Supplementary information

Plastic particles in soil: state of the knowledge on sources, occurrence and distribution, analytical methods and ecological impacts

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Table S1. Summary of commonly used analytical techniques for the identification and quantification of plastics in soil samples

Technique	Advantages	Limitations	Impacts on plastics
Stereomicroscope/Microscope	Inexpensive; easy to operate and use; can be used to provide morphological information such as size, shape, colour, and counts of plastic particles	Size dependent and open to bias; over-estimation or underestimation of plastic particles owing to misidentification; time consuming procedure; requires laboratory cleanliness in order to prevent false positives and other misinterpretations [1]; cannot be used to characterize chemical composition of plastic particles without the using FTIR and Raman spectroscopies	Non-destructive to plastic particles
FTIR	Polymer types of plastics could be identified quickly and directly by comparing the resulting spectra with those of known plastics; well established, fast and quite reliable; particle > 500µm can be analysed by ATR-FTIR, whiles particles down to 20µm can be analysed by microscopy coupled FTIR; FPA-FTIR shows better resolution.	Labour-intensive and time consuming; size dependent (> 20 µm); Organic and inorganic impurities, and additives in samples can overlap polymer bands; expensive and require experienced personals for operation and data processing; samples require pre-treatment prior to analysis [2]	Non-destructive to plastic particles, however focusing and pressing in ATR-FTIR can cause destruction to sample
Raman	Increases the accuracy of polymer type identification; suitable for small particles between 1 to 20µm and above with better spatial resolution than FTIR; insensitive to water interference [3]	Fluorescence could be interrupted by the presence of colour, additives, and microbiological, organic or inorganic impurities, pigment; labour intensive and time consuming; requires sample pre-treatment prior to analysis	Non-destructive to plastic particles
vis-NIR spectroscopy	Novel and fast technique, avoiding extraction steps, and directly quantifying the sum of plastics in samples	Only useful for pollution hotspots; currently works for selected plastics (LDPE, PET, and PVC); there is a need for a training set to predict the content and type of polymers within a soil sample; does not provide morphological and structural	-

		information of plastics	
Hyperspectral imaging technology together with chemometrics	Determine and visualize plastics with particle size from 0.5 to 5 mm on soil surface directly without plastics separation from soil	Only capable for imaging and detecting and visualize plastics (PE) on soil surface	Non-destructive to plastic particles
TED-GC-MS	Allows the analysis of plastic particles without any pre-selection/preparation of samples; enables the analysis of high sample masses which assures homogeneity of sample; suitable for complex environmental matrices	Information on dimension, number, size distribution and shape of particles cannot be determined; applicable to few polymer types	Destructive to plastic particles.
TGA-MS	Requires minimal sample preparation effort; generally cheaper than Pyr-GC-MS or TED-GC-MS; direct quantitative analysis of PET without further sample pre-treatment; easy and viable	Unable to provide morphological information including size, shape and colour; soils with high OM contents are likely to interfere with analysis.	Destructive to plastic particles
Pyr-GC-MS	Fast identification of plastics with high certainty; enables quantitative estimation of mass of plastics irrespective of particle size and shape; provides a basis for the uniform reporting of results as compared to the use of conventional FT-IR and Raman; enables simultaneous analysis of polymer types and organic plastic additives	Information about size, shape, colour and numbers of particles are lost; laborious sample pre-treatment and pre-selection/pre extraction might be needed, can be time consuming	Destructive to plastic particle
PLE	Plastics are dissolved with appropriate solvents and either identified or quantified with appropriate analytical technique; not much sample pre-treatment/preparation is needed; practically faster and rapid measure of plastics; reduces processing and labour times needed to pre-treat samples	Depends on the solubility of plastics which makes the technique unsuitable for broad application to analyse all polymer types; does not deliver information on size, number, shape and colour of particles; expensive technique	Destructive to plastic particles
Soil universal model method (SUMM) based on TGA [4]	Provides a fast pre-screening method for analysis of plastics (PE, PS, PVC and PET) in soils; the technique can determine plastic particle load in soil without any further detection techniques; simplicity, low costs, time efficient and no sample pre-treatment required	Indicators are promising for qualitative and quantitative determination of studied plastics (PS, PET and PVC) except PE in soil samples,	Destructive to plastic particles -
Time-of-flight secondary ion mass spectrometry (ToF-SIMS) [5]	Novel method that provides a reference data; applied to identify particle size and abundance of PP,PVC, PET and PA6; suitable for the analysis of inorganic elements	The fragmentation ions of different microplastics in mass spectrometry were different, and which was difficult	-

	and organic compounds and can carry out rapid mass spectrometry scanning and characteristic organic ion imaging; can provide information on particle sizes and their distribution	to distinguish from each other. For instance PP and PE could not be distinguished just based on their observed ions hence it was necessary to calculate the relative ion intensity from suspected PP areas and compare it with those obtained from the PE and PP standards; sample pre-treatment may be required as analysis is susceptible to interference from natural organic matter present in the soil	

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