Community-Scale Composter operating manual

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Jennifer Perry and John Culpepper, North Country School

Community-Scale Composter

operating manual and reference document

Drafted by: John Culpepper ~ Co-founder, Compost for Good. Document updated March 2021

> "This operating manual is about using our design to compost food waste on a community scale. This design can be adapted to meet the needs of communities all across the globe. We believe that community composting is an important part of building a more resilient world. By keeping food waste local, we keep money and nutrients local, which allows us to directly support our land and our neighbors."

Acknowledgements:

In 2016, North Country School and Camp Treetops, in partnership with the Adirondack North Country Association (ANCA), received a $35,000 grant through the New York State Energy Research and Development Authority (NYSERDA) to design a low cost, in-vessel drum composter for medium to large communities. This pilot composter was so successful that $120K was awarded by NYSERDA to build and install 3 additional units.

North Country School and Camp Treetops opted to distribute the 3 systems to remote site hosts. Concurrently, a boarding school in New Jersey has constructed and is operating a system following the North Country School and Camp Treetops model. As the lead project designer, I, John Culpepper, realized the need for a document to support current and future organizations and individuals operating the in-vessel composter design. I have drafted this manual to offer such support.

All of the ideas that led to the development of this system are a result of time spent with people smarter than, or more experienced than me. I was simply the conduit through which this idea of designing and building an in-vessel composter came to be. I acknowledge legions of others who have inspired, taught, or otherwise helped me in this. I also acknowledge and appreciate the extent to which various executive directors at North Country School and Camp Treetops and the all-volunteer board of trustees have allowed me the opportunity to explore this and many other sustainability initiatives for our campus. I would like to express my appreciation to the following individuals and organizations whose support has allowed me to experiment with various versions of this project:

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About Compost for Good

Compost for Good grew out of John Culpepper's composting work at North Country School and Camp Treetops. It was the school's longstanding commitment to sustainability and John's passion for composting that inspired the design and build of an innovative community-scale composter.

The first of these composters was installed at North Country School and Camp Treetops, is operated by the students and campers, and processes all of the food waste of the organization. This operating manual is designed to accompany that composter.

With the success of this composter, there was a growing demand from communities around the world for more information about this design. To meet that demand, John founded Compost for Good with Jennifer Perry and Katie Culpepper. Though our reach is increasingly global, we are building from a local focus. We are grateful to have organized under AdkAction, as one of their projects. ADKAction is a nonprofit organization that creates projects that address unmet needs, promote vibrant communities, and preserve the character of the Adirondacks. Working with ADKAction strengthens our ability to help communities within the Adirondacks and beyond to implement composting systems that meet their unique needs.

Community-scale Composter Operation Manual

Introduction

My great hope is that by putting this design out into the world, free of charge, others will find ways to build it more easily, for less money, and to adapt it to reflect their unique organics recycling needs. This composter was originally designed to process unsorted food, but we have subsequently demonstrated that the composter is capable of processing a wide array of organic materials. I believe this design could have implications in communities around the planet, in both industrial and non-industrial areas. By reimagining our organic waste streams, we can build business opportunities, while closing our nutrient loops and decreasing environmental degradation across the globe.

This composter can play a vital role in ending the foolish endeavor of throwing away valuable plant and soil food, only to import nutrients from somewhere else. I hope that this composter is a resource for communities who want to keep their resources close to home, decrease pressures on landfills, decrease greenhouse gas emissions and build up their local economy.

Please visit our website at **adkaction.org/compost** for more information. Also, more resources are available at our Facebook page: **https://www.facebook.com/compostforgoodteam.**

-- John Culpepper

LIABILITY/DISCLAIMER: North Country School and Camp Treetops, its agents and employees are not liable for any claims, actions, damages, losses, expenses and costs of every nature and kind, including attorney's fees, up to and through any and all appeals incurred by or asserted or imposed against North Country School and Camp Treetops resulting from the operation of this composter. Manufacturers and site hosts assume all risks associated with construction, installation, and implementation of the drum compost system.

I. Introduction

This operating manual includes general composting instruction and guidelines interspersed with specific details from experience operating the composter at North Country School and Camp Treetops since May of 2016. Contact the author if on-site training or other consultation is desired. A design document, educational blog posts, and more information about the Compost for Good project can be found on our website and a list of additional resources can be found in section X; the user is encouraged to reference them.

The design for the community-scale composter was born from a desire to find an affordable and efficient way to compost mixed food waste, in a way that produces high-quality soil amendments on a community scale.

A variety of very good in-vessel composters can be purchased on the open market. This composter is designed to be built affordably, using materials found worldwide, constructed by reasonably competent mechanics in a reasonably well-equipped shop, and if desired, placed inside a 40-foot shipping container. The 20-foot long, 4-foot diameter drum is constructed from a polyethylene highway culvert. The system optimizes the environmental conditions for the organisms that do the hard work of breaking down unsorted food wastes and other organics.

Our composter addresses many community-scale composting challenges, making the process more feasible for institutions and organizations. North Country School and Camp Treetops has demonstrated that this composter design can be managed by a single adult, with middle school-age children assisting, and can process up to 50,000 pounds of food waste, and 13,750 pounds of carbon bulking materials and other organic material per year[1].

At the time of this writing, there are five of our composter designs in operation. Four are in Upstate New York and one is in New Jersey. On the North Country School and Camp Treetops campus, the in-vessel composter has reduced the amount of time needed to process organic material from 12 to 3 months. Additionally, the finished compost is much higher quality with more fertility and stable carbon compounds than from previous composting processes. Food waste takes anywhere from 25-45 days to pass through the drum, at which point the material is stable, but still needs to go through secondary decomposition in a static pile. Many other organics can be processed in even less time.

Poor operation of the system can create conditions that could pose negative public relations and health issues, so it is highly recommended that this document be reviewed several times before the composting system is put into operation. By following the enclosed recommendations, the operator will safely create conditions that are favorable to beneficial microbes, create minor offensive odors, and operate in a way that does not attract flies, dogs, and vermin.

It is the many trillions of bacteria, and bacteria-like organisms that do most of the work of decomposition. Our job as operators is to maximize the environmental conditions within the drum for the organisms. In other words, the better you care for these little guys, the more effective they will be.

1) We believe that the steel frame and drive system of this composter could be modified to accommodate a 5-foot diameter drum, increasing the volume inside of the drum more than 1.5 times. A 6-foot diameter drum should also be possible, allowing more than 100,000 pounds of food scraps per year to be composted. We also believe that more than one composter could be operated in tandem, with opportunities for automation.

II. Composting basics

Composting is simply a way of breaking down carbon-based materials into simpler compounds. The composting process creates conditions where decomposition happens more quickly than in nature.

Currently, most large scale composting happens in windrow systems. While this can be an effective strategy, this process requires a fair amount of land and time, and can pose a host of other issues with run-off and pests. In-vessel systems optimize environmental conditions, thus significantly reducing both the time and space typically needed by windrow systems. Because the composting process is contained within a drum, pest pressure is vastly reduced.

Proper operation of this in-vessel system requires the drum to be ½ full at all times. At ½ full, a 4-foot diameter, 20-foot long drum contains approximately 3,200 pounds of material. Within the composting material, there are roughly the same number of microbes as there are the number of grains of sand on all of the beaches on planet earth. Each microbe generates a very small amount of heat as it metabolizes proteins, sugars, etc. Keeping the microbes 'happy' results in high thermal energy, and rapid decomposition.

Bacteria

Bacteria are the primary microorganisms during the primary phase of composting. There are two major types of bacteria: aerobic and anaerobic. Aerobic bacteria flourish in the presence of oxygen and anaerobic bacteria flourish in the absence of oxygen. Anaerobic bacteria live in human guts, and other places where oxygen is excluded.

Successful composting creates conditions for aerobic, oxygen-loving bacteria. If the conditions in the drum are not maintained properly then anaerobic bacteria begin to multiply, generating foul smelling and potentially flammable methane. These conditions should be avoided.

Aerobic bacteria fall into two basic categories at higher temperatures: mesophilic ('prefer' temperatures between 77°F to 104°F), and thermophilic ('prefer' temperatures over 113°F).

For aerobic bacteria to thrive, the carbon to nitrogen ratio and moisture levels need to be within certain ratios, and the material needs to be aerated frequently.

The ideal range for composting unsorted food waste within the drum is between 122°F and 140°F. At these temperatures flies will not lay eggs, weed seeds are destroyed, and pathogens are eliminated. Temperatures significantly lower than 122°F suggest that conditions inside the drum are not conducive for primary decomposition, and temperatures too far above 140°F will begin to reduce the overall species diversity of bacteria.

The end result

When proper primary decomposition is achieved (25-45 days), the material exiting the drum will be mostly stable, should not have an overly offensive smell, and should not attract flies, dogs, or rodents.

This material can be used as a topdressing on gardens and in landscaping, even before going through a secondary decomposition phase. At this stage, the compost should not be tilled into the soil, because of the presence of large organic material that will borrow nitrogen from the soil, thus taking it away from plants, as it continues to break down.

If you do not use the material as topdressing, it should be placed in a pile for secondary decomposition. This pile should be large (we recommend a pile that is at least 6 feet by 6 feet

122°F - 140°F

– The ideal range for composting within the drum

and 4 feet high), with the least amount of surface area possible, adding enough moisture to keep the pile damp but not soggy. These conditions will encourage the microbes to reheat the organic material. To a point, the larger the pile the better. Temperatures at this phase often reach 140°F. Watering and turning the secondary decomposition pile (or piles) will greatly aid the continuing decomposition process. Piles that are in the high temperature range will dry out fairly quickly. If the pile becomes too dry then the composting process stops, potentially producing odor and fly issues. When proper conditions are maintained, then over the course of several weeks, temperature will begin to drop. This is a sign that the bacteria and bacteria-like organisms are dying off or going dormant and higher-order organisms, including fungi, are beginning to proliferate. It is these higher organisms that break down the carbon containing molecules into much smaller molecules like humic and fulvic acids and when the real magic of composting happens. When added to soil, these small carbon compounds persist for years or decades, aiding water retention, cation exchange between the soil complex and plant roots, and helping to facilitate additional microbial life in the soil.

If compost will be bagged, it is important to allow the material to fully mature. If overly wet or immature compost is bagged, it will produce mold as well as foul-smelling compounds. Compost that is stable will have a deep, earthy smell very similar to forest soil, has a high retail value, and is capable of making soils much more productive.

III. Feedstock

With a few caveats, just about any common organic material can be composted with this in-vessel design.

Below is a list of items that we have had success with and those that we have not had success with. Operators may wish to try other items but it is suggested that this be done with care, testing small amounts at a time until it can be determined if the drum composter is a good fit for the experimental feedstock. In some cases, a compostable product or material does not fully decompose during primary decomposition, but may decompose during secondary decomposition or by running the material through the drum a second time.

Winners

The following items have proven to do well in this composter:

- All unsorted food waste coming from kitchen meal prep and from plates after a meal (greens, meats, eggshells, bones, etc): Bones and shells come out clean but not decomposed. There is valuable calcium and magnesium in these items. After primary decomposition, we suggest that you crush these items and apply to soils. If selling compost, sending the crushed bones and shells back through the composter is recommended.
- Some paper towels. Ripping paper towels (brown or white) before adding them to the composter will prevent the paper from rolling into balls inside of the drum.
- Coffee grounds and filters: Coffee grounds, filters, tea bags, and paper towels can be collected in a bucket next to coffee machines.
- Animal mortalities or animal offal: At North Country School and Camp Treetops, contents after chicken and turkey harvests are placed into the drum. This includes heads, feathers, feet, etc. For larger animal mortalities, Cornell University's method of decomposing in wood chips is recommended. For large animal parts after a harvest, larger parts are cut up before they go into the composter.
- Bags of spoiled or weevil infested grain and maggot infested food waste
- Large shredded craft paper bags
- Miscellaneous: Old cotton t-shirts, old leather shoes, belts, etc.
- Animal manures: We do not place cat manure in the composter, but have put large quantities horse, sheep, chicken, goat, and other manures in.
- Human urine mixed with wood pellets: We are in the process of exploring the viability of large-scale urine collection and composting in a separate facility. The environmental and cost benefits are compelling.
- Hair or fur
- Weeds from gardens: Given the bulky nature of weeds, they are typically composted in separate, open, static bay composting bins, however the composter could process them as well.
- Limited amounts of wood ash: If that ash comes from a high efficiency, wood gasification biomass plant, then much of the ash has properties similar to biochar.

Losers

These items do NOT do well, or are incompatible in the drum composter:

- Wax paper or wax cardboard
- Large amounts of shredded paper: Shredded paper tends to ball up during rotation, creating conditions that don't allow for decomposition.
- Fossil fuel based plastics: We are experimenting with compostable plastics, however early results indicate that they do not breakdown during our typical composter retention time. These products often need six months or more in a high temperature composting environment to fully break down.
- Paper plates: The retention time in the drum does not seem to be enough to process paper plates. A second run through the system might result in full decomposition.

IV. Recipe

Microbes that break down food waste and other organics require a carbon to nitrogen ratio around 30 parts carbon to 1-part nitrogen (30:1). Normal food waste, especially if it is fresh, is typically high in nitrogen and low in carbon. Providing a carbon bulking material provides more surface area for the bacteria, provides the necessary carbon for the microbes to metabolize the other organics, and soaks up the liquids created from the breakdown of cell walls thereby increasing the air spaces within the material. This space is vital to maintaining healthy populations of aerobic bacteria.

We have previously used wood chips (relatively dry and not so dry), wood shavings, and commercial grade wood pellets. Other carbon sources may be appropriate, but these are the only tested carbon types to date.

Each of these materials has pros and cons. Wood chips tend to be the least expensive, often times free for collecting; sometimes tree trimming services will deliver for free. However, wood chips need to be screened after primary decomposition, or left to decompose during an extended period of secondary decomposition. Also wood chips often have a higher water content. Combined with the liquids liberated during decomposition, using a high moisture content carbon bulking material can reduce air spaces in the mix, reducing the availability of oxygen for the oxygen-loving bacteria. These issues can be overcome by adjusting the mix, and by using sawdust to mop up liquids generated either at the end of the composter or through small penetrations along the length of the drum.

Wood shavings work well, but they tend to be expensive. Commercial wood pellets can be expensive, but if your facility is operating pellet stoves or boilers for space heating purposes then you may be buying pellets in bulk, which can lower the cost. At the North Country School and Camp Treetops facility they purchase pellets 20 tons at time, lowering the cost. (They have also found that pellets can be a good substitute for animal bedding in some situations.)

Because of the densified nature of wood pellets and because of their shape you can reduce the storage space needed for the carbon bulking material, and you can move those pellets mechanically with the use of flexible augers or vacuum systems, making it possible to employ automation in the composter loading process. Additionally, pellets quickly turn into sawdust in the composter, and they are fairly well decomposed when they come out of the drum.

Whether you use wood chips, wood shavings, or wood pellets you will need to experiment with the recipe to make sure that the mix is neither too wet or too dry. If too wet, often indicated by liquid coming out of the end of the composter, then add more carbon bulking material. If too dry then reduce the amount of carbon.

Making Compost

food scraps

carbon source

It is important to experiment with the ratio of carbon bulking material to food scraps to find the right balance for your materials.

Successful recipe

In the North Country School and Camp Treetops composter, each pound of food scraps from the kitchens and dining rooms is mixed with .275 pounds of wood pellets (this is a mass to mass ratio) before being added to the composter. So for example, if you are processing 50,000 pounds of food scraps per year, then you should plan on using approximately 13,750 pounds of densified wood pellets for the carbon source. At the time of this writing the average cost of pellets in Upstate NY is $240/ton. So if you were processing 50,000 pounds of food scraps annually, then you should plan on spending approximately $1,700 in pellets.

When using undried wood chips we've used two volumes of wood chips to one volume of food scraps. (Due to the complications of weighing large amounts of undensified wood chips, a volume to volume ratio was found to be easier.) The food scraps in these examples contain a mix of vegetable, dairy, and meat products.

Due to different types of feedstocks (food scraps and other organics) and the type of carbon bulking material that is used, each facility will need to experiment with their carbon bulking material to food scraps ratio to find what works best for them. The best indicator that everything is going well is internal temperatures of over 125 degrees F.

Composting is as much art as it is science. With experience you will find the right type and amount of carbon bulking material for your feedstock.

V. Daily operation

Each facility will develop their own processes that meet their particular needs. The information below is an overview of how North Country School and Camp Treetops set up their composting system.

Start up

Because the microbes that break down food waste are already in the environment, it is not necessary to add purchased bacteria. However, it is never a bad idea to add a couple shovel loads of active compost when you begin to load your drum composter for the first time. If available, using compost from more than one source ensures that you have a wide variety of microbe species.

Collection and delivery to the composter

Once a day, unsorted food waste is collected in 8-gallon pails with lids and transported to the composter in a garden cart. They use more than two carts during the seven weeks of Camp Treetops when they are feeding approximately 300 people. The food waste is taken to an area next to the composter where it is weighed and recorded. The food waste is then dumped onto a concrete floor enclosed by a wooden bin.

Preparing the food waste/carbon mix

With shovels or lawn edging tools, the food waste is lightly chopped, focusing on larger scraps with intact skin, like apples and oranges. The weight of the food waste determines the amount of carbon bulking agent to add (see recipe section above). With flat shovels, the food waste is lightly mixed with the carbon bulking material (wood pellets), then placed in different 8-gallon containers. That blend is carried to the loading door of the drum and dumped inside.

After placing all of the food waste and carbon bulking material inside the drum, we add dry sawdust to the floor of the mixing area to soak up liquids and grease. Sawdust is also added to any area under the drum where liquids accumulate. Once the sawdust has done its job, it is added to the drum to compost.

Loading the composter

Before loading the blended mix into the drum it is important to measure and record the temperature inside. Each time the door is opened to be loaded, a thermometer is placed just inside the loading door to determine how well the composting process is going. We have also added two Onsite/HOBO temperature data loggers that travel with the composting material, recording temperature every five minutes.[3] Once the data loggers exit the drum, the data is downloaded and translated into graph form.

Safety Tip: Pinch points

Care must always be taken when rotating the drum. The interface between the drive wheels and the drum, the chains and sprockets and close walls or ceilings represent pinch points. Those pinch points must be isolated or monitored to avoid injury. It is highly recommended that a momentary switch thereby stopping the drum rotation be housed within a locked cover for additional injury protection. Locating the switch to the side of the drum, provides a line of site of the entire system allowing the operator to release the switch if he or she determines that someone is getting too close to the pinch points.

It is helpful to have a hoe or other tool to push the material away from the door as more blended mix is added. We use a tool called a Mcleod that serves this purpose well.

Once the food waste/carbon bulking agent is loaded into the drum, the loading door is closed. After the supervising adult ensures that no one is close to the composter pinch points, he/she will unlock the momentary switch door, and rotate the drum the appropriate number of times to ensure that it remains ½ full (each rotation lasts ~60 seconds). We rotate the drum 1-5 full rotations depending on the amount of material in the drum and how much material was placed inside the drum that day. If it is allowed to get more than ½ full, the number of

3) Each time the drum is rotated, the temperature drops significantly, and it takes some time for it to stabilize and start climbing again. For maximum organic breakdown in the shortest time possible, the goal is to maintain an operating temperature of 120-140 °F as consistently as possible. We are looking for ways to reduce these dramatic temperature swings. Rotating the drum every other day helps, but rotating the drum every 3-4 days does not. This is likely due to decreased oxygenation due to decreased tumbling. Research is ongoing and encouraged by other hosts.

rotations needed will increase substantially in order to move the material to the discharge end.[4] Determining how many rotations to give the drum each time material is placed inside the drum becomes easier with experience.[5]

At the end of each number of rotations, the mixed material inside of the drum comes to rest at an angle. This angle is known as the angle of repose. The drum should always be stopped when the angle of repose matches the bottom of the door, leaving the door at an angle when at rest. Stopping the drum at this point will allow new material to be loaded into the drum on the next day without the existing material inside of the drum spilling out of the drum. You might consider painting a mark on the drum in such a way that you can always stop the drum in the correct position.

Clean up

Carefully consider where the food scraps collection buckets will be washed. This can be a messy job. With a spatula, clean out the collection buckets well so that food particles don't go down a drain when cleaning the buckets. Cleaning up well after each loading session also reduces smells and flies. Applying dry sawdust on the floor of the mixing area will help soak up liquids and oils making the composting area much neater. Sweeping the floor and loading deck also helps.

Retention time

The amount of time that compost stays in the drum is determined by how much organic material is added each day. During times when a small amount of food waste is added fewer rotations are needed and the retention time is longer. When larger quantities of food waste are added, more drum rotations are needed and the retention time is shorter.

For us, the shortest retention time has been 20 days. The shorter the retention time, the less decomposed the material is going to be as it exits the drum. The opposite is true for longer retention times. The average duration that it takes for material to travel the length of the drum is 35 days. We monitor this by recording the date that a golf ball enters and exits the system.

In all cases, the goal is to have enough retention time, and a robust composting process, to stabilize the organic matter before being discharged.

Finished product

Since the drum is on an incline, during rotation the material that has undergone primary decomposition falls out the discharge end. Secondary decomposition will be necessary to break down round balls of undecomposed organics and to finish breaking down large carbon-containing molecules into stable organic acids. Secondary decomposition can be accomplished by placing the material in piles or windrows at a remote site, or at the exit point of the drum.

We allow exiting material to build up in a space that is approximately 12 feet x 8 feet, and to a height of about 3 ½ feet. The accumulated material is run through an electric trommel, however sifting the material on a wood frame, covered by ¼ inch metal hardware cloth will also work. The fine material from the sifting process is piled again to undergo additional primary decomposition and then secondary decomposition. Coarse material from the screening process is put back into the composter. See "Composting Basics" for more information.

In a smaller space, like a 40-foot shipping container, the material should be taken to a storage area each day, or when needed, by wheelbarrow (double wheel wheelbarrows are more stable). The material can also fall into a large bin that can be moved by hand or with equipment once it is full. The ability to hold a week's worth of discharged material before it needs to be removed is ideal.

Quality control

Monitoring the smell of the material inside the drum and of the discharged pile helps determine how effectively the composting process is working. Strong, foul smells including the smell of ammonia is a sign that species of aerobic bacteria are dying out and anaerobic bacteria are becoming prominent. This is an indicator that the recipe needs to be adjusted.

The most common reason that your compost begins to develop foul smells is because the microbes that do so much of the work inside of the drum are not getting enough oxygen. The reason is often because the recipe is too wet, creating little opportunity for oxygen to diffuse throughout the mixed material. If this is the case then the material coming out of the discharge end of the drum will be wet, and often you will see liquid dripping from the end of the drum and sometimes along the bottom of the drum. The solution is simply to adjust your recipe to incorporate more dry carbon. Do this a little at a time and monitor the results, which often take days or weeks to make a difference. I suggest increasing the carbon bulking material by only 5% at a time. Solving the problem of low oxygen will often result in a concurrent increase in the temperature of the mixed material inside of the drum. Remember that there are lots of variables to consider: the type of feedstock; the type of carbon bulking material and its moisture content; the environment in which you are working; the frequency of rotation; how full the drum is (always try and keep the drum ½ full); etc.

Under certain conditions, flies can be attracted to the compost operation. It is therefore important to have fly control measures in place during the warmer months. (More on this in the miscellaneous section.)

4) During decomposition, large quantities of water vapor and carbon dioxide are released, causing both the mass and the volume of the material inside the drum to decrease. Therefore, there is not a one-to-one ratio of material going in and material going out.

5) It may possible to determine a ratio between the amount of material loaded into the drum and the number of times one would have to rotate the drum each day to keep the drum ½ full.

VI. Housing the composter

Our drum composter is designed to be housed inside a 40-foot shipping container (see details below), however the following guidelines apply regardless of what the composter is housed in.[6]

Electric

A 100amp electric panel will provide more than enough power for all of the needs of the composter. Install as many receptacles and circuits as you deem necessary, but must include:

- One 220V/20A circuit and receptacle for the motor to be plugged into, unless you are using a different type of drive motor.
- One spring-loaded momentary switch (double pole) that will only operate when the switch is being held down. This switch should be installed in such a way that the operator can look at the entire length of the drum when holding down the switch. This allows the operator to make sure that no one is near the rotating pinch points when the drum is rotating.

If you have 3-phase electric service, then we suggest that you run your drum motor with a 3-phase motor to reduce upfront and operating costs. Check with your local electrician for details.

Additional considerations

- Non-motor circuits should be at least 15amp
- Miscellaneous plug loads (future use)
- Space heater sized to provide supplemental heat during the coldest months of the year
- Ventilation fan
- Lights

Safety Tip: Methane Gas

Under certain conditions (low oxygen due to too much water, etc.), anaerobic bacteria can produce methane gas which is combustible. An exhaust fan running on slow speed all of the time, and on higher speeds during the summer to exhaust moisture and odors will ensure that harmful gases do not build up. We recommend installing a methane monitor to be attached to a light or sound alarm especially when installed in small vessels such as a shipping container.

Ventilation

If your composter is in a confined space, like a shipping container, then a hardwired ventilation fan with rheostat, off switch, and intake vent/louver are required. The fan and intake grate should be sized to cool the container in the hottest parts of the summer and to ventilate smells and gases generated during the composting process. If not properly maintained, the composting process can build up ammonia or methane, which needs to be

6) The original composter at North Country School and Camp Treetops is located in a space that is approximately 36 feet wide, by 20 feet long, with two concrete pony walls that create three separate bays, each 12 feet x 20 feet. The ceilings are insulated and the walls are lightly insulated. Even though the winter will usually produce one or two -30°F days, the building is able to maintain comfortable operating temperatures within the drum with only a portable electric heater for backup heat.

vented. The intake vent/louver should be close to the discharge end of the composter.

For shipping containers, so that the roof is not compromised, both exhaust fan and intake louver should be sited on the sidewall of the container. The exhaust fan should be sited at the loading door end of the composter drum. The intake louver should be located at the other end of the container.

Site preparation for shipping container

Site should be level, hard packed (gravel or pavement) and capable of handling a large truck maneuvering around to off-load the container.

Platform

The opening of the drum could be as high as 36" (actual height is based upon the desired outflow height). Therefore, it is recommended that a platform be built to access the composter loading door. The surface area of the platform should safely and easily accommodate 1-2 people with 8-gallon buckets. The platform at North Country School and Camp Treetops is 6'x9', located 31 inches off the ground with 3 steps leading up to it.

Heat and light

Consider a 5kW heater to keep the temperature inside of the shipping container or other structure high enough to make the microbes inside of the drum happy. If the recipe and other conditions are correct the microbes generate a tremendous amount of thermal energy and don't need much supplemental heat. I have seen this composter work very well in temperatures of 10 degrees F or lower within a moderately insulated building.

Flat profile lights with plastic diffusers work well. In the space of a shipping container, unprotected standard bulbs will likely break.

Other considerations

- 40-foot shipping containers can be purchased with two side-swinging doors on one end or both ends. The containers with only one set of side-swinging doors are less expensive. There are many places that can install a 6' roll up door on the solid end. Both ends of the container should be locked when not in use.
- Having access to running water for washing compost buckets and other cleanup is very helpful. Since primary decomposition generates heat, that heat will dry out your pile. Having water at your site for primary and secondary decomposition is very helpful to keep the composting process going.
- Include a space on the loading end of the composter for a mixing area. This is where compost can be chopped and mixed with carbon. For the North Country School and Camp Treetops composter, the mixing area is 3 1/2 feet by 4 feet and is built out of rough sawn lumber.
- Insulation is not required, but would contribute to a more pleasant environment with fewer climate control needs.

Additional safety tips:

- Consider posting warning signs at the pinch points of the system
- Consider how you plan to restrict access to the container doors when it is unattended
- Develop a plan to restrict the ability of anyone to be near the wheels and gears when the system is in operation. A loaded composter is heavy and unforgiving. Fingers could easily be severed if caught between the roller and steel band when the composter is rotating. While restricting access to the pinch points is critical, it will also be important to be able to gain access to the wheels, chain, motor, and reduction drive for future repair and service.

Before installing the composter

For shipping container installations, there will be a total of 16 linear feet of available space once the composter has been sited within the container. The operator needs to consider how the drum will be situated. In the middle of the shipping container? With more space on one end than the other? Consider the throughputs of the system and how it will be fed and how the compost will be moved out of the container.

The composter can be raised off the ground to varying heights. Consider how the compost will be moved out of the container (forklift, wheelbarrow, tractor, etc.) to determine how high you would like the end chute to be off the floor of the container. Within an 9'6" high cube shipping container, the highest the discharge end can be raised is approximately 4'6". The higher the drum is raised, the higher the platform should be on the loading door end.

VII. Maintenance

We have found that maintenance is infrequent and fairly simple and includes the following:

Daily

- Listen to changes in the sound of the composter as it is rotating. A squeaky sound may be an indication that one of the wheel bearings is failing.

Weekly

- Clean around the loading end door, including the hinges, to ensure that it closes properly.

Monthly

- Lubricate the chains, as needed.
- Check chain tension. If too loose, adjust by loosening the bolt to add tension.
- Check the drive wheels to make sure that they have not slid one way or the other on the axle. Each of the rubber drive wheels are originally set such that they roll on the steel bands that go around the drum, and in between the bolts that go through the steel bands to the 3 x 3 inch angle iron on the inside of the drum. If any of the wheels slip then they will ride over the bolts, damaging the rubber wheel.

Yearly

- Apply grease to the zircon fittings on the bearings, as needed.
- Check the level of the oil in the gear reduction drive.
- Change the oil in the gear reduction box every 2-3 years.

VIII. Miscellaneous

Fly control

Food waste that is composting effectively will generate enough heat to prevent flies from trying to lay eggs in the material inside of the drum. However, because the inside of the loading door tends to be somewhat cooler than the decomposing material, maggots can sometimes be found on the inside of the drum loading door. Those maggots can be scraped off with a plastic dust pan, placed inside the drum and covered with hot, decomposing food waste.

Occasionally maggots have been seen in the material that is discharged from the drum. Typically, this means that the material is not piled high enough to encourage reheating or that it is spread out too much, or the material has not been kept moist enough.

It is important to keep all spaces where food waste is temporarily stored or processed clean and dry. Spreading dry sawdust on the floor where food waste is chopped and mixed with the carbon bulking agent will soak up excess liquids, and if brushed around with a broom, the dry sawdust will pick up grease that comes from the waste.

Parasitoids purchased from a supplier can be placed around the compost facility. The tiny parasitic wasps hatch and look for fly larva to parasitize. You can purchase parasitoids through Spalding Labs. A schedule can be set up to receive parasitoid larvae every few weeks.

While there are many commercial flytraps to choose from, Victor Fly Magnet reusable traps have proven highly effective. During problematic summers these traps capture thousands of flies. Dead flies are added to the composter or fed to chickens.

Rodent control

While rodents don't necessarily eat the compost, a warm facility is likely to encourage mice or other vermin during cool/cold weather. Commercial traps work well however homemade mouse traps using 5-gallon buckets or other containers full of water are also effective. Dead mice can also be composted.

Nutrient testing

Whether producing compost for sale or use on site, it is a good idea to test for nutrients and other variables like maturity. Penn State compost lab is one option, but there are many labs out there that can test every aspect of your compost.

Composting permits

Each state and municipality has different requirements for permits associated with composting. We strongly recommended that you contact your local regulatory and code enforcement offices for details.

Local code officials will likely require a conversation about an in-vessel compost facility, and may have restrictions on the use of 40-foot shipping containers, and/or require an electrical inspection.

Long periods of inactivity

During times when the drum is not being loaded regularly, it is important to rotate the drum one time every other day to keep the material mixed and oxygenated. If a facility is likely to be inactive for weeks at a time, then once every 3-4 days may suffice. If you anticipate months of inactivity (such as summer vacation), partnering with parents, local restaurants or other facilities to receive food waste once a week would help maintain the biological processes. The presence of a responsible adult when the drum is rotated is a must.

Data collection

Without good mass and volume data it is difficult to know how much food waste is being processed or how much compost is created. An outdoor appropriate floor scale that can be tared, allows the weight of the bucket or container holding the food waste and other organic material to be automatically subtracted. The ACCUTEK440lb is a heavy-duty digital postal scale costs approximately $45 and works well for this.

Temperature data is one of the most important indicators of the composting process. Compost thermometers will allow for temperature measurements at various depths in the drum and finishing pile. You can purchase thermometers from Reotemp for approximately $25. For North Country School and Camp Treetops' composter, we purchased two temperature data loggers, which are each zip tied to a whiffle ball and travel with the mixed material from loading end to discharge end. When the data logger/whiffle ball combination comes out of the drum, the data logger can be connected to a USB cable and the data downloaded for analysis. We use the HOBO, U12-015 model. Each data logger costs approximately $285 including shipping. When the battery runs low, the unit has to be sent back to the company for a new battery. We have seen the battery in our data loggers last well over two years before needing to be sent back to the manufacturer. The data can be viewed and printed either in raw form, or in graph format and can be enormously helpful in understanding the composting process within the drum.

Determining retention time

Determining retention time can be done with a golf ball. Assuming the golf ball travels at the same rate through the drum as the other material, the retention time is the time it takes for the golf ball to exit the drum. We have tested a single golf ball compared to two golf balls (screwed together to prevent rolling) and loaded on the same day. They seem to come out at about the same time.

Consistency of operations

It is important that the responsibility for the operation of the composter not be spread over several people. Ideally, there is one person who is able to train new people, deal with problems that emerge, monitor safety, perform maintenance, be responsible for all operations, etc.

Emptying the drum

In the event that all contents need to be removed, the end screen assembly is removed, and the drum is rotated until all contents are out. Increasing the drum angle will assist with this process. The system is designed in a way that most all parts, with the exception of the drum itself, are able to be replaced without emptying the drum.

Education

Composting food waste is deeply connected to biology, microbiology, agriculture, environmental science, horticulture/plant science, social studies, physics, chemistry, business, and many more fields. Operating a composter has the potential to be a significant laboratory for student learning. Contact Compost for Good for supplemental materials including lesson plans, presentations, videos, and other resources.

Research opportunities

TEMPERATURE: Data from the Onsite HOBO temperature data loggers has identified many potential research questions including: what happens to the temperature of the material within the drum when the drum is rotated? Why does the temperature change when the drum is rotated? What happens to microbial species diversity if the temperature gets above a certain point, and why? What is the relationship between temperature and the number of rotations per day, and why? Other than bacterial species, what additional types of microbes exit in the drum, and does the type of organism change with changing temperatures? A great many additional questions could be asked that are not necessarily related to temperature, such as: How much Carbon Dioxide is produced during primary decomposition? How much water vapor is produced during primary decomposition? (Both of these questions relate to the difference between the mass of the material going into the drum and the mass of the material exiting the drum.)

COMPOSTABLE PRODUCTS: Conversations and concerns surrounding compostable products such as cutlery and food containers are occurring on multiple levels. Some of this work is already being done by BPI (see resources section). However, much work needs to be done on how compostable products behave in our composter design.

FEEDSTOCK: University researchers and others have expressed interest in partnering to study the effectiveness of this design, its ability to compost other organics, and the use of a drum composter to compost human urine.

REDUCING GREENHOUSE GAS EMISSIONS: When food waste (and many other organics) are landfilled, anaerobic decomposition within the landfill produces methane. According to the US EPA, methane is 28-36 times more potent as a greenhouse gas than carbon dioxide. Composting food waste not only yields a valuable soil amendment but also reduces your carbon footprint. By composting approximately 50,000 pounds of food waste per year, we estimate that we reduce our carbon footprint by approximately eight metric tons of carbon dioxide equivalent per year. Finding a way to measure what, if any, methane is produced in our composter design would be helpful.

The above are only a smattering of the many interesting research questions that could be asked. There are many more.

IX. General guidance

Guidance document when considering implementation

System management

Depending on the amount of food waste, loading the composter, for one adult, takes 10-15 minutes/day. Managing the compost produced, and acquiring the carbon bulking material depends on various factors, but will likely take an average of four hours/month of additional time.

Recommendations

- Read this operation manual completely.
- NEXT: Identify a point person to manage all aspects of the composter, including the safety concerns.
- NEXT: Learn the basics of the composting process. There are a great many resources out there that go into the composting process in much greater detail. For community-scale composting, I highly recommend James McSweeney's book (see the resource section).
- NEXT: Customize the recipe and monitor whether that recipe needs to change over time.

Feedstock management

- Can range from zero to 200 pounds/day (occasionally more)
- Consistent feedstock is best, but not necessary
- It is best to secure a supply of carbon bulking material that is consistent in terms of moisture content, size, etc. However, if the carbon bulking material changes then you will likely need to tweak the ratio of the new carbon bulking material to food scraps (or other organic matter that you are composting)

Need to control

- Moisture content
- Temperature
- Flies
- Rodents or other pests

Site considerations

- Proximity to power – 3 phase ideal but not required
- Proximity to water for adding water to compost, if needed, and washing buckets, tools, etc.
- Access to a road or parking lot for food waste delivery
- Remote locations could operate a composter with a generator, a solar PV array, or by hand
- Level site under cover
- Avoid locations that could offend neighbors
- Avoid proximity to environmentally sensitive areas such as wetlands or rivers that might trigger need for permits.

X. Resources

- The US Composting Council: https://www.compostingcouncil.org/
- Local master composters
- Local commercial composting businesses
- *Community Scale Composting Systems; A Comprehensive Practical Guide for Closing the Food System Loop and Solving Our Waste Crisis,* by James McSweeney
- EPA – metrics and GHG estimates
- Penn State Composting Lab
- The Biodegradable Products Institute (BPI). https://www.bpiworld.org/ This organization does research on the vast amount of compostable products coming on into the market. (Some of which are more compostable than others.)

Additional info

Various resources, including consulting services are available from Compost for Good. adkaction.org/compost/

NYS resources

- NYS Association for Reduction, Reusing and Recycling: NYSAR3
- NYS Department of Environmental Conservation: NYSDEC
- Pollution Prevention Institute
- Cornell Cooperative Extension

Rotating drum composter process flow diagram

1 0-400 lbs of food scraps delivered to system

2 Scraps are chopped with hand held lawn edgers or other sharp implements

3 Wood chips, wood pellets (or other high-carbon material) are mixed with food scraps in a 1:4 ratio

4 Food scrap carbon blend is loaded into loading end of composter

5 Switch on motor to rotate drum for one or more rotations

6 Maintain temperature between 110F - 150F. Rotate more frequently to lower temp

7 Day 25-45: Compost exits drum. Finished material either used immediately for top dressing or sifted and moved to a curing location for sale or use.

One design, five composters (and counting!)

CLOCKWISE FROM TOP: THE PINGRY SCHOOL, BASKING RIDGE, N.J.; HERMON DEKALB CENTRAL SCHOOL, DEKALB JUNCTION, N.Y.; THE WILD CENTER, A NATURAL HISTORY MUSEUM, TUPPER LAKE, N.Y.; THE SHIPMAN YOUTH CENTER IN COLLABORATION WITH LAKE PLACID HIGH SCHOOL, LAKE PLACID, N.Y.; NORTH COUNTRY SCHOOL AND CAMP TREETOPS, LAKE PLACID, N.Y.