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Microplastics in Terrestrial Soils: A Refined Extraction Approach with Comprehensive Risk and Diversity Assessments

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Microplastics (<5mm) are a growing environmental concern, with their prevalence in terrestrial ecosystems remains underexplored compared to the extensive research conducted in aquatic environments. Accurate quantification of soil microplastics remains methodologically challenging, necessitating refined and validated approaches to address existing biases. Methodological challenges in quantifying soil microplastics hinder comprehensive studies across land uses, highlighting the need for baseline assessments to understand their regional abundance, distribution, and ecological impact.

This study aimed to develop an improved soil microplastic extraction method and explore their distribution, behavior, and ecological effects across various land-use types. Various individual and sequential ratios of soil-to-density extraction solutions (using NaCl, $ZnCl_2$ and NaBr) were explored to identify an optimal combination of solutions and proportions. Similarly, varying concentrations of hydrogen peroxide (H_2O_2) were applied at different temperatures to effectively remove soil organic matter. The methods were tested with digestion either preceding or following density separation to assess the sequential efficiency in each scenario. To ensure validation, recovery rates for microplastic particles of two size ranges: small (10–100 µm) and large (100–5000 µm) were analyzed. The approach was applied to soils from different land uses, and risk and diversity models were incorporated to assess microplastic dynamics.

The method using optimized ratios (weight of soil(g):volume of density solution(ml)) of 1:6 and 1:3 for low (NaCl) and high-density ($ZnCl_2$/NaBr) solutions respectively, achieved 95% microplastic recovery. Furthermore, the recovery rate of 99% was achieved after removing organic matter using hydrogen peroxide (H_2O_2) in the ratio of 1:3. Recovery for small (10-100µm) and large (100-5000µm) particles ranged from 88-99%. Microplastics in field samples were characterized by shape, size, color, and polymer composition. Industrial areas had the highest mean microplastic concentrations (3710±1127 particles/kg), followed by dumping sites (3310±2195 particles/kg) and municipal areas (1247±386 particles/kg). Diversity indices revealed notable variations across land-uses, with wetlands exhibiting minimal ecological risk and industrial areas showing high contamination. These findings provide key insights into microplastic diversity and risks, forming a foundation for developing targeted mitigation measures.