ABSTRACT

The global shift from reusable to single-use plastics has resulted in a tremendous increase in plastic waste. Plastic waste comprises mainly polyethylene (PE) and polypropylene (PP). Physical, chemical, and mechanical factors cause fragmentation of the plastic waste into smaller microplastics (<5 mm in size). Microplastic (MPs) pollution is now ubiquitous in the environment and is a threat to ecosystems and human health. However, our understanding of the factors influencing the formation of microplastics under different environmental conditions is limited. The objective of this study was to evaluate the potential for recovering plastics from waste and factors affecting the formation and migration of microplastics in different environmental media by simulating natural conditions.

The degradation behavior of LDPE and PP in four different media (air, DDW, potable, and saline water) was evaluated under continuous UV radiation. Plastics like LDPE and PP deteriorated completely in air within 90 and 30 days, respectively. These plastics did not deteriorate to any significant extent during the same period in aqueous environments. Therefore, plastics (LDPE and PP) retrieved from landfill sites are difficult to recycle unlike those recovered from aqueous environments.

The release of microplastics from disposable paper cups into hot water was also studied. The interior of these paper cups is laminated with a thin hydrophobic film made of plastic (polyethylene) or its copolymer. When exposed to hot water (85-90 °C), this film deteriorates and releases MPs and ions like fluoride, chloride, sulphate, and nitrate into the water. Approximately 25,000 micron-sized MP particles were released into 100 mL of hot water in 15 min.

A soil column experiment was set up for 180 days under simulated rainfall conditions to assess the vertical migration of different types (PP, PE, PET) and sizes of MPs in porous media (sand). Only PE resulted in the formation of MPs that penetrated through the depth of the column and were detected in the effluent after 60 days. The ratio between the size of MPs and sand particles (d_{MP}/d_{sand}) determined the penetration depth of microplastics. MPs with $d_{MP}/d_{sand} < 0.11$ penetrated to a greater extent in sand media than larger-sized MPs. Structural deterioration and mechanical abrasion caused the larger-sized MPs to fragment into smaller sizes and continued to appear in the effluent water even at 180 days.

Keywords: Strength; Salinity; Young's modulus; Microscopy; UV radiation; Degradation; ions; Heavy metals; Nile red; Microplastics; Wet-dry cycle; Porous media; Effluent water; Particle diameter; Thermal stability; Recovery potential