Options to reduce the content of microplastics in composts made from urban greenery

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Introduction

The lack of mineral fertilizers and their ever-increasing cost force farmers to look for other sources of nutrients to ensure soil fertility that is more economically affordable and yet safe for humans and the ecosystem. There is the possibility of using compost. Truly biodegradable plastics should not be visible in compost since it is specified that these plastics should not be visible after 12 weeks in the composting process, and 90% should be mineralised after six months (Amery et al., 2020). However, parts can still be present in the compost as micro and nano plastics.

The increased biodegradation of fine-grained PET particles was demonstrated by Farzi et al. (2020). The article deals with the identification of the proportion of chemical compounds that identify microplastics and additives and their ability to release them into the aqueous environment depending on the size of the compost particles and the choice of measures to limit their migration.

Material and methods

Research on microplastics and additives released from them was carried out at the OZO Ostrava composting plant. OZO Ostrava uses only municipal green waste from the maintenance of urban greenery and brown bins containing biowaste from individual housing in Ostrava (Czech Republic) as feedstock. The composting plant processes up to 15,000 tonnes of biowaste/year. Composts were collected during 2022. Microplastics and additives were monitored both in the matured compost (after six months) and during the composting process in the input material and after six weeks of maturation.

Microplastics were determined by pyrolysis chromatography with mass detection, which allows the analysis of individual components forming plastics and their additives in the dry matter and in the aqueous leachate. Analyses were carried out for individual granular grades of compost, which were prepared by sieve analysis according to EN 15428 "Soil improvers and growing media – determination of particle size distribution". In addition, phytotoxicity tests were carried out to assess the effect of microplastics and their additives on plant growth, and a germination index (Pane et al., 2015) for watercress and white mustard was determined. In addition, leachable nutrient forms ($N\text{-}NH_4^+$, K^+) were determined in the aqueous leachate according to ISO 14911:2019 and dissolved organic carbon (DOC) and nitrogen according to ISO 20236:2018.

Results and discussion

Matured composts made from urban greenery contain microplastics (PET – polyethylene terephthalate, PE – polyethylene, PP – polypropylene, and PS – polystyrene) in a concentration of 40 – 80 mg/kg and additives in a concentration of 50 – 100 µg/kg. The input material for composting contains 500 – 800 mg/kg of microplastics and 186 – 320 µg/mg of additives. The following plastics have been identified in the most considerable quantities in matured compost: PET > PS > PE > PP.

PET relics are present in the highest amount in composts, which make up 50% of microplastics; approximately 20% are PE and polystyrene PS. The highest concentration of microplastics was found in the grain size class of 0.31 – 0.63 mm and 0.63 – 1.25 mm. The highest concentration of additives was found in class 0.31 – 0.63 mm, which is also about 1.8times higher than the concentration in the total sample. The highest yield by weight of 20% was found in the grain size class 1.25 – 2.50 mm and 19% in the class 2.50 – 5 mm. A maximum of 15% of the total content of chemical compounds identified in the dry matter passes into the aqueous leachate. Most PET compounds are released into the aqueous environment, the smallest amount of compounds is leached from PE (0.5 – 5%). The relationship between carbon content in compost and microplastics has not been demonstrated. The mechanism of decomposition of biogenic organic matter and microplastics is different.

The leaching analysis has not confirmed that the leaching ability of additives and microplastics is affected by grain size. The leachability of additives ranges from 1 to 33%. Some additives have shown a statistically significant dependence between the content in dry matter and the leachability (7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione, butylated hydroxytoluene, n,n dibutyl formamide, and for phthalates, only diisobutyl phthalate). The leaching of additives is affected by the leaching of soluble organic carbon. A statistically significant dependence has been shown to confirm that higher leachability of DOC reduces the leachability of additives. The presence of humic acids (the main component of DOC) limits the leaching of additives.

A germination index of 68% was found for compost sampled in March 2022 with a total microplastics content of 4,000 mg/kg, and for composts (May 2022) with a total microplastics content of 2,400 mg/kg, the germination index for watercress was higher (87%), which characterises the better properties of the compost.

Conclusions

Repeated analyses have found that during the composting process, the highest accumulation of microplastics occurs in the 0.63 – 1.25 mm grain size class. No relationship between the extractability of additives and the grain size has been demonstrated, but for some compounds, a statistically significant relationship between the concentration in dry matter and the extractability has been demonstrated. For identified phthalates (endocrine disruptors), this relationship has only been confirmed for diisobutyl phthalate.

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