Separation and quantification of microplastics in green waste compost

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Biological treatment of organic waste, mainly green waste, into fertilizers and their application to agricultural land is a common practice that promotes the return of nutrients to the soil and increases soil fertility. However, green compost can potentially be a source of microplastics and contributes to their release into the environment. Microplastics in green compost are mainly formed due to the incomplete decomposition of bio- and oxo-degradable waste disposal bags (Markowicz & Szymańska-Pulikowska, 2019). In addition, accidentally caught plastic waste breaks down during the mechanically pre-treatment of green waste such as shredding and sieving and turns into microplastics. Post-treatment of compost, such as sieving, can significantly reduce but never wholly remove microplastics (Weithmann et al., 2018).

Weithmann et al. (2018) investigated large (1−5mm) microplastics in several organic fertilizers after the biological treatment of organic waste. According to their investigation, microplastics amount varies from 0 for fertilizer after energy crop digestion till 895 particles per kilogram dry weight in commercially available fertilizer from a second biowaste digester. Braun et al. (2020) found that compost application to agricultural fields goes along with plastic loads of 84,000 to 1,610,000 plastic items ha^{-1} a^{-1} or from 0.34 to 47.53 kg plastic ha^{-1} a^{-1}. The presence of microplastics in the soil after compost application was confirmed by Watteau et al. (2018).

This work aims to develop a general algorithm for microplastics quantification in green compost samples and determine the concentration of microplastics in real green compost samples.

For this investigation, green compost samples were taken from the Alytus MBT facility. The primary substrates for this compost production are wood, biodegradable garden and park waste collected from city Alytus and neighboring regions. Green waste is composted in long rows (windows) due to the technological process's simplicity and cheapness. Ready compost is used for agriculture purpose.

The needed weight of samples is varied between studies (Prata et al., 2018). For the presented investigation, the weight of the dry compost sample was 20 g. As microplastics are polymer particles with the largest dimension, ranging from 1 µm to 5mm (Duis & Coors, 2016), samples were sieved using 5 mm sieves and then 1 mm sieves. Microplastics from fraction 1−5 mm were extracted manually. Particles were identified as microplastics visually based on color and shapes, and FTIR analysis was used for polymer type determination.

For a fraction less than 1 mm, the first step was removing organic matter that may embed microplastic by Fenton's reagent, the safest for microplastics method. The next step was density separation. For proper microplastic separation, it is essential to choose a solution with an appropriate density. Microplastics have different densities, some of them, like PP or PE, have even a lower density than seawater (1.10 g/cm3). In comparison, microplastics, such as PET or PVC, have a density around 1.40 g/cm^{-3} or greater than that, so different solutions are used to separate them from samples (Mai et al., 2018). For this investigation, the potassium formate solution was used (Zhang et al., 2016). The supernatant fractions were then vacuum filtered.

For microplastic identification and quantification, Nile Red dye was used. In order to correctly identify microplastics, filters should not present fluorescence when stained. Prata and others (2019) tested different filters and recommended using glass fiber or PCTE filters when using Nile Red staining dye protocols. Therefore, for the current investigation, glass fiber filters were used. Filters were stained with Nile Red solution and then observed under the fluorescent microscope. Fluorescent particles were photographed with a microscope camera and then measured in the ImageJ.

On average, compost samples contained 5733 ± 850 (mean±SD) plastic items kg^{-1} dry weight. Most microplastics (about one third) had sizes from 100 to 200 µm and were films, which probably means that they were formed due to the incomplete decomposition of disposal bags. The amount of microplastics in green compost is difficult to compare with other studies due to the difference in approaches to measuring the amount of microplastics and the accuracy of methods. For example, Weithmann et al. (2018) measured the concentration of large microplastics, while small microplastics were not studied. Zafiu et al. (2020) analyzed the amount of microplastics up to 0.63 mm in size and measured the amount by weight.

Nowadays, the amount of microplastics larger than 2 mm in ready compost is covered by the new European Fertilisers Regulation. According to the new regulation, compost should not contain impurities larger than 2 mm, such as plastics and inert materials, more than 0.5% of dry weight. Large microplastics from green compost samples were weighed, and their concentration did not exceed 0.5%. Therefore, green compost from the Alytus MBT meet requirements about inert materials in the compost. However, current requirements do not concern amount of microplastics smaller than 2 mm and their effects on our environment.

Little know nowadays about microplastics effects. However, the last investigation mentioned that microplastics can change soil biophysical properties, including soil aggregation, bulk density and water holding capacity (Machado et al., 2018; Wan et al., 2019), effect on earthworms, be absorbed by plant roots (Rilling et al., 2019) and migrate within food webs.

Conclusion.

Terrestrial emissions of microplastics have different sources, and organic fertilizers are one of them. Current practice for separate collection of green waste allows getting a very suitable substrate for clean bio-compost. According to the investigation, the amount of large microplastics (1−5) in green compost, which is used for agriculture purposes, meets all requirements.

However, current EU requirements about impurities in compost do not consider small microplastics. Studies of both small and large microplastics have shown an average concentration of microplastics 5733 ± 850 plastic items kg^{-1} dry weight.

References:

Braun, M., Mail, M., Heyse, R., & Amelung, W. (2020). Plastic in compost: prevalence and potential input into agricultural and horticultural soils. *Science of the Total Environment*, https://doi.org/10.1016/j.scitotenv.2020.143335.

Duis, K., & Coors, A. (2016). Microplastics in the aquatic and terrestrial environment: sources (with a specific focus on personal care products), fate and effects. *Environmental Sciences Europe*, 28, 1–25.

Machado, A.A.S., Lau, C.W., Till, J., Kloas, W., Lehmann, A., Becker, R., & Rillig, M.C. (2018). Impacts of microplastics on the soil biophysical environment. *Environmental Science & Technology*, 52, 9656–9665.

Mai, L., Bao, L.-J., Shi, L., Wong, C. S., & Zeng, E. Y. (2018). A review of methods for measuring microplastics in aquatic environments. *Environmental Science and Pollution Research*, 25(12), 11319–11332. doi:10.1007/s11356-018-1692-0.

Markowicz, & Szymańska-Pulikowska. (2019). Analysis of the Possibility of Environmental Pollution by Composted Biodegradable and Oxo-Biodegradable Plastics. *Geosciences*, *9*(11), 460. https://doi.org/10.3390/geosciences9110460.

Prata, J. C., da Costa, J. P., Duarte, A. C., & Rocha-Santos, T. (2018). Methods for sampling and detection of microplastics in water and sediment: a critical review. *TrAC Trends in Analytical Chemistry*. doi:10.1016/j.trac.2018.10.029.

Rillig, M. C., Lehmann, A., de Souza Machado, A. A., & Yang, G. (2019). Microplastic effects on plants. *New Phytologist.* doi:10.1111/nph.15794.

Wan, Y., Wu, C., Xue, Q., & Hui, X. (2019). Effects of plastic contamination on water evaporation and desiccation cracking in soil. *Science of the Total Environment* , 654, 576–582.

Watteau, F., Dignac, M.-F., Bouchard, A., Revallier, A., & Houot, S. (2018). Microplastic Detection in Soil Amended With Municipal Solid Waste Composts as Revealed by Transmission Electronic Microscopy and Pyrolysis/GC/MS. *Frontiers in Sustainable Food Systems*, 2. doi:10.3389/fsufs.2018.00081

Weithmann, N., Möller, J. N., Löder, M. G. J., Piehl, S., Laforsch, C., & Freitag, R. (2018). Organic fertilizer as a vehicle for the entry of microplastic into the environment. *Science Advances*, *4*(4), eaap8060. https://doi.org/10.1126/sciadv.aap8060.

Zafiu, C., Binner, E., Hirsch, C., Vay, B., & Huber-Humer, M. (2020). Makro- und Mikrokunststoffe in österreichischen Komposten, *Österr Wasser- und Abfallw*. https://doi.org/10.1007/s00506-020-00701-9

Zhang, K., Su, J., Xiong, X., Wu, X., Wu, C., & Liu, J. (2016). Microplastic pollution of lakeshore sediments from remote lakes in Tibet plateau, China. *Environmental Pollution*, 219, 450–455. doi:10.1016/j.envpol.2016.05.048