CLOSED LOOP partners
CENTER FOR THE CIRCULAR ECONOMY

COMPOSTING CONSORTIUM

DON'TSPOIL THE SOIL

THE CHALLENGE OF CONTAMINATION AT COMPOSTING SITES

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About the Center for the Circular Economy & the Composting Consortium

About the Center for the Circular Economy

The Center for the Circular Economy at Closed Loop Partners is an innovation center for research, analysis and collaboration to accelerate the transition to a circular economy in which materials are shared, re-used and continuously cycled.

The Center specializes in convening brands and industries to solve seemingly intractable material challenges, harnessing design, innovation and the power of collaboration to reimagine products and packaging for sustainable impact at scale, creating the systems change necessary for the advancement of the circular economy. The Center takes a holistic approach to innovating, testing and scaling the circular solutions of the future, evaluating the full lifecycle of a product.

About the Composting Consortium

The Composting Consortium, managed by the Center for the Circular Economy at Closed Loop Partners, is a multi-year collaboration across the entire compostable packaging value chain to pilot industry-wide solutions and build a roadmap for investment in technologies and infrastructure that enable the recovery of compostable food packaging and food waste.

The Consortium's 33 partners include consumer brands and retailers, packaging manufacturers, composters, the United States Composting Council, various packaging trade groups, environmental NGOs and academic institutions. We are working together to enable systems change and achieve impact at scale.

Acknowledgments

Partners and Field Teams: This report would not be possible without the commitment and partnership of our 10 compost manufacturer partners: Ag Choice, Atlas Organics, Black Earth Compost, Dirt Hugger, Happy Trash Can Curbside Composting, Napa Recycling & Waste Services, Specialized Environmental Technologies, Inc. (SET), Veteran Compost and Windham Solid Waste Management. Thank you to our Founding, Supporting, and Industry partners who supported this work and to our Advisory Partners who provided feedback and review.

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Design: Guyang Chen-Ware designed this report.

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Foreword

Diverting food waste from landfills across the U.S. is a critical component of climate change mitigation. Today, food represents the single largest category of materials in municipal landfills across the U.S., where it emits methane, a potent greenhouse gas. This wasted food costs people, the planet and businesses.

What will it take to transition from our current wasteful linear system to one where valuable food nutrients are not wasted? First, we must look upstream to prevent food waste early on, whether it's optimizing harvesting processes at the farm level, prolonging shelf-life and reducing in-home waste, or donating excess food to food banks. Second, we must scale up composting infrastructure in the U.S. so that more food waste is diverted from landfill and can contribute value-additive nutrients back to the organics cycle through composting.

While curbside organics collection in the United States has increased by 49% since 2021, there are still only about 200 full-scale commercial composting facilities in the U.S. that accept food waste, and even fewer that accept compostable-certified packaging.[1] Most only handle yard waste.

One of the biggest barriers to greater acceptance of food waste and compostable packaging by composters is their concern about increased contamination. A contaminant is any unwanted material in the composting process that does not contribute to the end value of the finished compost.

Yet, today, there is little to no publicly available data or transparency across the composting industry on what typical contamination rates are at facilities, what materials most often constitute contamination or how much money is being spent by composters to address contamination.

The Composting Consortium, a collaborative initiative led by the Center for the Circular Economy at Closed Loop Partners, set out to address this data gap by working with 10 compost manufacturers of varying sizes across the continental U.S. The Consortium aimed to capture a geographically and operationally diverse dataset on contamination volumes and decontamination practices.

Our findings from the field put five commonly held beliefs to the test, challenging what many industry stakeholders had previously assumed as fact. For example, we found that whether a composter accepts compostable packaging or not does not necessarily result in higher contamination rates. We also found that as much as 85% of feedstock contamination, by volume, is from conventional plastics.

The Composting Consortium's approach is rooted in multi-stakeholder collaboration, convening leading voices across the entire composting and compostable packaging ecosystem to address a systemic waste challenge. This work represents our efforts to break siloes and bring together the key players — upstream, midstream and downstream — to remove barriers and advance a circular economy for organics and compostable packaging. Addressing contamination requires enhancing transparency, intensifying educational efforts and championing innovation. Together, we can pave the way for a circular future, turning food waste into a valuable resource and relieving composters from the burden of contamination.

Kate Daly

Kate Daly
Managing Director,
Center for the Circular Economy at
Closed Loop Partners

INTRODUCTION AND METHODOLOGY

INTRODUCTION

There is a growing spotlight on curbside organics collection and infrastructure as one way to help address the food waste crisis in America. Today, nearly 40% of food is wasted in the U.S., costing the country a staggering $430 billion,[2] and only about 4% of all post-consumer food waste generated by Americans is sent to composters.[3] While the overwhelming majority of composting facilities in the U.S. today only process yard trimmings, curbside organics collection has surged by 49% since 2021.[4] Composter feedstock acceptance policies are shifting to match this demand, but at a slower pace, with approximately 200 full-scale compost facilities in the U.S. that process food waste today.[5]

Apart from regulatory permitting hurdles, the hesitation to accept food largely stems from the assumption and perception that post-consumer food waste carries high levels of contamination like glass, metal, plastic and other non-compostable material. There is eagerness among compost manufacturers to be a part of the food waste solution, but contamination in the organics stream complicates their willingness to participate as a solution provider. Similarly, compostable packaging that can act as a vessel for diverting food waste is often assumed to further increase contamination risks, largely due to look-alike, non-compostable packaging which creates confusion for consumers, haulers and composters alike. Thus, the problem of contamination and packaging waste is closely connected to food waste.

The Composting Consortium set out to study contamination, dispel myths through greater data transparency and evaluate how composters are addressing contamination challenges at their sites, knowing this systemic issue will need to be solved to scale food waste composting infrastructure in the U.S.

OUR GOALS AND OBJECTIVES

Contamination in the organics stream is not a new problem, but it requires new solutions. Our goal was to address the contamination challenge head-on and support the composting industry by bringing new insights from the composting field to the public. For this research, we sought to quantify and characterize contamination in the feedstock, overs and finished compost, assign a monetary value to contamination, and compare contamination rates between facilities that do accept compostable packaging with one that does not.

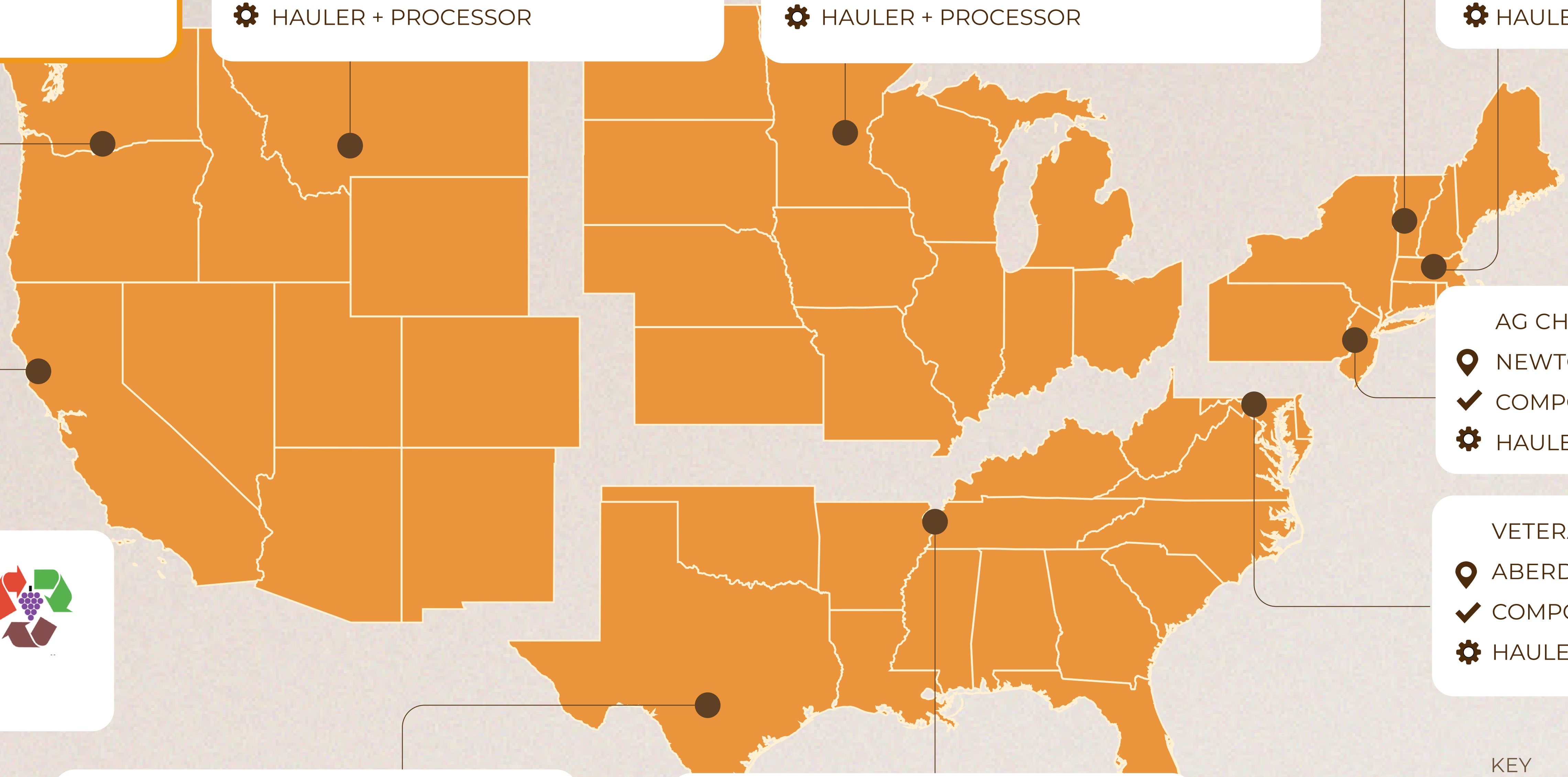
The Composting Consortium's mission is to scale food-waste composting and increase processing of compostable packaging across the U.S. As we set out to achieve these objectives, we partnered with 10 full-scale compost manufacturers of varying sizes across the continental U.S. to capture a geographically and operationally diverse dataset. Nine out of the 10 composters who participated in our study accept compostable packaging; the control facility does not. All composters in this study accept a combination of residential and commercial food waste.

What is Compost?

Compost is produced by the regulated aerobic, biological breakdown of biodegradable materials. Compost is a stable product that undergoes controlled exposure to both moderate and higher temperatures, diminishing the presence of pathogens and weed seeds, while also stabilizing the carbon such that it is beneficial to plant growth.[6] Compost is commonly applied as a soil amendment, and provides numerous benefits, including the ability to improve soil structure, fertility and water retention, suppress plant diseases and reduce the need for chemical fertilizers.[7]

COMPOSTER PARTNERS ACROSS THE U.S.

We partnered with 10 compost manufacturers of varying sizes across the continental U.S. to capture a geographically and operationally diverse dataset. Nine out of the 10 participating composters accept compostable packaging; the control facility does not.



WINDHAM SOLID WASTE MANAGEMENT
📍 BRATTLEBORO, VT
✓ COMPOSTABLE PACKAGING
⚙ PROCESSOR ONLY

DIRT HUGGER
📍 DALLESPORT, WA
⊘ COMPOSTABLE PACKAGING
⚙ PROCESSOR ONLY

HAPPY TRASH CAN
📍 BOZEMAN, MT
✓ COMPOSTABLE PACKAGING
⚙ HAULER + PROCESSOR

SET
📍 MINNEAPOLIS, MN
✓ COMPOSTABLE PACKAGING
⚙ HAULER + PROCESSOR

BLACK EARTH COMPOST
📍 GROTON, MA
✓ COMPOSTABLE PACKAGING
⚙ HAULER + PROCESSOR

AG CHOICE
📍 NEWTON, NJ
✓ COMPOSTABLE PACKAGING
⚙ HAULER + PROCESSOR

VETERAN COMPOST
📍 ABERDEEN, MD
✓ COMPOSTABLE PACKAGING
⚙ HAULER + PROCESSOR

NAPA RECYCLING
📍 NAPA, CA
✓ COMPOSTABLE PACKAGING
⚙ HAULER + PROCESSOR

ATLAS ORGANICS
📍 SAN ANTONIO, TX
✓ COMPOSTABLE PACKAGING
⚙ PROCESSOR ONLY

ATLAS ORGANICS
📍 MEMPHIS, TN
✓ COMPOSTABLE PACKAGING
⚙ PROCESSOR ONLY

KEY
✓ ACCEPTS COMPOSTABLE PACKAGING
⊘ CONTROL FACILITY. DOES NOT ACCEPT COMPOSTABLE PACKAGING
⚙ BUSINESS MODEL

OUR METHODOLOGY

While industry insights have hinted at the impact of contamination on composting facilities for years, most city and state waste characterization studies are done at transfer stations and landfills, rather than at compost facilities. In contrast, our study captured and measured organics samples at compost facilities to get a comprehensive understanding of what materials were making their way to the compost site and into the finished product. Our field team modeled our methodology on the 2021 Minneapolis Organics Sort, which sorted materials into categories classified as organics, plastic-lined paper, recyclables and "other contaminants".[8]

A key differentiator of the Composting Consortium's study is that we measured materials and contaminants in both mass and volume, and we expanded the definitions of these material categories. For example, instead of "recyclables" we included several sub-categories, like rigid plastic, flexible plastic and multi-materials.

Given this study's sample size, results are not statistically significant, nor do we make claims about how closely the samples represent the average feedstock at these faciliites, as our study does not account for seasonality. Rather, these findings serve as foundational reference points that should encourage future studies.

Measuring Contamination: Mass vs. Volume

Contamination can be measured on a mass basis and on a volume basis. Measurement by weight has been widely adopted in the waste industry due to its practicality, precision and convenience for marketing discrete commodity quantities. However, at a composting facility, a weight-based approach has its shortcomings.

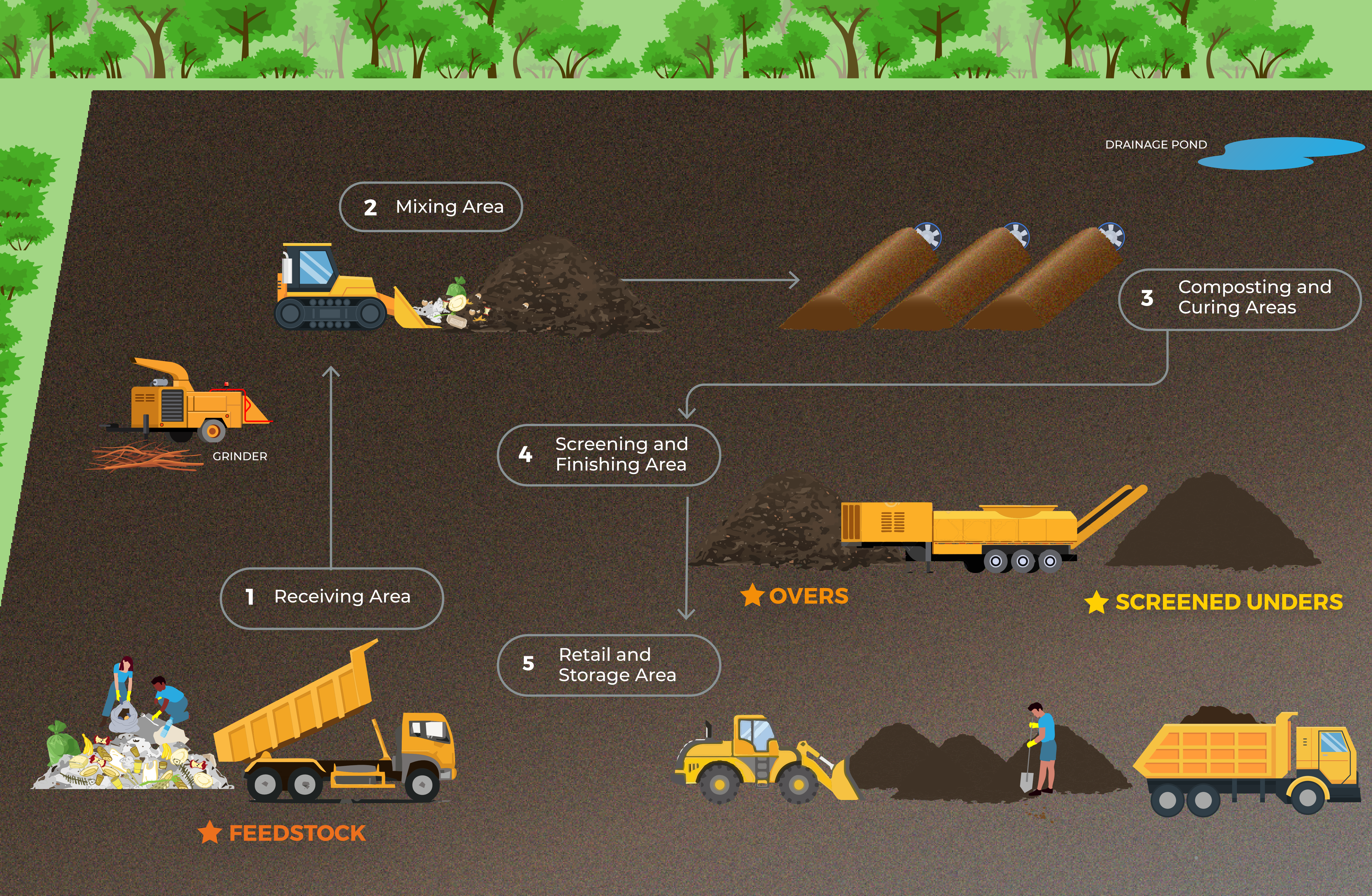
First, many composters charge on a volume (yardage) basis when receiving tipping material and sales are typically made by the cubic yard. Second, composters rely on visual inspections to gauge levels of contamination, and results are expressed on a percentage basis, by volume. According to data from a 2023 survey conducted by BioCycle, most composters measure incoming feedstock contamination by volume.[9] A volume-based approach also allows composters to account for low-density materials, such as thin plastic films, which may not significantly contribute in terms of weight, but can still signifcantly impact compost quality. It is worth noting that when evaluated by volume instead of weight, conventional plastics and compostable products constitute a larger proportion of the feedstock.

For these reasons, we have chosen to prioritize volume measurements in this report. Findings expressed on a weight basis can be found in the Appendix.

Where We Collected Samples

The field team conducted sampling at three stages of the composting process to assess contamination rates of the incoming feedstock and gain insights into facilities' ability to address contamination throughout their operations (see compost facility illustration on next page). All three samples were collected on the same day for a given facility, providing an understanding of contamination levels at different stages of the composting process at each facility.

This analysis of contamination took place at a singular moment in time, so it does not track the same set of organic materials from start to finish of the composting process. Therefore, definitive claims cannot be made. However, by collecting three distinct samples throughout the compost process at each site, we could analyze comparative contamination rates and explore potential relationships between a facility's ability to handle contamination at different points of their operations. While this study is a snapshot in time, it holds significance for the industry as it provides insight into the true costs associated with contamination.



THE SAMPLING PROCESS

★ **FEEDSTOCK:** Within 24 hours of material arrival, the field team collected a 200-pound representative feedstock sample from the compost site's drop-off pad/receiving area. Samples were taken from the top, middle and bottom of the pile.

Note: The 200 lb. sample size is a standard sample size and was chosen based on a manageable workload for a field team of two to three individuals over one workday.

★ **OVERS:** The sample of overs was mixed and sub-sampled using a five-gallon bucket or bucket loader to create a representative 200-pound sample.

★ **SCREENED UNDERS:** The field team collected a one-gallon sample of screened unders using procedures recommended in the Test Method for the Examination of Composting and Compost (TMECC),[10] taking multiple samples from different areas of the pile and blending them together into a composite sample. The type of contamination that persists in screened unders is typically small and difficult to identify by eye. As such, the one-gallon sample was shipped to the lab for closer analysis.

Across all three samples, contaminants were sorted and organized into distinct categories: natural organic feedstocks (food and yard waste), compostable products (fiber and various certified compostable plastics) and technical materials (conventional plastics, glass, etc.).

KEY

FEEDSTOCK is the incoming material received by a compost facility, which can include food waste, yard waste, packaging materials and contaminants.

OVERS are mostly larger woody materials, which can include contaminants or undesired items, that remain after the initial screening and sorting processes during compost production. Overs are commonly recycled back into the compost stream for further processing.

SCREENED UNDERS, in the context of this study, are equivalent to the finished compost (i.e. finished product).

WHAT IS CONTAMINATION

Conventional Plastic

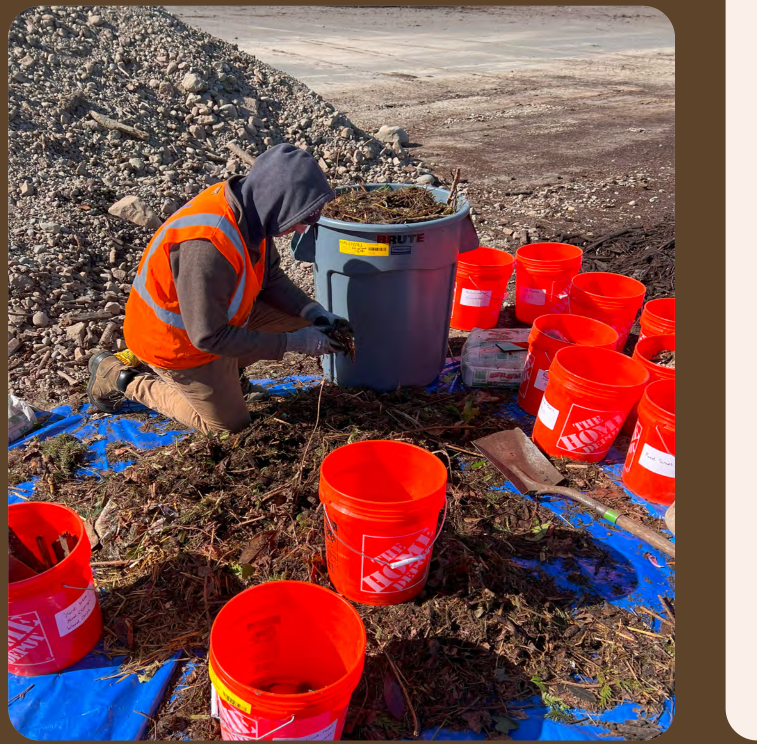
RIGIDS, FILMS AND FLEXIBLES, PLASTIC-LINED PAPER

Durable materials

GLASS, METAL, TEXTILES, ETC.

Natural inorganic material

LARGE ROCKS



DEFINING CONTAMINATION

A contaminant is any unwanted material in the composting process that does not contribute to the end value of the finished compost. While there are both physical and chemical contaminants, this study was limited to physical contamination.

Contamination was defined differently at various points of the compost process. When measuring contamination in the feedstock, our team separated out the organics, then placed contamination into one of a dozen five-gallon buckets. Each five-gallon bucket represented a different type of material category. For example, plastic-lined paper, rigid plastics, plastic films, glass, manufactured wood, etc. Similarly, overs were sorted into material categories such as rigid plastics and flexible plastics. Finally, one-gallon samples of finished compost (screened unders) were sent to Western Michigan University Paper Pilot Plant (WMU Lab) for analysis. Upon arrival, the samples were screened, rinsed, and tested[11] using FTIR spectroscopy, which uses infrared light to examine samples and identify their material characteristics (i.e., polymer type). Equipment used in the lab allowed for specific identification of material types, down to the polymer level (e.g., low density polyethene (LDPE) film), giving us a more detailed picture of both contaminant and non-contaminant types.

PART 1

CONFRONTING COMPOSTERS' GREATEST CHALLENGE: CONTAMINATION

ECONOMIC

Like those in many other industries, compost manufacturers strive to bring a high-quality product to the market, meeting demand and generating a profitable return. To succeed in the market, compost manufacturers need a finished product that is desirable, clean and competitively priced. Contaminated feedstocks create immense challenges for composters by diluting feedstock volumes and increasing the cost to handle organic material. Contamination can jeopardize a composter's business, finished product and reputation. Composters must constantly overcome these challenges to secure market demand and maintain operational credibility.

Contamination leads to extra time and labor costs in production, impacting a composter's profits.

Our study demonstrates commendable and effective efforts by compost manufacturers to tackle contamination, but the reality is contamination remains a persistent and costly issue.

Managing contamination can have a direct impact on a composter's ability to sell finished compost at a specific price point, or worse, sell it at all. The price of compost directly corresponds to its cleanliness and quality; contamination diminishes both, subsequently lowering its market value. To deal with contamination, composters take care during the composting processing to ensure the compost's market value matches the needs of the end markets that they sell into. The sale of a finished product typically represents around 20-30% of a composter's total revenue but can range from zero to 100% of total revenue depending on the composter's business model.

The removal of contaminants demands substantial investment in terms of time and money, and each compost facility adopts their own approach to dealing with it. The added expenses incurred in managing contamination cannot be offset by raising compost prices, necessitating a balance through increased tip fees or alternative revenue sources at the outset. This need for meticulous quality control throughout the composting process increases labor expenses, too. Consequently, there is a pressing need to find solutions that streamline contamination management. By doing so, compost manufacturers can redirect their resources towards business expansion, profitability and the production of high-quality compost — ultimately contributing to the enhancement of soil health and, by extension, more robust and sustainable food, fiber and land care systems.

As a last resort, or after repeated breaches, composters may be forced to reject incoming loads of feedstock if deemed too contaminated, or change their policies on what materials to accept altogether. As a recent example, A1 Organics, the largest composter servicing Colorado's Front Range, gained widespread attention for discontinuing the acceptance of all non-food compostable materials. This decision, which extended to compostable liner bags for food waste, was prompted by the amount of contamination flooding their facility.

ENVIRONMENTAL

Contamination poses a threat to the safety and quality of compost, diminishing its potential to enhance soil nutrition.

The environmental risks tied to contaminated compost vary depending on the type of contamination, whether it’s glass, metal, plastic or chemical. For example, glass shards not only create an immediate safety hazard to the customer but also degrade the overall aesthetic of the compost, which can be especially challenging for professional landscapers and farmers. Microplastics present their own set of challenges.

Microplastics are defined as plastic fragments less than 5 millimeters (approximately 1/8” in length).[11] Recently, research has shed light on the long-term risks that microplastics and nano-plastics may have on soil and water quality and human health. Given the pervasive nature of plastics in our environment, their removal has become increasingly difficult, raising concern within the composting industry regarding microplastics’ impact on the overall sustainability and health of our ecosystems. If conventional plastics are present in the organics feedstock at high levels, they may break down into microplastics during the composting process. This is particularly problematic because compost is primarily used as a soil amendment. This scenario could introduce microplastics into the soil, posing risks to agriculture, crops and human health. That said, it is important to note that no scientifically valid, peer-reviewed risk assessment has been performed to date on these scenarios.

The Problem with PFAS

PFAS (per- and polyfluoroalkyl substances) are chemicals used widely in commercial and consumer products including dental floss, non-certified compostable packaging, water resistant fabrics and some fertilizers. PFAS is frequently added to non-certified compostable fiber packaging to bolster the package’s resistance to grease, water, oil and heat. While this report does not delve into PFAS, it is crucial to acknowledge the emerging concerns related to these ubiquitous chemical compounds.

Several composting and compostable packaging industry groups have taken action to ban the use of PFAS. The U.S. Composting Council has publicly lobbied and supported a variety of bills in Congress, and states such as California and Vermont have banned the use of PFAS in everything from cosmetics to packaging. As of 2019, the Biodegradable Products Institute (BPI) no longer certifies compostable packaging containing PFAS. The Compost Manufacturing Alliance (CMA), a federally registered certifier, also excludes PFAS packaging from its field-testing certification program. In 2020, the Food and Drug Administration (FDA) engineered a voluntary agreement by the largest packagers in the U.S. to cease using PFAS in packaging. These actions reflect the packaging and composting industry’s response to the evolving environmental impact of PFAS in our soil and water and emphasize the need for ongoing scrutiny and pressure to remove these chemicals from products that may end up at compost sites.

SOCIAL

Contamination discourages composters who only accept yard trimmings from also accepting food waste, limiting the industry's role in contributing to a circular economy for food waste.

When food waste is not composted or anaerobically digested, it ends up in a landfill or an incinerator. In the landfill, food waste releases methane, a powerful greenhouse gas 28x more potent that carbon dioxide.[12] Composters can play a critical role in helping to solve the food waste crisis and address climate change — and there is tremendous opportunity to scale food-waste composting in the U.S.

Today, there are over 3,000 compost facilities across the country that only process yard trimmings.[13] Accepting food waste, beyond yard waste, is often viewed as risky by composters due to the potential for contamination, odors and pests, plus the increased costs of permitting and regulatory compliance (e.g., requirements for an impervious working surface and greater stormwater protection measures). If a composter anticipates increased business risks because of contamination, they may decide that the drawbacks of changing their business model outweigh the benefits.

PART 2

FIVE COMMON BELIEFS ABOUT CONTAMINATION, PUT TO THE TEST

WE TESTED AND ANALYZED FIVE COMMON BELIEFS ABOUT CONTAMINATION

FEEDSTOCK

COMMON BELIEF #1

Conventional plastic is the most common contaminant received by composters.

FINDINGS SUGGEST

Yes.

On average, 85% of the contamination that composters receive is conventional plastic, by volume.

FEEDSTOCK

COMMON BELIEF #2

Allowing compostable packaging in the organics streams leads to higher contamination rates.

FINDINGS SUGGEST

Not necessarily. Most composters had contamination, irrespective of whether or not they accept compostable packaging. Several factors contribute to the levels of contamination that a facility receives.

PROCESSING

COMMON BELIEF #3

Contamination is a nuisance, but it does not negatively impact a compost manufacturer's bottom line.

FINDINGS SUGGEST

No.

On average, 21% of composter operating costs are spent on contamination removal.

FINISHED COMPOST

COMMON BELIEF #4

Conventional plastic impacts the quality of composters' finished product, threatening their businesses and our environment.

FINDINGS SUGGEST

Yes.

Four out of 10 composters in our study had trace amounts of conventional flexible plastic in their finished compost.

FINISHED COMPOST

COMMON BELIEF #5

Compostable packaging does not break down and ends up in finished compost.

FINDINGS SUGGEST

Sometimes.

Eight out of nine composters who accept compostable products had no detectable amounts of compostable packaging in their finished compost.

COMMON BELIEF #1

Conventional plastic is the most common contaminant received by composters.

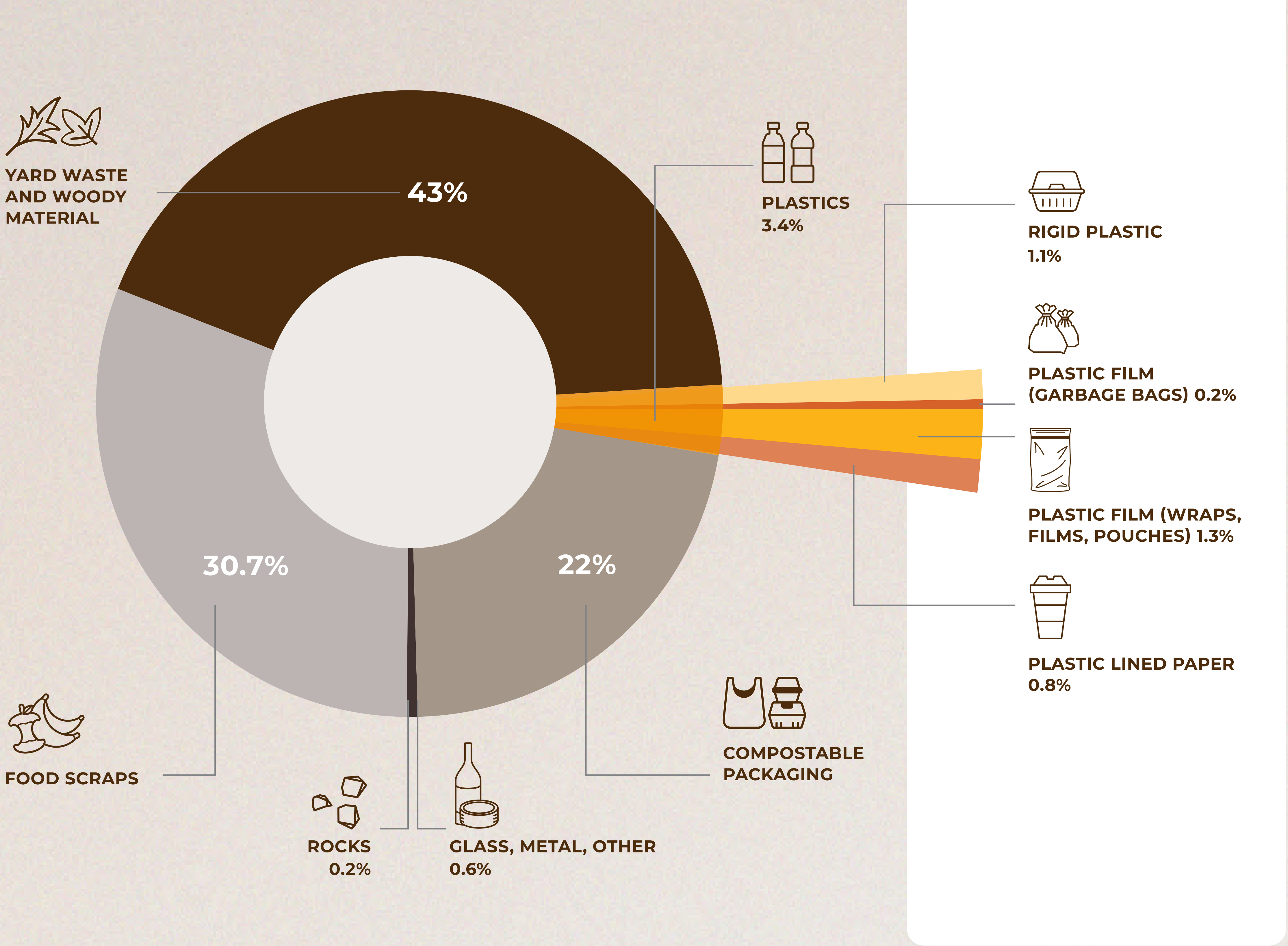
FINDINGS SUGGEST

On average, 85% of the contamination that composters receive is conventional plastic, by volume.

OUR FINDINGS

The results of the study aligned with our hypothesis that conventional plastics would constitute a significant portion of feedstock contamination at composting facilities that accept post-consumer and commercial food waste. **Our study found the average contamination rate across compost facilities who accept compostable packaging is 4% by volume.** Conventional plastic makes up 3.4% of the overall 4% contamination rate by volume. Figure 1 breaks down the material composition of those conventional plastics. Of course, plastic isn't the only issue composters have to manage. Our study shows that metal, glass and even textiles can make their way to compost facilities too.

FIGURE 1. FEEDSTOCK MAKEUP ACROSS NINE FACILITIES THAT ACCEPT FOOD WASTE AND COMPOSTABLE PACKAGING, BY VOLUME



WHY IT MATTERS

Even though contamination is a universal issue for composters, there is currently no industry average contamination rate to reference that can be used to track how contamination rates change over time. This poses a challenge for state agencies, industry organizations, policymakers and investors in understanding the true impact of contamination and how it can be handled. The Composting Consortium undertook this research to determine the average contamination rate observed among our composter partners, providing a baseline to help solve this problem on a national scale.

Composting requires a variety of processing techniques, like grinding, mixing and screening materials, to create a homogeneous product that can be used as a soil amendment. As the composting process progresses, contaminants are more likely to be reduced in size and become more difficult to remove. Since compost is typically directly applied to the land, there is no additional processing that happens after application. Therefore, even a small amount of plastic contamination in the finished product can be problematic, which is why it's important to identify and remove contaminants early.

This data underscores several realities and opportunities that exist across the U.S. today:

REALITY: Single-use plastic pervades our organics streams.

OPPORTUNITY: To eliminate look-alike products, brands and manufacturers must design compostable products in a way that clearly distinguishes them from their conventional plastic counterparts. A look-alike is a conventional product or package, usually made of plastic, that is indistinguishable from a compostable product due to similarities in labeling, design, appearance and touch. Because of their similarities, look-alikes make up a significant portion of the contamination problem in the organics stream.[14] Learn more about labeling and design in our joint report with BPI, Unpacking Labeling and Design: U.S. Consumer Perception of Compostable Packaging.

REALITY: A lack of standard disposal and sortation guidelines for businesses and residents across city, county and state lines exacerbates confusion about what can and cannot be placed in the organics collection bin.

OPPORTUNITY: To prevent non-compostable materials from ending up in the organics stream, municipalities, haulers and composters must agree on a separation process and collaborate to educate their customers and the communities they serve.

Recyclable or Compostable? Look-alike Products Can Often Be Mistaken as Compostable.

COMMON BELIEF #2

Allowing compostable packaging in the organics streams leads to higher contamination rates.

FINDINGS SUGGEST

Most composters had contamination, irrespective of whether or not they accept compostable packaging. Several factors contribute to the levels of contamination that a facility receives.

OUR FINDINGS

A common belief is that if compostable packaging is allowed in the organics stream, contamination rates will go up. This assumption is based on the premise that allowing packaging and food service ware might encourage the proliferation of conventional plastic materials, not just compostable packaging, into the organics stream. **Our study found that contamination is a common issue in the composting industry regardless of business model or accepted materials.**

To compare contamination rates across the nine facilities that do accept compostable packaging in our study, our team set out to find a control facility with a long-standing history of accepting only food waste. The selected control facility stopped accepting compostable packaging in 2017, initiating a broader regional trend in the Pacific Northwest that took hold shortly thereafter.[15] Moreover, the control facility undertook a myriad of measures to safeguard against contamination, including:

- **Longstanding awareness** and consumer education
  in the region;
- **Local training** of community members and haulers;
- **Blind waste audits** and surcharges for contaminated loads.

Because of these efforts, we hypothesized that the control facility would have the lowest contamination rate among our cohort of 10 composters, but our findings suggest otherwise.

Contrary to our hypothesis, the control facility, which does not accept compostable packaging, did not have significantly less contamination compared to the other nine facilities that do accept compostable packaging. In fact, the control facility fell in the middle of the pack. It had the sixth-highest plastic contamination rate (1.7% by volume) and sixth-highest overall contamination rate (2.8% by volume) in their feedstock, as shown in Figure 2.

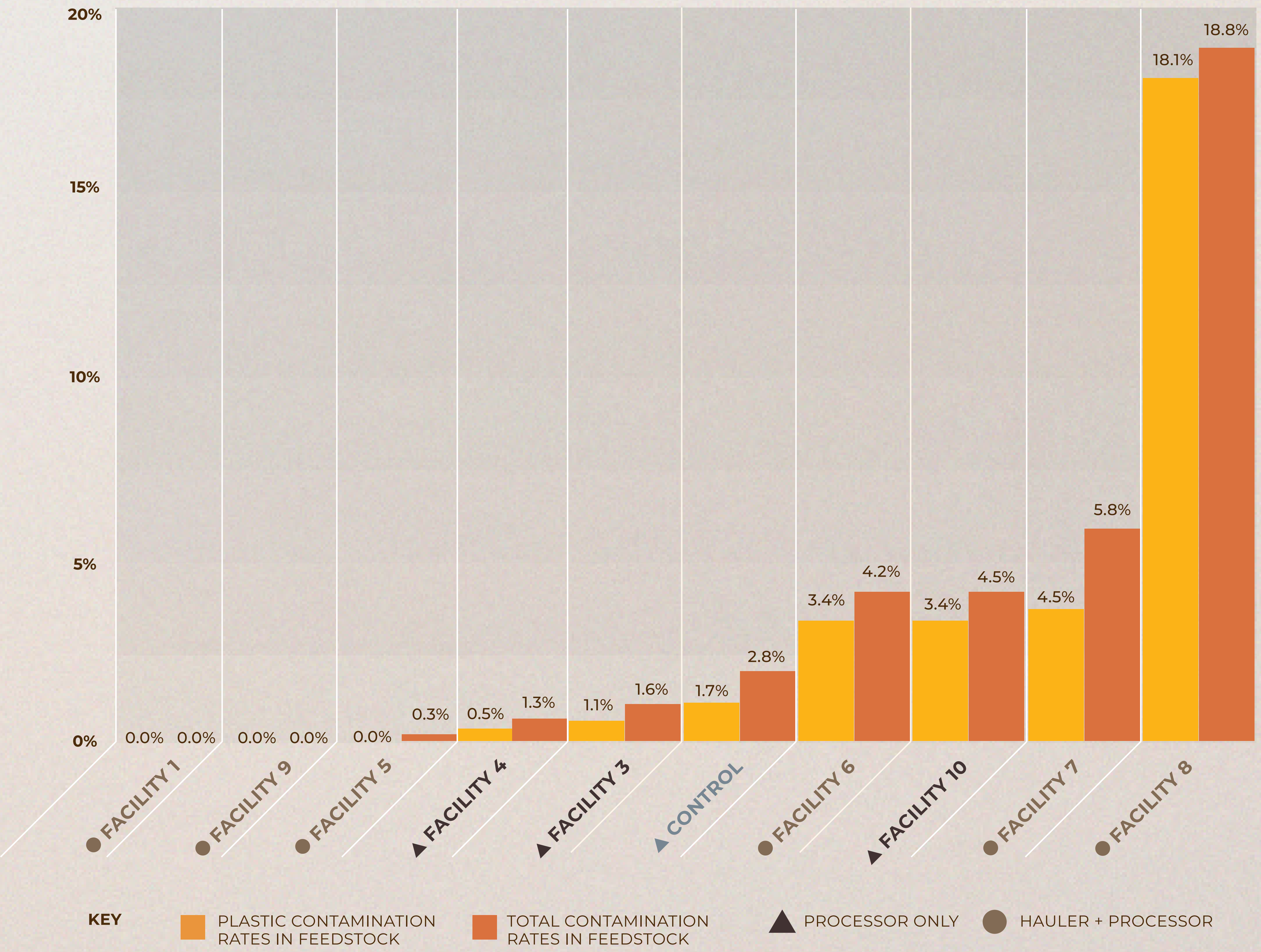
Taken out of context, single digit percentages may seem insignificant, but feedstock with contamination rates in the single digits are frequently untenable and rejected by composters. It is common for composters to reject loads nearing a 5% contamination rate by volume, whereas a contamination rate approaching 10% by volume[16] might even be visually confused for a pile of garbage.[17]

To further investigate the cause of the discrepancy, our team analyzed the impact of a composter's business model on contamination. We hypothesized that composters handling both collection and processing (i.e., vertically integrated) might have lower feedstock contamination rates compared to composters who were only processors. However, this wasn't the case. As Figure 2 shows, some vertically integrated composters had the lowest contamination, while others had the highest. **This variation in contamination rates among vertically integrated composters shows no direct relationship between business models and feedstock contamination levels.**

WHAT DOES 10% CONTAMINATION LOOK LIKE?

A contaminated pile of feedstock at a compost facility, meant to represent approximately 10% contamination by volume. Source: Resource Recycling Systems (RRS).

FIGURE 2. FEEDSTOCK CONTAMINATION RATES ACROSS ALL 10 FACILITIES, BY VOLUME



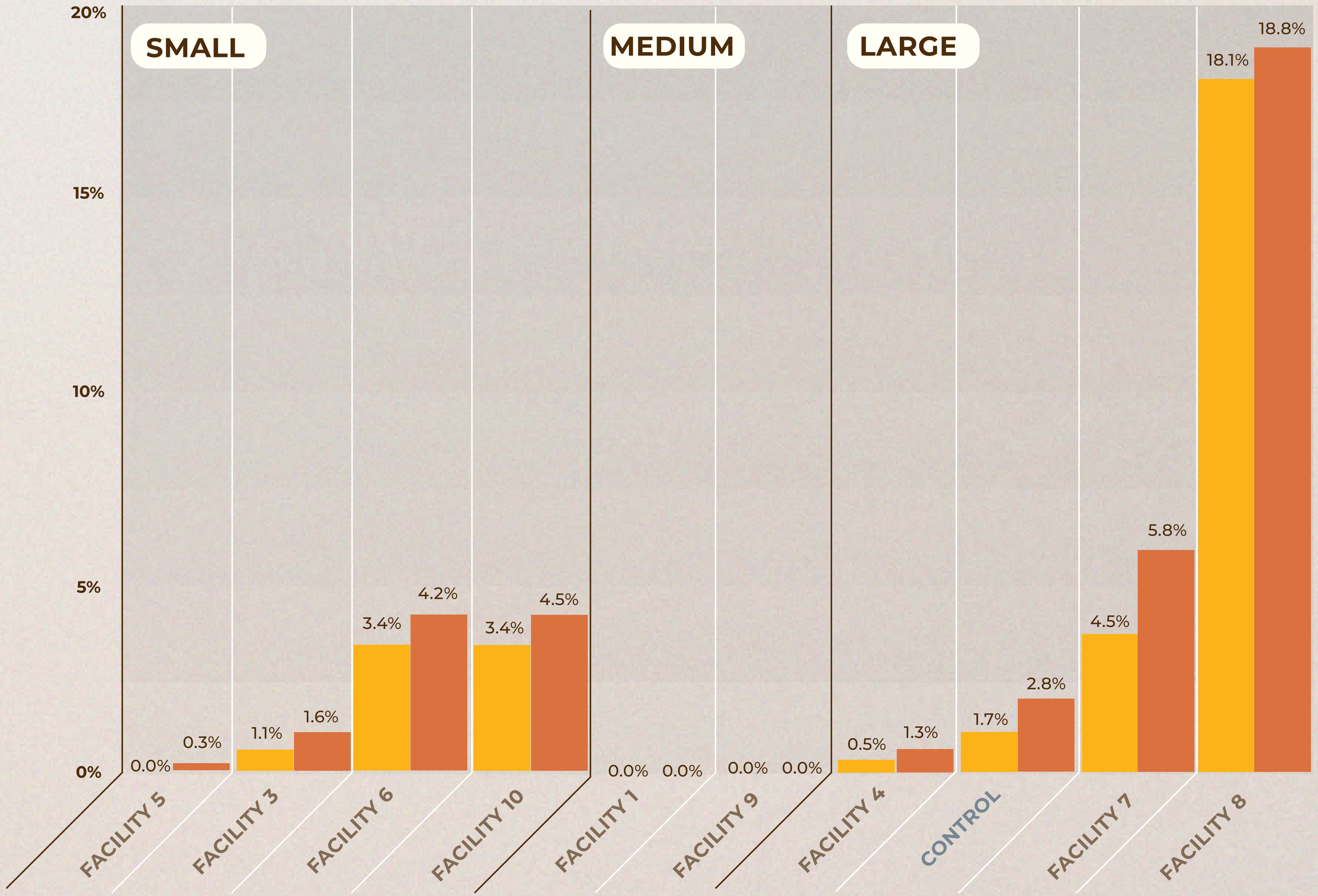
Finally, we analyzed the relationship between the amount of food waste a composter processes and the levels of contamination in their feedstock. We hypothesized that the more food waste a composter accepts, the more contaminated their feedstock would be compared to those who process less food waste. Figure 3 categorizes all 10 composters based on the total tons of food waste processed per year (i.e., small, medium, large). Larger facilities did appear to have the highest rates of contamination, but a couple of small facilities had similar contamination rates to the large facilities. **In our study, there was no direct or clear relationship between the amount of food waste processed and levels of feedstock contamination.**

WHY IT MATTERS

Our study did not find any one factor or couple of factors that are the root cause of contamination rates. These findings reveal that there are several variables impacting contamination rates, suggesting that an array of underlying factors expose a facility to contamination. To name a few:

- **Collection factors:** frequency of collection, default vs. subscription service, number of service providers (e.g., open market vs. franchise) and ratio of commercial to residential customers;
- **Policy and protocol:** local policy (e.g., food waste diversion mandates), economic incentives such as pay-as-you-throw (PAYT) schemes, types of compostable packaging accepted by hauler and composter and enforcement/consequences for violations;

FIGURE 3. FEEDSTOCK CONTAMINATION RATES ACROSS ALL 10 FACILITIES, GROUPED BY FACILITY SIZE



NOTE: GROUP SIZE IS DEFINED AS TOTAL TONS OF FOOD WASTE PROCESSED ANNUALLY.

KEY

🟧 PLASTIC CONTAMINATION RATES IN FEEDSTOCK

🟥 TOTAL CONTAMINATION RATES IN FEEDSTOCK

SMALL (n=4)
1,000 – 5,499 TONS OF FOOD WASTE PER

MEDIUM (n=2)
5,500 – 14,999 TONS OF FOOD WASTE PER YEAR

LARGE (n=4)
15,000 – 45,000 TONS OF FOOD WASTE PER YEAR

- **Customer education and communication:** how well residents and businesses are informed, participation levels, cultural factors and more.

Eliminating contamination is not as simple as addressing one or two factors, but rather, requires a multi-pronged approach. As such, future studies might examine one or a combination of factors listed above to see how those play a role in creating cleaner organics streams.

Counter to prevailing assumptions, this research demonstrates that contamination can be an issue even for composting operations that manage hauling and/or do not accept any kind of compostable packaging. These findings point to other challenges at hand and emphasize the need for additional contamination control measures upstream, starting with labeling and design of compostable and non-compostable packaging. Quality control measures are also needed along collection routes, regardless of whether or not a composter is vertically integrated. All stakeholders throughout the composting value chain — from brands to consumers to haulers — have a critical role to play to support clean organics streams and high-quality compost products.

Interested in learning more about how packaging design and labeling can improve disposal and reduce contamination? Read our report on consumer perceptions of compostable and non-compostable packaging, **here**.

COMMON BELIEF #3

Contamination is a nuisance, but it does not impact a compost manufacturer's bottom line.

FINDINGS SUGGEST

On average, 21% of composter operating costs are spent on contamination removal.

HOW TO USE THIS COST ANALYSIS

Using facility data from our ten composter partners, we established a foundational understanding of costs associated with contamination. The following analysis is conducted on a mass basis (i.e., per ton) to align with common practices that examine contamination, like waste characterization studies and needs assessments.

In the realm of innovation, investment, policy and programs like Extended Producer Responsibility (EPR), there is ample opportunity to explore and leverage the analysis of processing costs and expenses linked to contamination. This type of information can be used to enhance policy, strategically allocate funding and inspire new innovations. This analysis is meant to provide composters with a more comprehensive understanding of the time and costs spent on contamination removal.

OUR FINDINGS

Food waste provides valuable nutrients to the compost process, but it often comes laden with contaminants, like conventional plastic packaging, which necessitate considerable time and energy to remove. The composters in our study range in size and vary in throughput. While composters rely on different decontamination methods depending on their capacity and staff size, all composters manually handpick contamination from their feedstock or compost regardless of facility size, capacity and machinery. But depending on staff size and the equipment available to them, handpicking and screening may be their only option. One small-size composter in our study explains,

> ***"If there is any downtime, we are picking though the piles to address contamination. We cannot emphasize enough how much time we spend picking out contamination."***

In other instances, machinery and equipment can alleviate or expedite the decontamination process. Some composters have dedicated sort lines that operate continuously throughout the day. One composter in our study has an AI-powered sort line, which uses machine learning and cameras to identify contaminants on a conveyor belt. AI-technology is still emergent and relatively uncommon in the compost manufacturing industry.

Table 1 categorizes composters into two categories: low-tech and high-tech, to understand the relationship between contamination methods and hours spent on contamination. We define low-tech facilities as those who rely solely or predominantly on hand-picking and manual contamination removal efforts. By comparison, high tech facilities may use multiple pieces of equipment, machinery and/or automation to assist with the contamination removal process.

These findings suggest that high-tech facilities spend significantly less time on contamination removal. This could be because the high-tech facilities in our study have predominantly more capacity and annual throughput than their lower-tech counterparts. Of note, the control facility, excluded from Table 1, would qualify as a high-tech facility, having five pieces of equipment and a multi-staffed sort line to address contamination. Despite having a no-packaging acceptance policy, they dedicate 20% more time per 1,000 tons of organic material processed to contamination removal.

It's important to note that community education, as well as the size of the community serviced, can impact the amount of contamination that a composter receives. While those factors were not considered specifically in this analysis, they merit investigation in future studies.

TABLE 1. AVERAGE NUMBER OF HOURS SPENT ON CONTAMINATION REMOVAL ACROSS NINE FACILITIES THAT ACCEPT COMPOSTABLE PACKAGING.

Predominant Decontamination Methods	Average Hours Spent Addressing Contamination Per 1,000 Tons of Organic Material Processed
Low-Tech Facilities (n = 6)	94 hours
High-Tech Facilities (n = 3)	43 hours

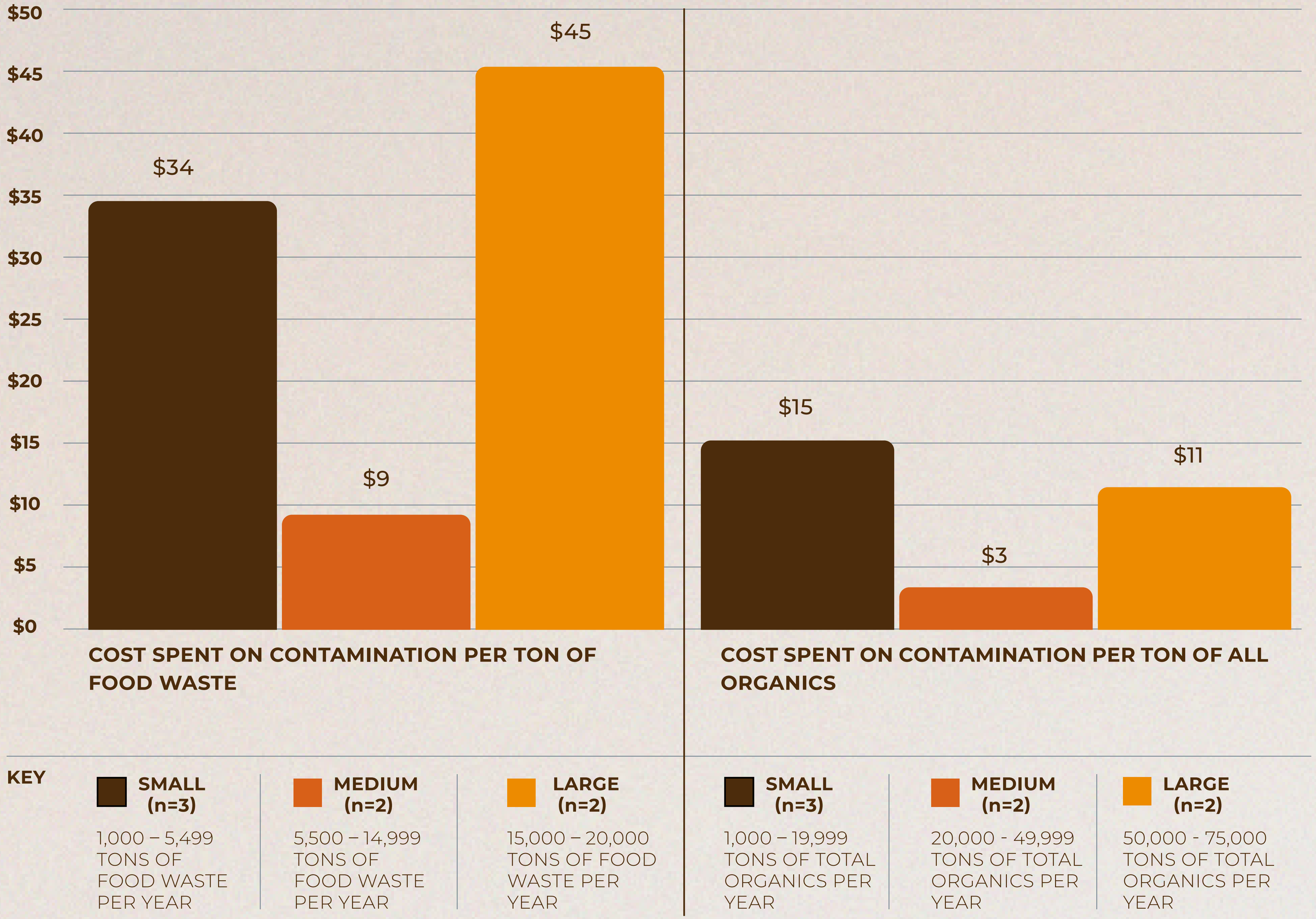
NOTE: HOURS REPORTED REPRESENT INVESTED TIME DURING PEAK OPERATING SEASONS.

Machinery and equipment can be useful to address contamination at different points in the composting process, but no matter what, removing contaminants is still a labor-intensive process. Seven of the 10 composters in our study cite labor as a leading cost driver in their overall operations. Of those seven, the number of full-time employees ranges from two people to 25 people.

Figure 4 shows the average cost of contamination management in two scenarios. The left side of the chart displays the average cost based on the amount of food waste processed at each facility per year, grouped into small, medium and large quantities. The right side of the chart shows the cost of contamination management normalized on a total tonnage basis (i.e. all organics processed per year). Contamination removal costs account for both labor and equipment expenses.

Contamination removal costs varied across facilities. Small and large-size facilities appear to have similar costs per ton of feedstock processed, which is surprising considering that small and medium-sized facilities in our study are predominantly low-tech while the large facilities are considered high-tech.

FIGURE 4. AVERAGE CONTAMINATION REMOVAL COSTS[18] ACROSS SEVEN FACILITIES THAT ACCEPT COMPOSTABLE PACKAGING



NOTES: COSTS ACCOUNT FOR LABOR AND AMORTIZED PROPORTION OF EQUIPMENT USED TO MITIGATE CONTAMINATION AT EACH FACILITY. SEVEN OUT OF TEN COMPOSTERS PARTICIPATED IN THIS ANALYSIS. CONTROL FACILITY NOT INCLUDED IN ANALYSIS.

Our findings show that medium-size facilities — those processing between 5,500 to 14,999 tons of food waste per year and between 20,000 to 49,999 tons of total organic waste per year — had the lowest contamination removal costs at $9 per ton of food waste processed and $3 per ton of total organics processed. Composters can use this understanding of contamination removal cost per ton of material processed to adjust their tip fees to account for the costs of contamination removal. Tip fees, however, may not cover all costs necessary to sort and remove contamination from the beginning. Therefore, assigning an appropriate value to the finished compost is equally important.

Our analysis also indicates that on average, 21% of composter operating costs are spent on contamination removal.[19] Of note, one compost facility in the low-cost group significantly increased the group average. Had that composter been excluded from the dataset, the average percent of total annual operating costs spent on contamination for the low-cost group would be 12%. Table 2 examines this relationship in more detail.

TABLE 2. PERCENT OF TOTAL ANNUAL OPERATING COSTS SPENT ON CONTAMINATION ACROSS SEVEN FACILITIES THAT ACCEPT COMPOSTABLE PACKAGING.

Annual Operating Costs	Percent of Total Annual Operating Costs Spent on Contamination (Group Averages)
Low-cost facilities: Less than $500,000 (n=3)	32%
Mid-cost facilities: $500,000 - $1M (n=2)	13%
High-cost facilities: Greater than $1M (n=2)	14%

NOTES: PERCENT OF TOTAL OPERATING COSTS SPENT ON CONTAMINATION = CONTAMINATION REMOVAL OPERATING COST PER YEAR / TOTAL ANNUAL OPERATING COST.[20]

WHY IT MATTERS

Most composters make the majority of their revenue through a tip fee, a charge based on the quantity or weight of the organic material dropped off at their site. A smaller, but still meaningful portion of revenue comes from finished compost sales. **The business model of compost manufacturing today relies on operational efficiency and the ability to optimize material flow through a facility.** Contamination complicates and slows down operational efficiency. The financial burden of increased contamination in post-consumer food waste necessitates financial assurances and incentives to offset the heightened costs associated with removal efforts.

Contaminated compost also presents a significant hindrance to waste management efforts, potentially incurring additional economic costs for the community being serviced. In the realm of waste management policy, EPR fees could be a vital resource to help composters address contamination. With the emergence of EPR packaging policies across the U.S., it's critical for state legislators and regulatory agencies to acknowledge the challenges compost manufacturers face with non-compostable products in their streams. EPR funds are just one source of financing that could be used to address and prevent contamination. Any responsible end market — whether it's a materials recovery facility (MRF) or a composting facility, is entitled to receive the financial support they need to successfully recycle or process the materials included in their state's EPR plans. Without that financial support, non-compostable materials will continue to be sent to compost facilities and contamination will persist.

As the U.S. looks to scale composting infrastructure to divert more post-consumer food waste from landfill, it will be critical to understand the cost implications for processing more complex and diversified feedstocks. This cost analysis serves as a starting point for composters, investors and policymakers to understand the added costs of processing complex organics streams that come with contamination.

COMMON BELIEF #4

Conventional plastic impacts the quality of composters' finished product, threatening their businesses and our environment.

FINDINGS SUGGEST

Four out of 10 composters in our study had trace amounts of conventional flexible plastic in their finished compost.

OUR FINDINGS

Across all 10 facilities, contamination accounted for less than 1% of finished compost by volume. Notably, eight out of 10 facilities in our study had an implied contamination removal rate of at least 95%[21] suggesting they are highly effective at removing contamination. This is supported by the small amounts of contamination found in the finished product.

Despite diligent efforts to combat contamination, conventional plastic can persist in the finished compost, potentially jeopardizing end market viability for composters. Conventional flexible plastic was the most pervasive contaminant in the finished compost. Four out of the 10 composters in our study had trace amounts of conventional plastic in their finished compost, ranging from 0.11% to 0.72% by volume. The highest plastic contamination rate was primarily made of polyethylene (PE) film. Plastic films and flexibles accounted for the greatest volume of plastic contamination in both the feedstock and finished compost.

WHY IT MATTERS

The pervasiveness of plastics in our environment makes their removal increasingly difficult, contributing to a growing concern about the impact of microplastics on the overall sustainability and health of our ecosystems. There is no standard procedure for measuring microplastics in compost or in food waste. While some states, like New York, impose compost quality regulations to limit non-compostable inert content in the finished compost, the U.S. lacks a national standard for this purpose.[22]

We've collectively witnessed and studied the immediate and lasting effects of microplastics in our oceans. Although research on the long term impact of microplastics on soils is limited, having microplastics anywhere in nature and in our ecosystems is undesirable and requires mitigation. The composters in this study have demonstrated their effectiveness in removing the majority of plastic contamination from their compost, but for 40% of those composters, plastics still persist in the finished product. Considering the detrimental impact of plastic on marine life and aquatic environments, it is crucial to minimize any plastic from entering the finished compost and subsequently contaminating our soils.

Whether compost is used in vegetable gardens, in agriculture, on turfgrass or in soil remediation, the bottom line is that plastic contamination reduces the product quality and may hinder the marketability of finished compost. It's critical to prevent a future in which composters' businesses and soil health are compromised due to plastics in incoming organics streams, which should not be there in the first place.

COMMON BELIEF #5

Compostable packaging does not break down and ends up in finished compost.

FINDINGS SUGGEST

Eight out of nine composters who accept compostable products had no detectable amounts of compostable packaging in their finished compost.

OUR FINDINGS

Counter to prevailing belief, we found no trace of fiber or compostable plastic packaging in the finished product at eight of the nine facilities that accept compostable packaging. One composter in our study had trace amounts of compostable cellulose paper in their finished compost—0.50% by volume.

Compostable fiber packaging was the only compostable product that appeared in both the finished compost and in the composters' overs. Eight out of the nine facilities that process compostable packaging had compostable fiber packaging in their overs; none of the composters who accept compostable packaging had compostable plastics in their overs. The median amount of compostable fiber packaging found in the overs was 2% by volume.

When materials are screened out of the stream (e.g., larger woody materials, compostable packaging, look-alike products, etc.) and into the overs, they do not make their way to the finished compost. If the overs are contaminated, they are diverted to landfill. Overs that are deemed clean enough are often recycled back into the composting process, allowing these materials more time to break down. **In this study, the volumes of compostable packaging found in the overs suggest that compostable packaging is by and large breaking down as designed and intended to do.**

WHY IT MATTERS

The number of composters who accept some format of compostable packaging has increased by 2.6x since 2018,[23] but skepticism around packaging disintegration performance remains. Of the roughly 200 food-waste composting facilities in the U.S., the majority (142) accept some kinds of compostable food-contact packaging. However, not all types of compostable materials are accepted across these facilities.

There is a tendency for composters to favor certified compostable fiber packaging because, as one composter in our study noted, composters, "don't mind fiber because to us, it's so much less confusing than [compostable] plastic… but we also know the disintegration [of fiber products] varies greatly." Fiber, unlike compostable plastics, also has the added benefit of adding complex carbon compounds like lignin and hemicellulose which can contribute significantly to the total mass of the compost, unlike compostable plastics, which care consumed as a food source by the microbes during the composting process.

Composters make deliberate choices about the types of materials they accept, driven by the desire to be profitable while creating high quality compost that enhances our soils. For example, composters who sell compost to the certified organic farming market cannot include compostable packaging as a feedstock to meet the U.S. Department of Agriculture's (USDA's) National Organic Program (NOP) standards.[24] The NOP requires that compost and compost feedstock are exclusively made from plant and animal materials. Under the current definition, all compostable packaging, including both compostable plastic and fiber, are considered synthetic, and are not allowed as feedstock. Including any of these materials as a feedstock would prevent the compost from being approved for sale under organic standards.

To avoid that risk, composters who sell compost to certified organic farms usually do not accept any form of packaging with their food waste or have separate piles for general use and use in certified organic agriculture. In Fall 2023, BPI petitioned the USDA to modernize the definition of "compost" and "compost feedstock" to meet current realities of composting in the U.S. today and include certified compostable packaging as a feedstock in compost piles.

According to the 2023 BioCycle National Compost Infrastructure survey, 58% of the composters surveyed who do not accept compostable packaging attribute their stance to concerns over the inadequate disintegration of compostable plastics during the composting process. The Composting Consortium recognizes these valid concerns, and in 2023 conducted research to understand how certified compostable packaging performs in the field at 10 compost facilities throughout the U.S.[25] Findings from this study will be publicly released in 2024.

PART 3

MOVING TOWARDS A CONTAMINATION-FREE FUTURE

POLICY AND FINANCIAL DRIVERS

Reducing the amount of contamination in our organics collection streams and at compost facilities will require collective action across the food waste value chain.

ReFED estimates that food waste recycling solutions in the U.S. — including animal feed, composting and anaerobic digestion — require an annual investment of $7 billion to support the growing need for food waste recovery.[26] Public funding, corporate financing and policy mechanisms all have a role to play in reaching that goal. Policymakers and state agencies must safeguard the economic interests of industries and activities that rely on contaminant-free, high-quality compost, like agriculture (conventional and organic), horticulture, stormwater control and recreation. Compost manufacturers should be compensated for the time and money spent on contamination removal. Higher tip fees and retail prices may be necessary to reflect true operating costs and effectively discourage contamination.

In December 2023, the EPA, USDA and FDA jointly unveiled their Draft National Strategy for Reducing Food Loss and Waste, marking a step towards developing a circular economy for organics. As part of that strategy, to address contamination in the organics stream, the EPA and USDA will provide expertise and technical assistance to state, Tribal, territorial and local governments and other entities. In coordination with its draft National Strategy to Prevent Plastic Pollution, the EPA is also exploring ways to scale and refine existing solutions to tackle non-compostable plastic contamination in the organic waste recycling stream.[27] This strategy indicates progress and momentum in the right direction, but more work remains to be done.

Grant funding is one financial mechanism that could support future research on contamination. Such studies could investigate potential relationships between screen size or agitation methods and contamination rates. Other studies might examine whether the size of the community being serviced has an impact on contamination rates. In all cases, future studies would benefit from larger cohorts of compost manufacturers and greater sample sizes. Regulatory agencies and nongovernmental organizations (NGOs) can provide funding to not for-profit entities to facilitate such studies, which would yield essential insights for informing future policies.

EDUCATION AND LABELING

The proliferation of compostable packaging has led to confusion among consumers, necessitating standardized labeling and the elimination of greenwashing. Brands and manufacturers can utilize publicly available resources like BPI's Labeling Guidelines[28] and the Composting Consortium and BPI's joint report: Unpacking Labeling and Design: U.S. Consumer Perception of Compostable Packaging[29] to enact better labeling and design across their product portfolios. In this study, we surveyed 2,700 Americans to test how different approaches to design and labeling impact how consumers identify, perceive and dispose of compostable packaging. We found that consumers best understood and preferred packaging that used two to three design elements (e.g., coloring, text, size, etc.) to indicate compostability. We also discovered that nearly 1/3 of Americans incorrectly believe they can place compostable packaging in the recycling bin, showcasing that a substantial portion of consumers don't know how to properly dispose of compostable packaging at its end of life.

Standardized labeling practices can help consumers identify and dispose of compostable packaging accurately, reducing the influx of look-alikes into compost streams. Education campaigns at both the consumer and municipal levels should be prioritized to enhance awareness and understanding of proper waste disposal practices. It is equally important that we do a better job of communicating the value of compost and healthy soil. By highlighting the benefits of compost, such as improved soil fertility, water retention and reduced reliance on chemical fertilizers, we can inspire widespread adoption of practices that positively impact both the environment and agricultural sustainability.

FUTURE RESEARCH AND INNOVATION

This research serves as a foundational step towards advancing the compost manufacturing industry and one that can lead the way in solving contamination. However, it is important to recognize that contamination remains an ongoing and persistent challenge, necessitating ongoing field research and the development of innovative solutions. The Composting Consortium found no conclusive evidence that one tactic works better than others at removing contamination from the composting process.

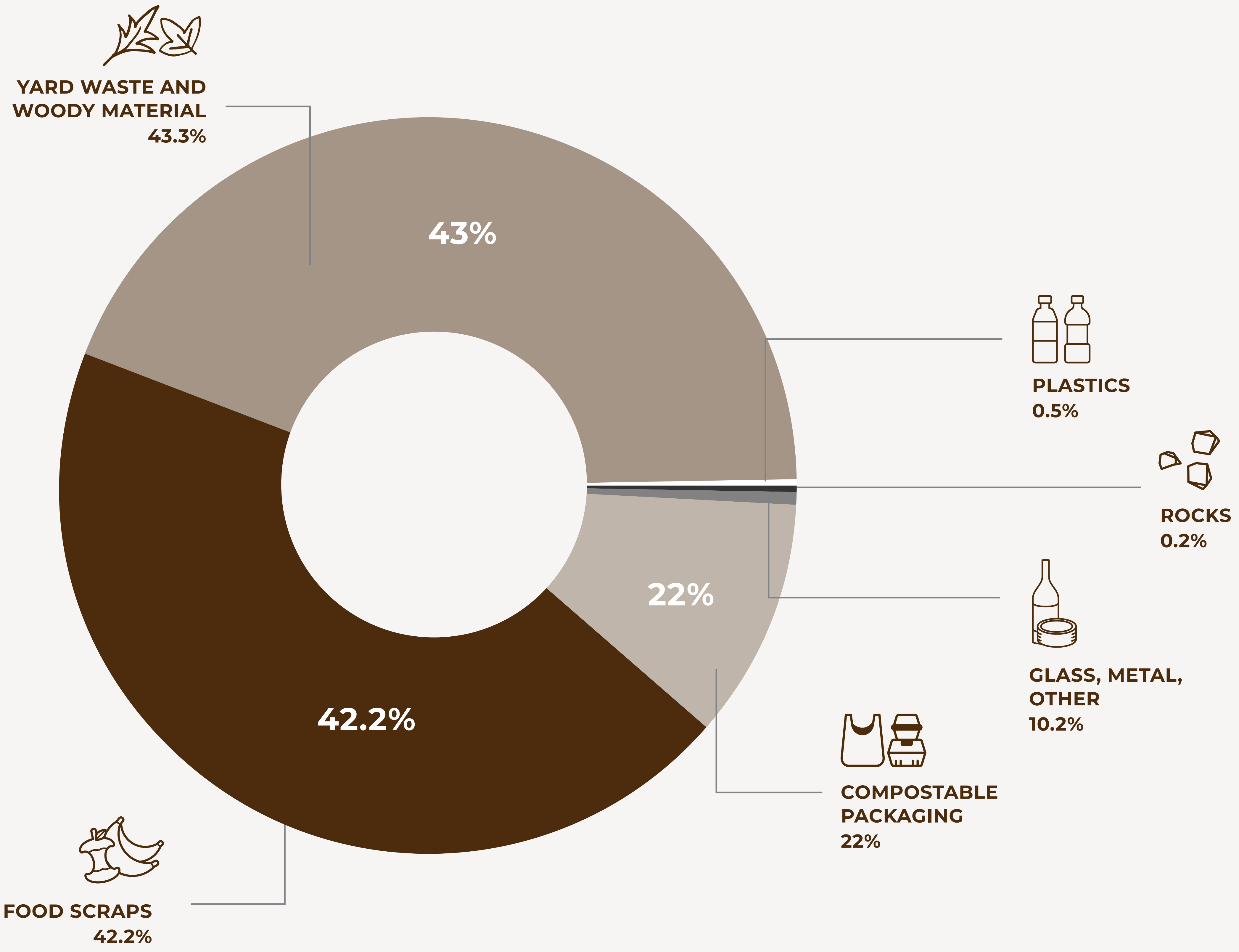
Building on the insights gained from the study, future research should focus on evaluating the effectiveness of various contamination mitigation techniques in relation to contamination removal. A future study that follows a similar methodology but with a larger sample size could help draw correlations from the field that best support contamination reduction to scale. In conclusion, the pursuit of innovative solutions and continued research is imperative to overcome contamination challenges, ensuring a resilient and sustainable future for the composting industry.

APPENDIX

APPENDIX: A SUMMARY OF OUR FINDINGS ON A WEIGHT BASIS

The average contamination rate by mass was 1.2% across all 10 facilities. Across the nine who accept compostable packaging, the average contamination rate was 1%. Rigid plastics were the most common contaminant found in feedstock. Seven out of nine composters had no detectable levels of compostable packaging in their finished compost, on a weight basis. Finally, five out of 10 composters had trace amounts of conventional plastic in their finished compost, ranging from .01% to .05%.

FIGURE 5. FEEDSTOCK MAKEUP ACROSS NINE FACILITIES THAT ACCEPT FOOD WASTE AND COMPOSTABLE PACKAGING, BY WEIGHT



ABBREVIATIONS & DEFINITIONS

- **Capacity**: In the context of composting, capacity refers to the maximum amount of organic waste or compostable materials that a composting facility can effectively process or handle within a given period, reflecting its overall capability and resource utilization.
- **Compost**: A stable, humus-like material produced through the microbial decomposition of organic materials, such as yard trimmings, food waste and agricultural residues, under controlled conditions. Compost is commonly used as a soil amendment to enhance soil structure, fertility and water retention.
- **Contaminant**: A contaminant is any unwanted material in the composting process that does not contribute to the end value of the compost.
- **Feedstock:** The term "feedstock" refers to what materials are accepted into a compost facility.
- **FTIR Spectroscopy:** Fourier-transform infrared (FTIR) spectroscopy is a technique that analyzes the absorption or emission of infrared light by molecules, providing detailed information about their chemical composition and structure.
- **PFAS:** Per- and polyfluoroalkyl substances (PFAS) are a group of human-made chemicals characterized by strong carbon-fluorine bonds, known for their persistent nature and widespread use in various industrial and consumer products.
- **Microplastics:** Microplastics are tiny plastic particles, typically measuring less than five millimeters in size, that result from the fragmentation or degradation of larger plastic items and are pervasive in the environment, including water bodies and ecosystems.
- **Organics:** In the context of this report, organics refers to the portion of the solid waste stream that is biodegradable. Curbside collection programs limit that to readily compostable materials, like food waste and certified compostable packaging.
- **Overs:** Refers to the portion of material that is screened out of the finished compost, such as larger woody particles or material that hasn't broken down. This could include non-certified compostable packaging, certified compostable packaging that hasn't broken down, and other contamination.
- **Screened unders:** In the context of this study, screened unders refer to the finished, saleable compost.
- **Screen:** In composting, a screen is a mesh or barrier used to separate finer materials from coarser ones, facilitating the refinement of compost by removing unwanted debris or particles.
- **Sifter:** A sifter (e.g., a wind sifter) is a mechanical device used in composting to separate lighter materials, such as paper and plastics, from heavier compostable elements, enhancing the quality of the final compost product.
- **Sort line:** A sort line is a designated area or conveyor system at a composting facility where workers manually or mechanically separate different materials, such as contaminants, from the compostable stream, ensuring the production of high-quality finished compost.
- **Throughput:** Throughput refers to the volume or quantity of materials processed within a specific timeframe in a composting facility, indicating the operational capacity and efficiency of the composting system.
- **Tip fee:** The charge imposed on individuals or entities for delivering organic waste materials to a composting facility for processing and conversion into compost. Composters charge tip fees on a tonnage or volume basis depending on the equipment they have on site. For example, those who have weight scales typically charge on a weight basis, while those who do not charge by volume.
- **Transfer station:** A facility where solid waste is temporarily deposited, sorted and transferred from smaller collection vehicles to larger transport vehicles for more efficient transportation to disposal or processing facilities.
- **Yard waste:** Encompasses organic materials such as grass clippings, leaves, branches and other plant-based debris generated from gardening, landscaping and yard maintenance activities.

ENDNOTES

1. BioCycle Nationwide Survey: Full-Scale Food Waste Composting Infrastructure In The U.S.
2. ReFED: Food Waste Facts
3. BioCycle Nationwide Survey: Full-Scale Food Waste Composting Infrastructure In The U.S.
4. Biocycle Nationwide Survey: Residential Food Waste Collection Access in the U.S.
5. BioCycle Nationwide Survey: Full-Scale Food Waste Composting Infrastructure In The U.S.
6. Association of American Plant Food Control Officials: 2019 Product Label Guide
7. U.S. Composting Council: What are the Benefits of Compost
8. 2021 Minneapolis Organics Sorts Findings
9. BioCycle Nationwide Survey: Full-Scale Food Waste Composting Infrastructure In The U.S.
10. Test Method for the Examination of Composting and Compost (TMECC)
11. There is currently no consensus among the research community on how to best measure microplastics. Some state regulations on compost quality impose a limit on physical contaminants, or inerts, in the final compost product at 0.50% on a weight basis, but there is no standard industry limit.
12. EPA: Importance of Methane
13. BioCycle Nationwide Survey: Full-Scale Food Waste Composting Infrastructure In The U.S.
14. Unpacking Labeling and Design: U.S. Consumer Perception of Compostable Packaging
15. A Message from Composters Serving Oregon: Why We Don't Want Compostable Packaging and Serviceware
16. BioCycle Nationwide Survey: Full-Scale Food Waste Composting Infrastructure In The U.S.
17. Resource Recycling Systems (RRS).
18. **COST SPENT ON CONTAMINATION PER TON OF FOOD WASTE** = (Contamination Removal Operating Cost Per Year + Adjusted Annual Equipment Cost based on Food Scraps Percentage) / Tons of Foods Scraps Processed per year.

    COST SPENT ON CONTAMINATION PER TON OF ALL ORGANICS = (Contamination Removal Operating Cost Per Year + Adjusted Annual Equipment Cost based on Food Scraps Percentage) / Tons of Total Organics Processed per year. Tons of Total Organics Processed per year comes from data reported in BioCycle Nationwide Survey: Full-Scale Food Waste Composting Infrastructure In The U.S.
19. 21% represents the non-weighted average, whereas 19% is the weighted average.
20. Our analysis only accounts for the cost of operating equipment to manage contamination (e.g., screens, sort lines, etc.), and does not include equipment like loaders, grinders, etc.

    CONTAMINATION REMOVAL OPERATING COST PER YEAR = Hours per year spent operating contamination removal equipment x Hourly cost to operate contaminant removal equipment.
21. Implied contamination rate was calculated using the following formula: 100 x ((% Contamination Feedstock - % Contamination Screened Unders) / % Contamination Feedstock).
22. BioCycle: Microplastics: How Many And How To Regulate?
23. BioCycle Nationwide Survey: Full-Scale Food Waste Composting Infrastructure In The U.S.
24. USDA National Organic Program
25. Closed Loop Partners Joins Forces with U.S. Composters and Composting Industry to Launch Large-Scale In-Field Disintegration Tests for Compostable Packaging
26. ReFED: Key Action Area, Recycle Anything Remaining
27. EPA: Draft National Strategy for Reducing Food Loss and Waste and Recycling Organics
28. BPI, Guidelines for the Labeling and Identification of Compostable Products and Packaging
29. Unpacking Labeling and Design: U.S. Consumer Perception of Compostable Packaging

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