Microplastics in Composts, Digestates & Food Wastes

A New Comprehensive Review of Scientific Literature Finds that Microplastics are a Systemic Challenge in Organics Recycling

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Background

Recent efforts to divert food waste to composting and anaerobic digestion raise concerns that microplastics (plastic particles <5 mm) from food packaging could be unintentionally added to agricultural soils[1] (**Figures 1** and **2**). During the December 2019 Universal Recycling Stakeholders Group meeting, participants expressed concerns over microplastic contamination in organic soil amendments derived from mechanically depackaged food waste[2]. Since that time, our interdisciplinary team conducted a systematic literature review, and discovered that microplastic contamination is a near ubiquitous challenge in organics recycling; no technology or processing strategy is inherently free of contamination risk.

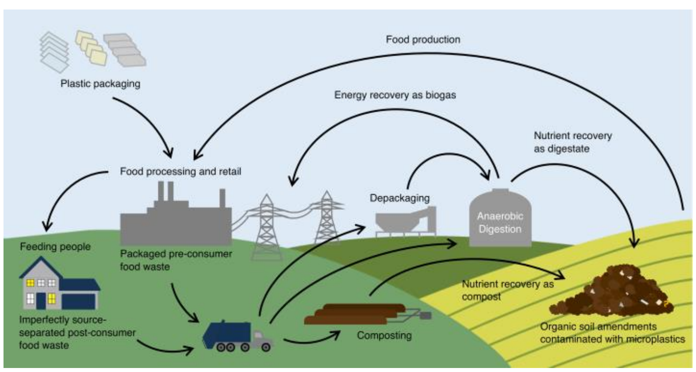

Figure 1. Pathways for microplastics entry into the environment via organic soil amendments

Microplastic Abundance in Organic Amendments

Few studies have characterized plastic abundance in composts, digestates, or food wastes (primarily in Europe and Asia). Reported plastic abundance varies widely both within and between studies. Researchers more frequently measure microplastic contamination in units of particle count per dry weight of material, however a smaller number have reported values on a weight per weight (*w/w*) basis (**Table 1**). The overlapping ranges of microplastic abundance in food-waste derived composts and digestates indicates that neither practice necessarily produces contaminant-free soil amendments.

Key Findings

1. There are limited studies (especially in the U.S.) that quantify and characterize plastic abundance in composts, digestates, and food waste.

2. Microplastic contamination is a systemic challenge in organics recycling; no technology or processing strategy is inherently free of contamination risk.

3. Microplastics enter agricultural soils in many ways (e.g., biosolids, plastic mulching, irrigation, atmospheric deposition) and the relative contribution of food waste-derived organic soil amendments is understudied. All sources should be comprehensively considered for microplastic regulation.

4. The lack of standard methods for measuring microplastics in complex organic materials (e.g., composts and digestates) complicates comparison among studies.

5. More scientific research is needed to understand the potential risks of microplastics in agricultural soils.

Our preliminary data for depackaged food wastes and digestate in Vermont fall within the range of values reported in **Table 1** (count per weight basis). The presence of microplastics in composts derived from green waste (e.g., yard waste) indicates that packaging from food waste is not the only possible source of microplastics in organic soil amendments.

Material	Plastics (particles/ dry kg)	Plastics (% *w/w* dry)
Green waste-derived compost	12 to 82,800 [Refs. 3,4]	0.00024 to 0.053% [Refs. 3,5]
Food waste-derived compost	20 to 30,000 [Refs. 6,7]	0.001 to 0.14% [Refs. 3,8]
Food waste-derived digestate	70 to 1,670 [Refs. 7,21]	0.01 to 0.25% [Refs. 9,21]
Food waste	40 to 1,400 [Refs. 9,10]	0.025 to 5.6% [Refs. 9,11]

Table 1. Typical ranges of plastic abundance reported in the scientific literature. Note that count and % *w/w* values in each row are not necessarily from the same studies. Some higher values have been reported for compost, digestate, & food waste.

Figure 2. Visible plastic contamination in (A) organic municipal solid waste compost windrows prior to screening (credit: E.D. Roy, S. Asia), (B) screw-press separated solid digestate from co-digestion of dairy manure and food waste (credit: E.D. Roy, United States), and (C–D) Putative microplastics found in food waste digestate (credit: K.K. Porterfield, United States).

Multiple Entry Points

Microplastics may enter agricultural soils through multiple pathways. Primary microplastics—those that are intentionally engineered to be small[12]—are applied directly to agricultural soils in the form of plastic-coated controlled-release fertilizers, treated seeds, and capsule suspension plant protection products[13]. Sources of secondary microplastics—formed by the breakdown of larger plastic particles[12]—include plastic mulching, land application of contaminated soil amendments (e.g., biosolids, composts, and digestates), irrigation water, roads, and atmospheric deposition[14,15].

Impacts on Soil, Plants, & Animals

Several studies report negative effects of microplastics in soil-plant systems. These include physical effects such as changes to soil porosity, water repellence, and bulk density[16,17], as well as biological effects such as changes in microbial community composition, reduced plant growth, and deleterious effects on organisms higher in soil food chains[18,19]. However, results are variable and there is currently no easy way to extrapolate the relevance of existing ecotoxicity studies to Vermont soils. More scientific evidence is needed before conclusions regarding the potential risks of microplastics in agricultural soils can be fully assessed.

A Need for Standardized Methods

Currently there is a mismatch between existing regulations and scientific approaches for measuring microplastics. Existing regulations and ecotoxicity studies typically delineate thresholds or toxicity levels on a *w/w* basis[1,20]. Conversely, the most common methods for identifying microplastics (light microscopy and Fourier Transform Infrared Spectroscopy) generate count per weight values. There is currently no consistent method to convert microplastic abundance between count per weight and *w/w* units, making the translation of scientific results into regulation challenging. Enforcement of regulatory thresholds defined by *w/w* units will require advancements in methods. Furthermore, plastic size classes included also vary widely across studies.

Methodological differences likely exert a strong influence on measures of microplastic abundance and underscore the need to develop standard methods for measuring microplastics in the environment.

Policy Recommendations

Precautionary microplastics legislation would be most effective with a broad focus on soil amendments versus any one technology or material. We are in an early stage of beginning to understand this systemic issue. It is critical for legislation to bolster monitoring and research on microplastics to enable design of data-driven, risk-based regulatory standards that protect Vermont soils and enhance the sustainability of organics recycling.

We recommend the following specifically related to H.501 as currently written.

- A priority for microplastics >1 mm is a practical choice as measuring particles <1 mm is more challenging.
- The overall 0.5% dry weight limit (with a stricter 0.1% by dry weight limit on film plastics) is arbitrary but likely to identify materials with higher plastic content.
- H.501 be amended to include efforts to quantify baseline plastic contamination in agricultural soils and support scientific research on microplastic risks and management strategies.
- Standardized methods are necessary to implement H.501, including standard sampling, isolation, and identification protocols, which are feasible but will require adequate funding and resources to overcome multiple challenges. Measuring microplastics on a % dry weight basis is more challenging than on a count per dry weight basis. A stricter limit on film plastics is advantageous due to their light weight and abundance, but adds complexity.
- Time and cost associated with measurements could create substantial burdens for practitioners, depending on implementation details. For example, time needed to analyze a sample may exceed the time an operation can store that material on site.
- H.501 be amended to require reevaluation of regulatory limits when more data become available.
- Given the similarity of H.501 to German policy, we suggest asking German experts for lessons learned.

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