution pH and degree of aging.

Keywords: *Aging, Desorption, Organic pollutants, Vector transport, Chemisorption*