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Plastic Pollution in Soils: Can Metal Isotopes Reveal Its Fate?

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Since plastic use continues to grow, a lot of plastic waste ends up in the environment. Whereas studies have shown the presence of plastic waste in all environmental compartments, data on its accumulation and transformation in soils remain limited. Tracking plastics degradation and mobility in terrestrial environments remains challenging. The aim of this study is thus to explore the use of new tracers of plastic pollution in soils.

Additives, either organic or inorganic, are incorporated during the plastic formulation to provide particular properties and increase its durability. In this study, we investigated elemental concentrations and metal isotopic compositions as tracers to fingerprint plastic pollution in soils, focusing on major and trace elements incorporated as additives (pigments, fillers, ...).

Everyday plastics of different types and colours were collected and identified using infrared spectroscopy. After a microwave digestion, their major and trace element concentrations were determined by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). Results show that blue and green plastics contain significantly higher concentrations of copper (Cu), which is consistent with the use of Cu-based pigments. However, the elemental composition of plastics is highly heterogeneous, reflecting variations in their formulation.

To further evaluate metal isotopes as tracers, a subset of samples was analysed for Cu and/or strontium (Sr) isotopic composition using multi-collector ICP-MS. Selected samples represent different plastic types (PE, PP, PS and PVC) and colours. Cu and Sr were isolated using two different protocols of separation on chromatographic columns. All samples exhibited positive δ^{65}Cu values from 0.11 to 1.36 (± 0.10), indicating enrichment in isotopically heavy Cu. The Cu isotopic signatures varied among plastic samples, suggesting Cu is a potential source-specific tracer. Strontium isotopic ratios (^{87}Sr/^{86}Sr) displayed a wide range of values from 0.707650 to 0.713200 (± 0.000018), reflecting the geological diversity of Sr sources present in plastic additives.

Following these first Cu and Sr isotope measurements in plastics, further work will investigate whether isotopic fractionation occur during experimental plastic degradation in a suspended soil system under agitation. This approach could provide new insights into the fate of plastics in terrestrial environments and serve as a complementary tool for tracking plastic-derived contamination.