A novel method for magnetic labelling and extraction of small-sized microplastics (4 μm) from soil

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Abstract

Ubiquitous microplastics (MP) have emerged as a global environmental concern. However, limited attention is given to the behaviour of small-sized MP ($<$ 10 μm) due to the challenges associated with separating and quantifying MP from an exceedingly complex matrix. We hypothesised that magnetic labelling of MP would greatly facilitate MP extraction efficiency. Magnetic labelling was achieved by heating MP (4 μm polystyrene spheres) to induce surface melting in a suspension containing Fe3O4 magnetic nanoparticles (MNS) in water, followed by shaking at room temperature, thus fixating MNS in the MP surface layer during cooling, and extraction using a magnet. Herein, 4 μm MP (1581 items) were spiked in 5 ml water, the conditions were optimized for maximizing MP recovery. Incubating MP and MNS at 90∘C for 2.5 h gave the highest MP recovery rate of 91.67 $\pm$ 7.09% in water. The same MP were then added to a sandy soil suspension to assess and optimize labelling efficiency (via ultrasonication, dispersant type, digestion) and extraction efficiency in soil (via MNS type, concentration, and storage time). Ultrasonication did not increase labelling or extraction efficiency. Higher extraction efficiency was obtained in 0.1 M NaCl, and with extracted sample digestion using 30% H2O2 at 60∘C for 1 h. Additionally, the mass ratio of freshly prepared MNS1 to soil was set at 7 mg/g as the optimal label addition. Compared to conventional soil detection, the recovery rate of MP improved from 26.26% to 93.96 $\pm$ 12.34% in this study. This research is the first time to effectively separate MP $<$ 10 μm in soil, facilitating further exploration of small-sized MP detection technologies and risk assessment.

Keywords: Microplastic detection, labelling, magnetic nanoparticles, magnetic extraction, soil, labels stability.

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