The 23rd World Congress of Soil Science

Soil and the Shared Future for Humanity

Assessment of the reliability to extract soil microplastics by a flotation sieving method

Yen-Cheng Chen[1], Yi-Jie Liao[2], Chien-Hui Syu[3], and Kai-Wei Juang[1]*

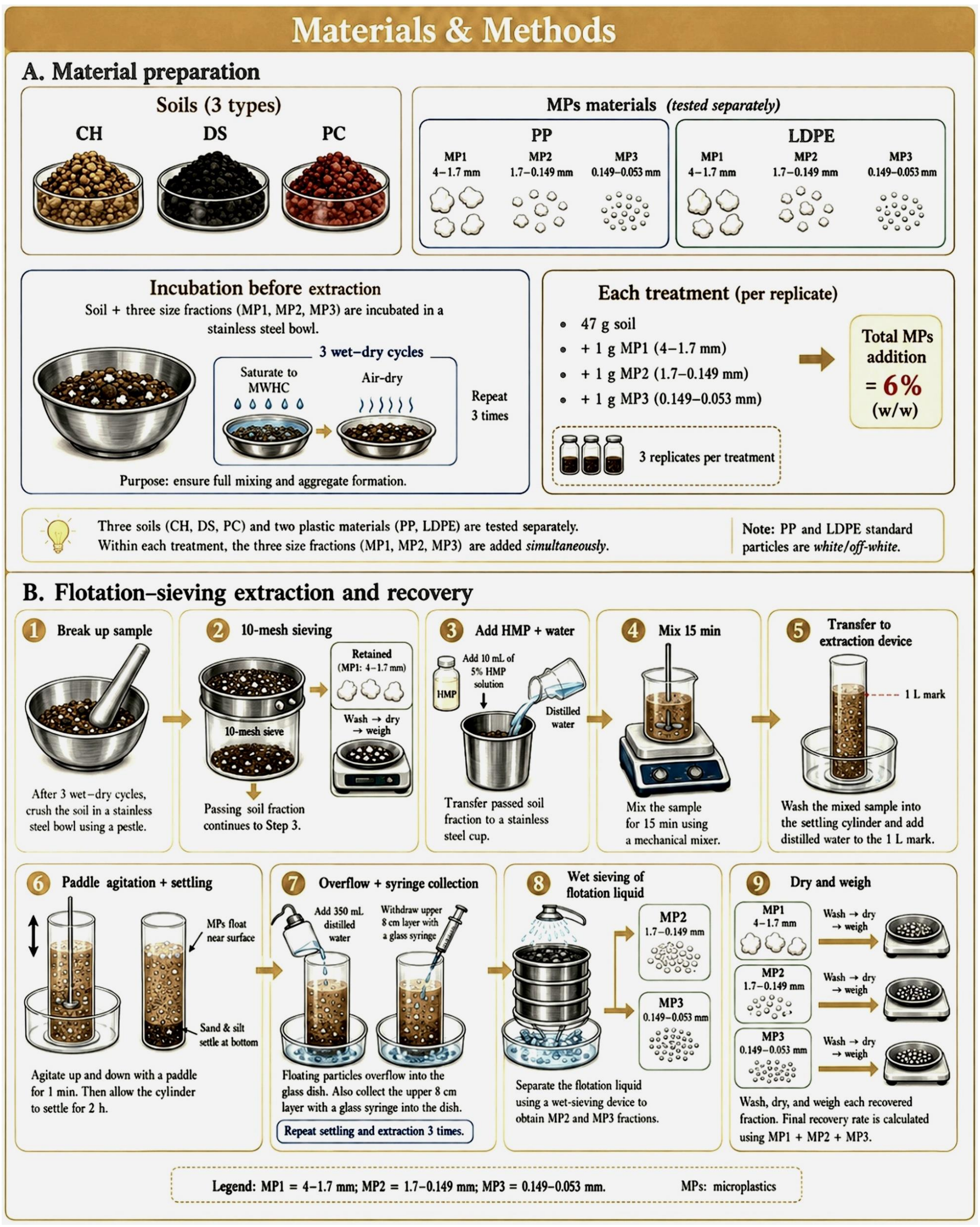
[1] Department of Agronomy, National Chung Hsing University, Taichung, Republic of China

[2] Master Program of Green Technology for Sustainability, Nanhua University, Chiayi, Republic of China

[3] Taiwan Agricultural Research Institute, Ministry of Agriculture, Taichung, Republic of China

Introduction

Microplastics (MPs, <5 mm) have become a critical environmental concern, with agricultural soils serving as a major terrestrial sink due to the use of plastic mulches, sludge applications, and contaminated irrigation. Despite their prevalence, extracting and quantifying MPs from soil remains highly challenging. The complex soil matrix causes MPs to bind with soil particles and organic matter, complicating density flotation methods. Furthermore, the lack of standardized protocols means that recovery rates fluctuate based on soil texture, organic matter content, and MP particle size. To address these analytical gaps, this study evaluates the efficiency of a flotation-sieving method using spiked recovery tests across various soil types and plastic polymers. Coupled with gravimetric analysis, we aim to establish reliable recovery rates and method detection limits for micron-scale MPs, providing a standardized foundation for future agricultural soil surveys.



Result & Discussion

Spiked recovery tests evaluating the sieving-sedimentation extraction method demonstrated stable recovery rates for two plastic polymers across three distinct soil types, achieving an average total recovery of 90.8% (Table 1). Specifically, microplastics in the 4–0.149 mm size range exhibited recovery rates approaching 100%, albeit with instances of slight overestimation. Conversely, recovery rates for smaller particles (0.149–0.053 mm) remained stable at approximately 70%, indicating a significant underestimation for fine microplastics.

To further determine the factors influencing extraction efficiency, we compared the recovery rates across particle sizes, plastic materials, and soil types (Figure 2). Statistical analysis indicated that neither the type of plastic polymer (PP vs. LDPE) nor the soil type significantly affected the recovery rate. The only significant factor was particle size, where the fine fraction (MP3, 0.149–0.053 mm) exhibited a markedly lower recovery rate compared to the larger fractions. This confirms that decreasing particle size is the primary factor limiting extraction efficiency in this flotation method.

Table 1. Recovery rates of microplastics extracted from spiked soil samples.

Soil	Plastic	Recovery rate (%±SE)			Total recovery rate
		MP1	MP2	MP3	(%±SE)
Chaikongtso	PP	99.8±1.1b	107.5±5.1a	67.7±2.5b	91.7±4.9a
	LDPE	107.8±2.6a	108.2±6.1a	66.4±9.2b	94.1±6.3a
Tapaisa	PP	99.7±0.7b	100.9±0.8ab	87.6±1.1a	96.1±1.7a
	LDPE	106.9±3.1a	89.0±2.7b	68.9±0.8b	88.3±4.3a
Pinchen	PP	99.9±0.7a	91.6±3.6b	69.8±1.8c	88.5±3.6a
	LDPE	104.6±1.3a	95.1±1.6b	58.0±3.9c	85.9±5.5a
AVERAGE		103.1±1.5a	98.7±3.3a	69.7±4.0b	90.8±1.6

Different lowercase letters within the same row indicate significant differences among particle-size classes (MP1, MP2, and MP3) within the same soil and plastic type according to Fisher's least significant difference (LSD) test at $p < 0.05$.

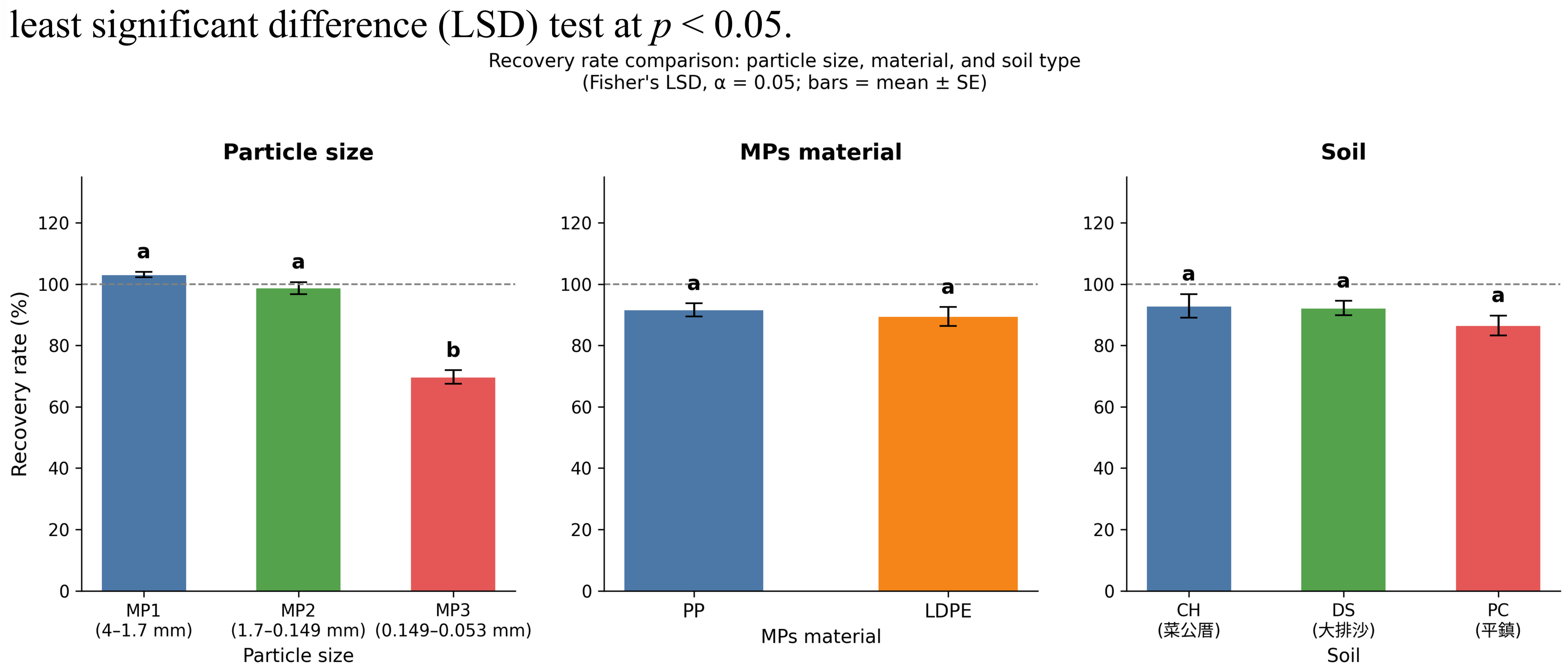


Figure 2. Comparison of microplastic recovery rates across different particle sizes, polymer materials, and soil types. Different lowercase letters indicate significant differences according to Fisher's least significant difference (LSD) test at $p < 0.05$.

Conclusions

Density flotation demonstrated high recovery rates for microplastics (MPs) larger than 0.149 mm across various soil textures and polymer types. However, extraction efficiency decreased significantly for smaller particles, which remained trapped in the residual soil. This indicates that stronger interactions between fine MPs and soil particles make standalone flotation unsuitable for extracting smaller microplastics. While flotation effectively recovers MPs > 0.149 mm, applying this method to actual field samples requires addressing interferences from high organic matter and other low-density impurities. Therefore, coupling density flotation with chemical oxidation is highly recommended to minimize these interferences and ensure accurate quantification in field applications.