



OPEN Detection and specific chemical identification of submillimeter plastic fragments in complex matrices such as compost

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Research on the plastic contamination of organic fertilizer (compost) has largely concentrated on particles and fragments > 1 mm. Small, submillimeter microplastic particles may be more hazardous to the environment. However, research on their presence in composts has been impeded by the difficulty to univocally identify small plastic particles in such complex matrices. Here a method is proposed for the analysis of particles between 0.01 and 1.0 mm according to number, size, and polymer type in compost. As a first demonstration of its potential, the method is used to determine large and small microplastic in composts from eight municipal compost producing plants: three simple biowaste composters, four plants processing greenery and cuttings and one two-stage biowaste digester-composter. While polyethylene, PE, tends to dominate among fragments > 1 mm, the microplastic fraction contained more polypropylene, PP. Whereas the contamination with PE/PP microplastic was similar over the investigated composts, only composts prepared from biowaste contained microplastic with a signature of biodegradable plastic, namely poly(butylene adipate co-terephthalate), PBAT. Moreover, in these composts PBAT microplastic tended to form the largest fraction. When the bulk of residual PBAT in the composts was analyzed by chloroform extraction, an inverse correlation between the number of particles > 0.01 mm and the total extracted amount was seen, arguing for breakdown into smaller particles, but not necessarily a mass reduction. PBAT oligomers and monomers as possible substrates for subsequent biodegradation were not found. Remaining microplastic will enter the environment with the composts, where its subsequent degradability depends on the local conditions and is to date largely uninvestigated.

In recent years the entry of plastic^{1,2} and microplastic^{3–12} materials into terrestrial ecosystems has increasingly become a concern. Especially microplastic contamination can have significant negative effects on terrestrial micro- and macrofauna^{3,4,13} and has also been shown to impede plant biomass production¹⁴. For convenience, microplastic is often divided into large microplastic (1–5 mm) and small microplastic (< 1 mm). Among other sources, compost has been identified as potential means of entry for microplastic into the environment including arable soils^{3,4,7,11,15–17}.

Compost is a popular alternative to artificial fertilizer, in particular for organic farming. Most of the above-cited studies regarding the possible contamination of composts with plastic residues tend to focus on particles and fragments > 1 mm, i.e. particles and fragments that are of relevance for current legislation, such as the regulatory restrictions for quality composts in Germany, which is given in the DöMV (Düngemittelverordnung). The DöMV specifies an upper limit of 0.1 dry wt% of plastic in the final composts but takes only particles > 1 mm into account. The regulation from the European union is less strict and allows up to 0.3 dry wt% for a given type of contaminant including plastic and considers particles > 2 mm, while the total sum of these impurities may not surpass 0.5 dry wt%¹⁸. Among the first to investigate the plastic contamination of different organic quality fertilizers produced in commercial or municipal composting plants with fragments > 1 mm were Weithmann et al.¹⁹. These authors used IR-spectroscopy to positively identify the chemical nature of the retained fragments.

¹Process Biotechnology, University of Bayreuth, Universitätsstrasse 30, 95440 Bayreuth, Germany. ²Macromolecular Chemistry II, University of Bayreuth, Bayreuth, Germany. ³Animal Ecology I & BayCEER, University of Bayreuth, Bayreuth, Germany. ⁴These authors contributed equally: Thomas Steiner and Lisa-Cathrin Leitner. ⁵email: ruth.freitag@uni-bayreuth.de

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Smyth MR.

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Analytical Chemistry Gary D. Christian, 1994-01-06 Extensively revised and updated this edition is concerned primarily with quantitative analysis techniques Describes how to design an analytical method how to obtain a laboratory sample that is representative of the whole and to prepare it for analysis what measurement tools are available automated analyses and the statistical significance of the analysis New and expanded topics include heterogeneous equilibria diode array spectrometers fiber optic sensors and solid phase extraction

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Standard Methods of Chemical Analysis: Special subjects Wilfred Welday Scott, 1925 Chemical Research Faculties American Chemical Society, 1996

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