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HIDDEN PLASTICS IN URBAN COMPOST: SOURCES, RISKS AND SUSTAINABLE MANAGEMENT

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Composting converts food scraps, vegetable residues and garden waste into a useful soil amendment. It reduces pressure on landfills, recycles nutrients and adds organic matter to soil, making it an important link between urban waste management and sustainable agriculture. Yet apparently clean compost may carry an almost invisible contaminant: microplastics. Plastic bags, food wrappers, disposable items, synthetic fibres and small labels enter the organic waste stream when segregation is poor. Large pieces may be removed during sorting, but fine films, fibres and fragments often remain. Compost can therefore return nutrients to soil while also carrying persistent plastic particles from cities to farms.

This concern does not justify abandoning composting. It calls for cleaner feedstock, better processing and stronger quality control so that the final product remains both agronomically useful and environmentally safe.

Understanding Microplastics and Their Sources

Microplastics are plastic particles smaller than 5 mm and occur as fragments, films, fibres, beads or foam. Primary microplastics are manufactured at a small size, whereas secondary microplastics form when larger products break down through heat, sunlight, abrasion and weathering. Most particles in municipal compost are secondary microplastics derived from ordinary consumer plastics.

Contamination usually begins before waste reaches the plant. Kitchen residues are often discarded in plastic bags or mixed with packaging, disposable cups and cutlery, coated paper, produce stickers, synthetic tea bags, wet wipes and textile fibres. Once these materials become mixed with moist organic waste, complete separation is difficult. Feedstock quality strongly determines compost quality. Separately collected kitchen, market and garden waste generally contains fewer plastics than mixed municipal waste. Films can resemble dried leaves, fibres become entangled with organic matter and tiny fragments pass through screens. "Biodegradable" or "compostable" plastics may also remain partly degraded when a facility does not provide the required temperature, moisture and treatment time.

Common polymers include polyethylene, polypropylene, polyethylene terephthalate, polystyrene and polyvinyl chloride. Their density, flexibility and resistance to weathering differ, which influences where they occur in compost and how easily they can be separated. Light films may remain near the surface, dense fragments may mix with mineral matter, and fibres can become embedded in partially decomposed residues.

Table 1. Major sources and forms of plastic contamination in municipal compost

Source	Likely form	Why it persists
Carry bags and packaging	Films and fragments	Tear during handling; fine pieces pass through screens.
Disposable food-service items	Rigid fragments and foam	Small items are difficult to separate from wet waste.
Textiles, wipes and cleaning materials	Synthetic fibres	Fibres entangle with organic matter and escape sieving.
Labels, stickers and coated paper	Small films and adhesive pieces	Their size and close contact with food hinder removal.
Compostable plastics	Partly degraded films	Breakdown remains incomplete under unsuitable conditions.

Fate of Plastics During Composting

Microorganisms convert degradable organic matter into carbon dioxide, water and stable humus-like material, but conventional plastics do not follow the same pathway. They may become brittle, cracked or discoloured without being completely mineralised.

Shredding, mixing, turning and screening can tear bags and wrappers into progressively smaller pieces. Heat, moisture and friction accelerate surface weathering, making particles harder to detect and recover. Plastic may also become relatively concentrated because organic mass declines during decomposition while most plastic remains. Ageing particles can release additives such as plasticisers, pigments and stabilisers, or bind other pollutants on their surfaces. Thus, disappearance from sight is not proof of biodegradation; composting may change the size and condition of plastics without eliminating them.

Why Microplastic-Contaminated Compost Matters

Compost is commonly applied repeatedly, so even modest contamination in each batch can create a cumulative input. Field evidence shows that a microplastic signal may remain in soil years after application stops. Once particles are dispersed through the plough layer, their removal is practically impossible.Films, fibres and fragments can alter soil aggregation, pore arrangement, bulk density, aeration, water retention and infiltration. The response varies with polymer type, particle shape, size, concentration and soil properties. Some experiments report adverse effects, others limited change, and a few temporary improvements in specific properties. The main concern is therefore not uniform or immediate damage, but persistent inputs that can modify soil processes in unpredictable ways.

Earthworms, nematodes and springtails may ingest particles or experience altered habitats. Because these organisms support decomposition, aggregation and nutrient redistribution, changes in their activity can affect soil functioning. Plastic surfaces also develop microbial biofilms, sometimes called the plastisphere, and may influence microbial communities and enzymes involved in carbon, nitrogen and phosphorus cycling.

Plants are affected mainly through changes in the root environment. Altered soil structure, moisture, nutrient availability and microbial activity may influence germination, root growth, photosynthesis and biomass. Very small particles can interact closely with roots, although crop uptake under realistic field conditions and its implications for food safety remain uncertain. This uncertainty makes prevention preferable to waiting for every long-term effect to be quantified.

Particles introduced with compost may not remain where they are applied. Wind erosion, surface runoff, drainage, soil movement and the activity of soil organisms can redistribute them vertically and horizontally. This creates a pathway from compost-amended fields to neighbouring land and water bodies.

Table 2. Potential effects in compost-amended soils

Component	Possible response	Scientific qualification
Soil structure	Changes in aggregation, pores and bulk density	Effects depend on polymer, shape, dose and soil type.
Water and air	Modified infiltration, retention and aeration	Films, fibres and fragments behave differently.
Soil fauna	Altered feeding, movement or reproduction	Much evidence comes from controlled experiments.

Microorganisms	Changes in biofilms, communities and enzymes	Responses may be positive, negative or negligible.
Crops	Effects on roots, photosynthesis and biomass	Field-scale and food-chain effects remain uncertain.
Co-contaminants	Additive release or pollutant sorption	Ageing and polymer chemistry influence interactions.

Detection and Quality Assessment

Microplastics are difficult to measure in compost because plant fibres, humus and mineral particles may resemble plastic. Representative samples must be collected from several locations within a batch, dried and sieved. Organic matter is removed by controlled digestion, and density separation is used to recover lighter particles. Suspected particles are then classified under a microscope. Visual identification alone is unreliable, so polymer identity is commonly confirmed by Fourier-transform infrared or Raman spectroscopy. Pyrolysis coupled with gas chromatography–mass spectrometry can estimate polymer mass even when individual particles are difficult to count.

Comparison among studies remains challenging because methods differ in sampling, minimum particle size, extraction solution, identification and reporting units. Traditional standards mainly regulate visible impurities, yet visually clean compost may still contain small particles. Quality systems should therefore combine feedstock traceability, limits for visible contaminants and progressively standardised microplastic monitoring. Monitoring should report both particle abundance and plastic mass, together with the size range examined. Without these details, a compost containing many tiny fibres may appear less contaminated than one containing a few heavier fragments, depending on the reporting method.

Management from Waste Generation to Farm Application

The most effective strategy is to prevent plastics from entering organic waste. Removing microscopic particles from finished compost is technically difficult and costly. Households, markets, hotels and institutions should separate food and garden waste without conventional plastic liners. Municipal collection must preserve this separation during transport; remixing segregated waste immediately undermines feedstock quality and public participation.

At compost plants, contaminants should be removed before shredding. Manual sorting, trommel screens, air classifiers, ballistic separators and optical systems target different materials, and staged separation is more effective than relying on final screening alone.

Decentralised processing of clean household, market and garden waste can further reduce handling and cross-contamination.

Producers should document feedstock origin, processing conditions, maturity, nutrient content and physical impurities. Independent testing and certification would help farmers distinguish reliable products from contaminated compost. Farmers should inspect compost for visible films and fibres, buy from traceable sources and avoid repeated application of poor-quality batches. Packaging producers and retailers must also reduce unnecessary materials, improve recyclability and support collection under extended producer responsibility. Management is a chain. Failure during segregation, transport, preprocessing, screening, certification or field use simply transfers the plastic burden to the next stage.

Municipal authorities should combine awareness with routine inspection, incentives for correct segregation and penalties for repeated mixing. Extended producer responsibility can further reduce difficult-to-recycle packaging entering municipal waste.

Table 3. Priority controls along the composting chain

Stage	Priority action	Expected benefit
Waste generation	Separate organic waste from plastics	Prevents contamination at source.
Collection	Keep streams separate during transport	Preserves feedstock quality.
Preprocessing	Remove plastics before shredding	Avoids fragmentation into smaller particles.
Composting	Use staged sorting and screening	Reduces films, fibres and rigid pieces.
Product quality	Test, certify and label compost	Supports informed purchasing.
Farm use	Inspect products and reject contaminated batches	Limits cumulative loading in soil.

The Way Forward

Municipal composting should remain part of sustainable waste and soil management, but success must be judged by product quality rather than only by the quantity of waste processed. Clean feedstock is the foundation; technology cannot fully compensate for mixed waste containing thin films, fibres and multilayer packaging. Progress requires practical, affordable and standardised methods for measuring microplastics, followed by enforceable quality limits. Long-term field studies should assess repeated applications across different soils, crops and climates. Research must also distinguish conventional, bio-based and certified compostable polymers because "biodegradable" does not guarantee complete breakdown in every facility.

The direction is already clear: segregate organic waste at source, maintain separation during collection, remove plastics before size reduction, certify finished compost and create market demand for clean products.

Conclusion

Municipal compost can recycle nutrients and improve soil organic matter, but contaminated feedstock can turn it into a pathway for microplastics. Mixed waste becomes still harder to clean after shredding and composting convert visible plastics into small fragments and fibres.

The answer is not to reject composting, but to produce better compost through source segregation, separate collection, early plastic removal, standardised testing and transparent certification. Shared responsibility can allow organic waste to return safely to soil without carrying the city's plastic pollution with it.

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