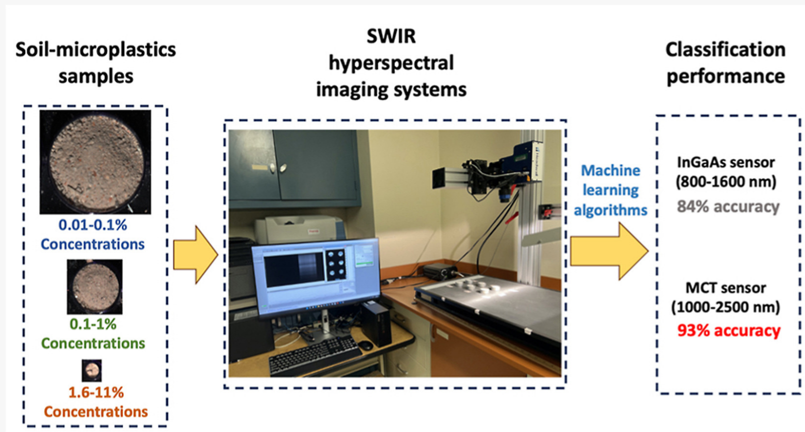
Seeing the invisible: hyperspectral imaging reveals hidden soil pollutants



High-Accuracy Detection of Soil Microplastics Using SWIR Hyperspectral Imaging.

GA, UNITED STATES, June 16, 2025 /EINPresswire.com/ -- Microplastic pollution in agricultural soils is an emerging threat to food safety and ecosystem health, yet detecting these tiny particles at low concentrations remains a major challenge. A new study offers a promising solution by leveraging short-wave infrared hyperspectral imaging (SWIR-HSI) to identify microplastics in soil at concentrations as low as 0.01%. By comparing two imaging sensors - mercury cadmium telluride (MCT) and indium gallium arsenide (InGaAs) - researchers found that the MCT system delivered over 93% detection accuracy across the tested levels of 0.01-12%, significantly outperforming its counterpart. This advance paves the way for faster, non-invasive soil monitoring methods and could transform how we assess environmental contamination in agricultural landscapes.

Microplastics - plastic fragments typically under 5 mm - have been studied extensively in oceans and rivers, but their accumulation in soil, especially farmland, remains underexplored. These particles can disrupt soil structure, alter microbial communities, and even be taken up by crops, entering the food chain. Conventional detection methods, such as chemical digestion followed by microscopy or spectroscopy, are time-consuming, labor-intensive, and often ineffective at identifying small particles, making them impractical for large-scale monitoring. Due to these limitations, there is an urgent need for efficient, non-destructive techniques capable of accurately and rapidly identifying microplastics in complex soil environments.

Now, scientists at Clemson University and the USDA Agricultural Research Service have developed a hyperspectral imaging technique that meets this challenge. Published (DOI: 10.1016/j.seh.2025.100157) in Soil & Environmental Health in May 2025, the study tested two types of short-wave infrared (SWIR) sensors on soil samples spiked with microplastics and evaluated their performance using advanced machine learning models. The MCT-based system stood out for its ability to detect both polyethylene and polyamide particles - even at extremely low levels of 0.01-0.1% - offering a fast, accurate, and field-adaptable method for identifying soil microplastic contamination.

The research centered on evaluating two short-wave infrared hyperspectral imaging (SWIR-HSI) platforms - mercury cadmium telluride (MCT) (1000-2500 nm) and InGaAs (800-1600 nm) - in their ability to detect microplastics at concentrations from 0.01% to 12%. Machine learning algorithms, including logistic regression and support vector machines, were applied to spectral data extracted from soil samples spiked with polyethylene (PE) and polyamide (PA). The MCT system achieved a detection accuracy of 93.8%, compared to 68.8% for InGaAs, particularly excelling in the lower concentration ranges. This performance advantage is linked to MCT's extended spectral coverage, higher sensitivity, and reduced signal noise, especially in the range where plastic-specific molecular bonds are most active. The study also found that increasing sample surface area and using full-spectrum analysis enhanced detection, particularly with MCT. These results support the use of MCT-HSI as a robust, scalable tool for soil monitoring without requiring time-intensive sample preparation.

“This study marks a significant advance in our ability to track microplastic contamination in terrestrial ecosystems,” said Dr. Bosoon Park, corresponding author and USDA researcher. “By combining hyperspectral imaging with machine learning, we can now detect trace amounts of microplastics with impressive accuracy - something that was previously very difficult using conventional methods. The ability to screen soils quickly and non-destructively holds great promise for agricultural sustainability and environmental protection.”

The potential applications of this research are far-reaching. The MCT-HSI system's non-invasive, high-throughput capabilities make it ideal for routine monitoring of agricultural fields, especially in areas heavily reliant on plastic mulch or vulnerable to plastic pollution. It can also facilitate studies on microplastic transport, transformation, and degradation in soil. Beyond farming, the technology could be applied to urban soils, landfills, and sites undergoing ecological restoration. Future studies should aim to validate this method in real-world conditions and expand its scope to include weathered and chemically diverse microplastics, ensuring broader relevance and practical deployment.

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