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ASSESSING BARRIERS AND BENEFITS TO A FOOD WASTE COMPOSTING PILOT
PROGRAM IN OBERLIN, OHIO

by

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Submitted to the Oberlin Department of Environmental Studies

Advisors: Professor Roger Laushman and Professor Cindy Frantz

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Abstract

Food waste represents significant amounts of money, energy, and natural resources throughout its lifecycle from production to disposal. Diverting the quantity of food waste sent to landfills is necessary to address the growing strain on resources and reduce greenhouse gas emissions. This study was a collaborative effort between the City of Oberlin and Oberlin College designed to identify challenges and benefits to establishing a pilot municipal composting program. Establishing a citywide composting program will help Oberlin achieve its goal of carbon neutrality. We used food audits, stakeholder interviews, and emissions reduction models to better understand the best approach to municipal composting in Oberlin. We found that our partner organizations face a variety of challenges to successfully participate in food waste composting. The study concludes with recommendations for the pilot program and expansion of citywide composting in Oberlin.

Glossary of Terms

- **Aerobic Decomposition** - the breakdown of organic matter in an oxygenated environment, producing ammonia, carbon dioxide, and water vapor
- **Anaerobic Decomposition** - the breakdown of organic matter in an environment that lacks oxygen, producing methane, carbon dioxide, and water vapor
- **Composting** - a biological process that relies on microorganisms such as bacteria and fungi to decompose organic matter in aerobic conditions
- **Diversion** - refers to the process of decreasing the amount of waste put in landfills. It can be expressed as the change in the amount of waste going to landfills over time.
- **Food Waste Audit** - a planned process that is used to determine the amount and types of waste produced by a business or organization
- **Food Waste** - produced when an edible item goes unconsumed and is disposed of
- **Municipal Solid Waste (MSW)** - refers to materials that are discarded by the public; the EPA definition of MSW does not include industrial, hazardous or construction and demolition waste
- **Organic Matter** - carbon-based compounds that originate from the remains and waste of organisms or chemical reactions

1. Introduction

In 2017, food was the largest source of municipal solid waste in US landfills, at 21% of total landfill volume (EPA, 2020). Food waste is a growing source of waste; a 2009 study found that food waste grew from 30% to 40% of the available food supply between 1974 and 2009 (Hall et al., 2009). As landfills expand, so does the strain on vital resources. Diverting food waste is crucial to addressing food insecurity, which approximately two billion people experience worldwide (FAO, 2020). The United Nations predicts that the world population will reach 9.3 billion by 2050, and will require a 70% increase in food production (FAO, 2009). These shortages can be addressed starting with diverting food that is produced but not consumed.

Food waste represents significant amounts of money, energy, and natural resources throughout its lifecycle from production to disposal. The USDA found that food waste costs the average US consumer \$390 annually (Buzby and Hyman, 2011). Food waste accounts for 25% of US freshwater use and approximately 300 million barrels of oil each year (Hall et al., 2009). Most importantly, it is a documented contributor to climate change due to the production of greenhouse gases, specifically methane. Global food waste generates 4.4 GtCO₂ eq annually, or 8% of total anthropogenic GHG emissions (FAO 2015). Additional negative environmental impacts that occur along the food supply chain include deforestation, agricultural runoff, nutrient depletion of soil, and air pollution (Buzby and Hyman 2011).

1.1 Waste Throughout the Food Supply Chain

Food waste occurs at the production, retail, and consumer levels of the food supply chain. Food waste at the production stages includes disposal due to food safety regulations, disposal due to physical imperfections, and difficulty predicting the demand for a certain product (Buzby and Hyman). At the retail level, food is often discarded due to damaged packaging, quality standards, lack of proper storage space, and un-purchased seasonal and perishable items. At the consumer level, such as in a home or restaurant, causes of food waste include aging of produce, confusion over “use by” and “best by” dates, socio-demographic factors, and industry standards (ex. plate waste from restaurants can’t be repurposed and served).

The US EPA proposes a tiered approach to reducing and repurposing food waste in the Food Recovery Hierarchy. The Food Recovery Hierarchy serves as a guide to reduce the quantity of food waste produced at all stages of the food supply chain (Fig. 1). In order of most preferred to least preferred, the EPA proposes source reduction, feed hungry people, feed animals, industrial uses, composting, and landfill or incineration. Source reduction entails reducing the volume of surplus food that is generated. Industrial uses of food waste include the use of waste oil as fuel and bio-digestion of food scraps to produce energy (EPA).

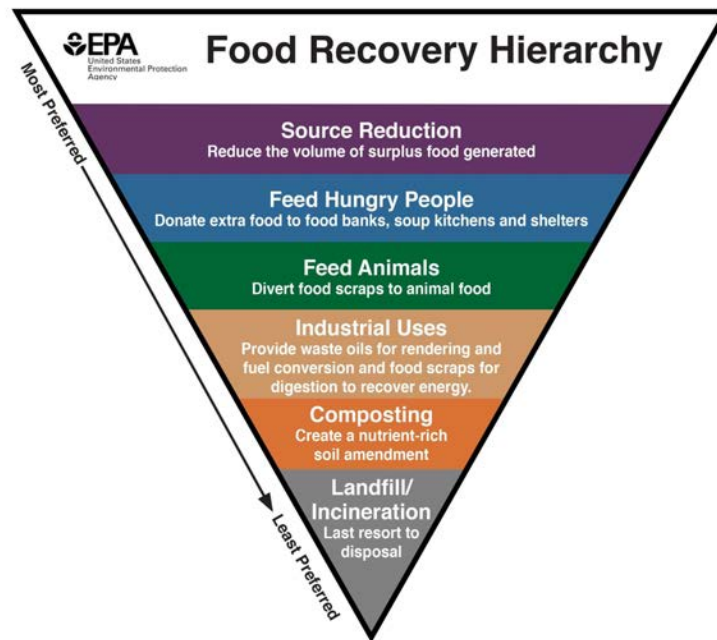


Fig. 1. The EPA Food Recovery Hierarchy demonstrates a tiered approach to reducing and repurposing food waste at all stages of the food supply chain.

1.2 History and Science of Composting

The use of organic matter to fertilize crops is an ancient practice. Composting was a conventional practice until the introduction of artificial fertilizers in the early 20th century (Texas Organic Soil, 2015). Composting is a biological process that relies on microorganisms such as bacteria and fungi to decompose organic matter in aerobic conditions (Trautman and Olynciw, 1996). The decomposition rate is determined by moisture content and temperature (Epstein, 1997). The microorganisms break down organic matter, producing chemical energy from carbon and nitrogen and releasing carbon dioxide, water, and heat. The nitrogen in the organic matter undergoes mineralization and nitrification, making it available for uptake by plants.

Composting organic waste is a beneficial alternative to disposing it via landfill. Landfills are typically anaerobic environments where decomposition leads to the production of carbon dioxide and methane. In addition, composting produces an end product that can be used to fertilize crops. Compost can be used to enhance soil quality because it enhances moisture retention, nutrient retention, and buffers soil pH. It supplies beneficial microbes and encourages root growth (Ron Alexander, 2005).

1.3 Municipal Composting Strategies in the Midwest

Midwestern cities have developed a variety of approaches to divert food waste from their landfills. These programs can be sorted in three categories: 1) opt-out curbside pickup, 2) opt-in curbside pickup, and 3) self drop-off. Beginning in July 2020, Athens Ohio, home of Ohio University, automatically enrolls its residents in organics recycling and provides them with compost bins. Compost bins are collected on the same day as trash and recycling. Cost for participation in the program is just over six dollars a month (City of Athens). Residents are able to opt out for any reason, and can do so by emailing the city. They also have the option to drop off their own compost for free at the Athens Hocking Recycling Center. In spring 2020, members of Athens city council debated the merits of an opt-out versus an opt-in approach. Supporters of the opt-out model argued that it would allow for greater participation in the program. They also pointed out that an opt-in model would largely attract those already aware of the environmental merits of composting (Burnette, 2020). Councilmembers in opposition argued that it was unfair to automatically enroll people in a program that they had to pay for, especially after many have suffered financially from the Covid-19 pandemic. Another challenge of automatically registering all residents is providing educational materials about composting and opting out of the program (Leckrone, 2020).

The city of Ann Arbor Michigan collects residential compost on an opt-in basis between April and December. Residents can pick up a large curbside bin or have it delivered for a \$59 fee (City of Ann Arbor, Stanton 2020). Vegetative waste was permitted in municipal composting in 2009, with all food waste permitted in 2014. Although much larger, Ann Arbor is comparable to Oberlin in that it is a university town with a high percentage of rental units and short-term residents. In a 2017 report, the main challenges to expanding residential composting were low landfill tipping fees, a lack of financing mechanisms, and a low rate of participation especially for food waste composting (Carlson et al., Manitius, and Morton, 2017). The panel of researchers recommended an education campaign to reduce contamination and increase participation, and the implementation of a “pay as you throw” financing model for compost bins. This type of model would charge participants according to the volume of compost they produced. The City of Ann Arbor Solid Waste Department now provides funding for 250 student workshops and 32 adult programs focused on recycling, composting, and climate change (EcoCenter, 2020). In a 2019 report, the city found that there was still a lack of awareness of what could be composted. However, they also found that the initial compost cart program raised awareness of composting, and that residents are willing to pay a small annual fee for the service (Aptim Environmental, 2019). The city of Ann Arbor saw an increase in participation in composting in the year 2020, with more people asking for compost carts. As a result, the city’s compost drivers had to work longer hours. Many participants also asked for year-round compost collection (Petoskey, 2021).

1.4 Case Study: City of Oberlin

The City of Oberlin has a population of approximately 8300 people, 3000 of whom are students at Oberlin College and Conservatory (City of Oberlin). Oberlin is known for its long history of commitment to social justice and progressive ideologies. The city's commitment to achieving carbon neutrality by 2050 exemplifies these principles. The City of Oberlin became a member of the International Council on Local Environmental Initiatives (ICLEI) in 2007, and uses the five-step model of ICLEI's focal program, Cities for Climate Protection (CCP), which are:

- 1) Conduct a baseline greenhouse gas emissions inventory
- 2) Adopt an emissions reduction target
- 3) Develop a local climate action plan
- 4) Implement policies and measures
- 5) Monitor and verify results

In 2009, the first baseline emissions inventory was conducted for the City of Oberlin. Next, the City Council's Climate Action Committee set a series of targets for reducing greenhouse gas emissions over time. In 2011, the first Oberlin Climate Action Plan outlined policies and measures that the local government could take to achieve its emissions goals (City of Oberlin Climate Action Plan). In 2013, then again in 2019, the City completed revisions of the Climate Action Plan based on new data and stakeholder input.

1.5 Treatment of Food Waste in Oberlin

The Oberlin community already has several food waste diversion measures in place, but there is ample opportunity for expansion. In its approach to waste management, the Climate Action Plan developed a Zero Waste Plan (ZWP) that provides a framework for reducing greenhouse gases produced from waste management activities. The ZWP establishes a goal of 90% waste reduction (or diversion) by 2050, outlining strategies such as source reduction, creating reuse opportunities, and increasing food waste recovery. The "Local Food and Agriculture" section of the 2019 Climate Action Plan includes a long list of questions intended to promote public engagement in reducing food waste. Oberlin has control over its waste collection system, which is unusual for a city of its size, presenting an opportunity for local intervention in how food waste is disposed of (City of Oberlin, 2013).

Oberlin College and Kendall Independent Living collectively rescue between 200 and 300 pounds a week of leftover prepared foods and donate them to the Oberlin Community Services food pantry and weekday community meals program (Oberlin Community Services, 2020). In past years, Oberlin College Dining Services has diverted some of the organic waste from campus dining halls to local farms, for both compost and animal feed (Pecherkiewicz, 2020). Oberlin College has also used composting and an organic matter pulper to dispose of organic waste in its dining halls. In January 2020, Oberlin college researchers conducted a

survey about food waste and consumer behavior. They identified trends in which types of food are most commonly thrown away, waste reduction strategies being used, and barriers to reducing food waste (Rosenblum et al., 2020).

Currently, there are no registered facilities in Lorain County that can accept food waste for composting (Lorain County Solid Waste District, 2016). As a result, composting programs in Lorain County towns such as Elyria, Amherst, and Grafton only collect yard waste. Barnes Nursery has been composting food and yard waste together to optimize the carbon-to-nitrogen ratio waste at their Huron (Erie County) facility since 1993 (Schanz, 2020).

1.6 Waste Pathways in Oberlin

Oberlin currently provides curbside trash and recycling collection. Trash is taken to the Republic Services Lorain County Landfill, which is approximately 3 miles from downtown Oberlin. Recycling is taken to Bfi Lorain County Recyclery, approximately 3 miles from downtown Oberlin. Individuals can drop recyclables off at the Lorain County Collection Center, approximately 11 miles from downtown Oberlin. The proposed composting program will transport organic waste to the Barnes Compost Facility located in Huron, approximately 33 miles from downtown Oberlin.

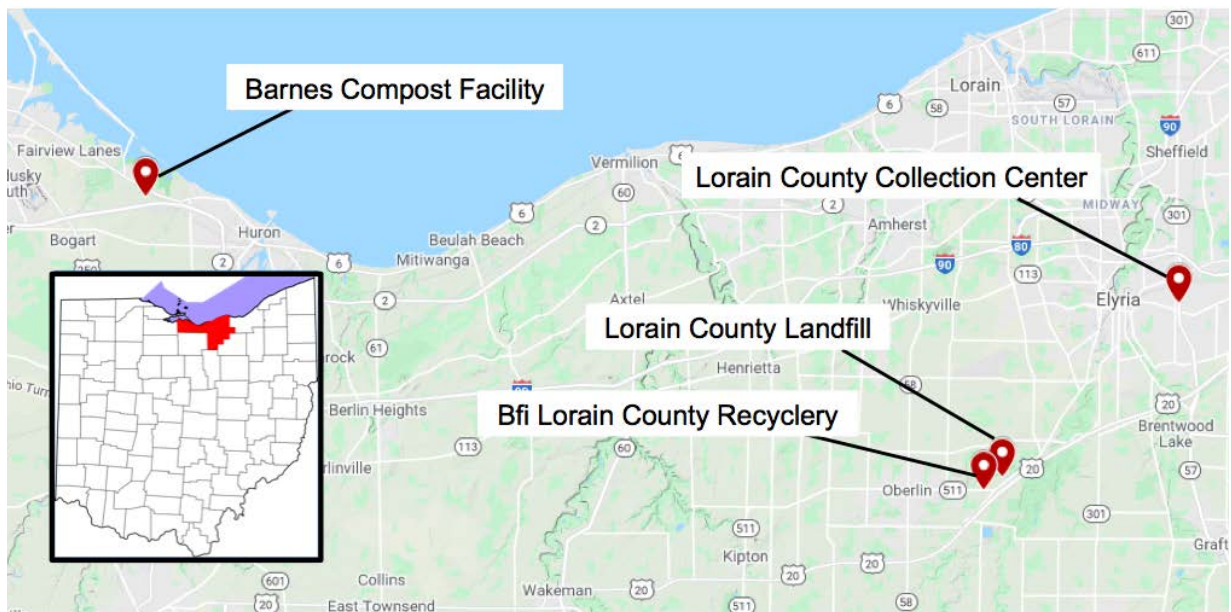


Fig. 2. Location of landfill, recycling centers, and industrial compost facility for Lorain County.

1.7 Oberlin Sustainable Reserve Fund

The Sustainable Reserve program is administered by the city of Oberlin in order to, “provide funding for municipal electric services, programs and/or projects demonstrating energy efficiency, energy conservation, green-house gas emission reductions and/or development of renewable generation resources” (City of Oberlin). In order to qualify for funding, projects must balance the environmental, social, and economic interests of the community. The program is funded with proceeds from the sale of renewable energy credits from long-term power supply contracts. Any group or individual can apply for any amount of funding. If project proposals meet the guidelines, they are presented to City Council for approval. Barnes Nursery is currently applying for an SRF grant to fund a pilot food waste composting project in Oberlin.

1.8 Community-Based Social Marketing Approach

Community-based social marketing is a pragmatic approach to causing behavioral change on a community scale. It serves as an alternative to information-intensive campaigns, which are used in many sustainability outreach efforts. This approach involves identifying barriers to a sustainable behavior, designing a strategy that utilizes behavior change tools, piloting the strategy with a small segment of a community, and evaluating the impact of the program (McKenzie-Mohr, 2011).

The Oberlin Composting Pilot Program falls under this model. This study used the guidelines provided by environmental psychologist Dr. McKenzie-Mohr to identify barriers that will affect the implementation of a pilot program. He recommends use of literature reviews, focus groups, and surveys to identify individual and community barriers to behavioral change. Dr. McKenzie-Mohr also emphasizes the importance of direct personal contact in order to encourage individuals to try a new, more sustainable, activity.

2. Methods

2.1 Food Audits

Under the guidance of Bob Schanz, manager of Barnes Landscape Materials and Organics Recycling, I contacted the owners of Oberlin businesses that produce food waste for permission to conduct a waste audit. The sites we selected were a grocery store, Oberlin IGA, and popular downtown restaurants The Fave and Thini Thai. We chose these sites because they represent two different models of food waste generation, and may face different challenges in participating in food waste composting.

IGA Audit Protocol

Volunteers and I sorted and weighed food waste as IGA employees brought trash cans to the dumpster. Each bag of trash was emptied onto a tarp and sorted into the following categories: packaged food, unpackaged food, liquids, metal, and trash. For the purposes of this study, trash is defined as any non-food, non-solid metal material. Items such as plastic utensils, food-contaminated aluminum foil, and paper products were all classified as trash. Solid metals were distinguished from trash due to their ability to be recycled. “Packaged” refers to food still in its packaging, while “unpackaged” refers to food without any wrapping.

After sorting, the waste was weighed in 5-gallon buckets, and the weight was recorded in a spreadsheet. All volumes were recorded in imperial pounds. This process was repeated from opening until the store closed, capturing a 24-hour cycle of data. A few miscellaneous items had been left in the parking lot for disposal, such as a shopping cart of expired dry goods and a pallet of discolored Gatorade. These items were weighed and cataloged as well.



Fig. 3. Tarp and buckets used for sorting, scale for weighing, and laptop for data entry at the back entrance of Oberlin IGA.

Feve/Thini Thai Protocol

The kitchens at the Feve and Thini Thai were asked to place food waste from their prep areas into a receptacle to be sorted and weighed the morning after, following the protocol described above (Fig. 3). Waste from in-person dining was not counted because in-person dining was still severely restricted at the time of collection. Due to miscommunications, on the first day of data collection, only food waste from Thini Thai was available. On the second and third days, only waste from the Feve was available. There appeared to be a disconnect between Adelman’s instructions to set aside organic waste and how the kitchen staff at each restaurant sorted it.

2.2 Stakeholder Interviews

A list of stakeholders was generated in order to gather firsthand accounts of potential challenges to composting food waste in Oberlin. Stakeholders included the owners of the food audit sites and waste management experts.

Those interviewed were:

- Leo Braido, owner of Oberlin IGA
- Matthew Adelman, co-owner of The Feve and Thini Thai
- Bob Schanz, manager of Barnes Landscape Materials and Organics Recycling

An IRB proposal for these interviews was filed and approved by the Oberlin IRB committee. Participants were then presented with an electronic consent form. Upon receiving their consent, I spoke with the participants via Zoom or phone call and typed a transcript of each call. Participants approved the use of their quotes for use in this paper.

2.3 Residential and OCS Data

Tim Kelley is an Oberlin resident who runs a neighborhood composting club. He provided data from between November 2020 to January 2021 via spreadsheet. The data recorded the number of households participating in composting, and total weight of food waste collected each week.

Sarah Prill is the head gardener at Oberlin Community Services, a non-profit organization that serves all of Lorain county. She provided weekly data on the volume packaged and unpackaged food waste produced at the OCS food pantry between January and March 2021.

2.4 EPA WARM Model

The EPA Waste Reduction Model (WARM) calculates the greenhouse gas emissions of different waste management scenarios. Change in greenhouse gas output is calculated by comparing the emissions associated with a baseline scenario (i.e., current practices) to the emissions associated with an alternative scenario. Each scenario is based on the amount of waste disposed of using source reduction, recycling, combustion, composting, anaerobic digestion, and landfilling. Greenhouse gas emissions from landfills are calculated using information about local landfill practices such as landfill gas capture rates and moisture conditions. Emissions from waste transport are calculated using local distances from landfills, recycling, compost, combustion, and anaerobic digestion facilities. The model differentiates between different types of waste such as food, yard waste, paper, plastic, and metal (US EPA, 2020). I made these models using the Excel-based WARM software from 2019.

Using the WARM tool in Excel, I constructed a baseline scenario for food waste in Oberlin using 2019 municipal solid waste data from the city of Oberlin, courtesy of Public Works Director Jeff Baumann. I then created two alternative waste management scenarios: one modeling a 5% increase in food waste composting to model an initial pilot program, and the second showing 25% of all food waste being composted after expansion of the program. In both scenarios, the rate of yard waste composting remained the same as the baseline.

3. Results

3.1 Food Waste Audits

At IGA, 35% of the food waste mass was unpackaged, while 28% was food in packaging. 23% of food waste weighed was liquid. Approximately 12% of the waste was trash and 1% was metal (Fig. 4a). At Thini Thai, 87% of the waste was unpackaged food (Fig. 4b). 10% of the waste was trash, with the remaining 3% composed of metal. 100% of the food waste collected from the Feve was unpackaged.

Table 1

Raw data from food audits, showing pounds (lbs) of waste collected by category. Blank cells indicate that no waste in that category was measured at a specific site. Each food audit documented a 24-hour cycle of food waste disposal.

Site, Date	Total Packaged Food (lbs)	Total Unpackaged Food	Liquids	Metal	Trash	Total Food
IGA 11/6/20	87.5	107.7	72.4	3.3	38.3	267.6
Thini Thai 11/19/20	-	20.9	-	0.7	2.4	23.3
Feve 11/21/20	-	12	-	-	-	12

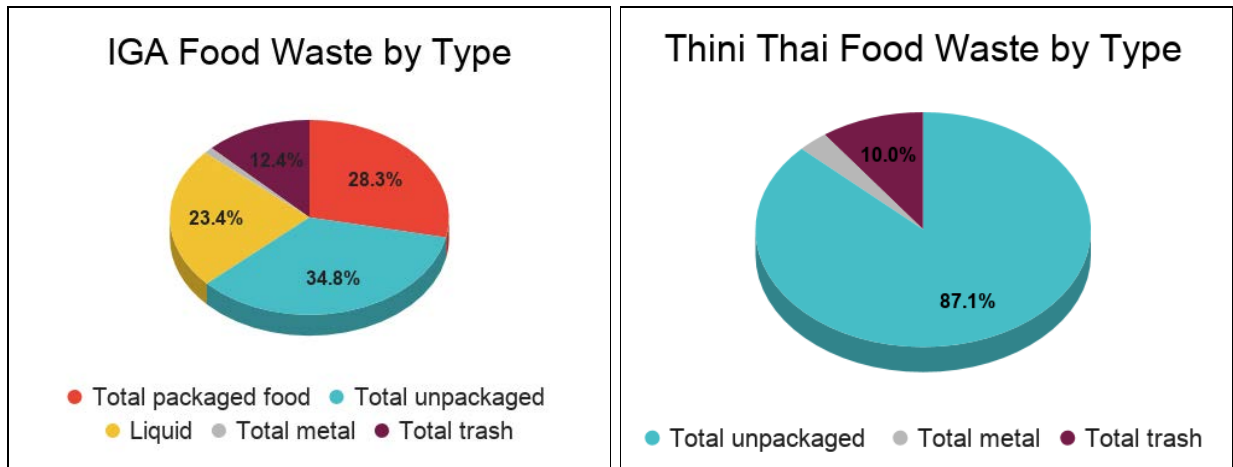


Fig. 4a. (left): Breakdown of food waste sorted at IGA by type

Fig. 4b. (right): Breakdown of food waste sorted at Thini Thai by type

3.2 Interviews with Business Owners

Braido and Adelman had some similarities in their attitudes about instituting food waste composting in their respective businesses. Both business owners indicated that they would be more likely to compost if it were free and if their garbage collection fee was lowered. In regards to if positive publicity would serve as an incentive, Adelman and Braido answered an affirmative “yes” (Table 2). Both Braido and Adelman cited the time and labor of sorting compostable material from their waste stream as the main obstacle to implementing food waste composting. Adelman also expressed that “implementing the proper tools is what I would imagine would be the hardest part,” such as placing compost receptacles in strategic locations throughout the kitchen (Adelman, 2021). “If we had a container in the back of [the] produce [section], it might not be too awfully difficult to do,” said Braido. Adelman added, “once we establish a system [for composting], then we would have very strong participation” (Adelman, 2021). Adelman also cited the challenge of using a shared dumpster, and if compost or recycling is contaminated, “we tend to receive blame if it’s not done properly” (Adelman, 2021).

Although they predicted similar challenges to composting, Adelman and Braido held different views of how composting would affect their businesses. Adelman said that eating at a restaurant with a visible receptacle for compost would be “one way to promote the idea.” According to him, the “halo effect” of being in an environment that was actively participating in composting might encourage others to start, as well as promote his restaurants as environmentally conscious businesses. “When people see the opportunity to compost they would feel good about that chance to do the right thing”, Adelman said. This halo effect of composting “might be 25% of the reason we would do it, the other 75% is being able to divert all this material that would be going to the landfill” (Adelman, 2021). His motivation to institute composting at the Feve and Thini Thai comes from both the positive publicity it would garner and from his personal values. He also thought that composting “changes the way many people

will feel about...how they participate in recycling,” especially as world economics hinder the viability of recycling (Adelman). Braido stated, although composting may not directly benefit his business, he is willing to compost “as long as it’s not negative on my business and it’s positive toward the community and the environment” (Braido, 2020).

Table 2

Initial questions asked to business owners during interviews.

Would you be more likely to compost if...	Leo Braido, Owner of Oberlin IGA	Matthew Adelman, Owner of Thini Thai and the Feve
If it were free	Yes	Yes
If your garbage collection fee decreased	Yes	Yes
If you received publicity as a “green business”?	Yes	Yes

3.3 Interview with Bob Schanz, manager of Barnes Landscape Materials and Organics Recycling

In response to the challenge of implementing proper composting practices in different businesses, Schanz recommended empowering “people within the organization who want to see it happen,” rather than people from the city or waste management professionals (Schanz, 2021). The role of Barnes, aside from collecting and processing food scraps for customers, is “trying to educate them, and disincentivize them from doing it with a charge” (Schanz, 2021).

Schanz cites, “the economic challenge that food waste composting can often cost a business more than throwing it in the trash” as the main obstacle for widespread participation in composting. According to Schanz, composting may be challenging in a business setting due to turnover in staff and management. He recommended combining a yard waste and food waste composting service, which “would give more volume, and more opportunit[ies] to recycle.”

3.4 Residential Data

Participation ranged from 6 to 15 households each week. The mean weight of food scraps collected weekly was 48.25 lbs, which came to 7.43 lbs per household per week on average.

Table 3

8 weeks of residential compost data spanning from November 2020 to January 2021.

Week	Total Weight (lbs)	# of households	# of households collected from	lbs/household/wk
11/20	34	6	4	8.5
11/27	49	6	6	8.2
12/4	38	6	4	9.5
12/11	41	6	4	10.3
12/18	48	12	8	6
12/26	56	12	10	5.6
1/1	58	14	10	5.8
1/8	62	15	11	5.6

3.5 OCS Data

The mean weight of food waste disposed of was 267 lbs per week (Table 4). 65% of the waste documented over 9 weeks consisted of unpackaged food, while 35% was packaged. Liquids comprised a small amount of waste recorded (Fig. 5). There was considerable fluctuation in the quantity of packaged and unpackaged foods being thrown away.

Table 4

9 weeks of Oberlin Community Services food waste ranging from January to March 2021.

Week	Total Packaged (lbs)	Total Unpackaged	Liquids	Weekly Total
1/8/21	36	213.5	0	249.5
1/15/21	56.5	283.5	0	340
1/22/21	153.5	158.5	1	313
1/29/21	33	110.5	0	143.5
2/5/21	115.5	145.5	0	261
2/12/21	160.5	84	0	244.5
2/19/21	28.5	128.5	0	157
2/26/21	141.5	253.5	0	395
3/5/21	111	183	2.5	296.5

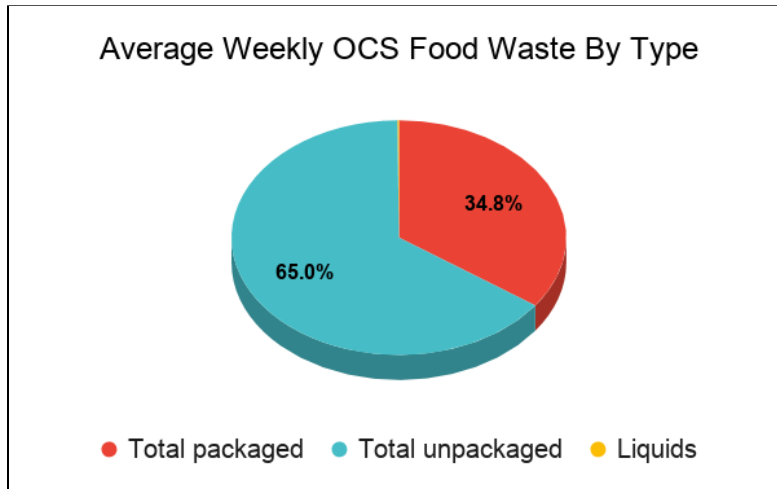


Fig. 5. Breakdown of averaged weekly packaged, unpackaged, and liquid food waste disposed of at Oberlin Community Services (OCS).

3.6 EPA WARM Models

Based on food waste disposal data from Oberlin in 2019, a 5% increase in food waste composting would result in approximately 7 additional tons of food waste diverted from landfills to compost annually. Increasing composting of food waste by 5% would result in an emissions reduction of 2.5 MT of CO₂ equivalent per year (Fig 6). Reducing greenhouse gas emissions by 2.5 MT is the equivalent of conserving 281 gallons of gasoline (Fig. 7).

Waste Reduction Model (WARM) -- Results	
Total GHG Emissions from Baseline MSW Generation and Management (MTCO ₂ E):	166.13
Total GHG Emissions from Alternative MSW Generation and Management (MTCO ₂ E):	163.63
Incremental GHG Emissions (MTCO ₂ E):	(2.50)
MTCO ₂ E = metric tons of carbon dioxide equivalent	

Fig. 6. Difference in emissions between current baseline rate of food waste composting and a 5% increase in total food waste composting.

Total Change in GHG Emissions (MTCO₂E):	(2.50)
This is equivalent to...	
Removing annual emissions from	1 Passenger Vehicles
Conserving	281 Gallons of Gasoline
Conserving	104 Cylinders of Propane Used for Home Barbeques

Fig. 7. Equivalent measures of the decrease in greenhouse gas emissions from a 5% increase in food waste composting.

Based on food waste disposal data from Oberlin in 2019, a 25% diversion rate would entail 151 additional tons of food waste entering the composting stream annually. In the scenario where 25% of food waste is diverted to compost, 54.12 fewer MT of CO₂ equivalent would be released into the atmosphere, compared to the current baseline. Reducing greenhouse gas emissions by 54 MT via composting has the same effect as removing 11 passenger vehicles or conserving over 6000 gallons of gasoline (see Fig. 8).

Waste Reduction Model (WARM) -- Results	
Total GHG Emissions from Baseline MSW Generation and Management (MTCO ₂ E):	166.13
Total GHG Emissions from Alternative MSW Generation and Management (MTCO ₂ E):	112.00
Incremental GHG Emissions (MTCO ₂ E):	(54.13)
MTCO ₂ E = metric tons of carbon dioxide equivalent	

Fig. 8. Difference in emissions between current baseline rate of food waste composting and a 25% rate of food waste composting, as calculated by the EPA WARM model.

Total Change in GHG Emissions (MTCO₂E):		(54.13)
This is equivalent to...		
Removing annual emissions from	11	Passenger Vehicles
Conserving	6,091	Gallons of Gasoline
Conserving	2,255	Cylinders of Propane Used for Home Barbeques

Fig. 9. Equivalent measures of the decrease in greenhouse gas emissions from a 25% composting rate for food waste, as calculated by the EPA WARM model.

4. Discussion

4.1 Audits and Interviews

A striking finding from the IGA waste audit was the quantity of liquid food waste, nearly a quarter of the total weight (Fig. 4a). Since liquid waste cannot be disposed of via traditional, aerobic composting, alternative treatments are required. In his interview, composting expert Bob Schanz recommended that liquid organic waste be treated at an anaerobic digestion facility. However, he cited the cost of transportation to the facility as an obstacle for a small city like Oberlin (Schanz, 2021). The volume of packaged food waste at IGA presents another challenge for food waste composting at this site. Additional labor will be required to remove the packaging

and dispose of the trash and compostable material separately. Liquid and packaged food comprise over half of IGA's food waste, but do not meet the compost service restrictions of the pilot program. These findings pose important considerations to diverting organic waste from landfills.

Miscommunications about the categories of compostable waste impacted data collection at Thini Thai and The Feve. The waste audit protocol was slightly different from the protocol used at IGA because the owners of the restaurants offered to separate their organic waste from their trash ahead of time. As a result, the waste I sorted lacked the liquid and packaged food components, and contained less trash than the waste I sorted at IGA. The data on food waste at The Feve and Thini Thai gave us a better understanding of how much compostable waste is produced from the kitchens while the majority of business being takeout dining due to the pandemic. Further research will be necessary to gauge the volume of food waste produced when the restaurants return to in-person dining at full capacity.

4.2 Residential and OCS Data

These datasets were self-reported, which eliminated some of the issues of communication that I faced when at Thini Thai and The Feve. The residential data showed irregularities in participation from week to week, even as membership grew. Between four and eleven households disposed of food waste for composting each week. Although the quantity of food waste fluctuated at OCS, the waste stream is more consistent than the residential composting group. The compost pilot program should be flexible enough to accommodate a fluctuating rate of participation over time.

OCS had a much higher percentage of unpackaged food in their waste stream compared to IGA. However, OCS and IGA had similar percentages of packaged waste, 35% and 28% of the total mass of waste reported, respectively (Fig 5, Fig 4a). The liquid waste reported from OCS was close to zero, unlike a substantial 23% of the IGA waste stream. A key benefit of OCS joining the pilot program is that it is located south of downtown Oberlin, while the majority of other partner organizations are located directly in the downtown area, adjacent to Oberlin College.

The residential composting data reported an average of 6.8 lbs of food waste per household per week (Table 3). The Ohio EPA estimates that the average household in Ohio throws away 9.1 lbs of food per week, while the city of Oberlin estimates that it's about 11.7 lbs per week (Ohio EPA, Baumann). Part of the discrepancy between the residential composting data and the local average of food waste could be explained by the fact that not all food waste gets composted in Oberlin. As observed at IGA, food waste can include large amounts of liquids, as well as other items such as bones and grease that are not permitted in typical composting programs. In addition, food waste generated on days when Tim collected the bins may not have entered the compost waste stream.

4.3 WARM Models

Seven tons of additional food waste would need to be composted each year in order to achieve a 5% increase in food waste composting. We found that by multiplying the audit data by 365 and converting the total unpackaged food waste into tons, The Feve would produce 2.3 tons a year, while Thini Thai would produce 3.5 tons. IGA would produce 17.8 tons a year. The residential compost participants would produce approximately 1 ton of food waste annually. OCS would produce roughly 6.3 tons, which shows that a 7 ton target is achievable. All of these calculations are based on the assumption that each waste audit represented a typical day of food waste at each site. These results show that IGA is a vital partner in the pilot program due to the scale of food waste it produces. A 5% increase in food waste composting would reduce annual greenhouse gas emissions by 2.5 tons (Fig. 6), equivalent to removing one passenger vehicle from the road.

For 25% of all food waste to be composted, 151 additional tons of food waste would have to be diverted from landfills into composting. Reaching this target would reduce greenhouse gas emissions by 54 tons annually, equivalent to removing 11 vehicles from the road. The sum of the annual tonnage from the participants is 31 tons of food waste, approximately one-fifth to the desired goal of 25% total diversion. This target provides a roadmap for the pilot program to expand. According to estimates from the City of Oberlin, 12-15% of food waste is currently diverted to composting (Baumann, 2021). Data from the waste audits suggests that it is possible to incrementally increase food waste diversion in order to eventually meet this goal, which would depend on the number and scale of participants. A diversion rate of 25% could be achieved by the participation of eight grocery stores comparable in size to IGA. This goal target could also be met by the participation of four grocery stores and twenty two restaurants.

In conversations with Bob Schanz, we discussed the possibility of combining yard waste and food waste collection in Oberlin. Although Oberlin currently provides yard waste pickup for composting, the Barnes facility could process food and yard waste together. When I put yard waste data in the WARM model, the results were surprising. Composting yard waste opposed to landfilling it increased the greenhouse gas emissions. The results were comparable when calculating the carbon footprint of transporting yard waste to Huron and composting it in Oberlin. This finding rejects the hypothesis that the distance the waste traveled was the cause of the unexpected results. However, these models should not be interpreted as evidence that composting yard waste produces more greenhouse gases than putting it in a landfill. The WARM model does not allow one to specify whether the yard waste is disposed of in plastic bags or loose, which would impact how much carbon dioxide and methane would be produced in an anaerobic, landfill environment. It also does not account for the other benefits of composting organic waste as described in section 1.2

5. Conclusion and Future Recommendations

One of the greatest challenges that the city will face in implementing the pilot program is educating all of the participants. As seen at Thini Thai and The Feve, inconsistencies due to miscommunication can happen easily. Following Schanz's recommendation, we advise each participating business to designate one employee to educate their team and establish a food waste composting protocol for their workplace. To ensure consistency in the protocol used, Barnes and the city should provide educational materials and support to all participants.

The enthusiasm of the partner organizations who participated in this study indicates that there is momentum to build off of. However, it is important to consider that the initial participants were already open to the idea of composting at the beginning of the project. Educational materials should communicate the environmental and economic benefits of composting in order to gain more widespread participation. The food audit data revealed the importance of involving larger-scale organizations in the composting pilot. Pursuing future partnerships with businesses such as Walmart, Drug Mart or The Hotel at Oberlin will support the city in achieving its goal of composting 25% of food waste.

The composting program should be accessible to as many people as possible. Compost pickup should be conducted in a variety of locations, and educational materials should be easy to understand and offered in multiple languages. Workers should be offered compensation for the additional labor that they perform in order to institute this new program. In addition to considering the barriers to composting observed in this study, community participation will be vital to designing a successful program. Through an environmental justice lens, it is important to consider who will reap the benefits of this program. In addition to curbing the production of greenhouse gases, compost can nourish local gardens and help feed the city of Oberlin. After implementing the pilot, the city should consider offering the finished compost product to Oberlin residents at a free or discounted price. Rather than having the compost taken to Huron and sold at an inflated price, this economic incentive would close the loop of material cycling and provide a sense of ownership over the composting program. Eventually, the city should consider taking steps to establishing its own composting facility. Such changes would be dependent on the identification of funding mechanisms.

Composting food waste is one important emission reduction strategy for Oberlin, but does not serve as a replacement for other emission reduction efforts. In terms of food waste, further projects should focus on the earlier phases of the Food Recovery Hierarchy such as source reduction and feeding people. As Adelman mentioned in his interview, the economic challenges of recycling are going to push communities to find new ways of diverting waste from landfills. Composting presents an opportunity to utilize existing waste management practices to keep organic waste out of landfills. Based on our analysis of the food waste stream in Oberlin, it will not be enough to plan for the composting of only unpackaged food waste. We must consider how to sustainably dispose of liquids and packaged foods as well.

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