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Release and characterization of micro- and nano-plastic particles from different types of macro-plastics

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In the environment, plastics are exposed to weathering processes such as mechanical cutting and abrasion, chemical and biological degradation, as well as UV radiation and heat. These processes breakdown larger plastics into smaller pieces and alter the physical and chemical properties of plastics. Most environment micro- and nano-plastics are generated via weathering of larger plastics. Micro- and nano-plastics are often more mobile, bioavailable, and toxic than their larger counterparts due to their smaller size. As a result, contamination of micro- and nano-plastics has become an increasing concern. Although many laboratory studies have been conducted on micro- and nano-plastics to understand their behavior in the environment, most studies were conducted using synthesized, mono-dispersed, polystyrene micro-spheres as surrogate for micro- and nano-plastics in the environment. The polystyrene micro-spheres, however, do not represent well the complex and diverse composition, size, shape, and other physiochemical properties of real-world micro- and nano-plastics. The objective of our research is to fill the gap by studying the micro- and nano-plastics released from macro-plastics including polystyrene (PS), high-density and low-density polyethylene (HDPE and LDPE), polypropylene (PP), and nylon under laboratory-controlled conditions. Plastic sheets or pellets were cut into small pieces, mixed with nano-pure water, heated, and filtered through 1 um membrane to collect fine plastics. Some macro-plastics were also “weathered” using UV radiation or high temperature. Particle concentration measurement showed that substantial quantities of fine plastics (~ 5*10^9 particles/mL) were released from PP and LDPE macro-plastics, moderate quantities were released from PS macro-plastics (~5*10^8 particles/mL), and practically no fine plastics were released from nylon or HDPE. SEM results indicated the fine plastic particles were of irregular shape and poly-dispersed with a size-range of ~100 to 400 nm, while the polystyrene micro-spheres were of spherical shape with a uniform diameter of 100 nm. Zeta-potential of LDPE fine plastics in 3 mM NaCl solution at pH 5 was ~-42 mV, more negative than those of polystyrene micro-spheres (~-25 mV). This study highlights the distinct properties of manufactured polystyrene micro-spheres and fine plastics released from macro-plastics. Results from our study suggest fine plastics released from macro-plastics may better represents the properties of micro- and nano-plastics in the environment.