Report on Microplastics and PFAS in Food Packaging and Food Waste

Pursuant to 2022 Act 170, Section 26

Submitted to:

the Senate Committee on Natural Resources and Energy and the House Committee on Natural Resources, Fish and Wildlife.

Agency of Natural Resources
Department of Environmental Conservation

VERMONT
AGENCY OF NATURAL RESOURCES

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Introduction

With one of the first food residual disposal bans in the country, Vermont has become a leader in organics recycling. In 2012, Act 148 was passed, phasing-in disposal bans of certain recyclable materials, leaf and yard wastes, and food residuals over the course of the next decade. As of July 1, 2020 all food residuals generated in the state were banned from disposal. The availability of previously disposed food residuals presented a tremendous opportunity to close the loop on the nutrient cycle and utilize resources locally to feed people, feed animals, create soil amendments and create energy. Generators, haulers and facilities stepped up to meet the moment, increasing their efforts, purchasing equipment and installing new technologies to assist the state with the organic diversion goals. As the food recycling system scaled up to serve all residents and business, so did the concern regarding contamination risks in improperly source separated food residuals and depackaged food residuals.

Food packaging and labelling is invaluable to the global food system preserving the quality of food during transportation and distribution. By excluding air, preserving moisture, etc., packaging increases the edible lifespan of foods and reduces the amount of wasted food. Food packaging excels at preserving the quality and cleanliness of the food we buy but can present various problems when introduced into the food recycling system. Insufficient source separation can lead to glass, plastic, rubber, metal and other inorganic contaminants in food residuals. Anaerobic digestion and composting are currently the primary means of recycling organics in Vermont and neither process is capable of decomposing those packaging materials to their elemental constituents. Additionally, there are additives used to provide specific performance characteristics to packaging that are not necessarily designed or approved for digestion, composting or environmental application – such as land applying to grow food or crops.

Applying digestates and composts containing packaging remnants to the soil poses risks to the environment and can alter soil's physical and chemical properties negatively impacting soil health.

It is appropriate to recognize that plastics are ubiquitous in the environment. Concentrations and types of microplastics found in the environment vary depending on location but are clearly associated with urban areas and anthropogenic activities. Researchers have found microplastics in ice samples from Antarctica. There are many ways that micro and nanoplastics can find their way into the air, soil and water. Personal care products, industrial processes, agricultural applications, degradation of plastic refuse, tire wear particles, and fibers released from washing synthetic clothing are all identified as significant sources of environmental plastic contamination. While this report focuses on the food recycling system's levels of microplastic and PFAS, ANR does not consider food itself or food recycling to be a major source of PFAS or microplastic in the environment.

Executive Summary

- ANR & AAFM do not recommend PFAS or microplastic legislation for organic solid wastes at this time. Given the positive preliminary data, ANR and AAFM find it appropriate to await the results of ongoing research to inform appropriate rulemaking.

- The sampling conducted in Vermont to date on plastic contaminants in finished composts and digestates made from source separated food residuals, depackaged food, and food processing residuals indicates that all products sampled meet the most stringent total plastic and film plastic contamination standards both domestically and internationally. There are no total physical contaminant sample results and insufficient PFAS sample results to report as of January 2024.

- Sampling methods and analytical methods need to be standardized before they can be relied upon for regulatory compliance monitoring and standards can be established. Until then, Vermont can choose to implement process and operational controls to assure clean food residuals are managed at organics management facilities.

- Vermont has a long-standing successful source separation program. Source separation is defined as separating compostable from non-compostable items at the point of generation. A largely effective source separation is one potential reason Vermont's food residual composts and digestates are cleaner than elsewhere in the country.

- To ensure effective source separation, ANR will work with generators, haulers, and organics management facilities on guidance to actively keep food residuals clean. In consultation with AAFM, ANR will begin rulemaking to maintain clean organics, govern organics management statewide and continue to support the food residuals management hierarchy of prioritized uses (see 10 V.S.A. § 6605k).

Report Pursuant to Act 170, Section 26

(1) A list of the organics management facilities certified in the State under 10 V.S.A. chapter 159.

Food residuals generated by Vermont residents and businesses are managed through a statewide network of transporters, transfer stations and treatment facilities. A brief overview will be provided in this section, however the complete list of organics management facilities certified under 10 V.S.A. chapter 159 is provided in Appendix A of this report. Solid waste transfer stations that accept municipal solid waste are required to also accept food residuals (per 10 V.S.A. § 6605(j)). Currently, approximately 114 transfer stations accept food residuals from residents. The Secretary has granted 3 transfer stations variances from the food residuals mandatory parallel collection requirements in accordance with 10 V.S.A. § 6613.

Licensed Haulers (Food Scrap Haulers)	Transfer Stations	Solid Waste Compost Facilities	Solid Waste Anaerobic Digesters (AD)	Solid Waste Depackagers	Farm Compost Facilities	WWTP's
416 (38)	114	12	4	1	10	1

A significant, but difficult to estimate volume of food residuals may be managed outside of the solid waste facility network such as on farms, at municipal wastewater treatment plants or via home composting.

(2) A summary of the organics management system in Vermont

Vermont is fortunate to have a robust and nation-leading food residual management system. The system also includes an effective food donation or food rescue system where retailers, residents, businesses, and nonprofits collaborate to separate and distribute quality edible food for people in need. The system has multiple transportation and destination options to suit the preferences of the generator. Those options allow flexibility to accommodate convenience, costs, the type of material being managed, and the logistical differences of organic waste hauling and management in rural vs urban areas.

Generation

Residential generators typically generate food residuals and either backyard compost at their homes, hire a licensed transporter for curbside pickup or self-haul to a local destination.

Businesses and institutions may generate food residuals, packaged food and/or food processing residuals. Food processing residuals are defined as the remaining organic material from a food processing plant such as whey, cheese making, brewery and ice cream residuals and excluding material from slaughtering, rendering, markets, groceries, and restaurants. Businesses most often contract with a licensed hauler for organics management services. Collected food residuals may be delivered to a composter, an anaerobic digester, a commercial organics transfer station, a depackaging treatment facility or to a farm for composting. Packaged food that is not source separated at the point of generation is mostly transported to a depackaging facility. Food processing residuals can be composted, but are most often direct hauled to an anaerobic digester or used as liquid substrate to assist the food depackaging treatment process. Some food processing residuals, such as high calorie candy or snack foods, are used to create animal feed mixes. Food processing residuals (and all other non-sewage wastes) that are delivered to a farm manure pit or anaerobic digester need to be registered with the AAFM non-sewage waste program.

Transportation

Vermont currently has a commercial transporter network of 416 hauling businesses, of which, 38 are specialized in food residual hauling. At the small-scale end of the spectrum food residuals in Vermont are transported in 45-gallon toters or even 5-gallon buckets by pickup trucks and even a donkey team. At the large-scale end, modified rear-load rendering style trucks, box trucks with lift gates and gasketed trailers with toter tippers are all used to move larger volumes of material at a time. In addition, there are a host of specialized non-sewage tanker vehicles hauling food processing residuals and depackager slurries which are typically liquid.

Transfer Stations

Most towns in Vermont have a transfer station and approximately 114 transfer stations and recycling centers currently state-wide offer food residual drop off services. Many residents are already in the routine of bringing their trash and recycling to their local transfer station. Dropping off food residuals at the transfer station is a convenient option for many residents. Additionally, there are a handful of food residual drop-off locations registered with the Program designed to aggregate organic materials from neighborhoods and reduce the number of curbside stops for the hauler.

Composting

Composting locally available “waste” organic materials closes the nutrient cycle loop and creates an amendment that can be used to build soils. Vermont has two regulatory pathways governing composting food residuals and food processing residuals.

1. The Vermont Agency of Agriculture, Food and Markets pursuant to Act 41 (2021) has oversight over the importation of 2,000 cubic yards per year or less of food residuals or food processing residuals imported to a farm for the production of compost provided the finished compost is principally used on the farm where it is produced, or the compost is produced on a small farm that raises or manages poultry.
2. The Agency of Natural Resources has regulatory oversight over all other solid waste composting activities that import organic solid wastes exceeding 100 cubic yards per year, or food residuals exceeding 42 cubic yards per year.

Food residuals at composting facilities are mixed with other organic materials and high-carbon bulking agents and actively managed over a period of 6-12 months until stabilized into finished compost. Solid Waste Certified facilities have construction and operational requirements to adhere to, as well as compost maturity and contaminant testing requirements to protect human health and the environment. The VAAFM rules governing composting are currently under development. Prior to the adoption of rules, Act 41 directs VAAFM to regulate farms who meet the definitional criteria of 10 V.S.A. § 6001(22) under the Agency of Natural Resources’ Solid Waste Management Rules (SWMRs). Nonetheless, the Required Agricultural Practices Rules also apply to on-farm compost operations in relation to water quality management including storage and containment practices. Until such time as rules are adopted, VAAFM is applying both the RAPs and the SWMRs (which address compost management including time and temperature requirements). To the extent the two rules conflict, VAAFM will apply the more stringent provision. More information can be found on VAAFM's website. The VAAFM commercial fertilizer registration program has labeling requirements and testing to verify product guarantees which applies to soil amendments such as compost.

Finished compost is primarily sold in bulk to home gardeners, farmers, and landscapers or blended into mixes for specific uses such as raised beds. Some Vermont composters have developed more specific marketing niches and may bag their products and ship for sale regionally. Some Vermont operations have developed composts that are sought nationally and shipped long-distance for greenhouse or microgreen production. Lastly, specialty products like vermicompost or compost teas can be used for specific applications.

Anaerobic Digestion

The known network of anaerobic digesters (AD) in Vermont that process organic solid wastes consists of approximately 9 farm digesters according to data from the EPA AgStar Database (although the number of farm digesters accepting organic solid wastes may be as high as 14 according to AAFM), 4 certified solid waste anaerobic digesters and at least one municipal wastewater treatment facility. To date, most of the anaerobic digestion of organic solid wastes occurring in Vermont capitalizes on the available capacity of pre-existing facilities. It is not likely that any new large stand-alone solid waste anaerobic digesters will be built due to the limited organic resources in-state and the expense of transporting materials long distance. However, smaller AD facilities co-located between several partner farms or on-site at food and beverage manufacturing facilities may be a viable model.

Since the majority of anaerobic digesters in Vermont are farm based, the products created from anerobic digestion are typically utilized onsite as fertilizers and soil amendments. The AAFM host farm’s nutrient management plan governs how much fertilizer can be land applied per season based on soil sampling and nutrient content of the fertilizer.

Of the four solid waste certified anaerobic digesters, only two are operating, the other two are under construction. Three of the solid waste certified anaerobic digesters send (or will upon construction) liquid digestate to municipal wastewater treatment facilities the other has a contract with an adjacent farm to land apply liquid digestate. Solid digestates undergo different separation methods, treatment processes and destinations at each location. The most common method currently is for solid digestates to be brought to a farm for land application. Currently the majority of solid digestates generated at solid waste certified anaerobic digesters in Vermont are land applied at one Vermont farm and one New York farm.

Depackaging Treatment

Relatively new to the organic waste management sector is mechanical depackaging technology. A significant portion of Vermont generated waste food residuals are in packaging. It is estimated that 30,000 tons per year or ~38% of total food waste generated in the state is in packaging (see the 2018 Waste Composition Study). Packaged food products may be expired, have a labeling issue, or perhaps contain a contaminant rendering them unsuitable for human consumption. Packaged food has historically been landfilled in Vermont until depackaging technology allowed for the recovery of packaged food for recycling.

A depackaging facility is capable of providing a combination of manual and mechanical separation to remove food contents from the outer packaging. The first step is manually pre-processing materials to remove packaging films, wraps, pallets and other inorganic, reusable or recyclable materials. Next a typical depackaging machine will utilize augers to sheer open and deliver packaged food into a closed chamber with a rotating shaft of paddles for agitation. As sheered packaged food is agitated within the chamber, small particles, slurried organics and liquids fall through an internal screen while larger particles and packaging components that do not pass the screen are separated for recycling or disposal. Feed auger and paddle shaft rotation speeds are adjustable. Depackager operators can also swap out screen sizes and paddle shapes to optimize recovery for a given batch of inputs. Finally, in addition to the operational adjustments, the recipe can have a major impact on the purity of the depackaged food residuals. A batch of 2-liter soda bottles behaves very differently than a batch of plastic tubes of sticky cookie dough, so finding the right input blends and recipes can be critical to the purity of the slurried organic outputs.

Currently, depackaged food residuals are primarily used as feedstocks for anaerobic digestion or composting in Vermont. However, in the new "Wasted Food Scale" and the associated evaluation of wasted food in the country, the U.S. EPA has identified and prioritized animal feed above composting and digestion as a destination for depackaged food residuals provided specific and stringent purity requirements can be met. We do not have data to quantify this practice in Vermont, but livestock feed supplement products made from depackaged food residuals such as bakery meals have been registered with AAFM's Commercial Feed program and cleared for sale in Vermont previously.

Businesses like food manufacturers, large grocers and distributors generate waste packaged food in such quantities that manual source separation at the point of generation is often not feasible. Depackaging provides an efficient means of recovering the organics from non-salable, non-edible packaged food items. The Solid Waste Management Program is currently developing a source separation and packaged food management policy including guidance to generators, transporters and facilities. The policy will describe a generator's source separation obligations as well as the types of packaged foods that a generator can outsource to a second party for source separation (i.e depackaging).

(3) A summary of the existing data on the levels of microplastics, plastics and PFAS in the material produced from organics management facilities in the State.

Currently, there is not a lot of information on levels of plastic and PFAS in products produced at solid waste certified facilities from source separated organics. The main reason we have little data is because there are no standardized methods for analyzing PFAS and microplastics in high organic matrices. Further, PFAS and microplastic monitoring has not been traditionally required for food residuals because the food is suitable for human consumption so there is logically less of a concern of PFAS or microplastic contamination via compost or digestate pathways.

Because there is concern about packaging or other contaminants finding their way into the organics recycling system finished products, several independent research projects have been initiated in Vermont to evaluate plastics and/or PFAS within the food recycling system. Many of them will be concluding this year, so complete results are not available as of the issuance of this report. The results we have gotten so far close some of the information gaps and help ANR and AAFM make more informed regulatory decisions. The data is summarized here, and more details on the current research projects can be found later in this section.

Plastic Concentrations in Vermont Composts and Anaerobic Digestates

The existing Vermont data for microplastics comes primarily from the UVM studies (see Table 1 below). UVM's microplastic research evaluated 1. mechanically depackaged ice cream, 2. source separated food residuals processed through a depackager, 3. whole anaerobic digestate (from a digester accepting primarily brewery residuals and up to 16% depackaged ice cream) and 4. composts (both food residual derived compost and compost derived without food residuals). Plastic was present in all depackaged ice cream slurries, all depackaged source separated food residuals and all digestate samples. Plastics were found in 79% (11 of the 14) of food residual derived compost samples and in 66% (4 of the 6) of the samples collected from non-food residuals derived compost, although at much lower concentrations. This indicates that depackaged food residuals and source separated food residuals may be associated with greater concentrations of plastic. It may also indicate that microplastics are introduced by other substrates and feedstocks utilized by these processes such as roadside leaves or recycled paper lawn bags.

Even though microplastics were widely present in compost and digestate samples gathered to date by the below referenced projects, microplastic concentrations in finished composts and whole anaerobic digestates were low and are within all established U.S., State, and European contamination limits specific to plastics (see the Standards Section below).

Table 1. Overview of Plastic Levels in Vermont Depackaged Food, Composts and Anaerobic Digestates

	Depackaged Ice Cream		Source Separated Food Residuals[1]		Whole Digestate[2]		Compost (derived from food residuals)		Compost (no food residuals)	
	Average	Highest Result	Average	Highest Result	Average	Highest Result	Average	Highest Result	Average	Highest Result
% by dry weight >0.5mm	0.19	0.35	0.062	0.12	0.018	0.044	0.0141	0.0561	0.0038	0.0198

[1] Source separated food residuals processed through a depackager machine into slurry

[2] Unseparated liquid and solid digestate from an anaerobic digester processing primarily brewery wastes and up to 16% depackaged ice cream

As you can see, from the summarized data above, all 20 finished composts analyzed by UVM had less than 0.0561% by dry weight for *total plastic* contaminants >0.5mm. For reference, H.501 proposed (but not passed) in Vermont's 2022/23 legislative session proposed a contamination standard of 0.5% by dry weight for *total physical contaminants* >1.0mm in size in finished composts, and the German *total film plastic* standard is 0.1% by dry weight for all film plastics >1.0mm. More information would be needed to make a direct comparison between Vermont total physical contamination levels and State and European total physical contaminant standards because State and European standards include all physical contaminants (i.e. glass, plastic and metal) and the UVM research recorded only plastics. However, UVM researchers recorded smaller plastic particle sizes (>0.5mm) overall, which is more stringent than any regulatory standard we are aware of.

This early data is reassuring and indicates that Vermont's baseline organics management processes result in cleaner feedstocks and final products than many other locales. Regardless, ANR and AAFM expect to gather more of a complete picture of microplastic presence in the VT food recycling system as the pending research projects conclude. As discussed in the Executive Summary and the Recommendations Section of this report, ANR will be focusing efforts on educating generators on optimal source separation practices and working with receiving facilities to establish load screening procedures both of which will help guarantee the purity of feedstocks processed by composting or anaerobic digestion. More information on the identified data gaps and next steps to better understand plastics in the state are identified in Section 5.

PFAS Concentrations in Vermont Composts and Anaerobic Digestates

PFAS are a large group of compounds widely used in consumer product applications and packaging because they are stable and are resistant to heat, water, oil, grease and stains. They have become a concern because of their persistence and because they have been shown to build up in the environment and in biota. Due to the widespread usage of PFAS in countless consumer products over the last few decades, and PFAS being ubiquitous in our current environment, PFAS contamination can be difficult to trace to a point source. Both AAFM and ANR have research projects underway now to assess PFAS concentrations in composts and digestates generated in the state. No data is available from either project as of the date of this report.

The EPA and a literature review conducted by the State of Minnesota have identified food contact materials, coated paper and yard waste as containing degraded PFAS constituents. Yard waste and paper are commonly accepted as compost feedstocks, and packaging may be inadvertently accepted in contaminated food residuals, so more information on the source and extent of PFAS concentrations in compost is needed. The Program hopes to gain more detail on the concentrations of these and other PFAS in composts generated from food residuals in 2024 to determine if additional measures or standards are necessary in consultation with AAFM and in accordance with the 2023 DEC PFAS Roadmap.

Lastly, in 2021, Vermont passed Act 36 which prohibits manufacturing or selling food packaging (for direct contact with food) where PFAS have been intentionally added – or are present in any amount. Ceasing the use of PFAS in direct contact food packaging will reduce PFAS in the food recycling system going forward.

Research

Three studies have been conducted by a research team at the University of Vermont (UVM), one by the Vermont Agency of Agriculture, Food & Markets, and one by the Agency of Natural Resources.

UVM Research

Researchers at UVM's Department of Civil and Environmental Engineering, Gund Institute for Environment and Rubenstein School of Environment and Natural Resources have been active in the space of microplastic contamination in the food recycling system. The three recent projects applicable to this report are:

Biogas Potential and Microplastic Content of Mechanically Depackaged Food Waste and Anaerobic Digestate in Vermont

This project was conducted in partnership with Casella Waste Management Inc. and evaluated macro and microplastics in 1) mechanically depackaged pre-consumer ice cream pints, 2) source separated food residuals (from a mix of residential and commercial generators) processed through the mechanical depackager, and 3) whole digestate (i.e. liquid and solids – unseparated) from a Vermont AD that processes primarily brewery waste and less than 16% mechanically depackaged ice cream slurry.

Microplastic Content of Composts Produced in Vermont

This project evaluated finished composts for macro and microplastic content. 20 total samples of finished compost were collected statewide for analysis. An interesting highlight of this research is that results can be used to compare composts made with food residuals and compost made with no food residuals.

Evaluation of Biomethane Potential, and Microplastic Impacts Food Waste Co-Digestion at Farm Anaerobic Digesters

This project is currently underway, so no results are available. However, the goals will be to assess farm capacity to, and interest in, co-digesting food waste and the nutrient and contamination impacts of importing food waste for digestion. ANR staff are in regular contact with UVM research members. Results from this study will be useful to inform the State's regulatory approach in this sector.

Vermont Agency of Agriculture, Food & Markets Research

In 2023, VAAFM initiated a 2-year research project evaluating whether imported depackaged food and source separated food residuals are at risk of contaminating agricultural land with PFAS and plastic from land applied composts and digestates. The goal is for AAFM to compare results from an AD and farm that accept depackaged food for digestion and land application with an AD and farm that land apply digestate but do not accept depackaged food. The two compost operations selected for the project both accept source separated food residuals. VAAFM's project is currently in progress, with a final report projected to be issued in November 2024, so final results are not available.

Agency of Natural Resources Research

ANR has received an EPA Pollution Prevention Grant to work with Vermont Food and Beverage Manufacturers to evaluate their processes and packaging for PFAS and microplastic contributions to the food recycling system. Part of this pollution prevention work will include sampling at various locations (depackaging, composting, anaerobic digestion, etc.) as well to determine the levels of these constituents across the landscape. The sampling on this project was delayed this year due to project staff shifting priorities to assist Vermonters with waste management needs following the July flood, but we hope to have the results finalized and report prepared by September 2024.

(4) A summary of the methods used domestically and internationally by jurisdictions with physical contamination standards to evaluate the percentage of physical contamination present

There are no standardized sampling methods for PFAS and microplastics in source separated food residuals, depackaged food residuals, finished composts, or anaerobic digestates. The British Standards Institute has issued a required sampling method (British Standard 12579) for compost sampling. The VTDEC has issued a guidance document on feedstock and finished compost sampling methods to obtain a representative sample for compost analysis, but it is not suitable for plastic analysis. The U.S. Department of Agriculture and the U.S. Composting Council have developed a robust and widely used compost sampling method in the Test Methods for Examining Composting and Compost 02.01 *Field Sampling Compost Materials* that is widely used in the United States. The issues with currently available compost and digestate sampling methods are 1) gaining a representative sample and 2) utilizing sample collection materials that will not contaminate the analyses being performed. Such as using a plastic bucket, or plastic sheeting to mix composite samples, and shipping in plastic bags or bottles for microplastic analysis.

Similarly, there are no standardized analytical methods for PFAS and microplastics in source separated food residuals, depackaged food residuals, finished composts or anaerobic digestates. Current commercial lab microplastic capabilities are limited to groundwater samples. The bulk of microplastic analyses being performed in the U.S. is conducted at academic labs. Many academic labs, such as UVM, have been working on developing methods to analyze microplastics in higher organic matrices such as biota tissues, food products, composts and anaerobic digestates, but there is no consensus across the researchers, and it has not resulted in a single standardized method. Further, current microplastics analysis at academic research labs has limitations including, long analysis time, expensive on a per sample basis, commonly used methods normally result in a particle count result which is not as useful as a quantification of plastic contamination by mass or polymer type, and it may not be sufficiently representative of contamination given the heterogenous nature of contaminants in organic substrates. Requiring organics recycling facilities to conduct compliance microplastic sampling at this time would not provide timely, reliable, and replicable results and it would present an unreasonably high cost to the facility. While compliance monitoring is not practical at this time, the program supports developing and utilizing performance monitoring standards to routinely provide timely and affordable feedback to facilities which they can use to make operational adjustments.

Domestic Standards

Currently, a dozen or so states have physical contamination standards for compost, but only a handful have standards that speak specifically to plastics. All states that address plastic contamination limits in compost are listed below (California, Maryland, Ohio and Washington) as well as a few selected states (North Carolina and New York) whose regulations only address total contamination for contrast. Interestingly, the standards established in the United States all center around a >4mm particle size. Perhaps driven by preexisting industrial standards, commercial lab detection capabilities, the expense of lab analysis for particles <4mm, and the turnaround time.

Table 2. Overview of Physical Contaminant Standards in Anaerobic Digestate and Finished Compost

	Limit for Total Physical Contaminants (glass, plastic & metal)		Limit for Total Plastics		Limit for Film Plastics	
Domestic	%/dry weight	size fraction	%/dry weight	size fraction	%/dry weight	size fraction
California	0.5	>4mm	-	-	0.1	>4mm
Maryland	2	4-13mm	-	-	2	>4mm
Ohio	1	>4mm	0.25	>4mm	-	-
Washington	1	-	-	-	0.25	-
North Carolina	6	>6.35mm	-	-	-	-
New York	2	-	-	-	-	-
International	Limit for Total Physical Contaminants (glass, plastic & metal)		Limit for Total Plastics		Limit for Film Plastics	
	%/dry weight	size fraction	%/dry weight	size fraction	%/dry weight	size fraction
European Union	0.3	>2mm	-	-	-	-
Germany	0.4	>1mm	-	-	0.1	>1mm

California

California has a standard that applies to both compost and digestate which is 0.5% by dry weight of all physical contaminants greater than 4mm, and 0.1% by dry weight of film plastics greater than 4mm.

Maryland

The state of Maryland has an implemented standard of 2% by dry weight for total physical contaminants between 4mm and 13mm in size. Additionally, Maryland has a 2% by dry weight limit on film plastics larger than 4mm.

Ohio

Only Ohio has a compost contamination standard that applies just to plastics. The standard in Ohio is 0.25 % by dry weight of all plastics larger than 4mm with an overall physical contamination standard of 1% by dry weight of all physical contaminants.

Washington

The state of Washington has a standard of 1% by dry weight for total physical contaminants, and a limit of 0.25% by dry weight of film plastics. If a compost exceeds 0.1% film plastic by dry weight, it must be labeled and the following information must be provided to the purchaser:

"This compost does not meet Department of Ecology standards for film plastic content for unrestricted use. This compost may only be used in locations where a means of removing or containing the film plastic on-site is put in place promptly after use. Acceptable controls include removal from the site, incorporation, planting, covering with soil or another media, or containment in a compost sock or similar device. This product may not be used adjacent to regulated waters of the state (e.g., wetlands, streams, lakes) or in environmentally sensitive areas." WAC 173-350-220 (6)(f)(iii)(D)(II).

New York

New York simply has a standard of 2% total physical contaminants by dry weight.

North Carolina

The total physical contaminant standard in North Carolina for Grade A compost is 6% by dry weight of all visually identifiable foreign matter greater than 0.25 inches (6.35mm). Grade A compost in North Carolina is approved for unlimited, unrestricted distribution.

International Standards

In 2022 the rules established by the European Union Fertilizing Products Regulation to address physical impurities in both compost and digestate went into effect. The rules established a standard in compost and digestate that glass, plastic and metal larger than 2mm shall not exceed 0.3% by dry weight. This threshold will be reduced to 0.25% by dry weight in 2026.

Some member states in the European Union have adopted their own requirements above and beyond the European Union Fertilizing Products Regulation.

Germany

Of the contamination standards used by other European countries, Germany's are perhaps the most stringent. The standard established in the German Fertilizer Ordinance for fertilizers (including anaerobic digestate and compost) is a maximum of 0.4% by dry weight of hard plastics greater than 1mm. Additionally, the standard for film plastics larger than 1mm is 0.1% by dry weight.

Industry Standards

In addition to governmental regulations, institutions sometimes work within the industry to establish voluntary standards for compost and anerobic digestate quality. Industrial standards can improve the marketability and distribution of composts and digestates by allowing operators to self-regulate to predetermined, non-regulatory standards.

Regulatory programs in England, Northern Ireland and Wales have adopted the standards established by the British Standards Institution in the Publicly Available Specifications (PAS) for compost and anaerobic digestate quality. PAS 100 establishes limits for plastic larger than 2mm in compost at 0.12% by dry weight. PAS 110 addresses limits for physical contaminants in anaerobic digestate, but allowable concentrations slide based on the final nitrogen content of the digestate and according to the maximum land application rates based on nutrient content.

In the United States, the US Composting Council has a voluntary industry standard program via the Seal of Testing Assurance Program, but the program does not specifically address plastic contamination as of the publication of this report.

(5) Identification of data gaps to the effective management of microplastics and recommendations on how to close those data gaps.

There are quite a few gaps in understanding right now. Some areas we will gain some clarity in the short-term, and some are further down the road. ANR has identified contamination within the organics recycling system as a priority to evaluate, and has been active to learn more this space – from our own research as well as other experts – so we can apply any necessary regulation judiciously. With the responsibility of protecting public health and the environment, the following data gaps have been identified:

1) Gain an understanding of background microplastic and PFAS levels in VT soils and the relative environmental plastic contribution from various activities and sources.
2) Learn more about the plant uptake, soil health and human health implications of compost digestate microplastic and PFAS pathways.
3) Track and participate in the development of standardized methods for microplastics and PFAS analytes in food residuals, depackaged food residuals, compost, anaerobic digestate and soil matrices. We need quick, reliable, replicable, and affordable analysis if we are going to implement regulatory compliance monitoring.
    a. Preferred reporting units –particle count is common, but it is the best option over mass of total plastics by dry weight or a summation of chemical composition to assess compounds of concern or additives present?
4) Evaluate fate and transport of microplasics and PFAS through composting and anaerobic digestion. Including comparisons of compost solids versus leachate and digestate solids versus liquids to understand if PFAS or microplastics are preferential to liquid or solids in these processes.
5) Extent of micro and nanoplastics as carriers of other chemical pollutants.
6) Gain a better understanding of the role of compostable plastics and products in the Vermont organics recycling system. Are compostable plastics and products filling a necessary role, or do they create more problems for organics management facilities.

(6) Recommendations on management changes that will reduce the levels of microplastics in the environment.

Ongoing research will help ANR and VAAFM build upon existing knowledge and determine if there is a risk to public health or the environment from current organic waste management practices.

(A) Recommendations on Special Management Requirements at Facilities

From a contamination standpoint, properly conducted source separation should not require improvements. ANR's strategy is to work with generators, by educating, providing guidance, timely feedback and motivation to source separate well. If generators do their part, a clean food residual stream is guaranteed to all receiving facilities.

Rulemaking

The Program is required to initiate rulemaking for the operation of food residual management facilities by Act 170, Section 27 following submittal of this report. It is anticipated that the following aspects of organic management facility operations will be evaluated for revisions during rulemaking.

<u>Facility Load Contaminant Inspection Protocols and Generator Feedback System</u> - One way to simultaneously encourage cleaner compost and digestate products from organics management facilities and support source separation is to require each facility (transfer stations, composters, anaerobic digesters and depackagers) to develop contamination inspection protocols for incoming food residuals. Following the dialogue from the Depackaging Stakeholder Group, the Solid Waste Management Program has already been implementing the recommendations in the report requiring load inspections at all food residual management facility certifications issued in 2023. The protocols include provisions for screening loads for contaminants, manually removing contaminants, feedback to haulers and generators if there are unsatisfactory levels of contamination and finally for financial penalties and possibly load rejection for significantly contaminated loads. Facilities are required to notify the Solid Waste Management Program of rejected loads so the state can provide guidance to the generator. The Program will evaluate Rule revisions to strengthen load inspections and generator notification processes to assure clean food residuals at facilities.

<u>Performance Monitoring</u> - Existing analytical methods are insufficient to be used for compliance monitoring, but the Program is interested in developing a method or using a method like the one developed by UVM researchers at facilities to screen for plastic contamination as an operational performance indicator. The selected performance monitoring method would need to be robust enough to reliably quantify plastics and identify polymers, which could be used by the facility and the Program to identify, target, and remove specific contaminants from inbound feedstocks and substrates. Other factors to consider while evaluating performance monitoring would be availability of labs to conduct testing, the cost to facilities to test and the timeliness of results.

<u>Depackaging Facilities</u> – Depackaging capacity is an asset to the State of Vermont, to businesses who generate packaged food and to the food recycling system. It is uniquely suited to recover organics bound in packaging that otherwise would be thrown away. In the absence of approved methods for physical and chemical contamination in high-organic slurries there are a few operational management requirements that could be implemented immediately to improve outcomes. Firstly, depackaging is not intended to be used as a means for cleaning-up poorly source separated food residuals. Contamination in food residuals needs to be communicated to the generator to remedy going forward. Secondly, outer packaging (i.e., secondary, tertiary and transportation packaging) do not contain the food and therefore may not be necessary to process through a depackaging machine. Those materials should be recovered for reuse and recycling as appropriate. Cleaner inputs equal cleaner outputs. ANR has been working with the existing depackaging facility operator to identify problematic materials and to develop pre-processing protocols. ANR will use the information presently available, and the information gathered by the ongoing research to develop simple and reasonable rules for depackaging. All regulated entities and interested citizens will be able to participate during the public rulemaking process.

(B) Recommendations on Bans on Certain Containers or Packaging that Pose Greater Management Risks

No recommendations at this time. As mentioned above, there is not enough information on the environmental risks of packaging or containers to make sound recommendations. Even though it is too soon for recommendations, plastic PLU (price look up) code stickers used on produce and compostable products/plastics have been identified as two categories of items that can cause contamination in composts and digestates and have been flagged for further investigation. ANR is working with select Vermont food and beverage manufacturers to evaluate food packaging and its potential contributions of PFAS and microplastic to the organics recycling system. The Program will gather data during the ongoing research project to evaluate the impact of containers and packaging, including PLU stickers and compostable products/plastics and determine if regulatory or statutory measures are warranted.

(C) Restrictions on the Location Managing Materials that contain high levels of microplastics

No recommendations at this time. More data is needed, but early results are positive, and ANR and AAFM do not recommend end-use restrictions for compost and digestate at this time. The Program intends to continue to evaluate the microplastic concentrations in products from solid waste certified organics management facilities and will confer with AAFM to assure that the end uses remain suitable.

(D) Recommendations on the implementation of the food residuals hierarchy set forth in 10 V.S.A. § 6605k or the current requirements around source separation of organics material from waste material

The Act 170 Depackager Stakeholder Group members agreed that there is value in having an established food recovery hierarchy to promote Vermont's resource management goals and priorities. The recommendations provided in their report were that ANR prioritize outreach and education efforts around the Food Recovery Hierarchy over enforcement. In response, the Program is working on issuing a clear and concise guidance to generators on source separation and how generators can partner with a depackaging facility to manage their packaged food residuals if they are unable to manually source separate at the point of generation.

No additional recommendations on the implementation of the food recovery hierarchy are made at this time.

(E) if possible in light of the data, a recommendation for a standard methodology for testing microplastics and a health-based standard for microplastics.

There are no available standardized methods for testing microplastics in food residuals, finished composts or anaerobic digestates. ANR supports adopting a physical contamination standard for depackaged food, compost and anaerobic digestate at certified facilities once standard sampling and analytical methods that are replicable, affordable, and effective exist. We will continue to track progress on method development by attending and participating in industry discussions and research.

Appendix A – Lists of Organics Management Facilities in Vermont

List of Compost Facilities in Vermont

Composting Facility Name	Jurisdiction	Facility Address	Town
Agri-Cycle - N. Hartland Annex	ANR	Quarry Road	N. Hartland
Black Dirt Farm	AAFM	Stannard Mtn Rd	Stannard
Cookeville Compost	ANR		Corinth
Cloud's Path Farm	AAFM		Sheffield
CSWD Green Mountain Compost	ANR	1042 Redmond Road	Williston
Dog River Farm	AAFM	Route 12	Berlin
Fairmont Farms	ANR	Vincent Flats Road	E. Montpelier
Firefly Farm	AAFM		Burke
Foster Brothers Farm	ANR	297 Lower Foote Street	Middlebury
Fyles Brothers Composting Inc.	ANR	816 Goodrich Cross Road	Benson
Hudak Farm	AAFM		Swanton
Kingdomview Compost	AAFM	2586 Pudding Hill Rd	Lyndon
Long Trail Compost Facility	ANR	639 North Rd	Bennington
LRSWMD Composting Facility	ANR	941 Wilson Road	Johnson
Mar-Jo Acres	AAFM	1647 Covered Bridge Rd	Irasburg
Middlebury College	ANR	890 South Street Extension	Middlebury
Sunrise Farm	AAFM		Hartford
Vermont Black Gold Compost LLC	ANR	1837 Jerusalem Hill	Rochester
Vermont Compost Company	AAFM	1996 Main St	Montpelier
VT Youth Conservation Corps	AAFM		Richmond
Windham SWMD Compost	ANR	327 Old Ferry Road	Brattleboro
Wyman Frasier Compost of Vermont	ANR	160 Wyman Road	Brandon

List of Anaerobic Digesters and Depackaging Facilities in Vermont

Anaerobic Digester Name	Jurisdiction	Facility Address	Town
Blue Spruce Farm	AAFM		Bridport
Chaput Family Farms	AAFM		North Troy
Gebbie's/Maplehurst Farm	AAFM		Greensboro
Gervais Family Farm	AAFM		S. Burlington
Green Mountain Dairy	AAFM		Sheldon
Jasper Hill Farm	AAFM		St. Albans
Maxwell Farm	AAFM		Coventry
Middlebury Resource Recovery Center (MRRC)	ANR	183 Industrial Ave	Middlebury
Monument Farms	AAFM		Weybridge
Pleasant Valley Farms	AAFM		Berkshire
PurposeEnergy Magic Hat	ANR	5 Bartlett Bay Rd	S. Burlington
Salisbury AD1 - Vanguard	ANR	589 Shard Villa Rd	Salisbury
The Saint	ANR	Benoit Drive	St. Albans
Westminster Farms	AAFM		Putney

Depackager Facility Name	Jurisdiction	Facility Address	Town
All Cycle Waste Inc	ANR	220 Avenue B	Williston

List of Transfer Stations Managing Organics in Vermont

Facility ID	Facility Name	Facility Address	Town
WS950	A.B.L.E. Waste Management Transfer Station	1515 Lynds Hill Road	Plymouth
AD500	ACSWMD - Regional Residential Solid Waste Transfer	65 Campground Road (Lot 6)	New Haven
AD401	Addison SWMD Transfer Facility	1223 US 7 South	Middlebury
OL030	Albany Transfer Station & Recycling Center	1030 Main Street	Albany
GI011	Alburgh Transfer Station	10 Dump Road	Alburgh
CH045	All Cycle Waste, Inc. Transfer Station (Casella)	220 Avenue B	Williston
WS995	ALVA Waste Transfer Station	1080 Charlestown Road	Springfield
WS051	Barnard Recycling and Transfer Station	TH29, 157 Chateauguay Road	Barnard
CA071	Barnet Transfer Station	Town Forest Road	Barnet
RU061	Benson Transfer Station	503 Glenn Road, TH#6	Benson
WS061	Bethel/Royalton Transfer Station	122 Waterman Road	Royalton
OG094	Bradford Recycling & SW Drop Off (Casella)	314 Fairground Road	Bradford
RU081	Brandon Transfer Station	61 Corona Street	Brandon
WH082	Brattleboro Salvage, Inc.	437 Vernon Street	Brattleboro
WA930	Budzyn Removal & Recycling	937 US Route 302	Barre
CH955	Burlington Transfer Station (Casella)	1496 Redmond Road	Williston
LA121	Cambridge Transfer Station (Casella)	Vt Rte 104	Cambridge
ES900	Canaan Transfer Station	186 Route 102	Canaan
BN771	Casella Manchester Transfer Station	4561 Sunderland Hill Road	Manchester
WA444	Casella Waste Management Recycling Facility	378 East Montpelier Road	Montpelier

BN081	Casella Waste Management Transfer Station	904 Houghton Lane	Bennington
FR311	Casella Waste Management Transfer Station	2 Transfer Station Road	Highgate
RU101	Castleton Transfer Station	393 Staso Road	Castleton
WS111	Cavendish Transfer Station	354 Route 131	Cavendish
OG131	Chelsea Transfer Station	72 Washington Turnpike	Chelsea
CH211	Chittenden SWM District Drop-Off Center	218 Colchester Rd	Essex
CH451	Chittenden SWM District Drop-Off Center	36 Landfill Road	Milton
CH771	Chittenden SWM District Drop-Off Center	87 Landfill Road	S. Burlington
CH200	Chittenden SWM District Transfer Station	907 Beecher Hill Road	Hinesburg
CH930	Chittenden SWM District TS - Williston	1492 Redmond Road	Williston
RU141	Chittenden Transfer Station	Holden Road	Chittenden
RU131	Clarendon Transfer Station	Rte 7B, North Clarendon	Clarendon
ES101	Concord Transfer Station	110 Brook Road	Concord
CH056	CSWD Burlington Drop-Off Center	645 Pine Street	Burlington
CH075	CSWD Yard Waste Depot	111 Intervale Road	Burlington
WA111	CV Landfill Transfer Facility (Casella)	Rte 2, 418 East Montpelier Rd	E. Montpelier
BN980	CWM Shaftsbury Transfer Station	639 North Road	Shaftsbury
RU151	Danby Transfer Station	130 Brook Road	Danby
OG1003	Donald Giroux's Trash Drop	3482 Rte 14	Williamstown
WH181	Dover Transfer Station	11 Landfill Road	Dover
ES061	East Haven Transfer Station	58 Commuity Building Road	East Haven
RU033	Fair Haven Transfer Station	175 Fair Haven Avenue	Fair Haven
OG950	Fairlee Transfer Station	Dump Road (off Rte 5)	Fairlee

WH991	Goodenough Rubbish Removal LLC	112 Mercury Drive	Brattleboro
GI251	Grand Isle Transfer Station	Lane	Grand Isle
WS996	Greater Upper Valley SWMD - Hartland TS	1360 Quarry Road	Hartland
CA040	Groton/Ryegate Transfer Station	269 School Street	Ryegate
CA144	Hardwick All Metals Transfer Station	2141 Route 15 West	Hardwick
WS280C	Hartford Transfer Station and C&D Processing	Off US Rte 5	Hartford
RU724	Hubbard Brothers Transfer Station	Clarendon	Rutland Town
LA050	Hyde Park Recycle Drop-off Depot (Casella)	1855 VT Rte 100	Hyde Park
WH301	Jamaica Transfer Station	Dump Road	Jamaica
OL045	Jay-Troy Recycling Ctr & TS	1375 Cross Road	Jay
OL050	K-N-S Tire Recycling	260 Main St	Albany
RU761	Killington Transfer Station	2981 River Road	Killington
LA331	Lamoille District Transfer Station	941 Wilson Road	Johnson
WH391	Londonderry Transfer Station	Route 100	Londonderry
WS331	Ludlow Transfer Station	336 Route 100 South	Ludlow
ES391	Lunenburg Transfer Station	47 Transfer Station Road	Lunenburg
AD002	Middlebury Recycling & Transfer Station (Casella)	533 Exchange Street	Middlebury
RU311	Middletown Springs Transfer Station	9 Firehouse Lane	Middletown Springs
FR550	Montgomery Drop-Off Center	86 Mountain Road	Montgomery
OL461	Morgan Recycling Center & Transfer Station	2140 VT Rte 111	Morgan
RU043	Mount Holly Transfer Station	36 Sharon Lane	Mount Holly
RU501	Mount Tabor Transfer Station	Route 7	Mount Tabor
CH172	Myers Recycling Facility	218 Red Can Drive	Colchester
CA511	Newark Transfer Station	1358 Newark Street	Newark
GI421	North Hero Transfer Station	362 West Shore Road	North Hero
CA384	Northeast Kingdom WMD Waste Mgmt Facility	224 Church Street, Lyndonville	Lyndonville

WA561	Northfield Transfer Station & Recycling Depot	69 Dog River Drive	Northfield
BN200	Northshire TS & Recycling Center (Casella)	310 Tennis Way	Dorset
ES033	Norton Transfer Station	249 VT Rte 114 South	Norton
WS511	Norwich Transfer Station	New Boston Road	Norwich
FR030	NWSWD Bakersfield Trash & Recycling	380 Main Street	Bakersfield
FR540	NWVSWMD	Rewes Drive	St Albans Town
FR600	NWVSWMD Recycling Center & Depot	158 Morse Drive	Georgia
CA571	Peacham Transfer Station	750 E. Peacham Road	Peacham
RU461	Pittsford Transfer Station	Depot Hill Road, TH 23	Pittsford
RU581	Poultney Transfer Station	Hillside Drive	Poultney
BN581	Pownal Transfer Station	645 Maple Grove Road	Pownal
RU601	Proctor Transfer Station	Deere Lane	Proctor
OG671	Randolph Transfer Station-Casella	Landfill Road	Randolph
BN612	Readsboro Transfer Station	610 Phelps Road	Readsboro
CH611	Richmond Waste and Recycling Dropoff (Casella)	80 Roger's Lane	Richmond
WH100	Rockingham/Westminster Transfer Station	7446 US-5, Westminster, VT	Westminster
WA163	Rodney Companion dba Rodney's Rubbish	1 River Road	Waterbury
RU623	Rutland County Solid Waste District/Casella T.S.	Gleason Road	Rutland City
RU681	Rutland Town Transfer Station	218 Northwood Park	Rutland Town
AD721	Salisbury Transfer Station	Upper Plains Road	Salisbury
BN421	Searsburg Transfer Station	18 Town Garage Road	Searsburg
BN741	Shaftsbury Transfer Station	526 North Road	Shaftsbury
RU781	Shrewsbury Transfer Station	130 Mt School Road	Shrewsbury
WS090	Springfield Transfer Station	Sewage Plant Road, Town Hwy #7	Springfield

CA721	St. Johnsbury Transfer Station (Casella)	548 High Street	St. Johnsbury
BN762	Stamford Transfer Station	610 Mill Road	Stamford
LA771	Stowe Transfer Station	370 Mountain Road	Stowe
WH960	Stratton Transfer Station	8 town Garage Road	Stratton
OG010	Thetford Transfer Station & Recycling Center	4706 VT Rte 113	Thetford
RU801	Tinmouth Transfer Station	Off Route 140 in Tinmouth	Tinmouth
WH421	Townshend Transfer Station	1102 Grafton Road	Townshend
OG841	Tunbridge Transfer Station	64 Recreation Road	Tunbridge
WA921	Waitsfield Transfer Station, Inc. (Casella)	Route 100	Waitsfield
RU901	Wallingford Transfer Station	90 Waldo Lane	Wallingford
WH891	Wardsboro Transfer Station	Dump Road off South Wardsboro	Wardsboro
CA051	Waterford Transfer Station	2727 Duck Pond Road	Waterford
WS921	Weathersfield Transfer Station	5024 Route 106, Perkinsville	Weathersfield
RU921	Wells Transfer Station	174 Bullfrog Hollow Road	Wells
OL980	Westfield Transfer Station	757 VT Route 100	Westfield
OL911	Westmore Transfer Station	6988 Vt Route 5A	Westmore
CA921	Wheelock/Sheffield Transfer Station	1090 Route 122	Wheelock
WH921	Whitingham Transfer Station	4185 Vt Rte 100, Jacksonville	Whitingham
WH941	Wilmington Transfer Station	55 Miller Road	Wilmington
WA080	Wilson Industrial Park Transfer Station (Casella o	109 Pitman Road	Barre Town
WH083	Windham SWMD Transfer Station, Med. Compost & HW D	327 Old Ferry Road	Brattleboro
BN961	Winhall Transfer Station	66 Old Town Road, Bondville	Winhall
LA921	Wolcott Transfer Station	142 Dump Road	Wolcott
WA231	Worcester Transfer Station	61 Calais Road	Worcester