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Determination of agricultural plastic waste in compost and vermicompost by NMR and Thermic Analysis

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Introduction

Different types of plastic materials are widely used in agricultural system become the accumulation of plastic debris a global environmental concern. More than 20 distinct groups of plastics have been identified for agricultural use, with different formulations available and a wide range of additives. Polyethylene-based polymers are one of the most dominant plastics used in agricultural soil (Jung et al., 2021) because of its low cost, good workability, high impact resistance, excellent chemical resistance and electrical insulation properties. Two different grade of polyethylene plastics were Low Density PolyEthylene (LDPE) and Linear Low Density PolyEthylene (LLPDE), which are thermoplastic made from monomer ethylene and are mainly used to produce films (for greenhouses, low tunnels, mulching, UV protection and silage), due to its high tear and impact strength. The presence of these plastics in complex matrices is difficult to determine, specially the microplastic fragments, and therefore quality assessment in several products vg. compost, biofertilizers etc. is hard to stablish and monitor. In our group we are developing analytical strategies to determine them by Thermal Analysis coupled to MS and by NMR in solid state.

Experimental

The experimental design consisted in a lab scale bioassay whereby the earthworms were exposure to a different agricultural plastic waste (AWP) presence in bio-waste under vermicomposting conditions. Normalized earthworm systems were stablished (100 individuals of *Eisenia foetida*) with organic feedstock containing 1.25% f.w. of LDPE or 1.25% f.w. of a customized AWP mix including (LDPE, LLDPE, PET and PS). In addition, in both scenarios, microbiome consortia (PMC, including plastic-degraders) was also used to promote AWP degradation. Control without AWP and PMC was also including in the set-up. Samples before and after vermicomposting were obtained, oven-dried to constant weight and ground to be used for AWP determination. TGA equipment was used (TGA/STA 449 F5 Jupiter from NETZSCH), determining thermal decomposition processes in an inert atmosphere and different masses associated with the

decomposition of various types of plastics (Martín de la Fuente et al., 2022). Solid-state NMR was performance with a 500 MHz (BRUKER AVANCE DRX500 with CPMAS spectrometer.

Results and Discussion

AWP determination in all the scenarios was carried out using NMR and TA. Presence of AWP in these matrices was affected by earthworm activity, microbiome activity and organic matter evolution. The different nature of AWP materials, the physical and chemical interferences induced by organic matter and the potential additional fragmentation produced a high grade of uncertainty.

Using TG-MS we determined certain ions useful for AWP discrimination: 41, 43, 56, 78, 104, 105 and 154 m/z, which appear in the decomposition of samples at high temperatures. In addition, techniques based on NMR in solid state were also very useful in determine the presence of different types of plastics, by also quantification below 1% (w/w) (Figure 1).

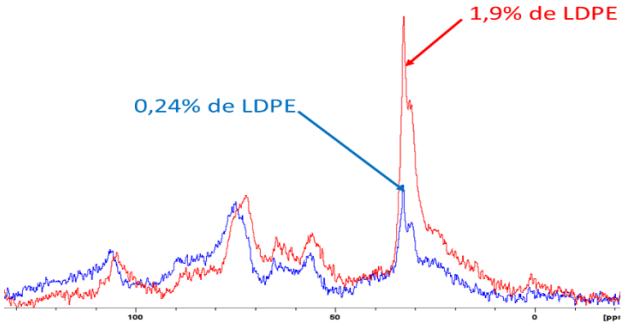

Figure 1. NMR spectra from compost with LDPE

Conclusions

Different types of plastics can be determined and quantified using analytical techniques developed in our laboratory, such as solid-state TG-MS and NMR. We have been able to optimize the different analyses using compost and vermicompost matrices, as well as to follow the possible decomposition of these AWP materials in the organic matrices.

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Biography

Raul Moral: Professor of Miguel Hernandez University. Former coordinator of the Spanish Composting Network. Leader of AGROALNEXT project. Expert in biofertilizer development and agronomic and environmental assessment.