Supplementary Materials

Quantification of microplastics in biowastes including biosolids, compost, and vermicompost destined for land application

Helena Ruffell[1], Olga Pantos[2], Brett Robinson[1], Sally Gaw[1]

[1]School of Physical and Chemical Sciences, University of Canterbury, Christchurch 8041, New Zealand.
[2]Institute of Environmental Science and Research, Christchurch 8041, New Zealand.

Correspondence to: Dr. Helena Ruffell, School of Physical and Chemical Sciences, University of Canterbury, 20 Kirkwood Avenue, Ilam, Christchurch 8041, New Zealand. E-mail: hcr38@uclive.ac.nz

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Table S1. Summary of previous studies on the presence of microplastics in biosolids from 2018-2023

Location	**Sample mass (g, dry weight)**	**Brief extraction method**	**Analysis method**	**Size range, lower size limit (µm)**	**Common morphotype**	**Common polymer type**	**Abundance (MP/g dry weight)**	**Reference**
New Zealand	30	Digestion with Fentons, density separation with water, followed by density separation with 1.8 g cm^{-3} NaI	Visual, 100% particles µ-FTIR	25	Fragment 60.7%, fibres 22.1%, films 16.4%, beads 0.8%	PP 29.3%, PE 26.3%, PMMA 16.2%, PET 13.1%, PU 6.3%	Average 2.71, range 0.90-4.94	This study
Australia	5 (wet weight)	Digestion with Fentons, enzymatic digestion, density separation with water, followed by NaI (1.8 g cm^{-3}) via centrifugation	LDIR of particles 20 – 500 µm, ATR-FTIR for particles 500 – 5000 µm	20	Fragment 38.5-55.7%, fibres 44.3-61.5.	PET and PU 24.3-80.9%	Range 11.1-150	Ziajahromi *et al.* (2024)

Location	Sample mass (g, dry weight)	Brief extraction method	Analysis method	Size range, lower size limit (µm)	Common morphotype	Common polymer type	Abundance (MP/g dry weight)	Reference
USA	5	Digestion with Fenton's, density separation with NaCl (1.17 g cm^{-3}) and ZnBr2 (1.72 g cm^{-3}) via centrifugation	Visual subsample of 20% (n = 27) <300 µm for ATR-FTIR	300	Fragment 44%, Fibres 39%, Films 10%, bead 5%, foam 2%	PE 34%, PET 17%, PP 13%	Average 9.1	Naderi Beni *et al.* (2023)
Canada	~1	Digestion with 30% H_2O_2	Visual	80 (filter)	Fibres 86%, fragments 13% (median)	NA	Median 636, range 228-1353	Sivarajah *et al.* (2023)
Australia	10	Digestion with Fentons, density separation with $ZnCl_2$ (1.6 g cm^{-3})	Visual, µ-FTIR	20	Fibres 74%, Fragment 26%	PET 42%, PE 20%, PA 17%, PVC 10%, PP 8%, PMMA 4%	Average 63.8, range 55.4-73.8	Rezaei Rashti *et al.* (2023)

Location	Sample mass (g, dry weight)	Brief extraction method	Analysis method	Size range, lower size limit (µm)	Common morphotype	Common polymer type	Abundance (MP/g dry weight)	Reference
United Kingdom	0.2	Digestion with Fentons, density separation with $ZnCl_2$ (1.5 g cm^{-3})	Visual, subsample between 40-61% for µ-FTIR	50	Fragments 57.5%, fibres 42.5%	PET 40%, PVA 14%, PE 13%	Average 70, range 37.7-97.2	Harley-Nyang *et al.* (2022)
Australia	4-20	Digestion with 30% H_2O_2, density separation with NaI (1.59 g cm^{-3}) via centrifugation	Visual with dye staining and 10 – 20% subsample for ATR-FTIR (> 500 µm) and µ-FTIR (25 – 500 µm)	25	Fibres 89%, fragments 11%	PET majority	Average 52, range 48.5-56.5	Ziajahromi *et al.* (2021)

Location	Sample mass (g, dry weight)	Brief extraction method	Analysis method	Size range, lower size limit (µm)	Common morphotype	Common polymer type	Abundance (MP/g dry weight)	Reference
Mauritius	20 (wet)	Density separation with NaCl (1.2 g cm^{-3}), supernatant digested with 30% H_2O_2	Visual, subsample of ~10% >500 µm for ATR-FTIR	250	Fibres 84%, foam 8%, fragments 6%, spheres 2%	Cotton-PA 88.85%, PE 2.77%, EVA 1.66%	Range 2.2-11.3	Ragoobur *et al.* (2021)
Spain	3	Density separation with water and NaI (1.7 g cm^{-3}) via centrifugation	Visual, subsample of 5 particles for µ-FTIR	50	Fragments > fibres > films	3 PP, 2 PVC	Light density average 18, heavy density 32 (total 50)	van den Berg *et al.* (2020)
Spain	1 (wet sludge and dry pellets)	Digestion with 33% H_2O_2, density separation with NaCl (1.2 g cm^{-3})	Visual, subsample of 172 particles (wastewater and sludge) for µ-FTIR	36	Fibres > fragments	PET > PMMA	133 wet sludge, 101 dry pellets	Edo *et al.* (2020)

Location	Sample mass (g, dry weight)	Brief extraction method	Analysis method	Size range, lower size limit (µm)	Common morphotype	Common polymer type	Abundance (MP/g dry weight)	Reference
Canada	10 cm^3 (wet)	Digestion with Fentons, density separation with water and NaI (1.8 g cm^{-3})	Visual, >300 µm ATR-FTIR, <300 µm µ-FTIR	50	Fragments between 63-73%	PE 43%, PP 20%, PET 17%	Average 11.5, range 8.7-14.4	Crossman *et al.* (2020)
Italy	50 mL (wet)	Density separation with NaCl (1.2 g cm^{-3}), supernatant digested with 15% H_2O_2	Visual, ATR-µ-FTIR	65	Fragments 53%, fibres 47%	ABS 27%, PE 18%, PET 15%	113	Magni *et al.* (2019)
China	10	Density separation with water, NaCl, and NaI via centrifugation, supernatant digested with 30% H_2O_2	Visual, subsample of 158 MPs by Raman	60	Fragment > bead > fibre	PA 78%, PP 14%, PE 5%	240	Liu *et al.* (2019)

Location	Sample mass (g, dry weight)	Brief extraction method	Analysis method	Size range, lower size limit (µm)	Common morphotype	Common polymer type	Abundance (MP/g dry weight)	Reference
China	20 (wet)	Density separation with NaCl (1.2 g cm^{-3}), supernatant digested with 30% H_2O_2	Visual, 10% subsample by µ-FTIR	37	Fibres 62.5%, shaft 14.9%, film 14%, flake 7.3%, sphere 1.3%	PP, PMMA, PE, PA	Average 22.7, range 1.6-56.4	Li *et al.* (2018)
Canada	5 (wet)	Digestion with 30% H_2O_2 and density separation with canola oil	Visual	100	Fibres 81.1%, fragments 20.9%	NA	Average 4.4	Gies *et al.* (2018)

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Table S2. Summary of previous studies on the presence of microplastics in compost from 2018-2023

Location	Feedstocks	Sample mass (g, dry weight)	Brief extraction method	Analysis method	Lower size limit (μm)	Common morphotype	Common polymer type	Abundance (MP/g dry weight)	Reference
New Zealand	VC: food waste, green waste, biosolids, industry processing waste BC: residential and commercial food waste, green waste, paper. BD: livestock manure, bark mulch, green	30	Digestion with Fentons, density separation with water, followed by density separation with 1.8 g cm^{-3} NaI	Visual, 100% particles μ-FTIR	18	VC: Fragments 59.3%, films 28.9%, fibres 11.4%, beads 0.4% BC: fragments 59.2%, films 34.5%, fibres 9.1% BD: fragments 71.5%, films 24.7%,	VC: PP 47.5%, PE 24.0%, PMMA 13.1% BC: PP 32.7%, PE 27.7%, PMMA 10.3% BD: PP 37.9%, PE 28.6%,	VC: average 2.69, range 0.52-6.92 BC: average 1.94, range 1.06-2.99 BD: average 1.1, range 0.48-2.61	This study

Location	Feedstocks	Sample mass (g, dry weight)	Brief extraction method	Analysis method	Lower size limit (µm)	Common morphotype	Common polymer type	Abundance (MP/g dry weight)	Reference
	waste					fibres 12.2%, beads 0.4%	PMMA 11.7%		
China	Livestock manure, bacterial residues, crop processing waste	20	Density separation with NaCl (1.2 g cm^{-3}) and $ZnCl_2$ (1.55 g cm^{-3}). Supernatant digested with 30% H_2O_2 and 2 mol/L HCl	Visual, 10 particles selected for µ-FTIR analysis	20	Film 39%, fibre 30%, fragment 29%, foam 2%	PE, PP, PVC, PET	Average 0.33, range 0-2.55	Zhang *et al.* (2022)
Germany	Municipal green waste, biowaste	200	Density separation with $ZnCl_2$ (1.8 g cm^{-3})	Visual	0.3 (filter)	Fragments 68-91%, fibres 5-13%	NA	Average 0.028, range 0.012-0.046	Braun *et al.* (2021)

Location	Feedstocks	Sample mass (g, dry weight)	Brief extraction method	Analysis method	Lower size limit (µm)	Common morphotype	Common polymer type	Abundance (MP/g dry weight)	Reference
Spain	Residential and commercial green waste and food waste, agricultural waste, wood processing waste	30	Digestion with 30% H_2O_2, density separation with $ZnCl_2$ (1.7 g cm^{-3})	Visual, 15% subsample for ATR-FTIR and µ-FTIR	25 (filter)	Fibres 42.7%, fragments 31.2%, films 22.1%, filaments 3.9%	PE > PS > PET > PP > PVC > PMMA	Range 5-20	Edo *et al.* (2021)
China	Rural domestic waste	5	Digestion with 30% H_2O_2, density separation with NaCl (1.2 g cm^{-3})	Visual, 21% subsample for ATR-µ-FTIR	50	Fibres > films	PET, PP, PE 70-80% of total	Average 2.4	Gui *et al.* (2021)
Lithuania	Municipal green waste	10-20	Digestion with Fentons,	Visual, 1-5mm FTIR,	50	Films 47.6%,	PE 42.7%, PP	Average range: SOW	Sholokhova *et al.* (2021)

Location	Feedstocks	Sample mass (g, dry weight)	Brief extraction method	Analysis method	Lower size limit (µm)	Common morphotype	Common polymer type	Abundance (MP/g dry weight)	Reference
	(GW), food waste (FW), stabilised organic waste (SOW)		density separation with $CHKO_2$ (1.5 g cm^{-3})	<1mm stained with Nile Red and visual analysis by fluorescent microscope		fragments 33.6%, undefined 6.7%, spheres 6.6%, fibres 5.5%	31%, PS 14.7%, PET 5.3%	46-62, FW 13-15, GW 11-13	
The Netherlands	Municipal waste and green waste	5	Density separation with water via centrifugation	Visual, 5 particles selected for ATR-FTIR	30	NS	NS	Average 2	van Schothorst *et al.* (2021)
Germany	Municipal waste and green waste	0.75-3 L volume (mass not specified)	Wet-sieved 5, 2, 1, 0.5 mm	Visual, ATR-FTIR	1000	Fragments > fibres > beads	Styrene-based > PE	Plant A (aerobic): 0.02-0.024; Plant B (anaerobic): 0.014-0.146	Weithmann *et al.* (2018)

VC= vermicompost, BC = bulk compost, BD = bagged compost

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Section S1. Sampling facility information

All samples were collected from facilities around Aotearoa New Zealand. Limited information is presented as the samples were collected under a condition of anonymity. All samples are the mature product.

<u>Biosolids</u>

The final treated product before it leaves the WWTP.

Table A1.1. Sampling facility information including basic WWTP treatment procedure and final biosolids destination

Facility	Basic treatment (WW and biosolids)	Product destination
1	WW: influent is screened, primary and secondary treatment with tertiary maturation ponds. Sludge: anaerobic digestion.	Land disposal (not rehabilitation)
2	WW: influent is screened, primary and secondary treatment, tertiary maturation ponds. Sludge: anaerobic digestion and polymer assisted flocculation, dewatering.	Land rehabilitation and composting
3	WW: influent is screened, SBR treatment. Sludge: Polymer assisted flocculation and dewatered.	Vermicomposting
4	WW: influent is screened, primary and secondary treatment, with tertiary UV. Sludge: anaerobic diegstion and dewatered.	Vermicomposting
5	WW: influent is screened, primary and secondary treatment, with tertiary UV. Sludge: polymer assisted flocculation, anaerobic digestion and dewatered.	Land rehabilitation

<u>Vermicompost</u>

All vermicompost facilities treated their samples by vermicomposting for between 6-18 months. Limited vermicomposting facilities exist in New Zealand, and as a result specific timeframes are not provided along with specific feedstocks to ensure confidentiality. Feedstocks used by vermicomposting facilities include green waste, organic waste (foodscraps), biosolids, dairy shed waste, dairy processing waste, paper processing waste, septic tank waste, oxidation pond waste, and livestock freezing works waste. The number of different feedstocks used by each facility is provided in the table below.

Table A1.2. Sampling facility information including number of feedstocks, bioplastics acceptance, manual removal of plastic, and final product destination.

Facility	**Number of different feedstocks used**	**Are bioplastics accepted?**	**Is plastic removed manually?**	**Final product destination and land use**
1	Three	Yes, unsure what kinds	Only large pieces	Agriculture and landscaping
2	Two	No	By screening	Agriculture and horticulture
3	No response to questionaire			
4	Four	No	By screening	Agriculture, horticulture, landscaping
5	Two	No	By screening	Agriculture, horticulture, landscaping

Bulk compost

Table A1.3. Sampling facility information including feedstocks, treatment processes, bioplastic acceptance, manual plastic removal, and final product destination

Facility	**Feedstock**	**Treatment processes**	**Are bioplastics accepted?**	**Is plastic removed manually?**	**Final product destination and land use**
1	Food and green waste	Hot compost, 12 weeks	Yes, certified compostable packaging	No	Horticulture
2	Food, green	Hot compost,	Yes – food	Yes by spot	Market

	waste, paper	3-6 months	waste liners, certified compostable packaging	picking and screening	garden
3	Food and green waste	Hot compost, 3.5 months	No	Yes	Residential, commercial, rural
4	Food, green waste, paper, compostable packaging	Hot compost, 4-6 months	Yes – PLA packaging	Yes	Market garden
5	Food, green waste, paper	Hot compost, 3+ months	Yes – PLA packaging	Yes by visual assessment	Market garden

Bagged compost

The brand names were omitted due to privacy reasons.

Table A1.4. Bagged compost brand feedstocks as stated on the product packaging.

Brand number	**Feedstocks**
1	Sheep manure, blood and bone, gypsum, fine bark material
2	Chicken manure, blood and bone, gypsum, bioinoculant granules
3	Green waste
4	Bark mulch, sawdust, pig and sheep manure
5	Green waste, bark mulch, manure

Section S2. Detailed sample collection procedure

Sample kits were sent to facilities around New Zealand. All equipment in sampling kits were pre-cleaned following the method in Section 2. The sampling kits contained 1x empty 1 L glass jar with lid (for field control), 3 empty 1 L glass jars with lids for the samples, an additional 1 L glass jar with lid for a sample from a reference site for soil samples, and a stainless-steel spoon to collect the samples with. Paper towels were included, and the sampler was instructed to wipe the sampling spoon with paper towels between each sample jar collection. The sampler was instructed to firstly adhere to their facilities personal protective equipment (PPE) requirements while on site collecting samples. Nitrile gloves and a N95 face mask were also provided in the sampling kit. The sampler was instructed to reduce the instance of sample contamination as much as possible by reducing the instance of synthetic clothing if possible and to wear disposable nitrile gloves while handling the samples. The samplers were instructed to open the empty control jar just prior to collecting a sample, and to replace the lid on the control jar between sample collections. The field control was an attempt to account for any airborne microplastics which may originate from the sampler, the facility, and from other sources.

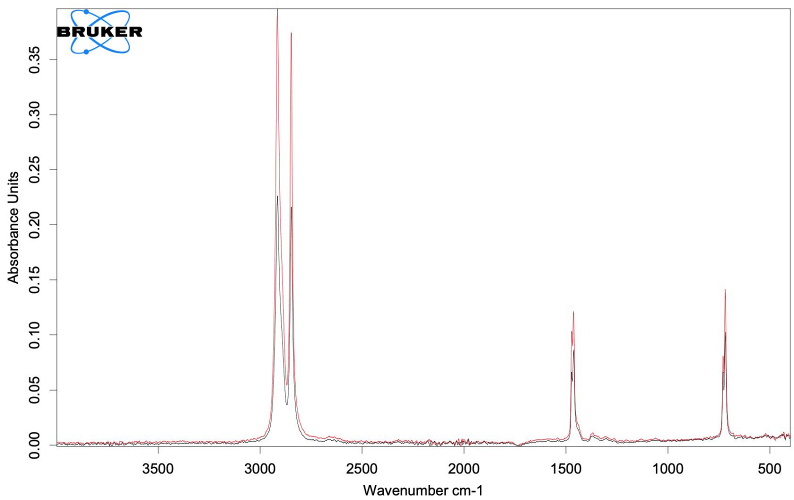
After seeking advice from an environmental statistician, the samplers were instructed to collect replicate samples in the following manner. It was recommended that in the instance where the final product was present as a pile or windrow, the three jars of sample would be collected from the same pile/windrow, to determine the variation within a pile and produce a relevant sample. The samples were to be collected from the middle height of the pile, with the top layer scraped off. Collecting from different piles would introduce uncertainties with the variation between the piles, where there may be differences in maturation time or sample treatment to name a few. For bulk compost and vermicompost, the sampler was instructed to randomly select one pile/windrow of mature compost and take the sample from each jar at different sections of the pile. For biosolids, there is generally only one available pile at the WWTPs as they are frequently shipped off-site for land application and do not need to be stored for maturation onsite like many composts do, and so were instructed to collect each jar from different sections of the same biosolids pile. For collecting samples of soil irrigated with effluent, the samplers were first instructed to collect a reference sample in one of the jars, which was the topsoil (with any grass/plant material scraped off, up to 10 cm depth) of an area nearby with no history of effluent application. The sample jars were collected in areas randomly chosen across the irrigation field, in areas directly receiving treated effluent, with the grass scraped off and the topsoil collected. The sampler was instructed to close the jar lids very tightly after sample collection, and to place the jars into a snaplock bag in the instance of a spill during transit. On arrival, the sample kits were stored at 4°C until drying of the samples.

Health and safety

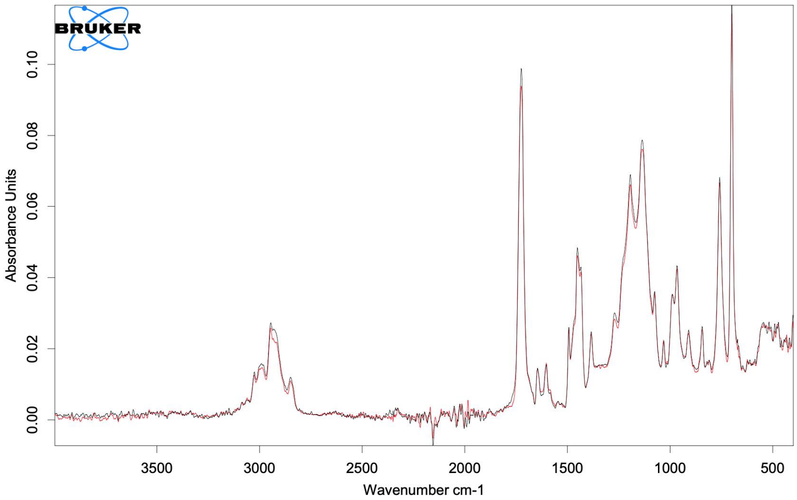
Advice from microbiologists was sought about minimising the risk of exposure to *Legionella* species while handling solid biowastes, particularly composts. Recommended advice for the collection of compost samples included the sampler wearing appropriate PPE (disposable nitrile gloves, N95 face mask) and sampling into a glass jar which can be sealed tightly. The fresh samples were to be stored at 4°C in a sealed container until oven-drying. *Legionella* species do not survive at temperatures past 70°C (Pascale *et al.*, 2022). Oven-drying of biowaste samples at 70-90°C for 3-4 days was recommended. Digestion of oven-dried samples with hydrogen peroxide was said to also reduce the viability of *Legionella* species. Biowaste samples were handled at all times with nitrile gloves and wearing of an N95 face mask. Biowaste samples were oven dried in a pre-heated oven, at the University glasshouse to minimise the risk of inhaling aerosolised *Legionella* species. All sampling equipment was thoroughly sprayed down after sampling with 70% ethanol and bagged. Upon returning to the laboratory, sampling equipment was washed in Decon90 to avoid transmission of *Legionella* species.

Section S3. Spectral tests of reference polymers before and after drying at 75°C.

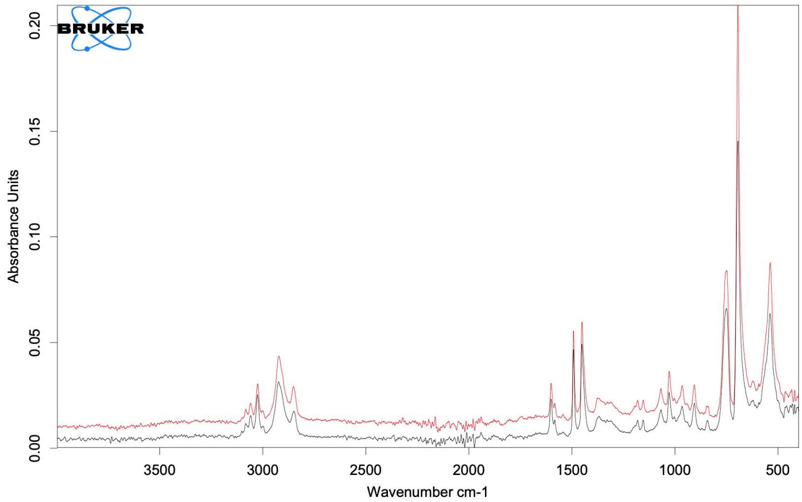
The polymers above were heated in the oven at 75°C for four days. 1x each fragment in size (500-1000 μm) of PET, PVC, HIPS, PP, ABS, HDPE, PA. Spectra are below. No major spectral changes were observed and the temperature was deemed acceptable.



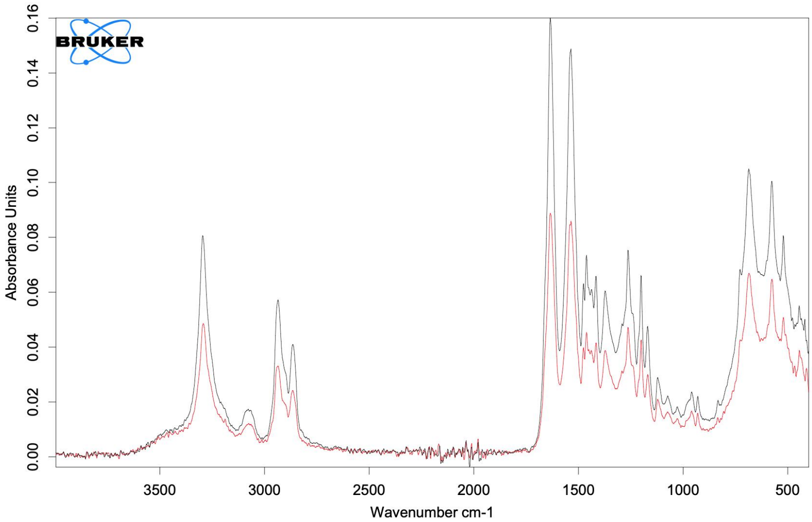
HDPE: Black = before, red = after



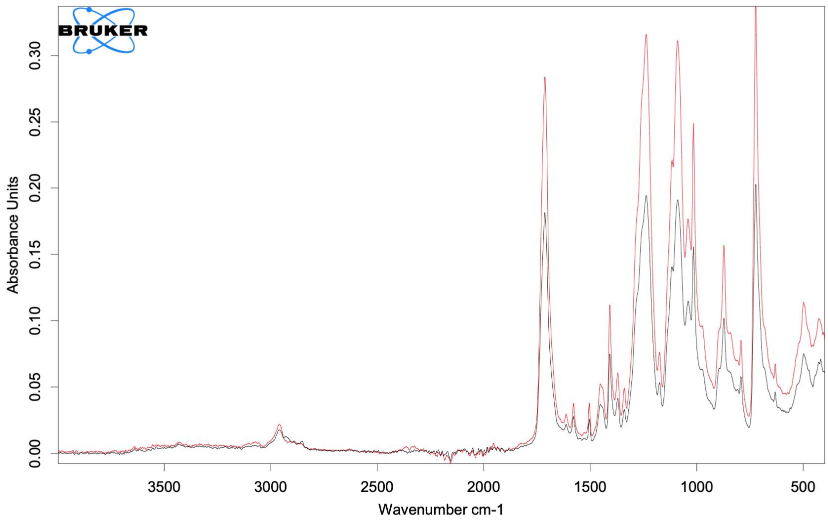
ABS: Black = before, red = after



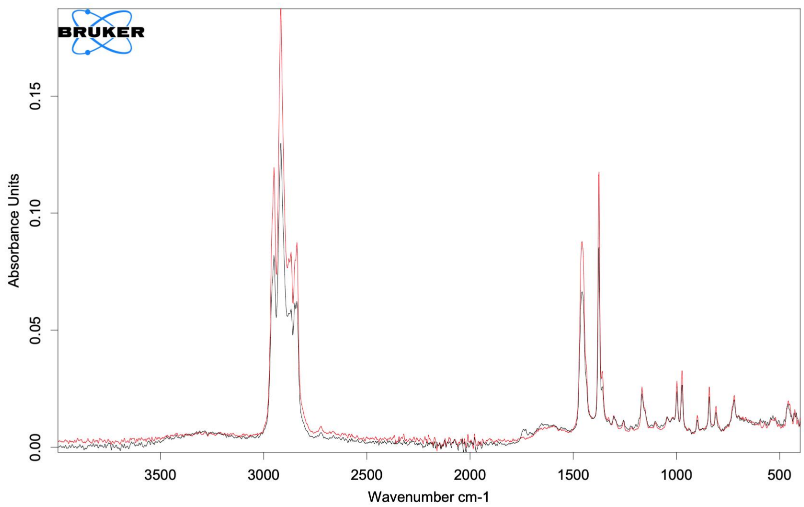
HIPS: Black = before, red = after



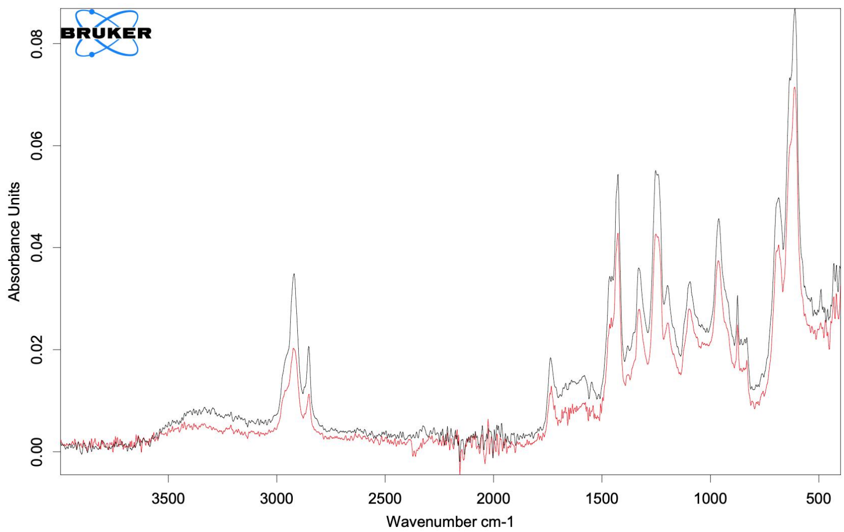
PA: Black = before, red = after



PET: Black = before, red = after



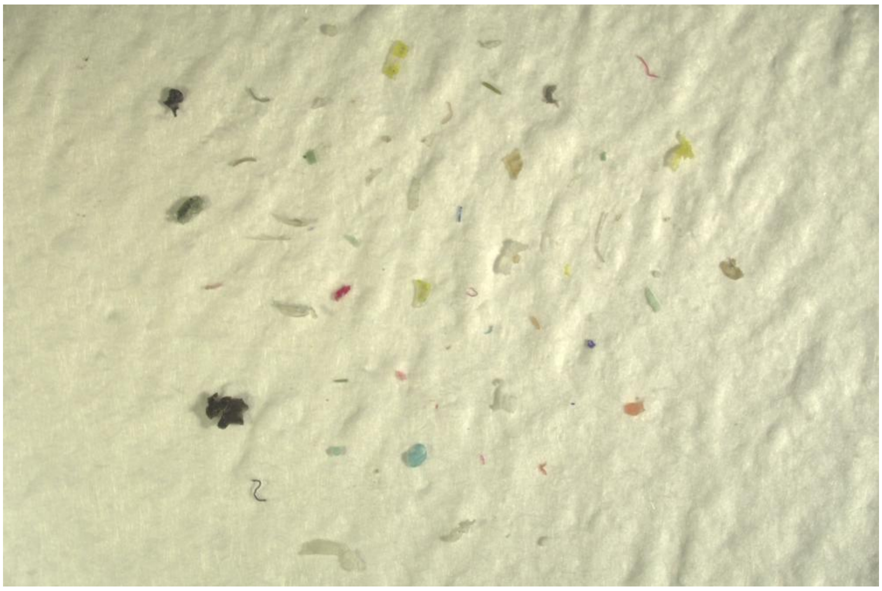
PP: Black = before, red = after



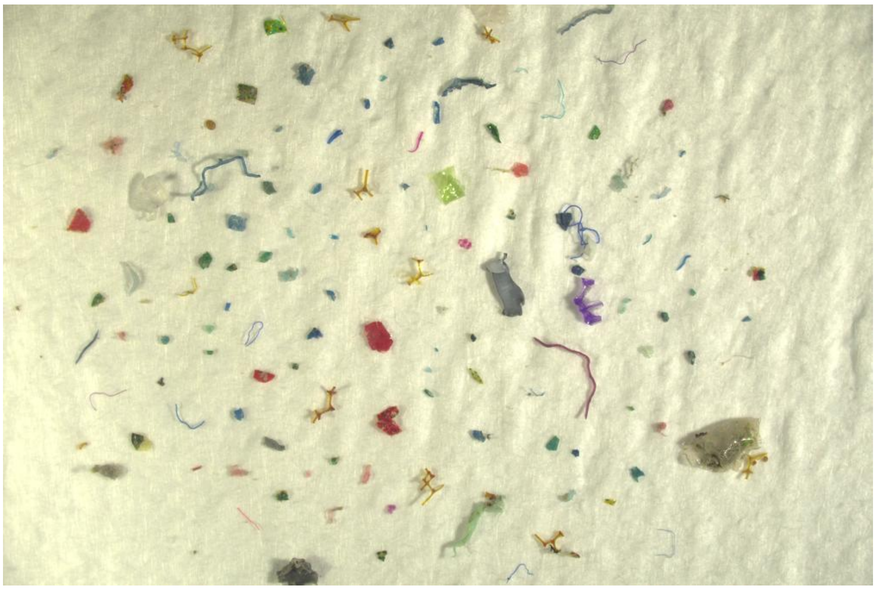
PVC: Black = before, red = after

Section S4. Criteria for suspected microplastics and example photographs of suspected microplastics in a biosolid sample

Criteria for suspected microplastics follows Rochman *et al.* (2019) as a guide. The following criteria were incorporated: particles of diverse shapes and colours; flexible fibres with clean-cut, pointed, or frayed ends; irregular shaped fragments of rigid structure; spheres with smooth surfaces; thin, flat, malleable films; and soft, compressible foams. It was observed that a number of confirmed microplastics in this study did not fit the criteria specified by Rochman *et al.* (2019), highlighting the ubiquity of microplastics characteristics and importance of polymer confirmation of all suspected microplastics.



B5 Jar 1 ultra-pure water density separation suspected microplastics



B5 Jar 1 NaI density separation microplastics

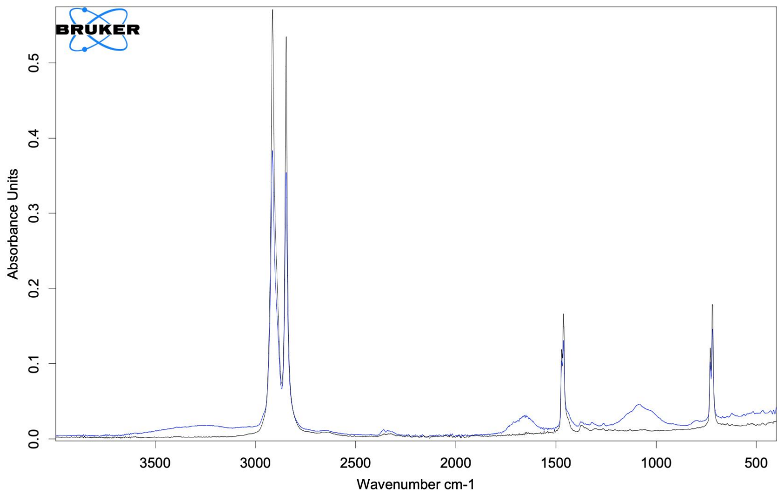
Section S5. FTIR spectral libraries

All µ-FTIR spectra were analysed against Wiley KnowItAll Informatics System spectral library database (Version 20.1.210.0) with the following libraries:

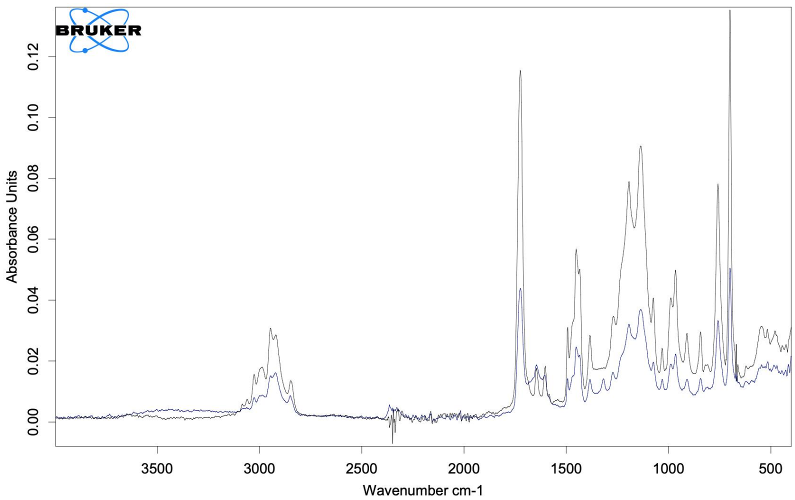
ATR-IR – Sadtler Plasticizers – Wiley; ATR-IR – Sadtler Polymers & Monomers (Basic) 2 – Wiley; ATR-IR – Sadtler Polymers & Monomers (Basic) 3 – Wiley; ATR-IR – Sadtler Polymers & Monomers (Basic) 4 – Wiley; ATR-IR – Sadtler Polymers – Wiley; IR – Automobile Paint Chips; IR – Microplastics Classifications – Wiley; IR – Polymer Additives, Hummel Industrial – Wiley; IR – Polymers, Hummel Defined – Wiley; IR – Polymers, Hummel Defined Basic – Wiley; IR – Polymers, Hummel Industrial – Wiley; IR – Polymers, Hummel Industrial Monomers – Wiley; IR – Polymers, Hummel Industrial Polymers – Wiley; IR – Sadtler Acrylates & Methacrylates – Wiley; IR – Sadtler Adhesives & Sealants (Subset) – Wiley; IR – Sadtler Adhesives & Sealants – Wiley; IR – Sadtler Coating Chemicals (Revised) – Wiley; IR – Sadtler Coating Chemicals (Revised) – Wiley; IR - Sadtler Coating Chemicals – Wiley; IR – Sadtler Epoxy Resins, Curing Agents & Additives – Wiley; IR – Sadtler Fibers & Textile Chemicals – Wiley; IR – Sadtler Fibers by Microscope – Wiley; IR – Sadtler Plasticizers – Wiley; IR – Sadtler Polymer Additives (Revised) – Wiley; IR – Sadtler Polymer Additives – Wiley; IR – Sadtler Polymeric Compounds – Wiley; IR – Sadtler Polymers & Monomers (Basic) 1 – Wiley; IR – Sadtler Polymers & Monomers (Basic) 2 – Wiley; IR – Sadtler Polymers & Monomers (Basic) 3 – Wiley; IR – Sadtler Polymers & Monomers (Comprehensive) – Wiley; IR – Sadtler Polymers & Monomers (Subset) 1 – Wiley; IR – Sadtler Polymers & Monomers (Subset) 2 – Wiley; IR – Sadtler Polymers, Controlled Pyrolyzates – Wiley; IR – Sadtler Polymers, Hummel – Wiley.

Section S6. Spectral tests of reference polymers before and after WPO

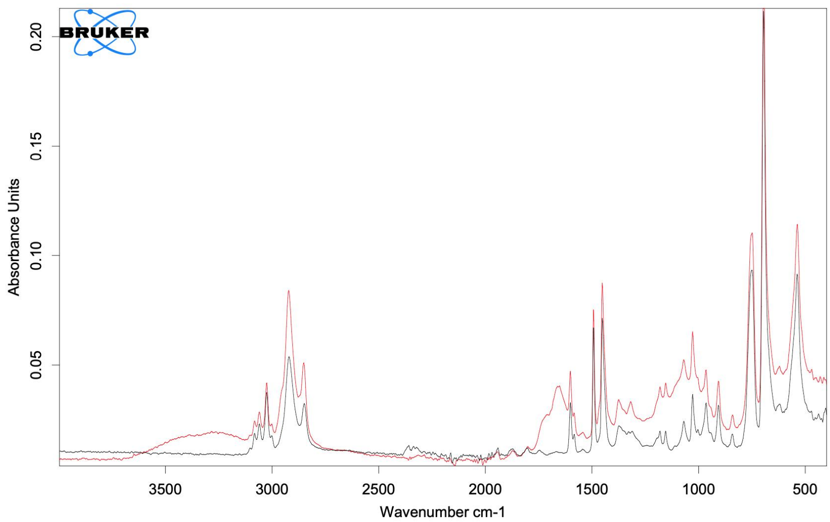
1x each fragment in size (500-1000 µm) of PET, PVC, HIPS, PP, ABS, HDPE, PA. After digest, the polymers were recovered, rinsed with ultra-pure water, and dried with a paper towel. The particles were checked by ATR-FTIR (Bruker Alpha II) for any spectral differences. No major spectral changes were observed and the method was deemed acceptable.



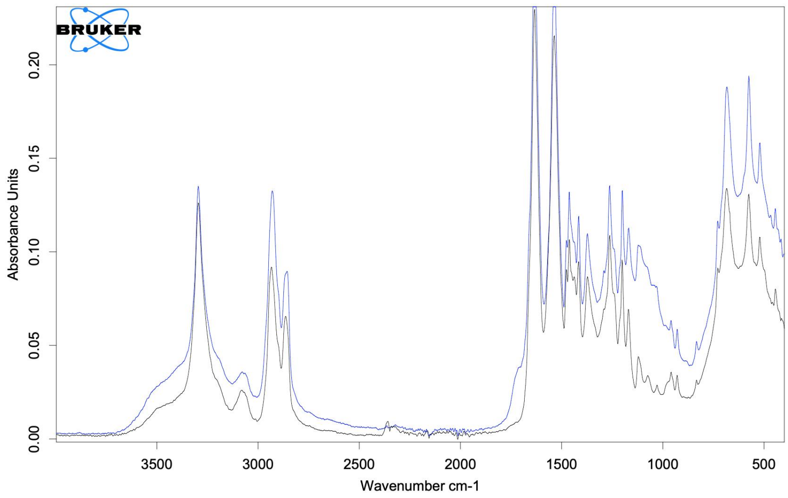
HDPE: Black = before, blue = after



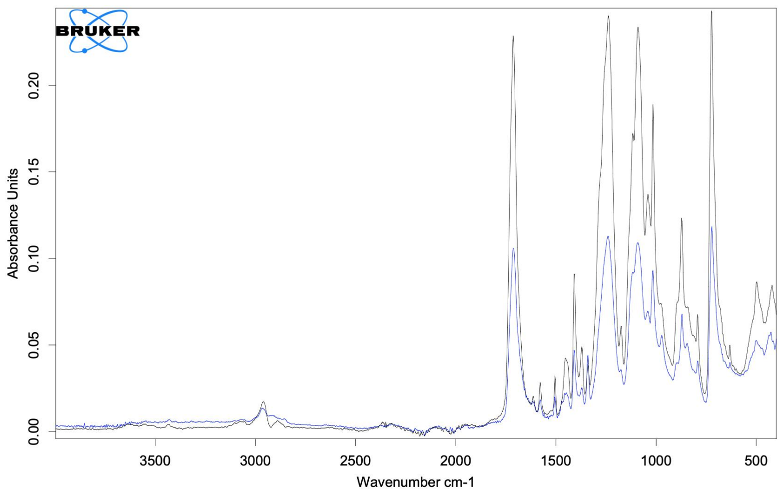
ABS: black = before, blue = after



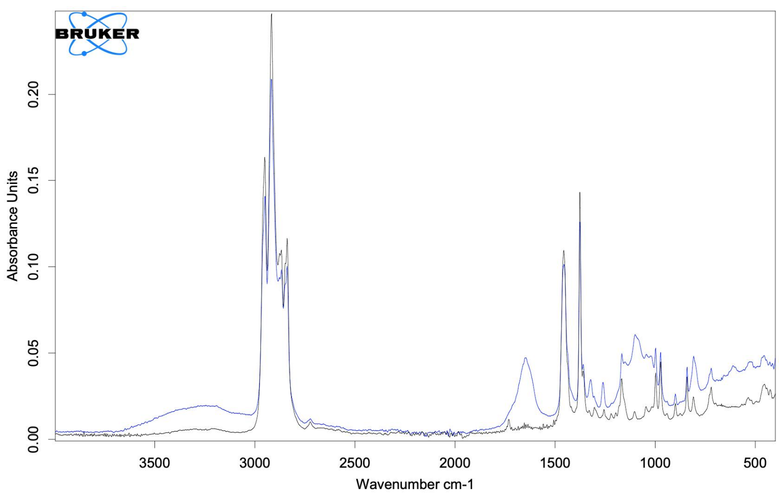
HIPS: black = before, red = after



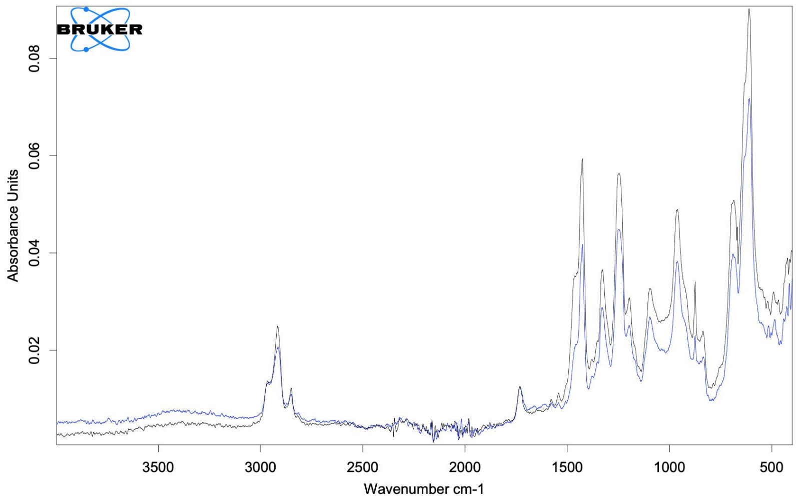
PA: black = before, blue = after



PET: black = before, blue = after



PP: black = before, blue = after



PVC: black = before, blue = after

Section S7. Spiked recoveries

Thermally dried biosolids were collected from a local WWTP, and silt loam topsoil and bagged compost was purchased from a local garden centre. All samples were dried at 75°C, and only soil and bagged compost were sieved < 2mm. Three x 30 g of biosolids, soil, and bagged compost were spiked with: 1x each fragment in size (500-1000 µm) of PET, PVC, HIPS, PP, ABS, HDPE, PA; 10x blue PE microbeads (between 100 – 500 µm), 10 x purple acrylic fibres (approximately 1 mm in length). The microbeads were sourced from a facial cleanser and the fibres were created from a ball of acrylic yarn purchased from a craft store. These plastics were added to the beaker with the dry samples prior to digestion. These samples followed the digestion and density separation procedures as described earlier.

Results of the spiked recoveries:

Biosolids

Sample 1: all reference fragments 7/7, 9/10 microbeads, 9/10 fibres

=100%, 90%, 90% = average of 93%

Sample 2: all reference fragments 7/7, 10/10 microbeads, 10/10 fibres

=100%, 100%, 90% = average of 100%

Sample 3: all reference fragments 7/7, 9/10 microbeads, 9/10 fibres

= 100%, 90%, 90% = average of 93%

Total average: 95%

Soil

Sample 1: all reference fragments 7/7, 10/10 microbeads, 10/10 fibres

=100%, 100%, 100% = average of 100%

Sample 2: all reference fragments 7/7, 10/10 microbeads, 9/10 fibres

= 100%, 100%, 90% = average of 97%

Sample 3: all reference fragments 7/7, 9/10 microbeads, 10/10 fibres

= 100%, 90%, 100% = average of 97%

Total average: 98%

Bagged compost

Sample 1: all reference fragments 7/7, 9/10 microbeads, 8/10 fibres

= 100%, 90%, 80% = average of 90%

Sample 2: all reference fragments 7/7, 10/10 microbeads, 8/10 fibres

= 100%, 100%, 80% = average of 93%

Sample 3: all reference fragments 7/7, 9/10 microbeads, 9/10 fibres

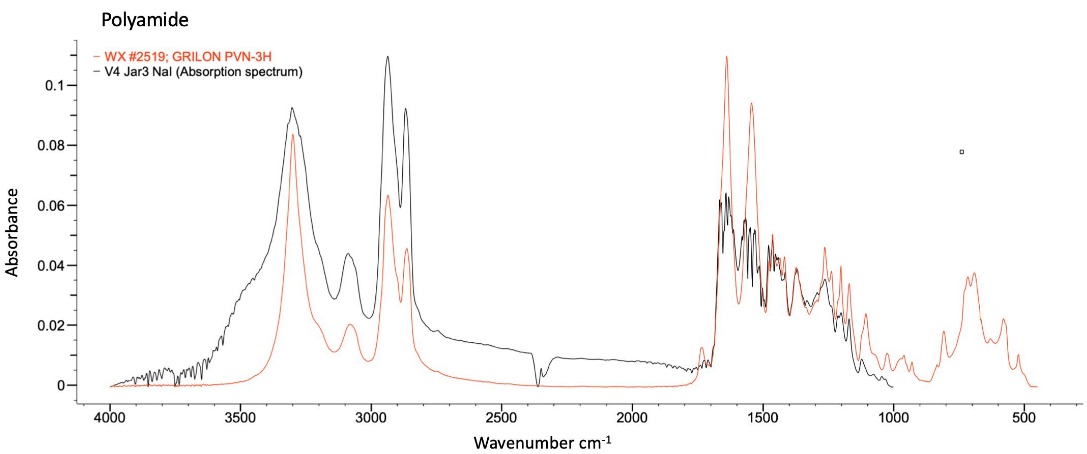
= 100%, 90%, 90% = average of 93%

Total average: 92%

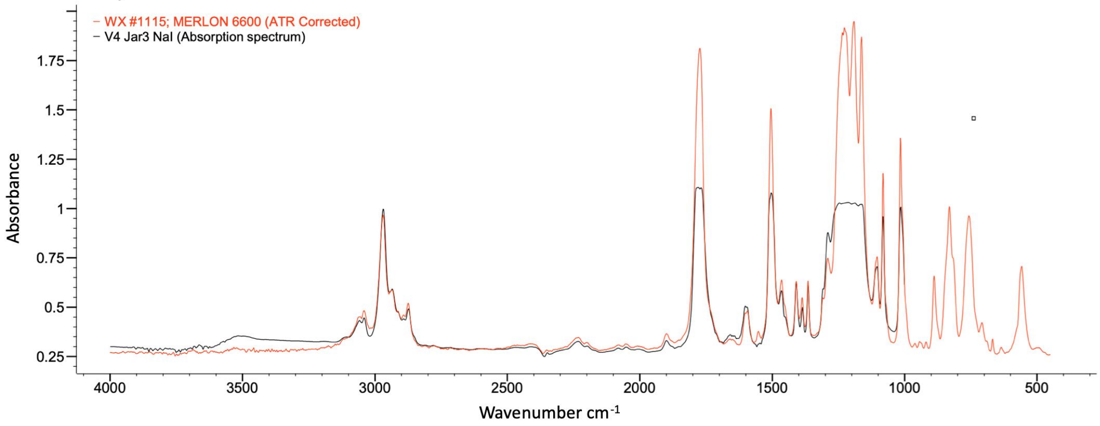
Section S8. Example µ-FTIR spectra of microplastics found in biowaste samples

Red = library match

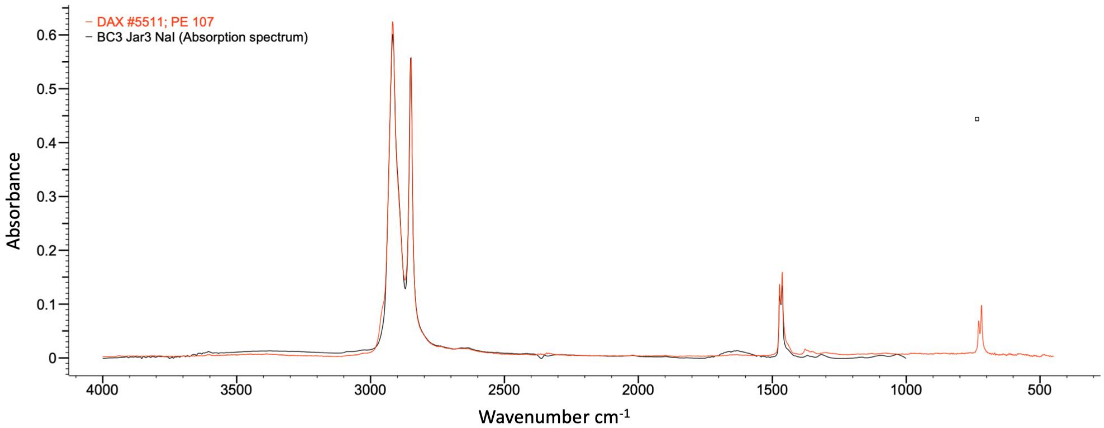
Black = environmental microplastic spectrum



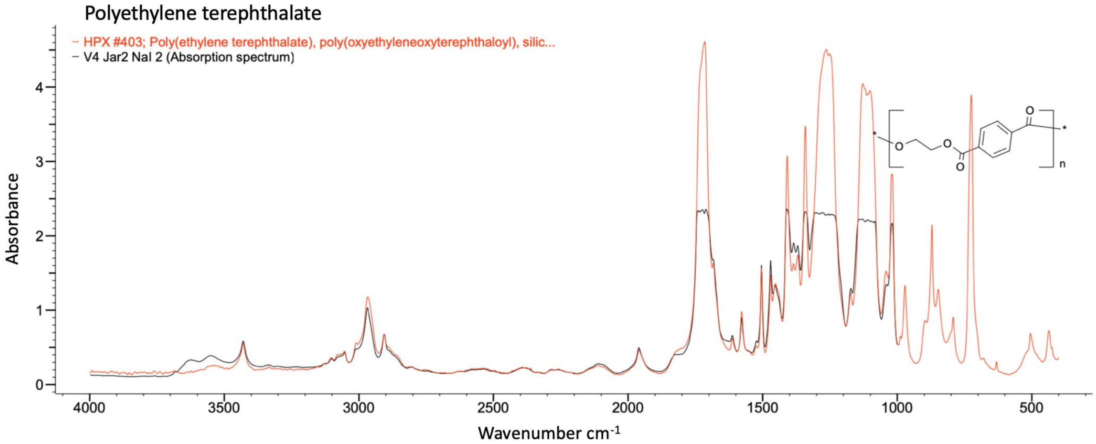
Polycarbonate

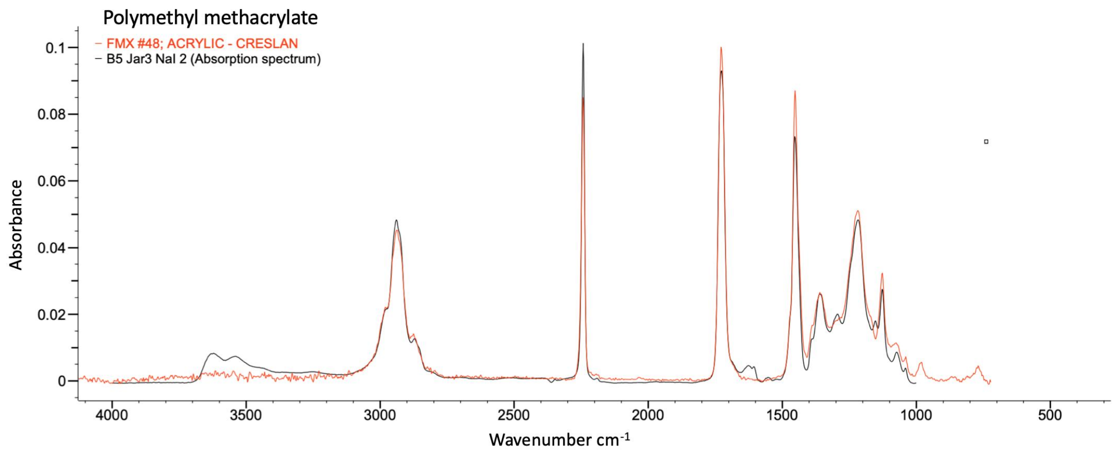


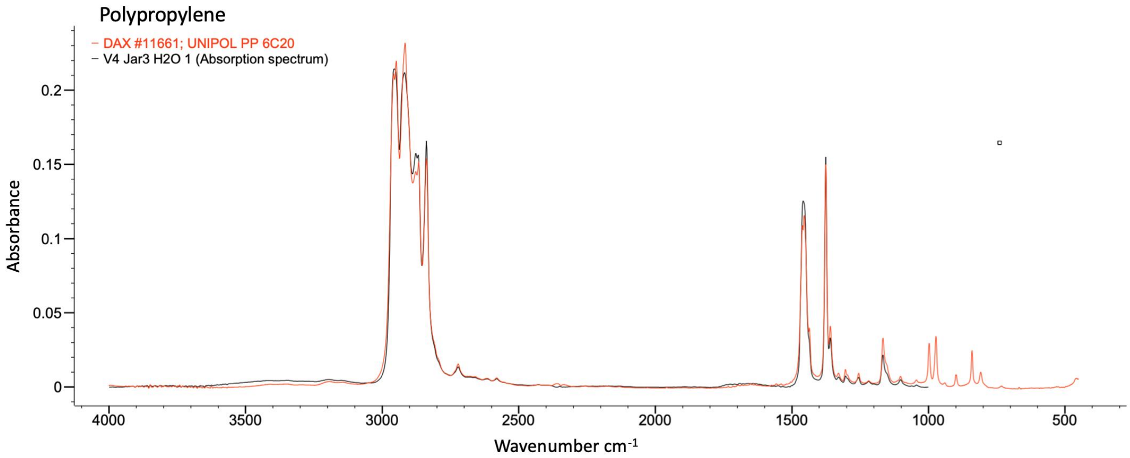
Polyethylene

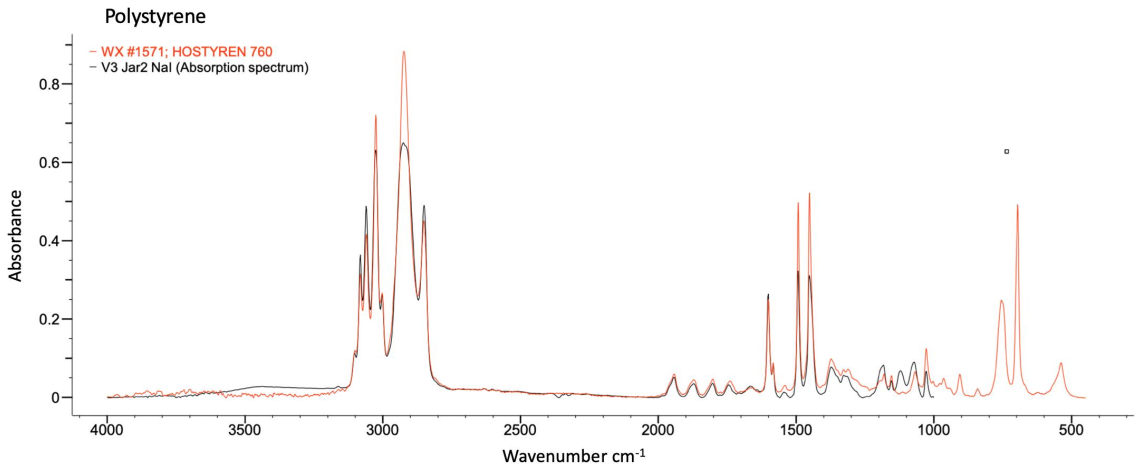


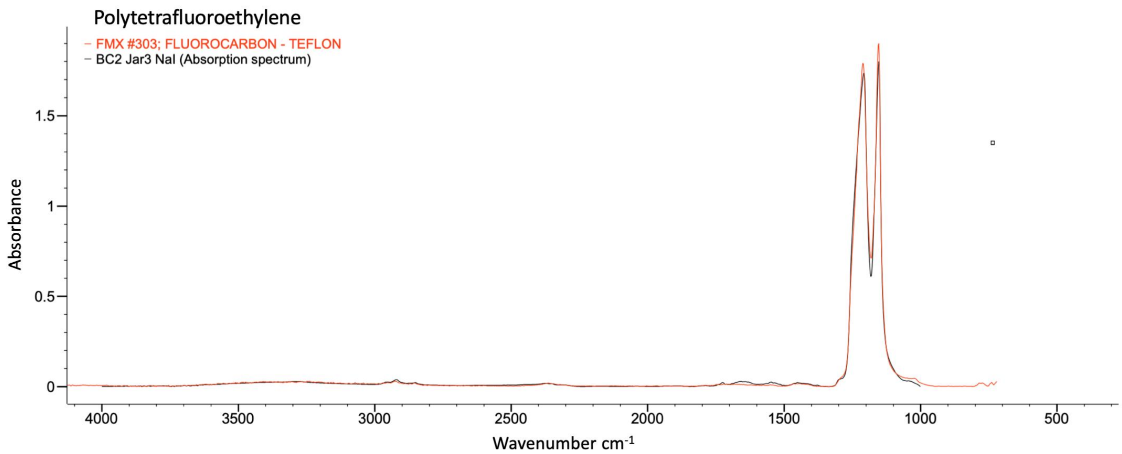
Polyethylene terephthalate

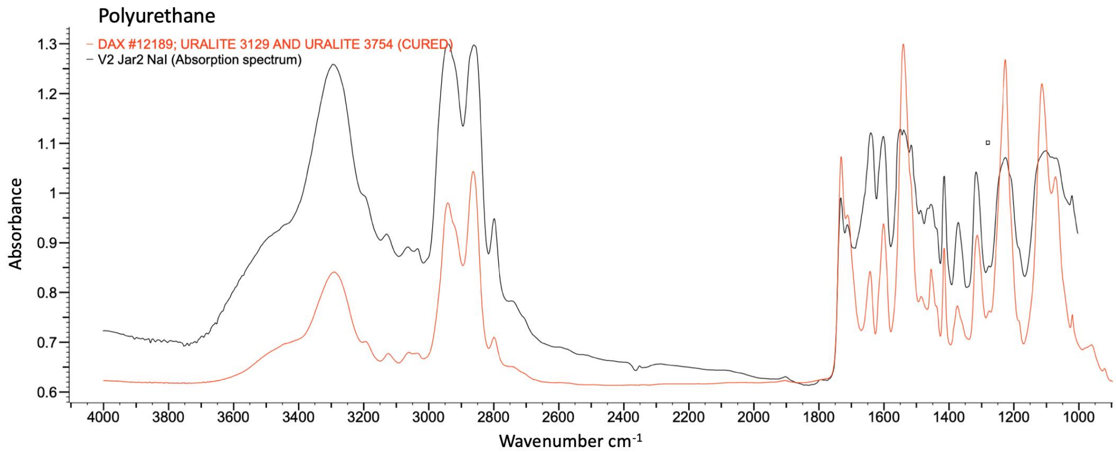


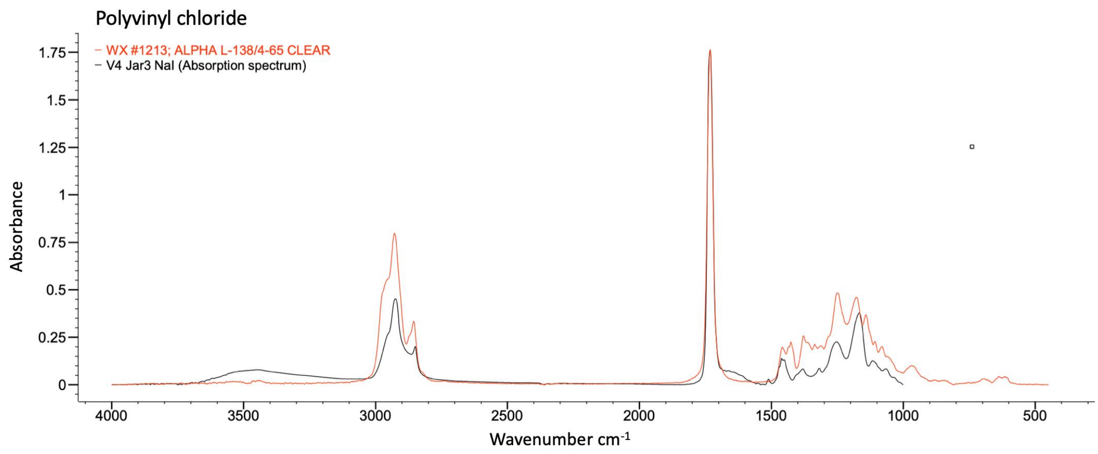

Polymethyl methacrylate
FMX #48; ACRYLIC - CRESLAN
B5 Jar3 NaI 2 (Absorption spectrum)
Absorbance
Wavenumber cm-1


Polypropylene
DAX #11661; UNIPOL PP 6C20
V4 Jar3 H2O 1 (Absorption spectrum)
Absorbance
Wavenumber cm-1


Polystyrene
WX #1571; HOSTYREN 760
V3 Jar2 NaI (Absorption spectrum)
Absorbance
Wavenumber cm-1







Section S9. Equations for the estimation of microplastic contamination to soil from amendment application

Equation 1: estimation of microplastic particles applied onto land with the amendment (particles/ha).

$$MP\ loading\ in\ amendment = (concentration\ of\ MP\ in\ amendment) \times (application\ rate) \times (conversion\ of\ units\ from\ g\ to\ tonne)$$

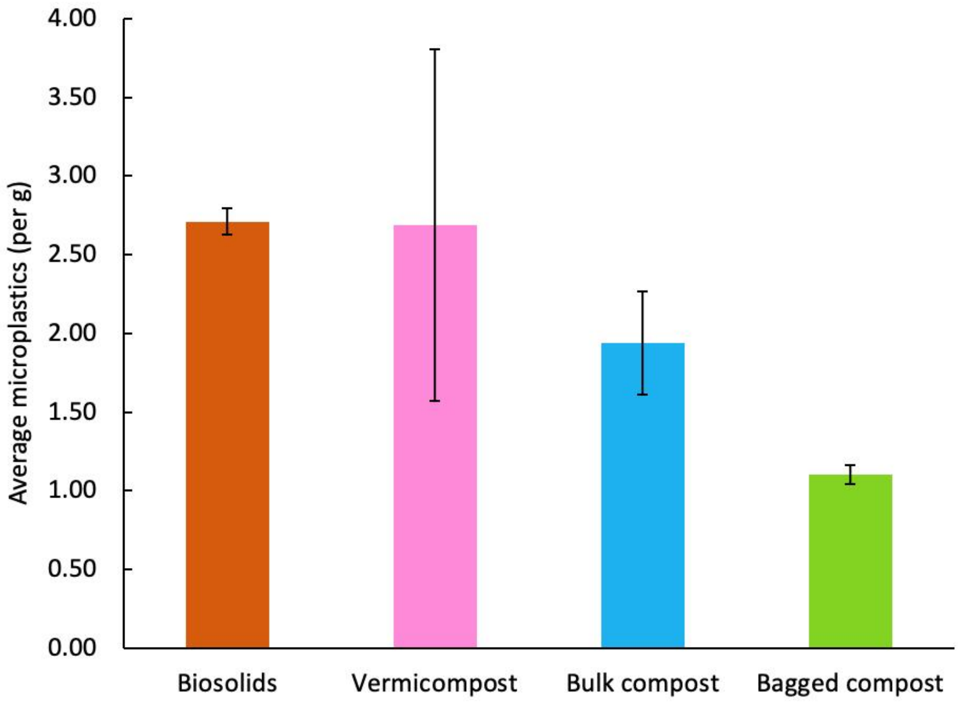
Where concentration of MP in amendment is in the units MP/g, application rate is 10 tonnes/ha, and the conversion of units from g to tonne is 1000000.

Equation 2: increase of concentration of microplastics in topsoil per application of amendment (particles/kg).

$$[MP\ in\ topsoil]increase\ per\ application\ of\ amendment = (MP\ loading\ in\ amendment) \div ((soil\ mass) \times (conversion\ of\ units\ from\ tonne\ to\ kg))$$

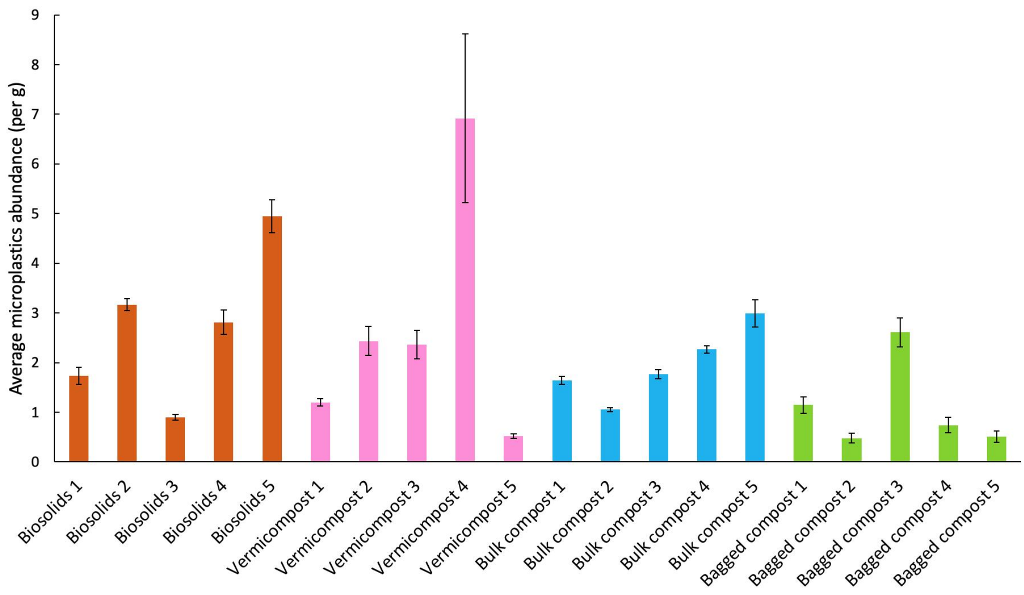
Where soil mass (t/ha) is equivalent to a soil depth of 0.15 m and density of 1.3 kg/m^3. Conversion of units (particles/t to particles/kg) is 1000.

Figure S1. Average abundance of microplastics in each biowaste sample type per g of dried sample



Note: Scale bars are standard error

Figure S2. Average abundance of microplastics at each biowaste facility/brand per g of dried sample



Note: Scale bars are standard error

Figure S3. Average morphotype proportion of microplastics at each biowaste facility/brand

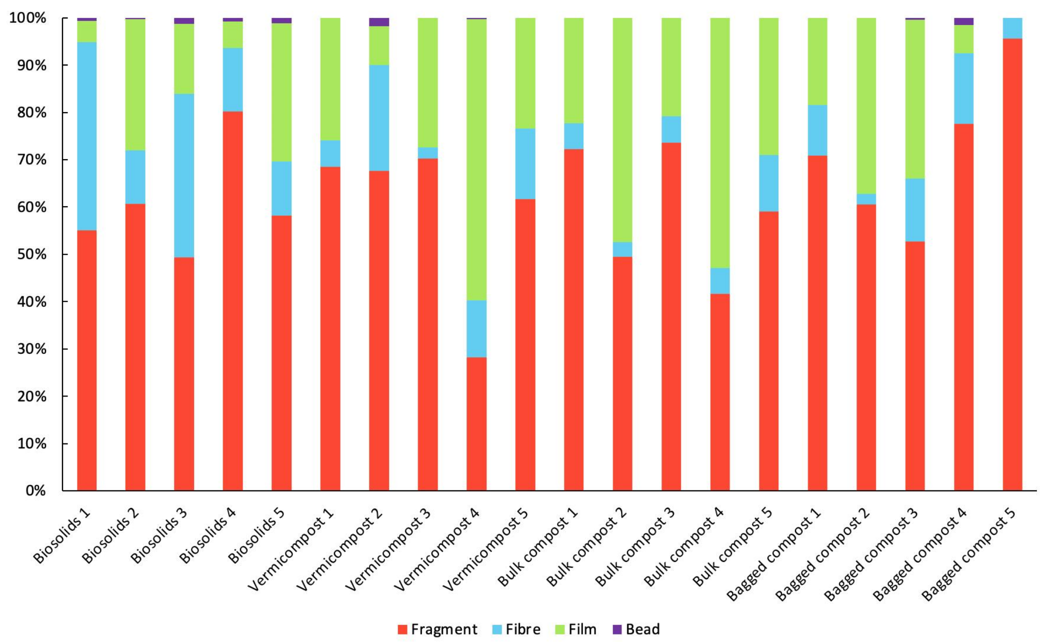
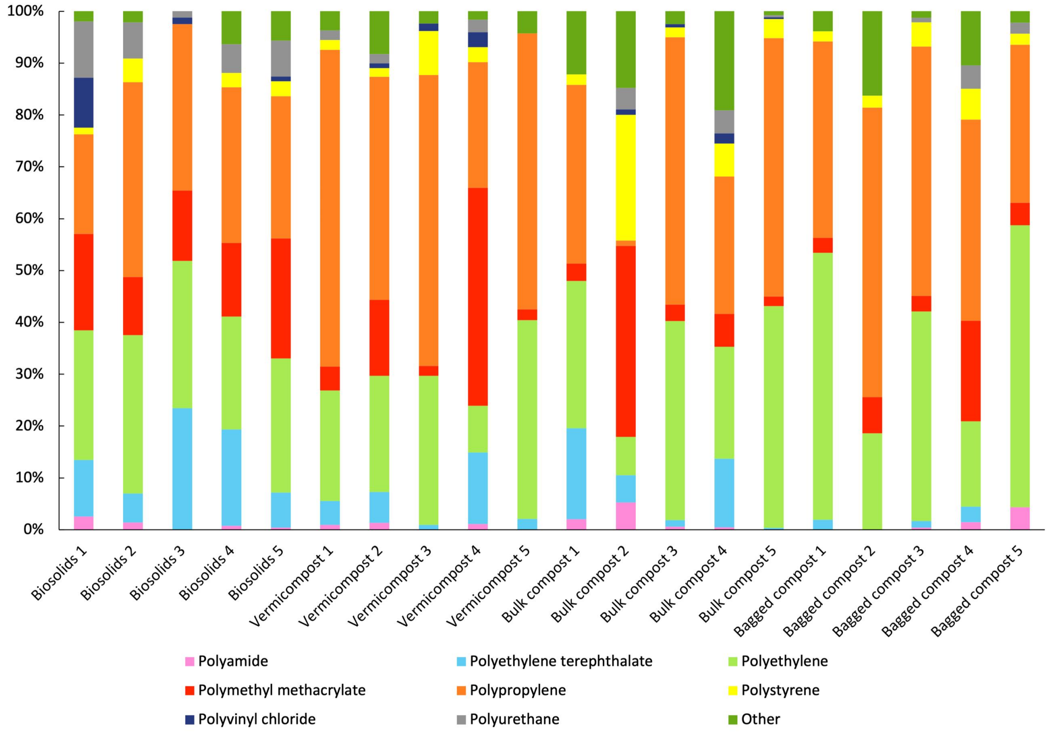


Figure S4. Average polymer type proportion of microplastics at each biowaste facility/brand



* Other includes: PC, PTFE, silicone, epoxy resin, ABS, SAN, EPM, EVOH, SBR, NBR, PLA, PBAT, PCL, PVM/MA

Figure S5. Average microplastics size distribution between sample types

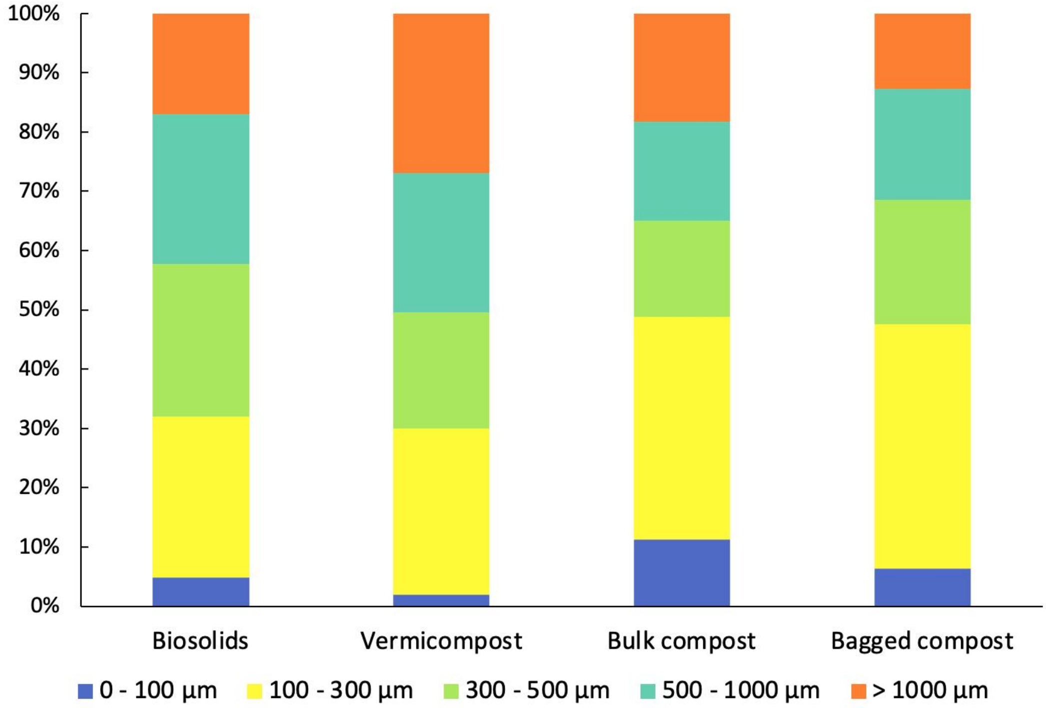


Figure S6. Average microplastic colour proportion between sample types

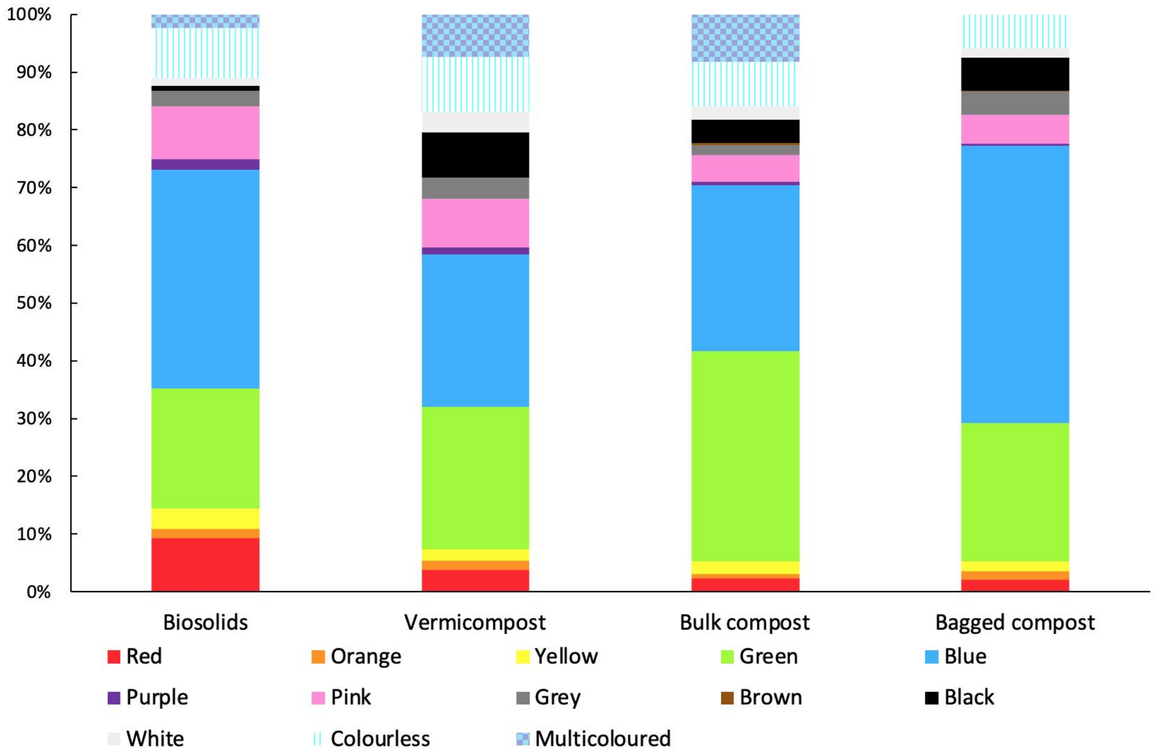


Table S3. Average microplastic morphotype proportion and mean abundance in biowaste from each facility/brand

Facility/brand	Fragment (%)	Fibre (%)	Film (%)	Bead (%)	Mean abundance (MP/g)	Mean standard error
Biosolids 1	55.1	39.8	4.5	0.6	1.73	0.18
Biosolids 2	60.7	11.2	27.7	0.3	3.17	0.12
Biosolids 3	49.4	34.6	14.8	1.2	0.90	0.06
Biosolids 4	80.2	13.4	5.5	0.8	2.81	0.24
Biosolids 5	58.2	11.5	29.2	1.1	4.94	0.33
Vermicompost 1	68.5	5.6	25.9	0.0	1.20	0.08
Vermicompost 2	67.6	22.4	8.2	1.8	2.43	0.29
Vermicompost 3	70.3	2.4	27.4	0.0	2.36	0.28
Vermicompost 4	28.3	12.0	59.4	0.3	6.92	1.70
Vermicompost 5	61.7	14.9	23.4	0.0	0.52	0.05
Bulk compost 1	72.3	5.4	22.3	0.0	1.64	0.08
Bulk compost 2	49.5	3.2	47.4	0.0	1.06	0.04
Bulk compost 3	73.6	5.7	20.8	0.0	1.77	0.09
Bulk compost 4	41.7	5.4	52.9	0.0	2.27	0.08
Bulk compost 5	59.1	11.9	29.0	0.0	2.99	0.28
Bagged compost 1	70.9	10.7	18.4	0.0	1.14	0.16
Bagged compost 2	60.5	2.3	37.2	0.0	0.48	0.10
Bagged compost 3	52.8	13.2	33.6	0.4	2.61	0.29

Bagged compost 4	77.6	14.9	6.0	1.5	0.74	0.15
Bagged compost 5	95.6	4.4	0.0	0.0	0.51	0.11

Table S4. Average microplastic polymer type proportion in biowaste from each facility/brand

Facility/brand	**Polyamide (%)**	**Polyethylene terephthalate (%)**	**Polyethylene (%)**	**Polymethyl methacrylate (%)**	**Polypropylene (%)**	**Polystyrene (%)**	**Polyvinyl chloride (%)**	**Polyurethane (%)**	**Other (%)**	**Total (%)**
Biosolids 1	2.6	10.9	25.0	18.6	19.2	1.3	9.6	10.9	1.9	100.0
Biosolids 2	1.4	5.6	30.5	11.2	37.5	4.6	0.0	7.0	2.1	100.0
Biosolids 3	0.0	23.4	28.4	13.6	32.1	0.0	1.2	1.2	0.0	100.0
Biosolids 4	0.8	18.6	21.7	14.2	30.0	2.8	0.0	5.5	6.3	100.0
Biosolids 5	0.5	6.7	25.8	23.1	27.4	2.9	0.9	7.0	5.6	100.0
Vermicompost 1	0.9	4.6	21.3	4.6	61.1	1.9	0.0	1.9	3.7	100.0
Vermicompost 2	1.4	5.9	22.4	14.6	43.0	1.7	0.9	1.8	8.2	100.0
Vermicompost 3	0.0	0.9	28.8	1.9	56.1	8.5	1.4	0.0	2.4	100.0
Vermicompost 4	1.1	13.8	9.0	42.1	24.2	2.9	2.9	2.4	1.6	100.0
Vermicompost 5	0.0	2.1	38.3	2.1	53.2	0.0	0.0	0.0	4.3	100.0
Bulk compost 1	2.0	17.6	28.4	3.4	34.5	2.0	0.0	0.0	12.2	100.0
Bulk compost 2	5.3	5.3	7.4	36.8	1.0	24.2	1.0	4.2	14.7	100.0
Bulk compost 3	0.6	1.3	38.4	3.2	51.6	1.9	0.6	0.0	2.5	100.0
Bulk compost 4	0.5	13.2	21.6	6.4	26.5	6.4	2.0	4.4	19.1	100.0

Bulk compost 5	0.0	0.4	42.8	1.9	49.8	3.7	0.4	0.4	0.7	100.0
Bagged compost 1	0.0	2.0	51.5	2.9	37.9	2.0	0.0	0.0	3.9	100.0
Bagged compost 2	0.0	0.0	18.6	7.0	55.8	2.3	0.0	0.0	16.3	100.0
Bagged compost 3	0.4	1.3	40.4	3.0	48.1	4.7	0.0	0.9	1.3	100.0
Bagged compost 4	1.5	3.0	16.4	19.4	38.8	6.0	0.0	4.5	10.4	100.0
Bagged compost 5	4.4	0.0	54.3	4.4	30.5	2.2	0.0	2.2	2.2	100.0
Average	1.2	6.8	28.6	11.7	37.9	4.1	1.0	2.7	6.0	100.0

* Other includes: PC, PTFE, silicone, epoxy resin, ABS, SAN, EPM, EVOH, SBR, NBR, PLA, PBAT, PCL, PVM/MA

Table S5. Average size distribution proportion of microplastics in biowaste from each facility/brand

Facility/brand	0 - 100 µm (%)	100 - 300 µm (%)	300 - 500 µm (%)	500 - 1000 µm (%)	> 1000 µm (%)	Total (%)
Biosolids 1	4.5	20.5	20.5	25.0	29.5	100.0
Biosolids 2	4.9	30.2	26.3	26.3	12.3	100.0
Biosolids 3	12.3	29.6	18.5	19.8	19.8	100.0
Biosolids 4	1.6	28.5	30.8	25.7	13.4	100.0
Biosolids 5	1.1	26.5	33.0	29.0	10.3	100.0
Vermicompost 1	2.8	38.9	23.1	18.5	16.7	100.0
Vermicompost 2	3.7	40.6	25.6	19.6	10.5	100.0
Vermicompost 3	0.0	3.8	13.2	29.7	53.3	100.0

Vermicompost 4	1.1	20.7	27.3	24.2	26.6	100.0
Vermicompost 5	2.1	36.2	8.5	25.5	27.7	100.0
Bulk compost 1	14.2	38.5	8.1	14.2	25.0	100.0
Bulk compost 2	31.6	55.8	7.4	2.1	3.2	100.0
Bulk compost 3	2.5	29.6	25.8	19.5	22.6	100.0
Bulk compost 4	2.9	23.5	17.6	30.9	25.0	100.0
Bulk compost 5	5.2	40.1	22.3	17.1	15.2	100.0
Bagged compost 1	6.8	34.0	18.4	24.3	16.5	100.0
Bagged compost 2	7.0	32.6	25.6	25.6	9.3	100.0
Bagged compost 3	3.0	33.2	19.6	18.7	25.5	100.0
Bagged compost 4	6.0	52.2	19.4	16.4	6.0	100.0
Bagged compost 5	8.7	54.3	21.7	8.7	6.5	100.0
Average	6.1	33.5	20.6	21.0	18.7	100.0

Table S6. Average microplastic colour proportion in biowaste from each facility/brand

Facility/brand	**Red (%)**	**Orange (%)**	**Yellow (%)**	**Green (%)**	**Blue (%)**	**Purple (%)**	**Pink (%)**	**Grey (%)**	**Brown (%)**	**Black (%)**	**White (%)**	**Colourless (%)**	**Multicoloured (%)**	**Total (%)**
Biosolids 1	19.9	1.9	0.6	19.2	37.2	2.6	4.5	0.0	0.0	0.6	3.2	10.3	0.0	100.0

Biosolids 2	2.5	1.4	3.5	21.8	41.8	2.1	12.3	2.1	0.0	1.4	0.0	10.5	0.7	100.0
Biosolids 3	13.6	0.0	3.7	14.8	46.9	1.2	2.5	4.9	0.0	0.0	0.0	9.9	2.5	100.0
Biosolids 4	4.7	4.0	2.4	27.7	32.0	1.6	16.2	5.1	0.0	1.2	0.8	4.0	0.4	100.0
Biosolids 5	5.8	0.9	7.2	20.7	31.5	1.3	10.6	1.6	0.0	0.9	2.5	9.0	8.1	100.0
Vermicompost 1	4.6	5.6	2.8	21.3	28.7	0.9	10.2	2.8	0.0	8.3	5.6	8.3	0.9	100.0
Vermicompost 2	5.5	0.5	0.9	28.3	40.2	2.7	5.0	4.6	0.0	1.4	0.0	11.0	0.0	100.0
Vermicompost 3	5.7	0.9	1.9	16.5	26.4	1.4	15.1	0.0	0.0	8.5	10.4	12.7	0.5	100.0
Vermicompost 4	3.4	0.8	4.3	14.6	17.3	1.4	7.4	2.6	0.2	3.5	1.9	7.2	35.3	100.0
Vermicompost 5	0.0	0.0	0.0	42.6	19.1	0.0	4.3	8.5	0.0	17.0	0.0	8.5	0.0	100.0
Bulk compost 1	1.4	0.7	1.4	53.4	23.0	0.7	1.4	1.4	0.7	3.4	0.7	10.8	1.4	100.0
Bulk compost 2	0.0	0.0	3.2	43.2	9.5	1.1	1.1	0.0	1.1	3.2	7.4	0.0	30.5	100.0
Bulk compost 3	6.9	0.6	1.3	33.3	35.8	0.0	1.9	3.8	0.0	3.1	1.3	11.3	0.6	100.0

Bulk compost 4	2.0	2.0	4.4	25.0	33.3	0.0	11.3	1.5	0.0	2.0	1.5	8.8	8.3	100.0
Bulk compost 5	1.5	0.4	1.1	26.8	42.4	1.1	7.4	1.9	0.4	8.2	1.1	7.4	0.4	100.0
Bagged compost 1	0.0	1.0	1.0	28.2	42.7	1.0	1.9	6.8	0.0	11.7	1.0	4.9	0.0	100.0
Bagged compost 2	2.3	2.3	2.3	11.6	65.1	0.0	2.3	0.0	0.0	0.0	0.0	14.0	0.0	100.0
Bagged compost 3	0.9	1.3	1.3	17.9	48.1	0.9	6.4	2.1	0.4	8.5	4.7	7.7	0.0	100.0
Bagged compost 4	3.0	3.0	1.5	35.8	29.9	0.0	10.4	9.0	0.0	4.5	0.0	3.0	0.0	100.0
Bagged compost 5	4.3	0.0	2.2	26.1	54.3	0.0	4.3	2.2	0.0	4.3	2.2	0.0	0.0	100.0
Average	4.4	1.4	2.3	26.4	35.3	1.0	6.8	3.0	0.1	4.6	2.2	8.0	4.5	100.0