DIY Composting Johnson-Su Bioreactor Guide

A guide to building your own Bioreactor
in Cincinnati

Green Cincinnati Plan

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Bioreactor Guide

Introduction

In 2021, 31.1% (23,310 tons) of all Cincinnati waste was organic material, meaning it was made up of once living material, such as vegetable scraps, leaves, sticks, and more. Of that 31.1%, 54% (12,592 tons) was considered food waste, and 46% (10,718 tons) was considered yard trimmings [1]. When these materials are sent to the landfill, they are buried underground where oxygen cannot reach them. When organic material begins to decompose without the presence of oxygen, it releases methane. Methane is a powerful greenhouse gas (GHG) emission that contributes to global warming by trapping heat in the air. By expanding composting, Cincinnati can lead in reducing these organic materials from ending up in our landfills, decreasing GHG emissions and creating nutrient-rich soil.

Not all composting systems function in the same way. Anaerobic decomposition occurs in the absence of oxygen and can produce unpleasant odors, slower decomposition rates, and methane, a potent greenhouse gas. In contrast, aerobic composting relies on oxygen-loving microorganisms that efficiently break down organic matter while generating minimal odors and producing a stable, nutrient-rich compost. Maintaining adequate airflow is therefore one of the most important factors in successful composting.

As part of two U.S. Department of Agriculture (USDA) Compost and Food Waste Reduction grants, the City of Cincinnati's Office of Environment & Sustainability (OES) has provided technical assistance, staffing and materials to build over 60 Johnson-Su Bioreactors at community gardens, orchards, and school campuses. Formally known as a "Johnson-Su Bioreactor" (created by Johnson and Su), this uniquely designed infrastructure is an effective, low-cost, and low-maintenance means to compost. Unlike more traditional 3-bay composting which requires frequent turning to allow oxygen to enter, a bioreactor is a no-turn composting system. Built with relatively simple materials, the donut shape allows oxygen to enter from all sides, meaning it can passively aerate with no additional effort. The center chimney is a key feature of the Johnson-Su bioreactor. The chimney remains empty throughout the composting process and provides a pathway for air to move into the center of the pile. Together with airflow through the outer sides of the bioreactor, this helps create aerobic conditions without the need for turning.

This composting infrastructure maximizes impact while minimizing hands-on

management time. Most of the 60 bioreactors were built as a "one time fill" where vegetative food scraps were layered alternately with wood chips over the span of a couple of hours, after construction of the container was completed. Several sites opted for a continuous fill model, whereby the structure was built, and a few initial layers of food scraps and wood chips were added to stabilize the structure, and then the community managed the on-going fill process.
Once filled, the Johnson-Su sits and "cooks" for approximately 9 months and then is harvested for use in adjacent growing beds/orchards.

This guide provides a detailed overview of how to build and manage your own Johnson-Su bioreactor. It includes a list of materials, step-by-step instructions for both large and small systems, how to harvest the compost for use in the garden, monitoring protocols and photographs to assist you in your DIY journey.
Many thanks to Marie Hopkins and Gary Dangel who tested and championed this approach during the first USDA grant, and to Laura Lair who stands on their shoulders and built 40+ bioreactors during the second USDA grant, writing the bulk of what follows. Additional thanks to Macda Mulugeta for finding photographs and to Riley Brown for her editing, design, and document creation of this guide. We are also grateful to the gardeners, growers and volunteers who have helped create Cincinnati's Johnson-Su network over the past four years and continue to benefit from its compost.

We hope this journey continues to grow and evolve in the years ahead.

Siting Your Bioreactor

The best location for a Johnson-Su bioreactor is on a flat, level surface with good drainage and partial shade. A dappled-shade area helps prevent the composting materials from drying out while protecting the beneficial fungal communities that develop within the bioreactor and encourage rodent activity.

Elevating the bioreactor on wooden pallets, concrete pavers, or another stable platform improves airflow underneath and helps prevent the bottom from remaining excessively wet. Allowing air flow under the bioreactor helps create air current through the chimney. As the air in the chimney heats up from the compost heating up, it rises, drawing upwards the air from below and creating an air current that helps keep the bioreactor aerated. This raised platform that allows air to flow from underneath is an intentional design element in the original bioreactor design, that allowed it to remain a no-turn system. Avoid placing the bioreactor directly on bare grass, as weeds and soil can contaminate the finished compost.

Locating the bioreactor in an accessible, visible area can make routine moisture checks and maintenance easier and may help discourage rodent activity. Having the food scraps properly covered, keeping proper moisture, and maintaining aerobic conditions; continues to keep rodents away. Keeping proper moisture is critical throughout the composting process; the materials should remain in approximately 70% moisture, similar to the feel of a wrung-out sponge. Regular watering or irrigation may be needed, especially during hot or dry weather.

For more information see Rodent Reduction Rubric on pg. 29 “System Placement.”

Materials Needed

The materials needed will vary in size depending on whether you are building a full-size or mini-Johnson-Su bioreactor. The size of the bioreactor you build should be based on the amount of organic material available, the space at your site, and how much finished compost you hope to produce.

Choose a Full-Size Bioreactor if:

- You have access to large quantities of food scraps, leaves, wood chips, or other compostable materials.
- You are composting for a community garden, orchard, school campus, urban farm, or other larger site.

- You have adequate space for a structure approximately 6 feet in diameter.
- You want to maximize compost production while minimizing maintenance.

Choose a Mini Bioreactor if:

- You have limited space.

- You generate smaller volumes of compostable materials.
- You are composting at a home garden, demonstration site, or educational project.
- You would like to learn about the Johnson-Su process before building a larger system.

Safety Gear & Precautions

- Wear gloves when handling fencing and hardware cloth.
- Wear safety glasses when cutting wire.
- Use caution around sharp cut wire ends.
- Lift materials with assistance whenever possible.
- Thermometer (optional)

Wooden Pallets/Concrete Pavers

- Full-size bioreactor: 4 pallets or pavers to create space ~96 x 80"
- Mini bioreactor: 1 pallet or pavers ~48 x 40"

Black Landscape Fabric

- Use 5-foot-wide black landscape fabric.
- Full-size bioreactor: approximately 40 feet of fabric needed
- Mini bioreactor: approximately 18 feet of fabric needed

Make sure fabric is a breathable and woven material

Flexible Metal Fencing or Remesh*

*Refer to Understanding Fencing, Remesh, Hardware Cloth Materials section below

For a full-size bioreactor, use approximately 25 feet of fencing or remesh:
- 19 feet for the outer ring
- 6 feet for the chimney

For a mini bioreactor, use approximately 13 feet of fencing or remesh:
- 11 feet for the outer ring
- 2 feet for the chimney

Use a roll of flexible wire fencing that is approximately 48 inches tall and has mesh openings of about 4 inches or smaller. A sturdy livestock or garden fence, such as 12.5-gauge woven wire fencing, works well for this application. One example is Red Brand 4-inch Mesh 12.5-Gauge Square Deal Goat and Sheep Wire Fence from Tractor Supply Co. Similar fencing can also be used, as long as it is a comparable height, gauge, and opening size.

Remesh, which is typically used to reinforce concrete, can also be used instead of fencing. Galvanized fencing is more flexible and will not rust. Remesh will rust, but the rust does not affect the compost or the lifespan of the structure.

Hardware Cloth-Metal*

*Refer to Understanding Fencing, Remesh, Hardware Cloth Materials section below

Use 48-inch-tall hardware cloth with ¼ - inch openings.
- Full-size bioreactor: approximately 6 feet
- Mini bioreactor: approximately 2 feet

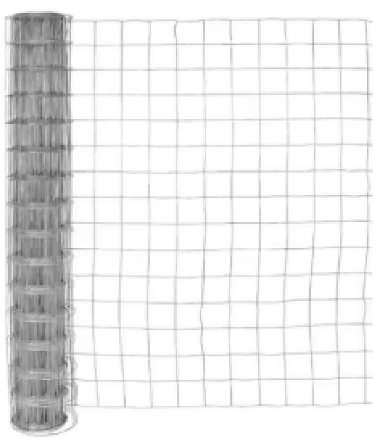
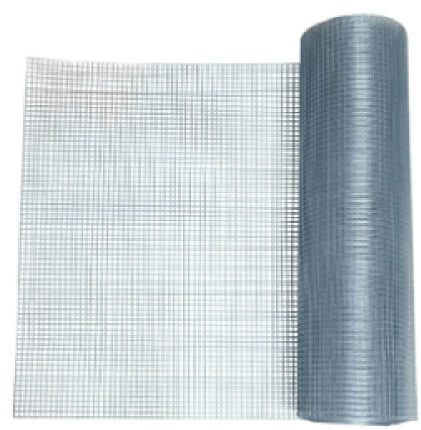
Extra hardware cloth can also be wrapped around the outside of the bioreactor if you plan to add food scraps gradually over a longer period of time and want to help deter pests.

If wrapping the entire outer ring, use approximately:
- Full-size bioreactor: 19 feet
- Mini bioreactor: 11 feet

Additional hog ring staples or zip ties will be needed if wrapping the entire composter in hardware cloth.

*Understanding Fencing, Remesh, Hardware Cloth Materials

Fencing, remesh, and hardware cloth are different materials that serve different purposes in a Johnson-Su bioreactor.

Fencing	Remesh	Hardware Cloth
A flexible wire mesh, typically sold in rolls for livestock or garden use. It is commonly used to form the outer ring and chimney because it is easy to bend into a cylinder. Galvanized fencing can be purchased to help extend the life of the structure.	A welded steel grid used to reinforce concrete. It serves the same structural purpose as fencing and can be used to form the outer ring and chimney, but it is generally heavier, stiffer, more brittle, and more difficult to shape.	A fine wire mesh with small openings (typically ¼ inch). It is not used as the main structure of the bioreactor. Instead, it is wrapped around the chimney to prevent compost materials from falling into the chimney while still allowing airflow.
		
Primary Use: Outer ring and chimney frame	Primary Use: Chimney wrap, pest exclusion	Primary Use: Chimney wrap, pest exclusion
Mesh Size: ~4 inches	Mesh Size: 4-6 inches	Mesh Size: ¼ inch

Both fencing and remesh provide the structural framework for the bioreactor, while hardware cloth helps maintain the open chimney needed for passive aeration.

4-Inch Zip Ties

- Full-size bioreactor: approximately 28 zip ties
- Mini bioreactor: approximately 18 zip ties

Hog Ring Pliers and Hog Ring Staples

Hog ring pliers and staples are used to attach the hardware cloth to the chimney. Zip ties can be used instead if you do not have hog ring pliers or do not want to purchase the tool.

- Full-size bioreactor: approximately 20 hog ring staples or zip ties
- Mini bioreactor: approximately 12 hog ring staples or zip ties

Staple Gun and Staples

A staple gun is used to secure the black landscape fabric to the pallets. Heavy-duty staples with 1/4-inch legs are sufficient, but longer staples can also be used.

3-Inch Screws and Driver

Use 3-inch screws to secure the chimney and outer ring of the composter to the pallet base. Drive a 3-inch screw through the bottom wire of the fencing and into the pallet deck board below. Use washers if available to help prevent the wire from slipping over the screw head.

- Full-size or mini bioreactor: approximately 12 screws

Tin Snips or Utility Knife

Use tin snips or a utility knife to cut the hardware cloth

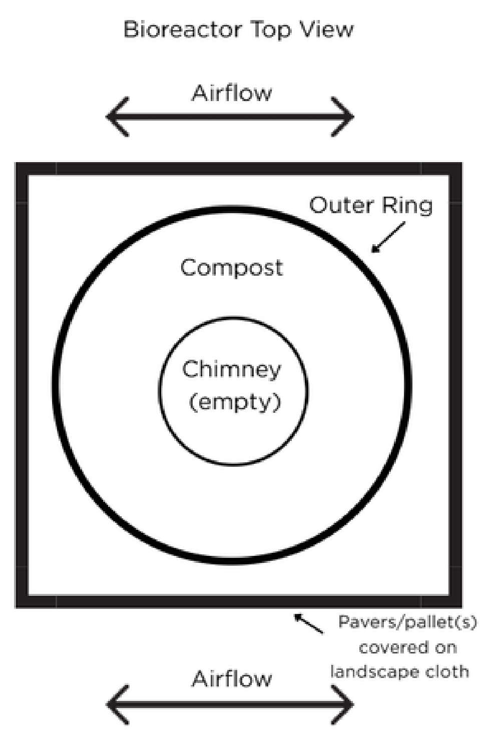
Scissors

Use scissors to cut the landscape fabric. A utility knife can also be used, but it may create a messier cut.

Small Bolt Cutters

Use small bolt cutters to cut the fencing or remesh to the correct lengths.

Diagram



How to Build

Full-Size Johnson-Su Bioreactor

- Base size to build on: 4 pallets or multiple concrete pavers: Approximately 96" L x 80" W total
- Height: 48 inches
- Outer diameter: approximately 6 feet
- Chimney diameter: approximately 2 feet
- Composting volume: approximately 2000 lbs.

Small variations in diameter are acceptable and will not significantly affect performance.

1. Prepare the Base

*See "Work Surface" in Rodent Reduction Reburic pg. 29

Figure 1A: 4 pallets

With location considerations in mind, utilize pallets or a concrete paver base and arrange four pallets or a base of concrete pavers to create a space that measures approximately 8 ft x 7ft into a square on solid, level ground. Avoid building on a slope. Once filled, a full-size bioreactor will be heavy, and building on uneven ground may cause it to slump to one side.

If desired, secure the pallets together where possible using 3-inch screws. This step is optional, but it can help make the base more stable.

Additionally, cement slabs can be placed under pallets to elevate them from the ground and deter pests.

2. Cover the Pallets with Landscape Fabric

Unroll the landscape fabric over the pallets. You will need to cut two strips of fabric to cover the full base.

Before cutting, make sure there is enough overhang on the sides of the pallets so the fabric can be tucked underneath. After cutting the two strips, unfold and arrange them so they overlap in the middle. Tuck the excess fabric tightly under the sides of the pallets.

The fabric does not need to look perfect, but it should be secure and tidy enough to stay in place. Small tears are acceptable and can be repaired using zip ties, staples, or patch pieces of landscape fabric.

If you do not want to fully wrap the pallets, or if you do not have enough landscape fabric, you can cover only the top side of the pallets.

Use a staple gun to secure the fabric to the pallets. Use enough staples to keep the fabric firmly attached.

Figure 3A: Stapling fabric to pallet(s)

3. Cut the Fencing or Remesh

Unroll the fencing or remesh.
For a full-size bioreactor, cut:

- 19 feet for the outer ring
- 6 feet for the chimney

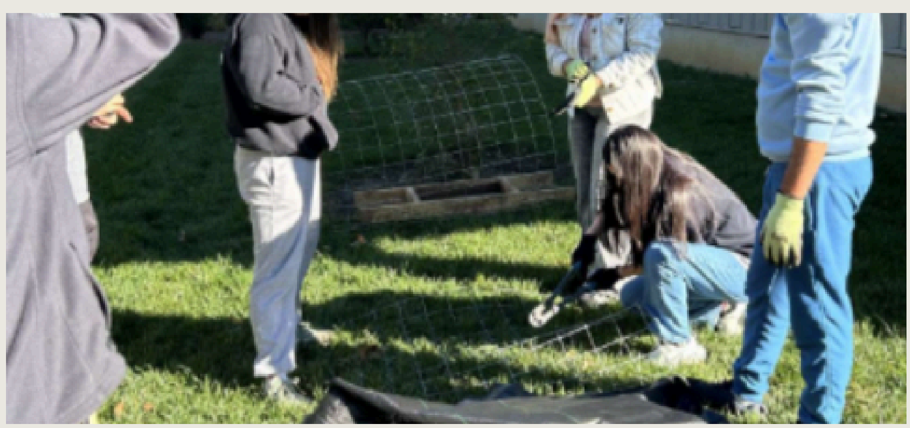


Figure 4A: Unrolling remesh

Figure 5A: Small bolt cutter

Use small bolt cutters to cut the fencing or remesh.

When cutting each strip, cut one end flush and leave longer wire pieces on the other end. These longer pieces can be bent into hooks and used to close the fencing into a cylinder.

It can be helpful to place heavy items, such as a tool bag, bricks, or logs, on the ends of the fencing while you work. This helps keep the fencing flat and easier to handle.

4. Build the Chimney

Roll the 6-foot length of fencing into a cylinder. Pull the cylinder into a nearly circular shape before fastening. Small imperfections are acceptable. Use the longer wire pieces to hook around the flush-cut side and close the fencing into a cylinder.

The finished chimney should be approximately 2 feet wide.

5. Wrap the Chimney with Hardware Cloth

Cut 6 feet of hardware cloth. Wrap the hardware cloth around the chimney.

One helpful method is to lay the hardware cloth flat on the ground, place the chimney on top, and roll the chimney into the hardware cloth.

Use hog ring pliers and hog ring staples, or small zip ties, to secure the hardware cloth to the top and bottom of the chimney.

The hardware cloth helps keep compost materials inside the “donut” shape of the bioreactor and out of the chimney. Hardware cloth is used here instead of landscape fabric because it allows for better aeration.

Figure 6A: Chimney remesh being wrapped in hardware cloth

6. Prepare the Outer Ring

Figure 2A: Black landscape fabric

Lay the 19-foot length of fencing flat on the ground. Weigh down the ends with bricks, large rocks, or items of heavy weight to keep it in place. Position the fencing so the ends curl upward toward the sky rather than downward into the ground.

Unroll the landscape fabric over the fencing. There should be about 8 inches of overhang on each short end of the fencing.

Cut the fabric, then unfold it so it covers the fencing completely. If the fencing is 4 feet tall and the landscape fabric is 5 feet wide, there should be about 6 inches of overhang on the long sides of the fencing.

You will need at least 6 inches of overhang on the long sides, so keep this in mind when selecting your fencing and landscape fabric.

Fold the overhanging fabric under the long sides of the fencing. Pull the fabric tight so it sits neatly and securely around the fencing.

7. Attach the Landscape Fabric to the Outer Ring

Use 4-inch zip ties to attach the landscape fabric to the fencing.

Poke the zip ties through the folded fabric along the long sides of the fencing (the horizontal running edges, the top and bottom edges of the fencing that form the continuous circle/circumference). You will be poking through two layers of fabric near the edge of the fencing. Close the zip ties around the edge of the fencing to secure the fabric.

Space the zip ties approximately 1.5 feet apart along the long sides of the fencing.

Figure 8A: Prepared outer ring – remesh wrapped in landscape fabric, secured with zip ties

8. Attach the Landscape Fabric to the Outer Ring

Carefully remove the heavy items from the ends of the fencing. Roll the 19-foot strip into a cylinder.

As with the chimney, use the longer wire pieces to hook around the flush-cut side and close the fencing into a cylinder.

9. Secure the Chimney to the Base

Figure 7A: Secured base by drilling 3-inch screws

Place the chimney in the center of the pallet base. Use 3-inch screws to secure the chimney to the base in two places.

10. Add and Secure the Outer Ring

Lift the outer ring over the chimney and set it down on the pallet base.

Figure 9A: Placing outer chimney around inner chimney

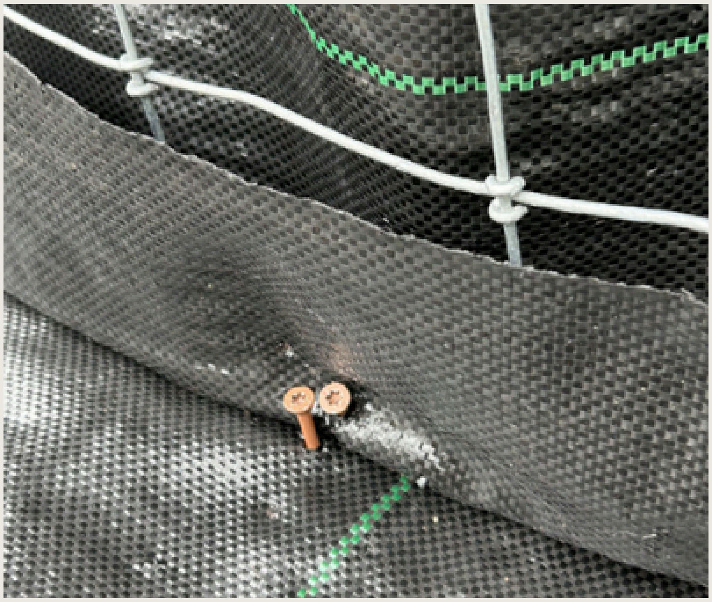


Figure 10A: Securing the base with 3-inch screws

Center the chimney inside the outer ring. Once both pieces are positioned correctly, use 3-inch screws to secure the outer ring to the base in three to four places.

Mini Johnson-Su Bioreactor

- *Base size to build on: 1 pallets or multiple concrete pavers: Approximately 48" L x 40" W total*
- *Height: 48 inches*
- *Outer diameter: approximately 3.5 feet*
- *Chimney diameter: approximately 8 inches*
- *Composting volume: approximately 750 lbs.*

Small variations in diameter are acceptable and will not significantly affect performance.

The mini Johnson-Su bioreactor follows the same basic construction process as the full-size version but uses one pallet as the base and shorter lengths of fencing or remesh.

Please note, pictures shown in Building a Full Size Bioreactor section can be used as a reference for the steps below, sizing and amount of materials will be different based on size for Mini Bioreactor.

Figure 11A: Mini Johnson-Su Bioreactor

1. Prepare the Base

Place one pallet on solid, level ground. Avoid building on a slope, as the bioreactor may shift or slump once it is filled.

2. Cover the Pallet with Landscape Fabric

Unroll the landscape fabric over the pallet. Make sure there is enough overhang on each side to tuck the fabric underneath the pallet.

Tuck the excess fabric tightly under the sides of the pallet, then use a staple gun to secure the fabric to the pallet. Use enough staples to keep the fabric firmly attached.

If you do not want to fully wrap the pallet, or if you do not have enough landscape fabric, you can cover only the top side of the pallet.

Note: If pests are a concern, you can reinforce the landscape fabric by putting hardware cloth underneath it.

3. Cut the Fencing or Remesh

Unroll the fencing or remesh. For a mini bioreactor, cut:

- 11 feet for the outer ring
- 2 feet for the chimney

Use small bolt cutters to cut the fencing or remesh.

When cutting each strip, cut one end flush and leave longer wire pieces on the other end. These longer pieces can be bent into hooks and used to close the fencing into a cylinder.

It can be helpful to weigh down the fencing with heavy items, such as a tool bag, bricks, or logs, while you work.

4. Build the Chimney

Figure 14A: Mini chimney cylinders

Roll the 2-foot length of fencing into a cylinder approximately 8 inches in diameter. Use the longer wire pieces to hook around the flush-cut side and close the fencing into a cylinder.

Because the mini chimney is smaller than the full-size version, adjust the cylinder so it fits comfortably in the center of the pallet base while still leaving space for compost materials around it.

5. Wrap the Chimney with Hardware Cloth

Cut approximately 2 feet of hardware cloth. Wrap the hardware cloth around the chimney.

Use hog ring pliers and hog ring staples, or small zip ties, to secure the hardware cloth to the top and bottom of the chimney.

The hardware cloth helps keep compost materials inside the outer ring and out of the chimney while still allowing airflow.

6. Prepare the Outer Ring

Lay the 11-foot length of fencing flat on the ground. Weigh down the ends to keep it in place.

Unroll the landscape fabric over the fencing. Leave enough overhang on the short ends and long sides so the fabric can be folded around the fencing and secured.

Fold the overhanging fabric under the long sides of the fencing. Pull the fabric tight so it sits neatly and securely around the fencing.

7. Attach the Landscape Fabric to the Outer Ring

Use 4-inch zip ties to attach the landscape fabric to the fencing.

Poke the zip ties through the folded fabric along the long sides of the fencing, near the edge. Close the zip ties around the fencing to secure the fabric.

Space the zip ties approximately 1.5 feet apart along the long sides of the fencing.

8. Form the Outer Ring

Carefully remove the heavy items from the ends of the fencing. Roll the 11-foot strip into a cylinder.

Use the longer wire pieces to hook around the flush-cut side and close the fencing into a cylinder.

9. Secure the Chimney to the Base

Place the chimney in the center of the pallet base. Use 3-inch screws to secure the chimney to the base in two places.

10. Add and Secure the Outer Ring

Lift the outer ring over the chimney and set it down on the pallet base.

Center the chimney inside the outer ring. Once both pieces are positioned correctly, use 3-inch screws to secure the outer ring to the pallet base in three to four places.

Figure 12A: Building complete! (Full-size bioreactor)

Filling Your Bioreactor

Important: The center chimney should remain open and free of compost material during filling and composting. Its purpose is to provide passive airflow to the center of the bioreactor.

Figure 13A: Time to start filling! (Mini bioreactor)

To fill a bioreactor, plan for approximately:

Full-Size Bioreactor
- Approximately 3.7 cubic yards of combined greens and browns
- Approximately 13-27 wheelbarrow loads

Mini Bioreactor
- Approximately 1.6 cubic yards of combined greens and browns
- Approximately 4-7 wheelbarrow loads

Actual amounts will vary depending on material density and particle size.

These dimensions are approximate and intended as a visual reference while building. Small variations are normal and will not significantly affect performance.

Generally aim for a ratio of 40% food scraps to 60% carbon material.

1. Start with a Base Layer of Bulky Browns

Begin by filling the bottom of the bioreactor with a layer of bulky “browns.” Browns are carbon-rich materials such as wood chips, twigs, and woody plant stems.

Browns (Carbon-rich)
Good materials:
- Wood chips
- Shredded leaves
- Straw
- Twigs
- Dried plant stems

An 8- to 12-inch base layer is ideal. This bottom layer helps create airflow and supports the composting process.

Figure 3B: Well covered layer of browns to complete filling in donut. Center chimney stays empty.

2. Fill Evenly Around the Chimney

Add materials evenly around the outside of the chimney. Avoid placing large amounts of material on one side at a time, as this can shift or deform the chimney. As the bioreactor fills, periodically check that the chimney remains upright, centered, and free of compost material. The bioreactors are sized so that all material composting is within 12″ of air space. This is crucial for them receiving appropriate airflow. Centering the chimney helps ensure material stays within this 12″

3. Choose a Filling Method

After adding the base layer, you can fill the bioreactor in one of two ways:
- Fill it all at once with a large amount of mixed organic material
- Fill it slowly, layering over time as food scraps and other materials become available

Both methods can work well. The best option depends on how much material you have available and how your site plans to manage the bioreactor.

4. Fill-All-at-Once Method

For this method, source a large amount of "greens" and "browns" to fill the bioreactor.
Greens are nitrogen-rich materials, such as vegetative food scraps and fresh plant material.

Figure 1B: Fill-all-at-once method – with mixed greens and browns

Greens (Nitrogen-rich)
Good materials:

- Fruit scraps
- Vegetable scraps
- Coffee grounds
- Tea leaves
- Green garden trimmings
- Fresh grass clippings

Do Not Use

- Meat
- Dairy
- Oils
- Pet waste

A good greens-to-browns ratio is approximately:

- 40% greens and 60% browns, or
- 50% greens and 50% browns

You can use more browns if needed, but adding too many browns may cause the materials to take longer to break down into finished compost.

There are two ways to add the materials:

- Mix the greens and browns together before placing them in the bioreactor, or
- Layer the materials inside the bioreactor using a "lasagna" method but always cover with browns

For the lasagna method, alternate thin layers of greens and browns, with each layer about 1 to 2 inches thick, until the bioreactor is full.

Once the bioreactor is full, cap it with a final layer of browns that is at least 6 inches thick.

Figure 2B: Lasagna method – alternate thin layers of greens and browns, cover scraps with browns until you can no longer see the scraps

5. Fill-Over-Time Method

For this method, use the same greens-to-browns ratios recommended above.

Add materials using the lasagna method by alternating layers of greens and browns. Each time food scraps are added, cover them completely with a layer of browns until no food scraps are visible.

Keeping food scraps fully covered helps the composting process and can help reduce odors and pests.

See Compost management in Rodent Reduction Rubric on pg. 29

Monitoring

Moisture

The top of the bioreactor is typically left open to allow natural rainfall to help maintain moisture levels. Monitor the moisture level of the compost over time. During filling, lightly water each layer if the materials are dry. The finished pile should feel like a wrung-out sponge—moist but not dripping.

Figure 4B: All done! Harvesting can begin once the bioreactor has cooked for 9-12 months and is ready for use.

During long periods of dry weather, you may need to water the bioreactor. If the compost dries out, the microbes needed for decomposition can die off, and the composting process may stall. Materials may be dry if they look dusty or there's little decomposition. In areas experiencing prolonged heavy rainfall, monitor the bioreactor to ensure it does not become waterlogged. If excessive moisture becomes a problem, a temporary cover may be used, such as a shade cloth, provided airflow is still maintained around the sides of the bioreactor. Ensuring proper moisture at the start is important too for avoiding trouble down the road of a pile drying out - it is a lot harder to rehydrate a pile that has dried out once it is built, than it is to hydrate in layers as the bioreactor is filled and to keep the bioreactor hydrated over time

Temperature

Monitoring temperature is very important in order to keep the microbial communities within the bioreactor operating. Monitoring includes managing both internal self-heating and external environmental conditions. If temperatures drop below 25°F (-6° C) you will need to have protection and put in place temperature control measures. Those control measures can be:

Internal Temperature Management

The core pile should naturally heat up to 55-70°C (131-158°F) for about four days to one week to kill pathogens and weed seeds. If higher than that, high-nitrogen materials may need to be pre-composted beforehand.

External Temperature Management

- **Summer:** Block the bioreactor from direct sunlight, which can dry out the compost and kill heat-sensitive microbes. Protect the bioreactor by using a breathable top cover, shade cloth, or place the bioreactor under an open-sided roof.
- **Winter & Freezing Conditions:** The bioreactor can handle temperatures down to -4°C (25°F) without major issues. For colder climates, protect the bioreactor by stacking it in a hoop house, wrapping the lower half with heat tape, or housing the unit in an unheated garage or shed.

Figure 5B: Temperature gauge to measure compost heat

Troubleshooting

Unpleasant Odors

A properly functioning bioreactor should have little to no odor. Strong or unpleasant smells may indicate:

- Too many green materials and not enough browns
- Excess moisture
- Poor airflow due to a blocked chimney

To address odors:

- Add additional brown materials such as wood chips, leaves, or straw.
- Verify that the center chimney remains open and unobstructed.
- Reduce watering if the materials are overly wet.

Immature Compost

Most compost-related problems occur when materials have not fully decomposed or have not reached temperatures sufficient to reduce pathogens and weed seeds. Immature compost may continue decomposing after application, temporarily tying up nitrogen in the soil and reducing nutrient availability to plants. Compost should be allowed to fully mature before use and should appear dark, crumbly, earthy-smelling, and free of recognizable feedstocks.

Dry Compost

If decomposition appears slow and the material feels dry or dusty, add water gradually until the compost reaches the moisture level of a wrung-out sponge.

Pests

Always cover food scraps completely with browns and do not add meat, dairy, oils, or pet waste. If pest activity becomes a concern, consider wrapping the outer ring with hardware cloth.

RODENT REDUCTION RUBRIC

CATEGORIES	1 - HIGH RODENT POTENTIAL	2 - LOW RODENT POTENTIAL	3 - RODENT PREVENTION	SCORE
SYSTEM PLACEMENT	The compost system is placed against a wall, in a dark corner, surrounded by clutter, overgrown by plants, or in the area with the least amount of foot traffic.	The compost system is placed against a wall, in a dark corner, or in the area with the least amount of foot traffic but there is at least 3' of clearance between the system and the nearest wall.	The compost system is placed in an open area with ample lighting and increased foot traffic.	__/3
WORK SURFACE	The compost system is located on loose dirt, mulch, sand, etc.	The compost system is located on compacted dirt, steel screen, or crushed gravel.	The compost system is located on a hard surface such as concrete pavers, concrete slabs, steel slabs, stone, etc. (Paver base should be reinforced with steel screen and metal edging.)	__/3
COMPOST MANAGEMENT	There is exposed food scraps on the site regularly, the compost is rarely turned, there is no tracking method for the age of material, frequency of turns or maturity of compost. There is no stock of carbon-rich feedstocks.	Food waste is properly stored and covered on-site, compost is turned more frequently but there is no method of tracking age and maturity of compost. There is a small portion of carbon-rich feedstocks on-site.	All feedstocks have their own storage containers and are properly stored. All nitrogen-rich feedstocks are covered with carbon-rich materials to reduce odors. There is a weekly turn schedule for each compost pile and a method of tracking age and maturity of compost. The site is always fully stocked with carbon-rich feedstocks such as wood shavings, shredded paper, dry leaves, and sawdust.	__/3
COMPOST BIOFILTER	New windrows or raw food scraps are not covered in any way.	New piles get covered with a tarp, a thin layer of browns or mature compost.	New piles get a 12" layer of mature compost and the piles continue to be sealed after every turn until there are no recognizable food scraps left in the material.	__/3

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Passing score is 8/12.
A score of 1 in any category negates a passing grade.

RODENT REDUCTION RUBRIC

1 = High Rodent Potential
2 = Low Rodent Potential
3 = Rodent Prevention

System Placement

1. The compost system is placed against a wall, in a dark corner, surrounded by clutter, overgrown by plants, or in the area with the least amount of foot traffic.
2. The compost system is placed against a wall, in a dark corner, or in the area with the least amount of foot traffic but there is at least 3' of clearance between the system and the nearest wall.
3. The compost system is placed in an open area with ample lighting and increased foot traffic.

Work Surface

1. The compost system is located on loose dirt, mulch, sand, etc.
2. The compost system is located on compacted dirt, steel screen, or crushed gravel.
3. The compost system is located on a hard surface such as concrete pavers, concrete slabs, steel slabs, stone, etc. (Paver base should be reinforced with steel screen and metal edging.)

Compost Management

1. There is exposed food scraps on the site regularly, the compost is rarely turned, there is no tracking method for the age of material, frequency of turns or maturity of compost. There is no stock of carbon-rich feedstocks.
2. Food waste is properly stored and covered on-site, compost is turned more frequently but there is no method of tracking age and maturity of compost. There is a small portion of carbon-rich feedstocks on-site.
3. All feedstocks have their own storage containers and are properly stored. All nitrogen-rich feedstocks are covered with carbon-rich materials to reduce odors. There is a weekly turn schedule for each compost pile and a method of tracking age and maturity of compost. The site is always fully stocked with carbon-rich feedstocks such as wood shavings, shredded paper, dry leaves, and sawdust.

Compost Biofilter

1. New windrows or raw food scraps are not covered in any way.
2. New piles get covered with a tarp, a thin layer of browns or mature compost.
3. New piles get a 12" layer of mature compost and the piles continue to be sealed after every turn until there are no recognizable food scraps left in the material.

Passing score is 8/12. A score of 1 in any category negates a passing grade.

Learn more: ilsr.org/articles/rodent-reduction

PRODUCED BY COMPOST POWER

Harvesting Your Compost

Your compost should be ready to harvest approximately 9 to 12 months after you finish filling the bioreactor. For continuously filled bioreactors, begin counting the composting period after the final addition of organic material.

To check if the compost is ready, dig down into the top of the pile. Finished compost should be dark brown, crumbly, and earthy-smelling. It should not contain identifiable food scraps. While visual and physical characteristics are often sufficient for evaluating compost readiness, laboratory testing can provide additional information about nutrient content, pH, soluble salts, organic matter, and compost maturity. Testing may be particularly valuable when compost is being used to support crop fertility programs, when source materials are uncertain, or when there are concerns about possible contaminants.

Tools and Supplies Needed

- Shovel
- Tarp
- Wheelbarrow
- Sifter, optional

Some people apply compost to garden beds without sifting, while others prefer to sift it first. This often depends on the size of the remaining bulky browns, such as wood chips. Compost used for seed starts should be sifted to create a finer texture.

1. Prepare the Harvesting Area

Lay a tarp in front of the seam where the side of the bioreactor opens. Place a wheelbarrow on top of the tarp.

2. Open the Bioreactor

Unbend the wire hooks at the seam to open the side of the bioreactor.

Figure 1C: Ready to harvest

3. Decide Whether to Sift

Figure 1D: Sifting (optional)

If you are sifting the compost, place the sifter on top of the wheelbarrow. Shovel compost into the sifter.

Use your hands to move the compost across the sifter until the finer material falls through into the wheelbarrow and only larger pieces remain on top.

The larger material left on top of the sifter is called “overs.” These pieces can be placed in a pile on the tarp and added back into the bioreactor after harvesting so they can continue breaking down.

4. Move Compost to the Garden

Once the wheelbarrow is full, take the compost to your garden bed and apply it where needed.

If you are not sifting, shovel the compost directly into the wheelbarrow and move it to the garden beds.

Figure 2D: Finished compost can now be moved to garden beds.

5. Refill the Bioreactor

After harvesting is complete, close the seam of the bioreactor. The bioreactor can then be refilled to begin the composting process again.

Compost Quality and Testing

The quality of compost can vary depending on the source materials used, composting methods, and the degree of decomposition. Finished compost may differ in nutrient content, moisture content, pH, organic matter, soluble salts, and biological activity. In some cases, compost can also contain contaminants such as pathogens, weed seeds, plastics, heavy metals, pesticides, pharmaceuticals, or other unwanted materials.

Compost testing can help determine whether finished compost is safe and suitable for its intended use. Laboratory analysis may measure characteristics such as nutrient content (nitrogen, phosphorus, potassium, and micronutrients), moisture content, pH, organic matter, soluble salts (electrical conductivity), carbon-to-nitrogen ratio, microbial activity, and compost maturity or stability. Additional testing can be performed to screen for contaminants when needed.

Unlike soil, which may only need testing every few years, each batch of compost has the potential to produce different results if source materials or management practices change. Testing may be particularly valuable when feedstocks are uncertain, when compost is being used to meet specific crop nutrient needs, or when it is intended to replace all or part of a fertilizer program.

For most home gardeners and community composters who control the materials added to their compost and primarily use compost to increase soil organic matter, routine laboratory testing is generally unnecessary. Many compost-related problems result from using compost before it has fully decomposed or from compost that did not reach temperatures sufficient to reduce weed seeds and pathogens. Immature compost may continue decomposing after application, temporarily tying up nitrogen that would otherwise be available to plants.

In many cases, physical observations provide a practical way to evaluate compost readiness. Finished compost should be dark, rich, and crumbly like fresh soil, smell sweet and earthy like a forest floor, feel cool to the touch, and contain few or no recognizable food scraps or feedstocks other than small woody pieces.

For composters interested in laboratory analysis, basic compost testing through a university extension laboratory typically costs about $50 per sample and may include measurements such as percent solids, organic matter, pH, soluble salts, total nitrogen, total carbon, and carbon-to-nitrogen ratio. Additional contaminant testing may increase costs to approximately $285-$350 per sample, while commercial-scale testing programs can exceed $700 per sample.

Penn State Extension offers an affordable compost testing program and additional resources on compost analysis: https://agsci.psu.edu/aasl/compost-testing.

Bioreactor Checklist

Before Filling

√ Pallets are level

√ Landscape fabric secured

√ Chimney wrapped in hardware cloth

√ Chimney centered

√ Chimney attached to base

√ Chimney interior empty and unobstructed

√ Outer ring attached to base

√ Materials for filling ready

During Filling

√ Alternate greens and browns

√ Cover food scraps completely with browns

√ Add water if materials are dry (consistency of a damp sponge, not dripping)

√ Keep chimney clear

During Composting

√ Monitor moisture monthly

√ Water during extended droughts

√ Check for settling or damage

√ Check for rodent activity

Appendix A: Material Sourcing Guide and Key Definitions

Appendix A.1 – Where to Find Materials

Many of the materials needed to build a Johnson-Su Bioreactor can be sourced from local farms, hardware stores, landscape suppliers, municipal programs, or reused materials already available within your community.

Wooden Pallets/Concrete Pavers

Where to Find Them:

- Garden centers
- Hardware stores
- Landscape supply companies
- Nurseries
- Warehouses
- Food distributors
- Online marketplaces such as Facebook Marketplace or Craigslist

What to Look For:

- Structurally sound pallets with no rot
- Heat-treated pallets (marked "HT") whenever possible
- Avoid pallets with significant chemical staining or damage

Black Landscape Fabric

Where to Find It:

- Home improvement stores
- Farm and garden supply stores
- Landscape supply companies
- Online retailers

What to Look For:

- Approximately 5 feet wide
- Woven landscape fabric is generally more durable than thin plastic weed barriers
- Fabric should allow water to pass through while helping contain compost materials

Fencing or Remesh

Where to Find It:

- Farm supply stores
- Tractor Supply Co.
- Rural King
- Home improvement stores
- Concrete supply companies (for remesh)

What to Look For:

- Approximately 48 inches tall
- Openings no larger than about 4 inches
- Galvanized fencing is preferred because it resists rust
- Remesh is acceptable and commonly available through construction suppliers

Hardware Cloth

Where to Find It:

- Hardware stores
- Farm supply stores
- Home improvement centers

What to Look For:

- ¼-inch openings
- Galvanized metal preferred
- 48-inch height works best for full-size systems

Zip Ties

Where to Find Them:

- Hardware stores
- Home improvement stores
- Dollar stores
- Online retailers

What to Look For:

- UV-resistant zip ties last longer outdoors
- 4-inch ties work well for most construction steps

Hog Ring Pliers and Staples

Where to Find Them:

- Farm supply stores
- Hardware stores
- Fencing suppliers
- Online retailers

Alternative:

- Zip ties can be used instead if hog ring pliers are unavailable.

Screws, Staples, and Tools

Common Sources:

- Hardware stores
- Home improvement stores
- Tool libraries
- Community makerspaces

Many community gardens already have access to staple guns, screwdrivers, drills, and bolt cutters that can be shared among volunteers.

Compost Feedstock Materials

Browns (Carbon-Rich Materials)

Potential Sources:

- Arborists and tree service companies
- Municipal wood-chip programs
- Yard waste drop-off sites

- Fallen autumn leaves
- Garden cleanup projects
- Straw from farms or garden centers

Greens (Nitrogen-Rich Materials)

Potential Sources:

- Household fruit and vegetable scraps
- School cafeterias
- Community gardens
- Coffee shops (coffee grounds)
- Farmers markets
- Grocery stores with produce waste

Always confirm that food scraps do not contain meat, dairy, oils, or compostable plastics unless your composting program specifically accepts them.

Appendix A.2 – Understanding Common Composting Terms

Term	Definition
Aerobic Composting	Composting that occurs in the presence of oxygen. Aerobic composting supports beneficial microorganisms that break down organic matter efficiently while producing minimal odors
Anaerobic Composting	Decomposition that occurs when oxygen is absent. Anaerobic conditions often produce strong odors and can slow the composting process.
Bioreactor	A contained composting system designed to create ideal conditions for microbial activity. The Johnson-Su Bioreactor is a passive, aerated composting system that requires little maintenance after filling.
Browns	Carbon-rich materials used in composting. Examples include: • Wood chips • Straw • Dry leaves • Twigs

	• Paper products (uncoated) Browns provide structure and energy for composting microorganisms.
Chimney	The open center cylinder within a Johnson-Su Bioreactor. The chimney remains empty and allows air to move into the middle of the pile, promoting aerobic decomposition.
Compost	Organic material that has decomposed into a stable, nutrient-rich soil amendment suitable for gardens, orchards, and landscapes.
Compost Feedstock	Any material added to a compost pile or bioreactor for decomposition.
Continous Fill	A management method in which new material is added to the bioreactor over an extended period rather than all at once.
Finished Compost	Compost that has completed decomposition and is ready for use. Finished compost is typically: • Dark brown to black • Crumbly in texture • Earthy smelling • Free of recognizable food scraps
Greens	Nitrogen-rich materials used in composting. Examples include: • Fruit scraps • Vegetable scraps • Coffee grounds • Tea leaves • Fresh grass clippings • Green plant trimmings Greens help microorganisms grow and reproduce.

Hardware Cloth	A rigid wire mesh with small openings used to contain compost while allowing airflow through the material.
Johnson-Su Bioreactor	A composting system developed by Dr. David Johnson and Hui-Chun Su that creates biologically rich compost through passive aeration and extended curing without turning.
Lasagna Method	A filling technique that alternates layers of greens and browns, similar to the layered structure of lasagna.
Moisture Content	The amount of water present in the composting material. An ideal moisture level feels similar to a wrung-out sponge: moist but not dripping.
Organic Matter	Material derived from plants, animals, or microorganisms that can decompose naturally.
Overs	Larger pieces remaining after compost has been sifted. Overs commonly include undecomposed wood chips, twigs, or coarse organic material and can be returned to a new bioreactor batch.
Passive Aeration	The movement of air through a compost pile without mechanical turning or forced ventilation.
Remesh	A welded steel mesh commonly used for reinforcing concrete that can also be used to create the structure of a bioreactor.
Sifting	The process of screening compost through mesh to separate fine finished compost from larger undecomposed materials.

Soil Amendment	A material added to soil to improve physical properties, biological activity, nutrient availability, water retention, or drainage.
Thermophilic Composting	The high-temperature phase of composting during which microorganisms rapidly break down organic materials. Temperatures often exceed 131°F (55°C).
Windrow Composting	A composting method that utilizes long rows of organic material that are regularly turned to maintain aeration.
Wrung-Out Sponge Moisture Level	A common composting reference point. If a handful of compost feels moist and holds together when squeezed but does not drip water, it is generally at the proper moisture level.

HOW TO USE THIS COMPOSTER:

- Deposit fruit & veggie scraps or garden waste. Spread in a thin layer.
- Cover scraps (greens) with an equal amount of wood chips, straw, or leaves (browns). No food scraps should be visible. This keeps pests and odors at bay, and is the right recipe for making compost.
- Monitor moisture levels. Compost should be as moist as a wrung-out sponge. Water compost if needed.
- When the composter becomes full, allow the compost to cure for 9-12 months before harvesting.

NO

- MEAT, DAIRY, BONES, EGGSHELLS
- PRODUCE STICKERS
- COMPOSTABLE PLASTICS

Want to start composting your food scraps here? Become a member of this composting site on

MakeSoil

www.makesoil.org

ADD YOUR <u>*VEGETATIVE*</u> FOOD & GARDEN SCRAPS TO THIS COMPOSTER!

NO:

ANIMAL PRODUCTS (MEAT, DAIRY, BONES)
PET WASTE
EGG SHELLS
GREASE / OIL
COOKED FOOD
COMPOSTABLE BAGS
COMPOSTABLE SERVICEWARE (FORKS, ETC.)
PRODUCE STICKERS
PLASTIC
WEEDS

THIS COMPOST IS CURING

DO NOT ADD FOOD SCRAPS OR GARDEN WASTE!

PLEASE WAIT FOR THIS COMPOSTER TO BE EMPTIED BEFORE ADDING MORE SCRAPS

Use the MakeSoil app to find another composting site near you