Microplastics in composts, digestates, and food wastes: Findings from Vermont and beyond

Sarah Hobson & Kate Porterfield
Drs. Matthew Scarborough, Deb Neher, Meredith Niles, and Eric Roy*
University of Vermont

Presentation Order

Background

Research Questions

Methods

Results & Implications

Organics diversion initiatives as of June 2021

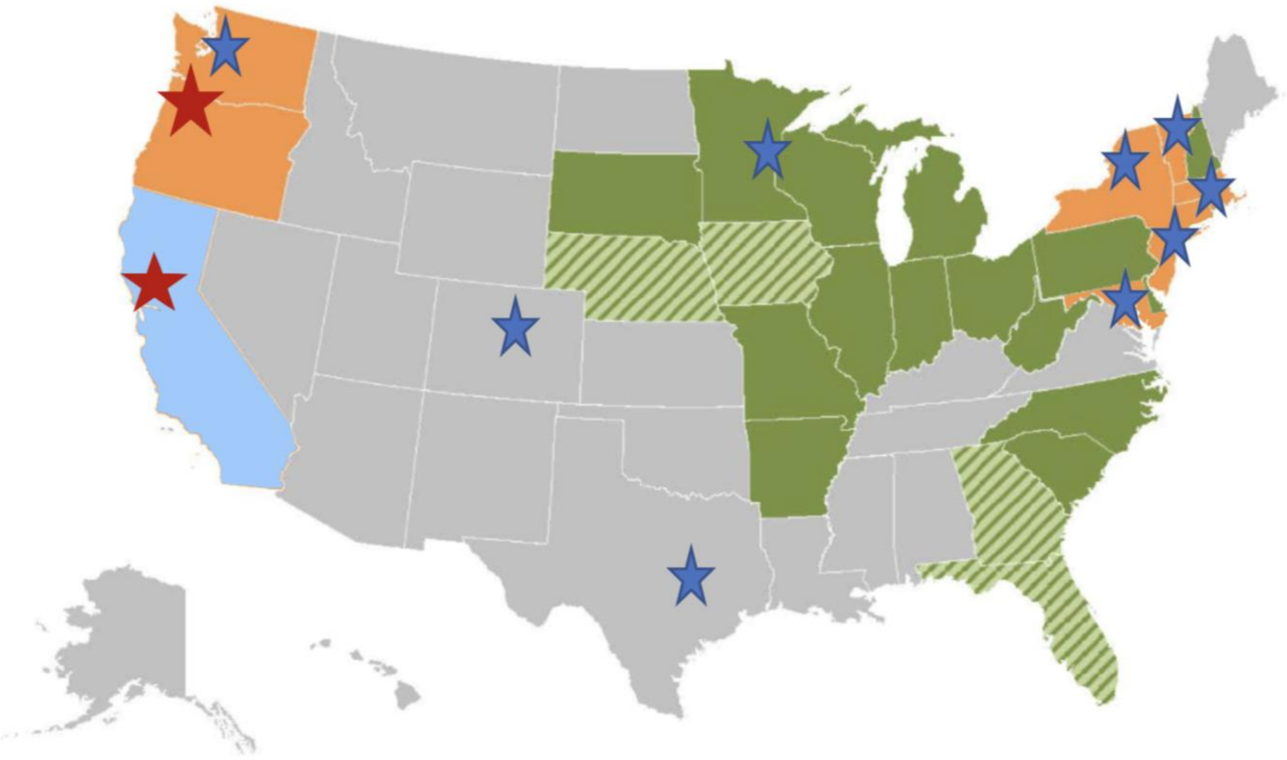


Image: US Composting Council

Cities with Organics Bans

Cities with Food Scrap Collection Requirements

Yard debris bans: Arkansas, Delaware, Illinois, Indiana, Maryland, Michigan, Minnesota, Missouri, New Hampshire, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, South Dakota, West Virginia, Wisconsin

Yard debris bans with exemptions for landfills with gas collection systems: Florida, Georgia, Iowa, Nebraska

Food scrap collection mandates or aggressive legislation for keeping out of landfills: California, Connecticut, Massachusetts, New Jersey, New York, Oregon, Vermont, Washington

State Organics Diversion Requirements: The State of California, rather than banning organics from landfills, instead requires municipalities to create organics plans, as of January 2022.

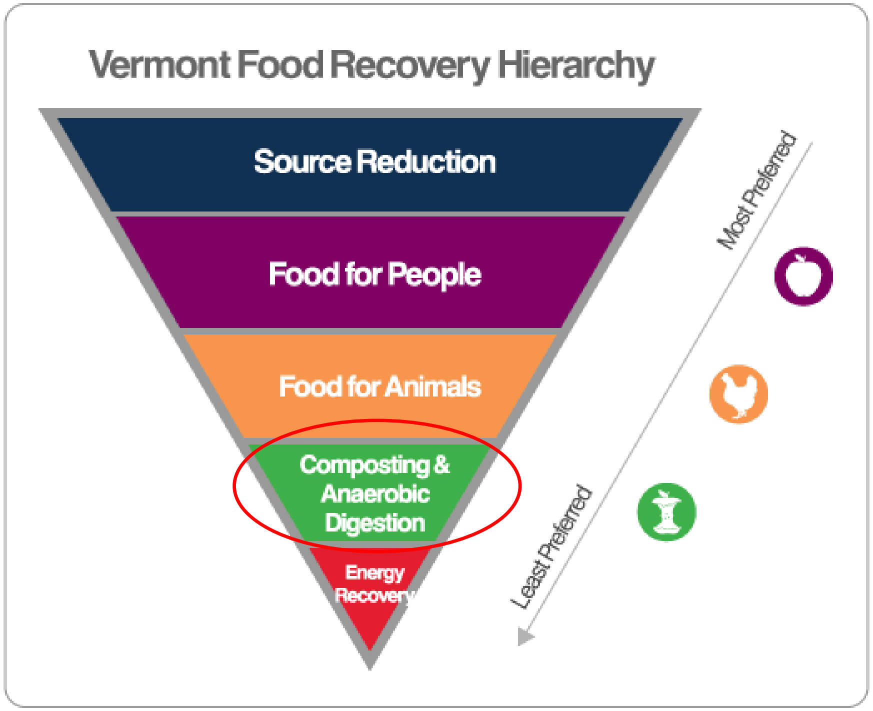
Organics Recycling: Vermont Context

Universal Recycling Law (Act 148, 2012)

→Diversion of organics from landfills by 2020

Boom in organics recycling underlines challenges

→Plastic contamination compost and digestate



Hierarchy for management of food waste (VT DEC)

Food waste is often mixed with plastic packaging

Pre-consumer packaged food waste

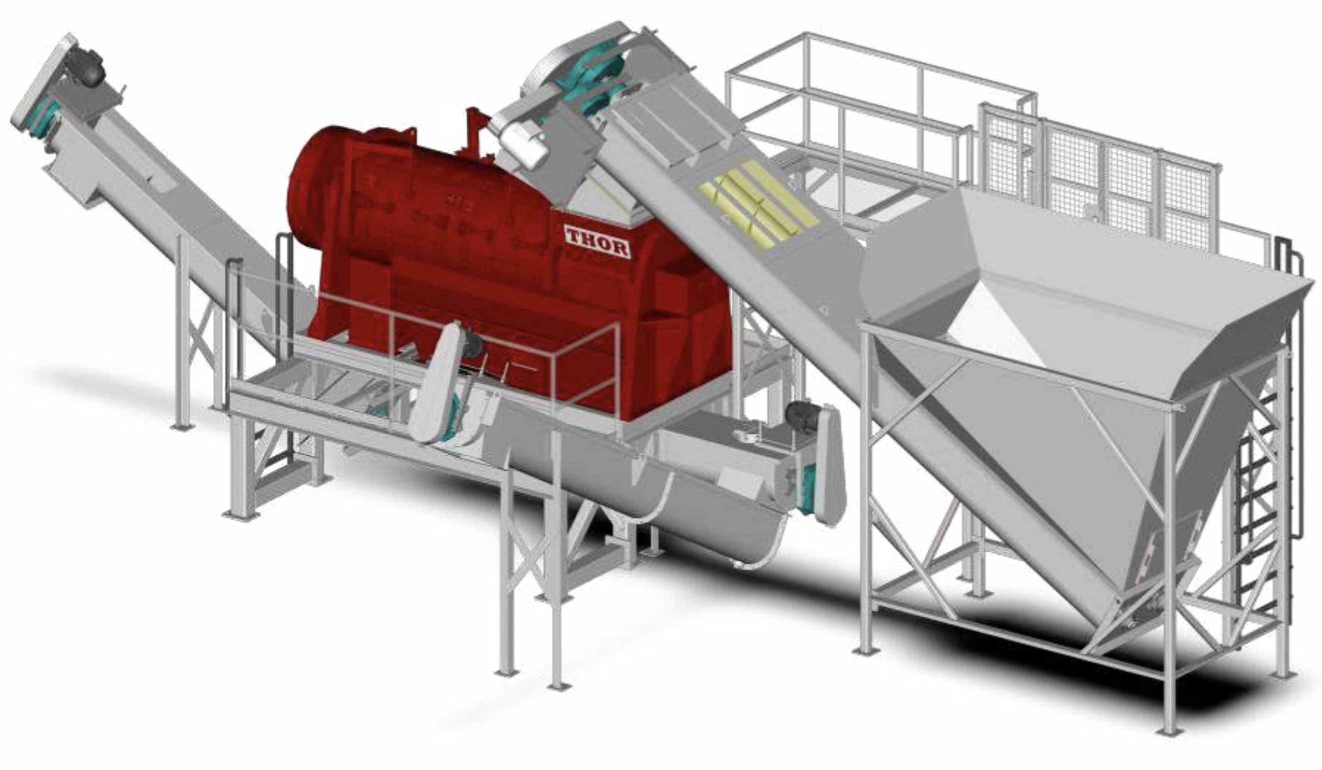
Post-consumer source separated organics

Mechanical Depackagers

Many different models on the market

Use low-force paddles and screens to separate organics from residual packaging

Reported organics recovery and purity rates >99% by weight[1,2]

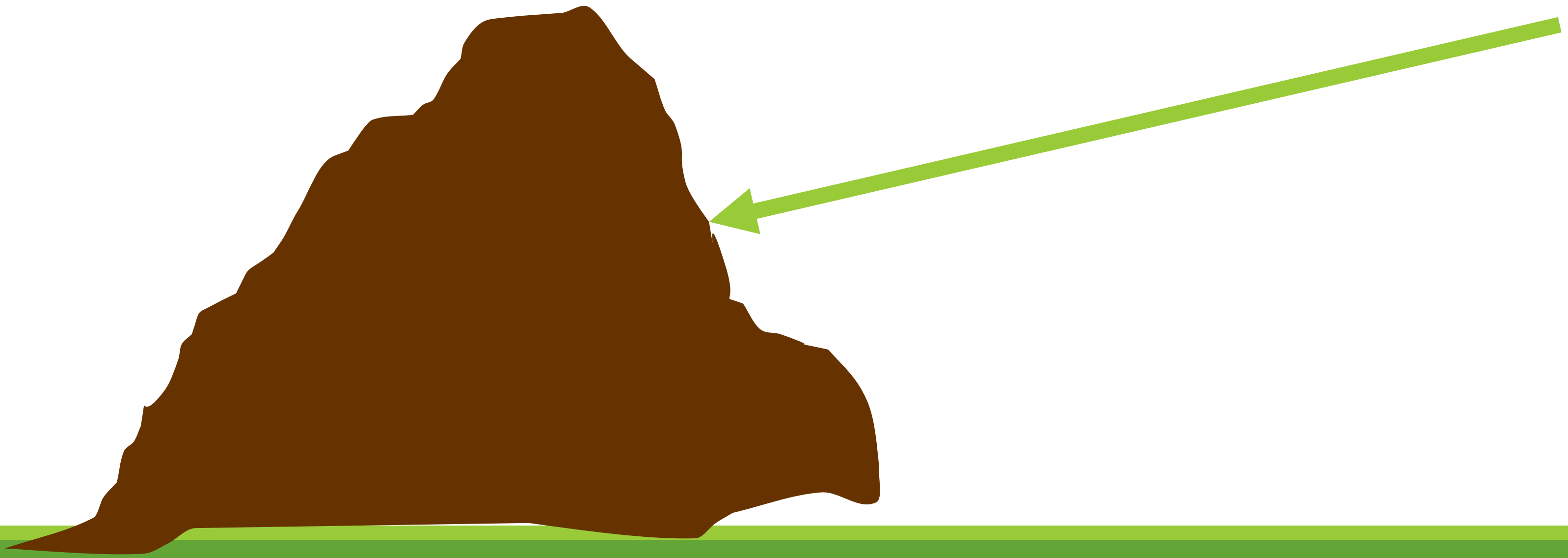


[1]Coker, 2019; [2]do Carmo Precci Lopes et al., 2019; Image: Scott Equipment Co.

Compost feedstock considerations

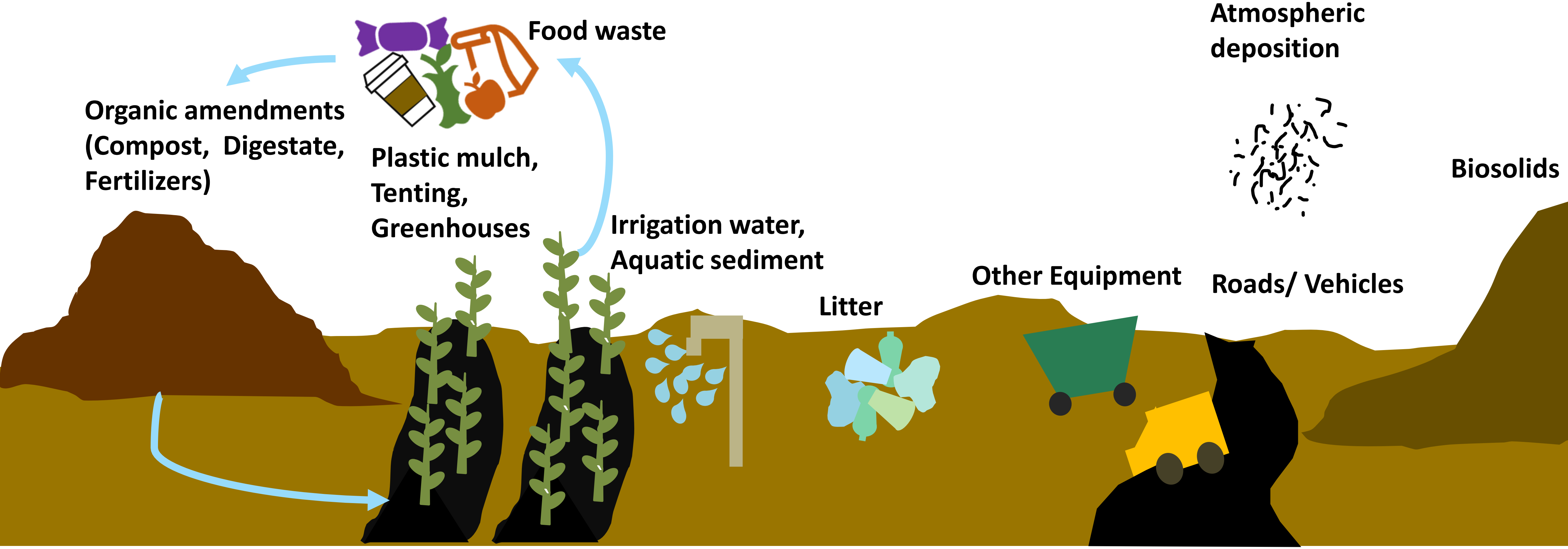
Potential feedstocks

Wood shavings/chips, food waste, leaves, hay, straw, manure, animal biomass, ash, paper, and compostable plastics



3. Mohanan et al., 2020

Plastic pathways to soil



4. Büks & Kaupenjohann, 2020

Potential plastic impacts

Physical

→Aeration, water repellence, porosity, bulk density, aggregate size, water holding capacity

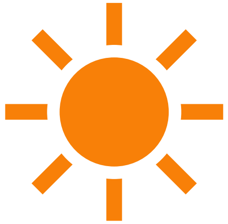
Biological

→ Species dominance, diversity, richness, and functions

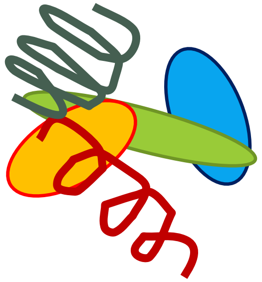
Chemical

→ Soil nitrogen, carbon, and phosphorus cycling; nutrient adsorption/transportation

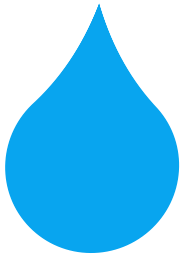
Plastic degradation over time



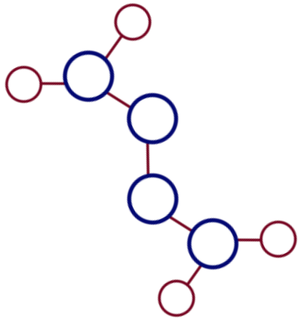
Photodegradation



Biological degradation



Hydrolytic degradation



Thermo-oxidative

→ Formation of smaller, more numerous plastics

What are microplastics?

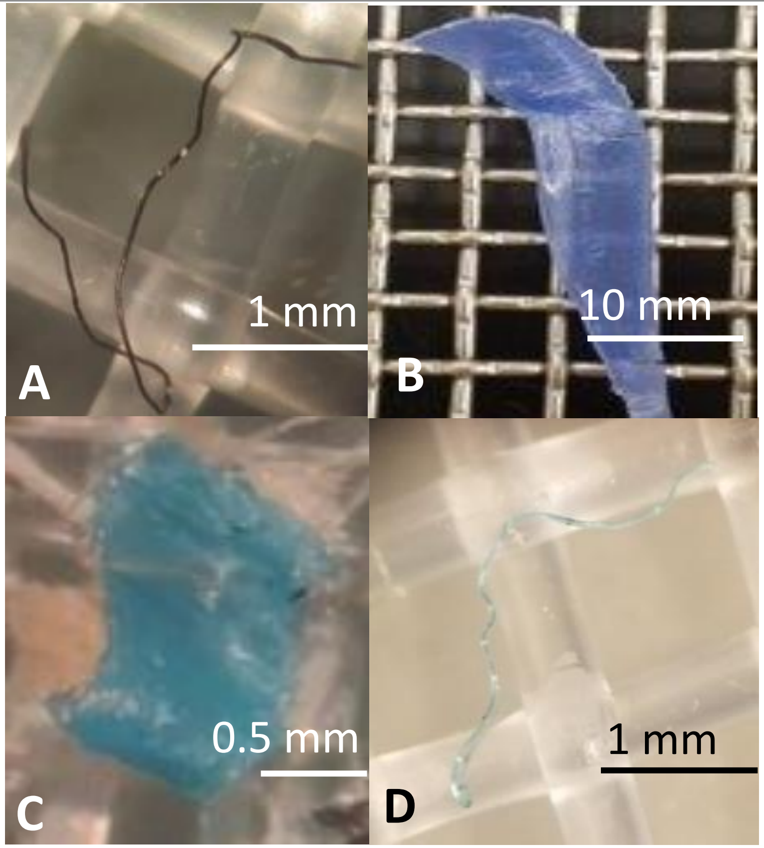
- Plastics of 0.01 - 5 mm size
- Also macro-, meso-, and nanoplastics

Shape Categories

- Fibers (A, D), fragments (B), films (C)

Type Categories

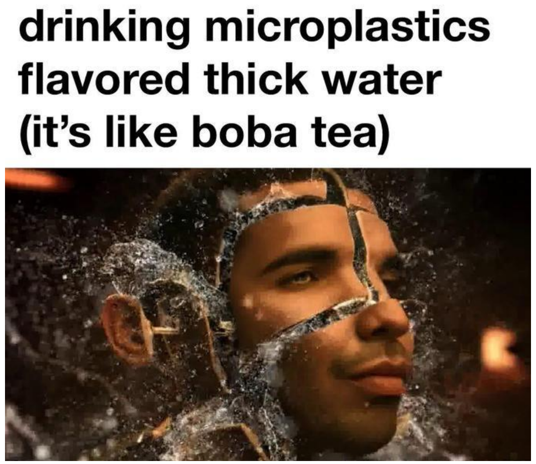
- Thermoplastics (include polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyvinyl chloride (PVC))
- Thermosets (include epoxy resins and polyester (PES))



A = Polypropylene Fiber B = High-density Polyethylene Fragment
C = High-density Polyethylene Film D = Polyamide Fiber

Need for more information

Concern in popular media



Our Work

Our work on microplastics in organic residuals

Literature review

Received: 11 July 2022 | Accepted: 29 December 2022 | Published online: 5 February 2023

DOI: 10.1002/jeq2.20450

Journal of Environmental Quality

REVIEW & ANALYSIS

Microplastics in composts, digestates, and food wastes: A review

Katherine K. Porterfield[1,2] | Sarah A. Hobson[3] | Deborah A. Neher[2,4] | Meredith T. Niles[2,5] | Eric D. Roy[1,2,3]

[1]Department of Civil and Environmental Engineering, University of Vermont, Burlington, VT, USA

[2]Gund Institute for Environment, University of Vermont, Burlington, VT, USA

[3]Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, USA

[4]Department of Plant and Soil Science, University of Vermont, Burlington, VT, USA

[5]Department of Nutrition and Food Sciences & Food Systems Program, University of Vermont, Burlington, VT, USA

Correspondence
Katherine K. Porterfield, 81 Carrigan Dr., Burlington, VT 05405, USA.
Email: kporterf@uvm.edu

Assigned to Associate Editor Mikhail Borisover.

Abstract

Diverting food waste from landfills to composting or anaerobic digestion can reduce greenhouse gas emissions, enable the recovery of energy in usable forms, and create nutrient-rich soil amendments. However, many food waste streams are mixed with plastic packaging, raising concerns that food waste-derived composts and digestates may inadvertently introduce microplastics into agricultural soils. Research on the occurrence of microplastics in food waste-derived soil amendments is in an early phase and the relative importance of this potential pathway of microplastics to agricultural soils needs further clarification. In this paper, we review what is known and what is not known about the abundance of microplastics in composts, digestates, and food wastes and their effects on agricultural soils. Additionally, we highlight future research needs and suggest ways to harmonize microplastic abundance and ecotoxicity studies with the design of related policies. This review is novel in that it focuses on quantitative measures of microplastics in composts, digestates, and food wastes and discusses limitations of existing methods and implications for policy.

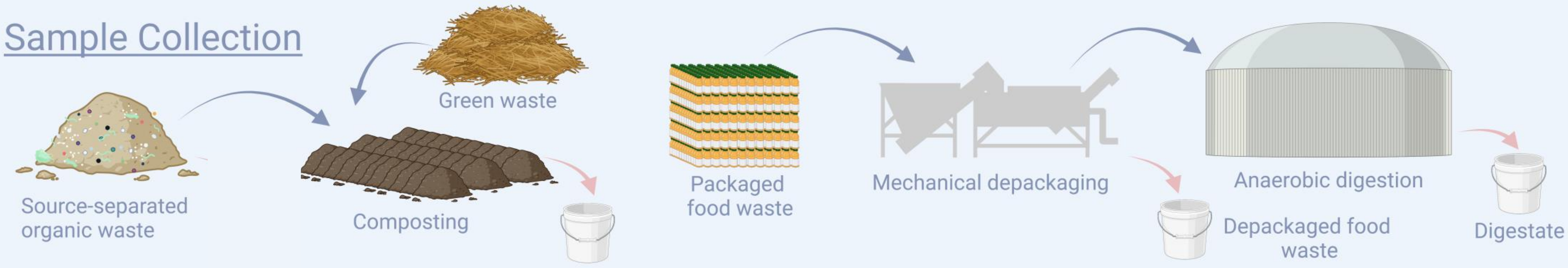
Primary data collection

We measured plastic content in:

- Depackaged source separated food waste
- Depackaged ice cream pints
- Digestate derived in part from depackaged ice cream pints
- Composts derived from green waste
- Composts derived in part from source separated food waste

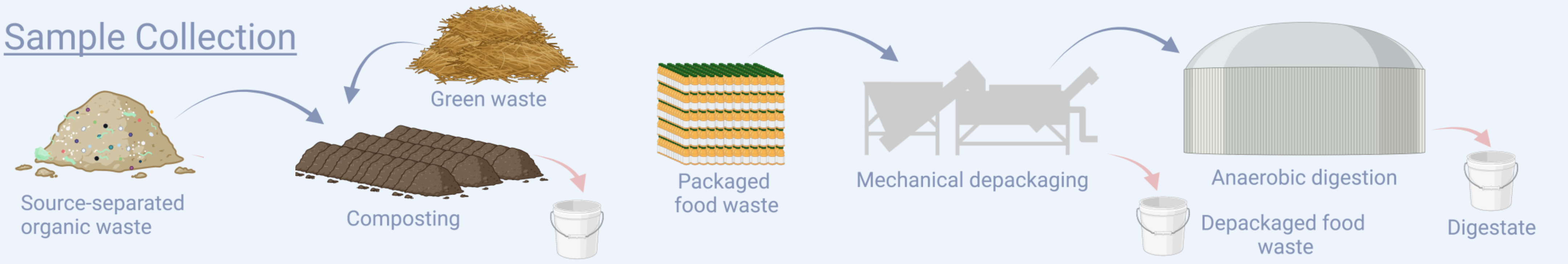
Methods

Sample Collection

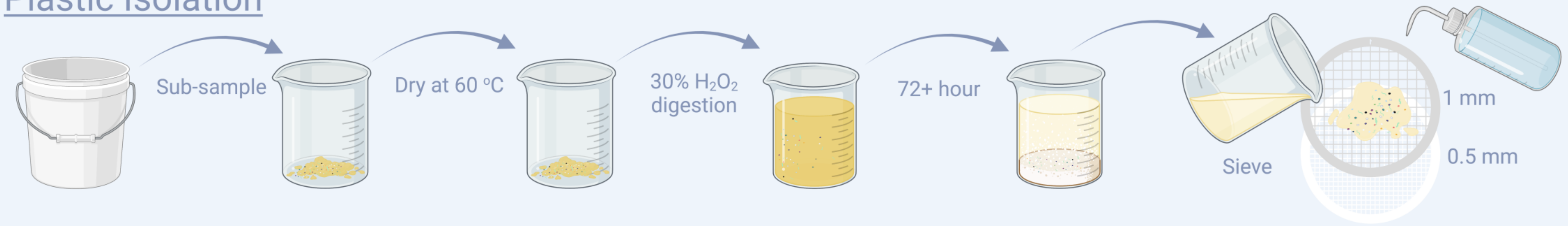


Created with BioRender.com

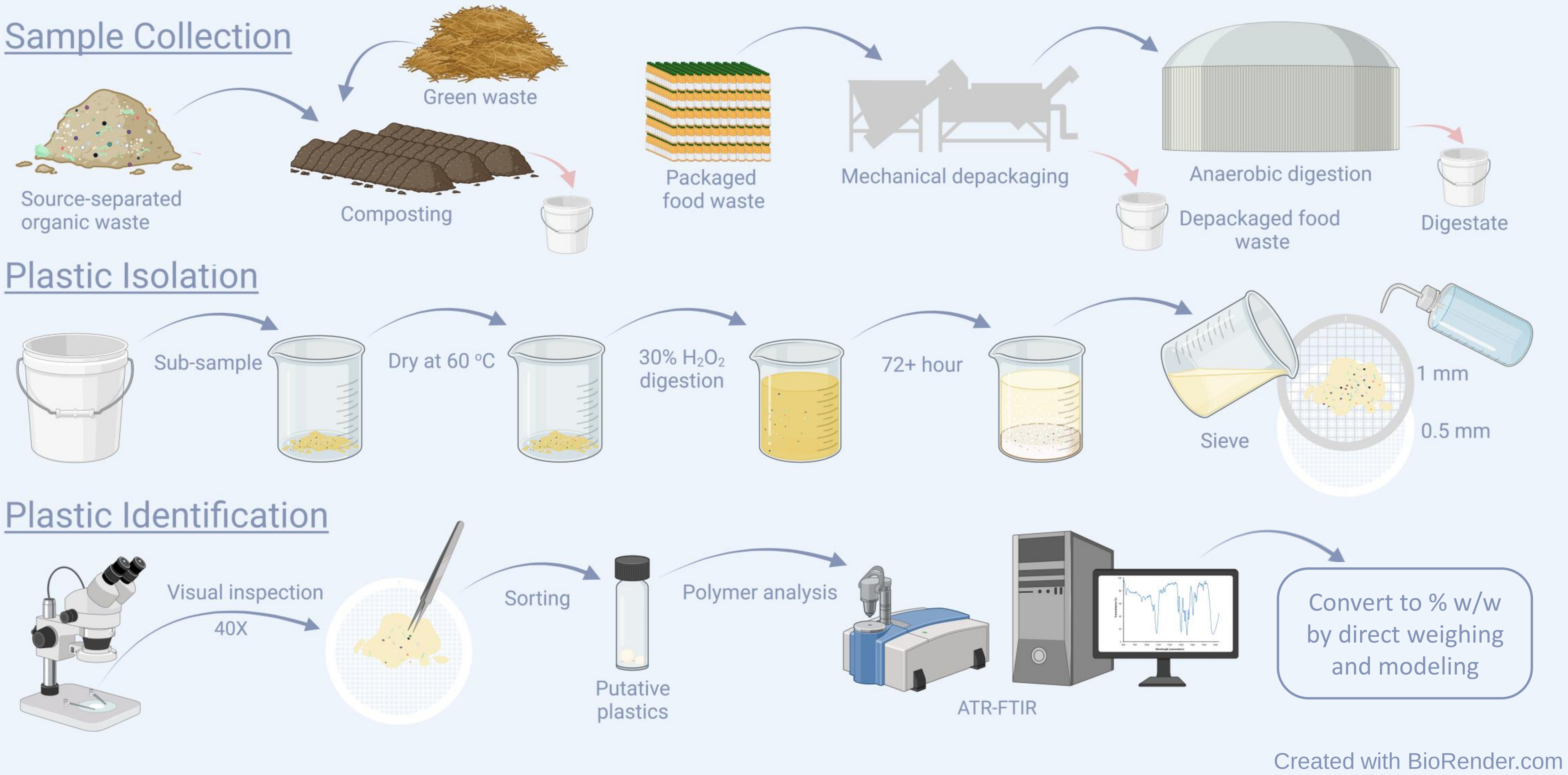
Sample Collection



Plastic Isolation



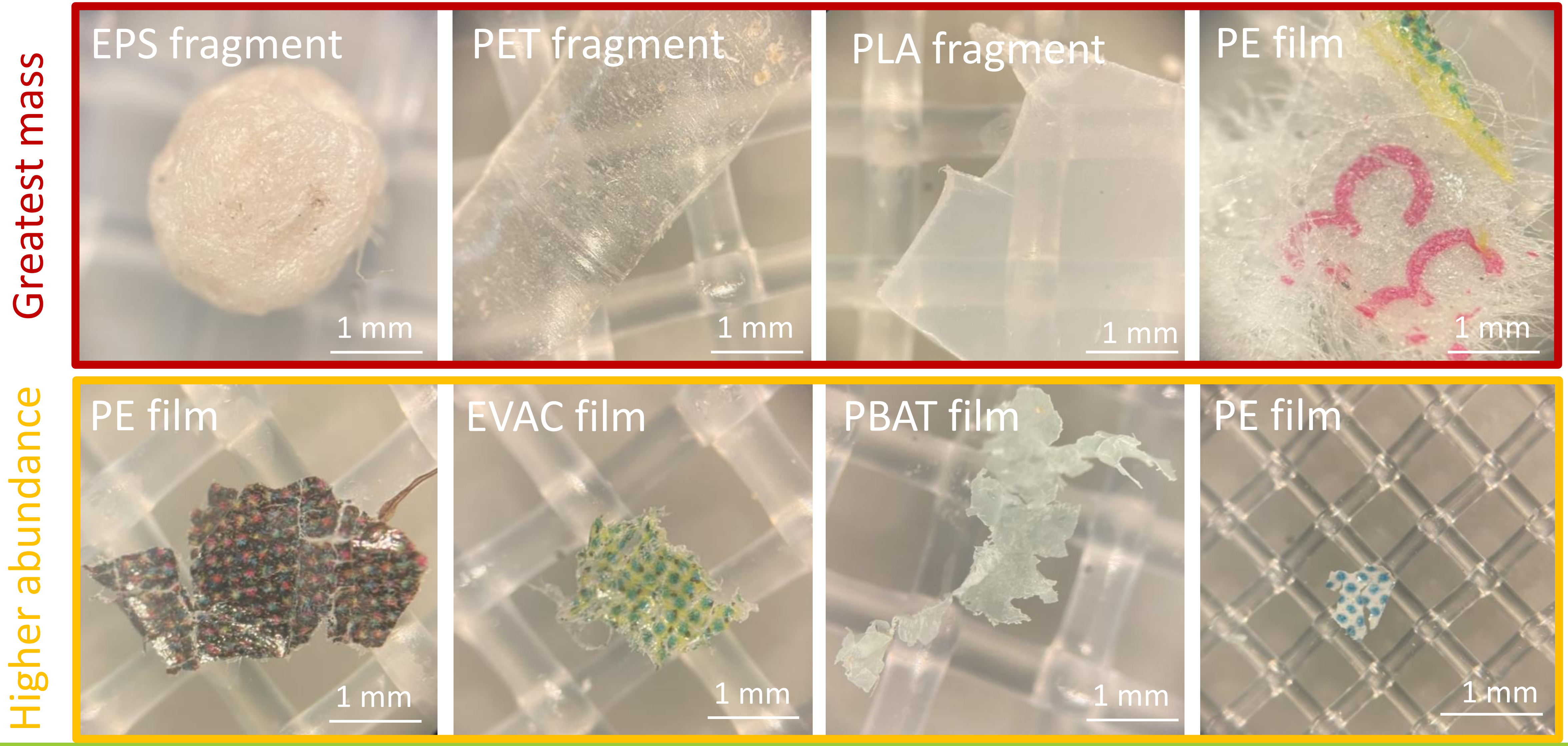
Created with BioRender.com



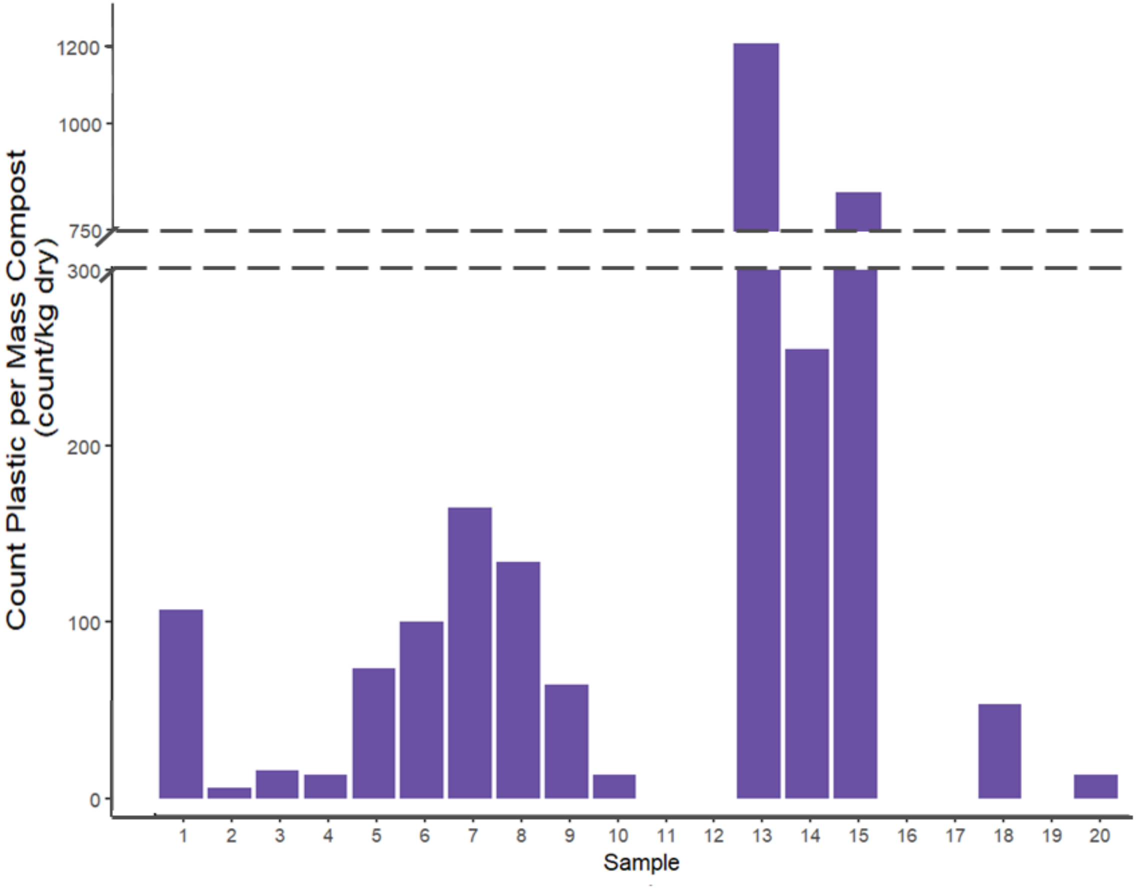
Sample Collection
Green waste
Source-separated organic waste
Composting
Packaged food waste
Mechanical depackaging
Anaerobic digestion
Depackaged food waste
Digestate
Plastic Isolation
Sub-sample
Dry at 60 °C
30% H_2O_2 digestion
72+ hour
Sieve
1 mm
0.5 mm
Plastic Identification
Visual inspection
40X
Sorting
Putative plastics
Polymer analysis
ATR-FTIR
Convert to % w/w by direct weighing and modeling
Created with BioRender.com

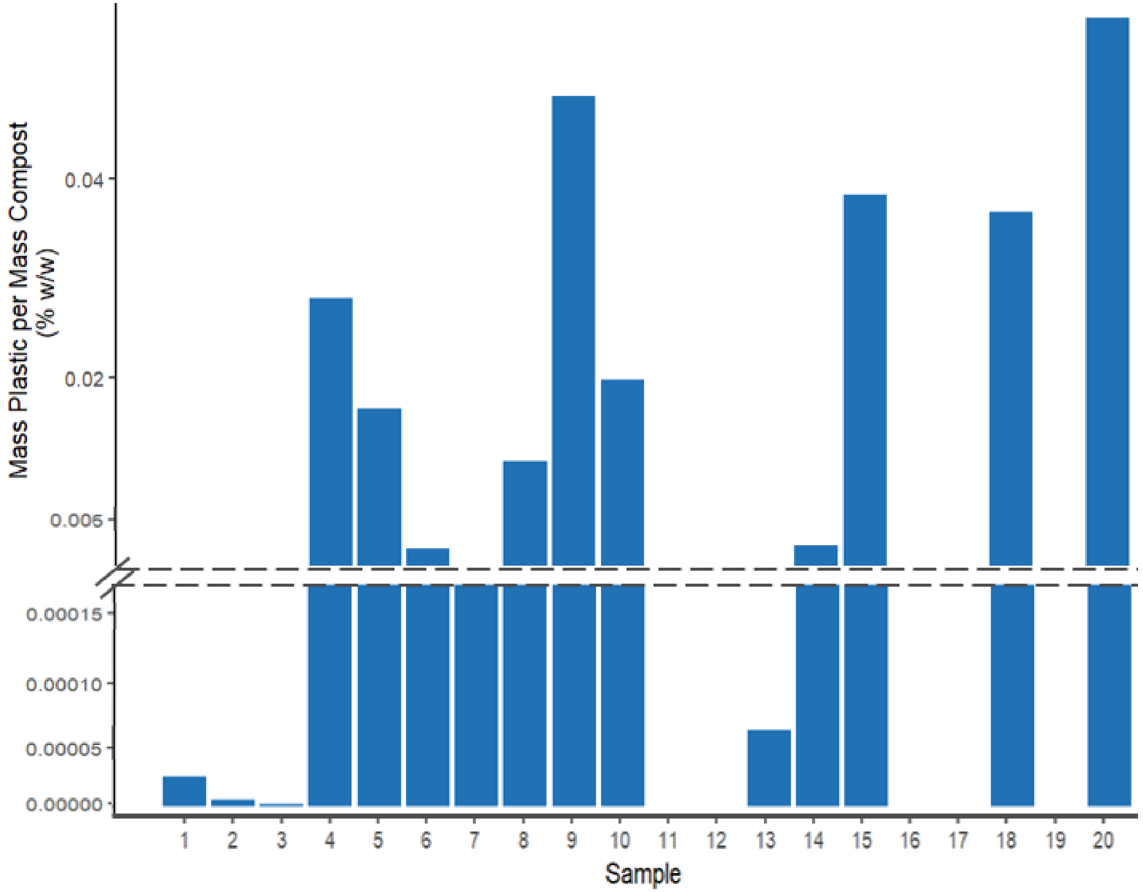
Results

Examples of plastic recovered from organic residuals



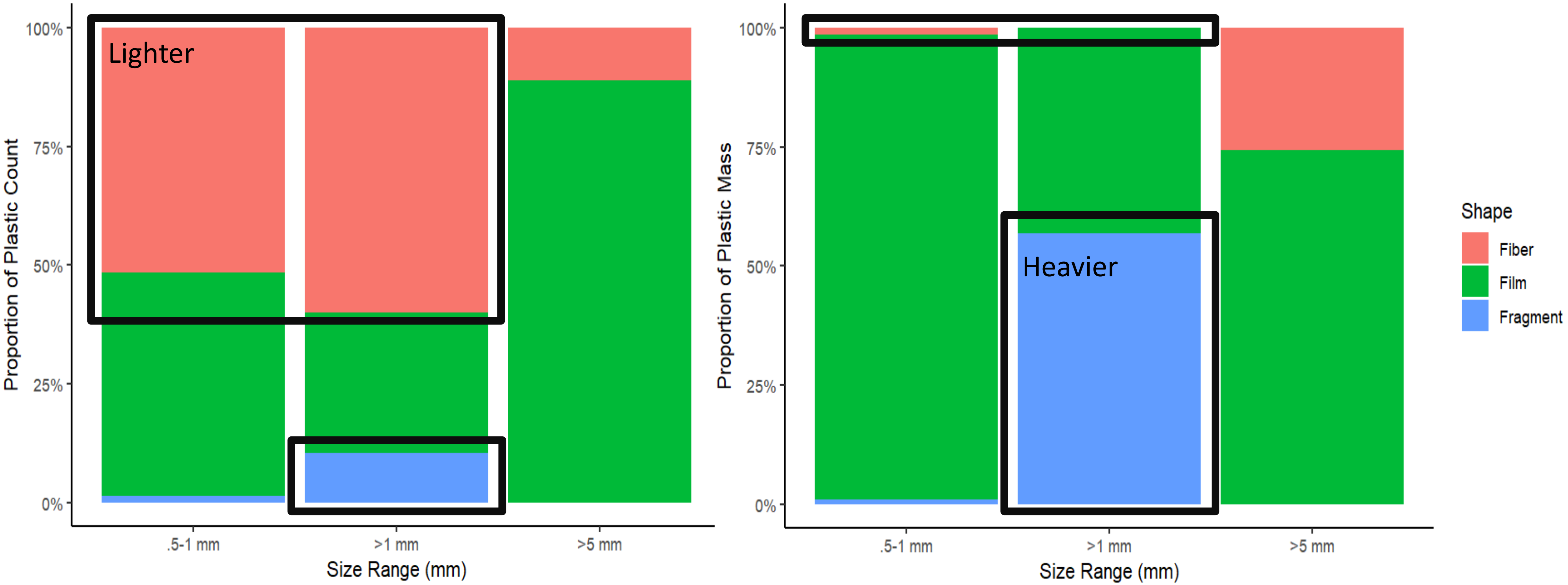
Plastic count and mass by sample, all sizes





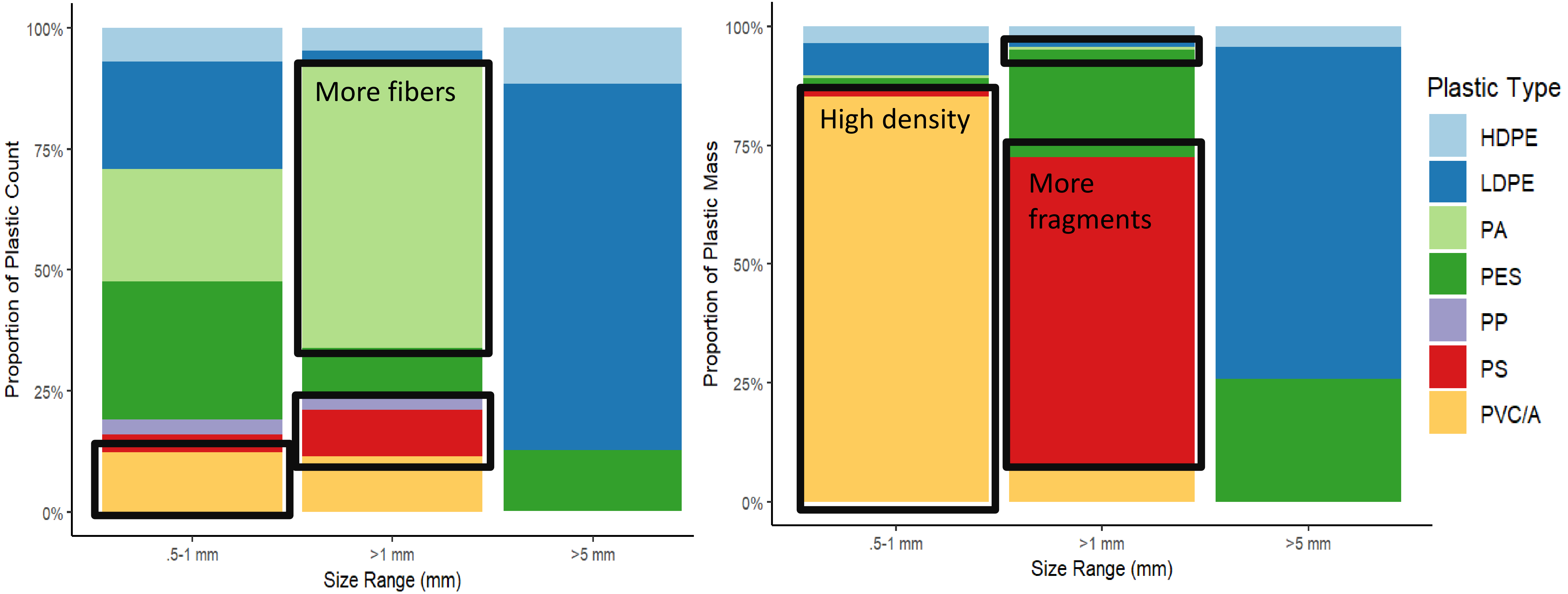
S. Hobson, K. Porterfield, E. Roy

Plastic proportions by shape and size



S. Hobson, K. Porterfield, E. Roy

Plastic proportions by type and size

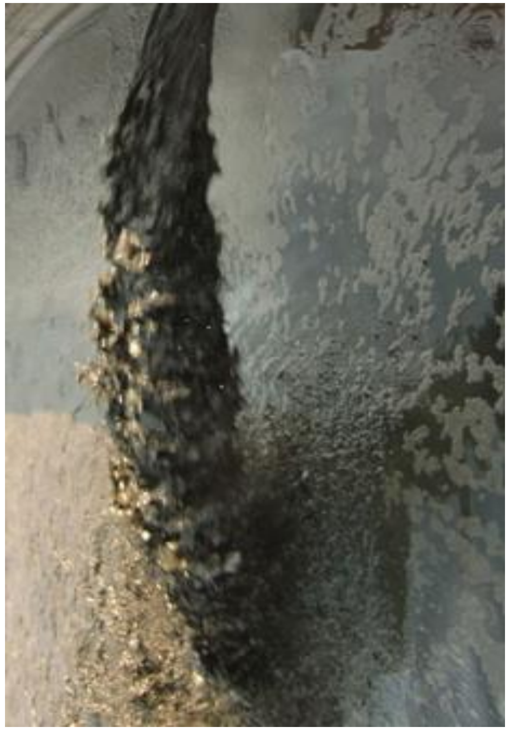


S. Hobson, K. Porterfield, E. Roy

Plastic content documented in organic residuals

	Material	Plastic Content (% w/w TS)	Reference
Compost	Compost (green waste derived)	0.00024–1.0	Bläsing & Amelung, 2018; Braun et al., 2021; Huerta-Lwanga et al., 2021; Sholokhova et al., 2021
	Compost (SSOW derived)	0.001–0.1358	Bläsing & Amelung, 2018; Braun et al., 2021; Müller et al., 2020; Schwinghammer et al., 2020
	Compost (≤5% SSOW)	0.000–0.0198	Our team's unpublished data
	Compost (15–30% SSOW)	0.000–0.0561	Our team's unpublished data
Digestate	Digestate (SSOW derived)	0.01–0.25	Kawecki et al., 2020; Müller et al., 2020; O'Brien 2019; Schwinghammer et al., 2020
	Digestate (depackaged ice cream derived)	0.002–0.044	Our team's unpublished data
Food Waste	Source separated organic waste (SSOW)	0.025–5.6	do Carmo Precci Lopes et al., 2019; Kawecki et al., 2020; Schwinghammer et al., 2020
	SSOW (mechanically depackaged)	0.04–0.12	do Carmo Precci Lopes et al., 2019
	SSOW (mechanically depackaged)	0.014–0.12	Our team's unpublished data
	Ice cream pints (mechanically depackaged)	0.066–0.35	Our team's unpublished data

Comparison considerations



→Variable organic matter reduction

→Bulking agent dilution

Insights from our work

Observation	Policy Relevance
Plastic contamination in organic residuals has been documented in most cases when people have attempted to measure it	No processing strategy is inherently free of contamination risk; Programs to minimize plastic contamination should be applied broadly
There is often high variance in plastic content measured within single materials	A single sample may not be representative of the average contamination of a material
Plastic contamination rates vary depending on the food waste stream	Clear management guidelines are needed for different food waste streams
Differences in methods make it difficult to compare results across studies	Standard methods for measuring microplastics in organic residuals are needed (w/w units, detection limits etc.)
Particles 0.5–1 mm in size can be most abundant, but particles >1 mm contribute disproportionately to total % w/w plastic when present	Using 1 mm as a lower limit of detection may capture the bulk of plastic contamination on a mass basis, given that risk-based standards are not yet possible
Film and fiber particles can be most abundant shape in food wastes, but fragments can contribute disproportionately to total % w/w plastic when present	Separate more stringent standards specific to film plastics may be necessary if the goal is to limit visible plastic contamination
Both conventional and compostable plastics were identified in organic residuals	Further work is needed to develop compostable plastics that fully degrade under real world processing conditions

Key take-aways

Conclusions:

→Vermont compost and digestate samples are comparable to previous studies

→Composts with high food waste had higher average plastic counts and masses

→Diversity of color, type, size, and shape of plastic particles

Future Work:

→Need for standard methods and reporting

→Collaboration to find best methods in preventing/removing plastic

→ LCA analysis of organics residuals management scenarios

Thank you! Any questions?

We would also like to acknowledge and thank:
State-wide composters and digesters
Composting Association of Vermont
EMERG and NCED lab groups
Heiser Fund
Gund Institute for the Environment
Casella Waste Systems

Contact information:
Sarah Hobson: sahobson@uvm.edu
Kate Porterfield: kporterf@uvm.edu
Dr. Eric Roy: eroy4@uvm.edu