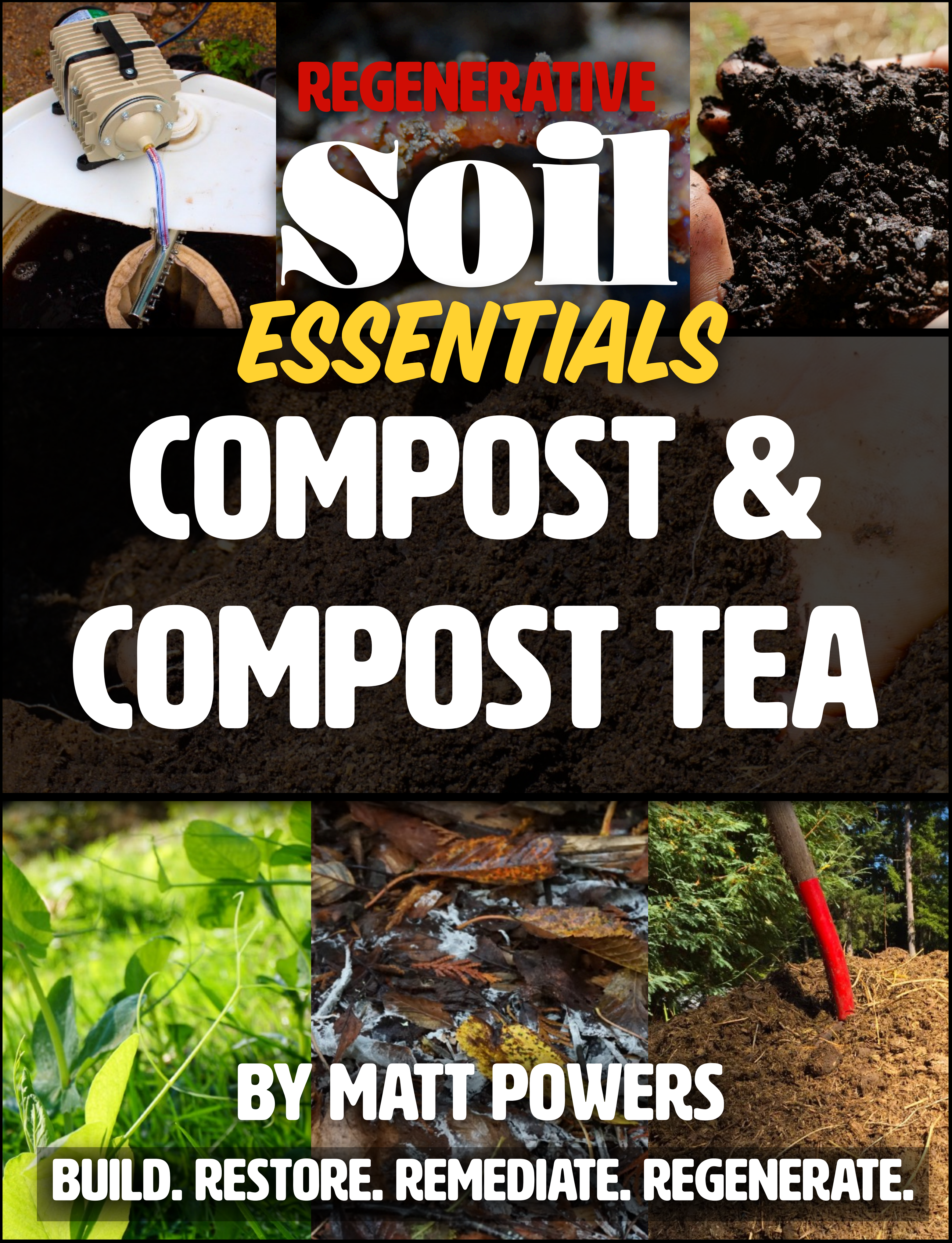


REGENERATIVE Soil ESSENTIALS

COMPOST & COMPOST TEA

BY MATT POWERS

BUILD. RESTORE. REMEDIATE. REGENERATE.

Written by Matt Powers - 2nd Edition
Illustrations by Matt Powers and at least one by Brandon Carpenter as labeled
Cover is a combination of photography by Matt Powers
Charts, Illustrations, and diagrams by Matt Powers unless labeled otherwise
Most photos are from Wikimedia, Unsplash, and other open source outlets.
Other photography by Matt Powers unless labeled otherwise—all photos are used with author permission
Formatted by Matt Powers
Printed on 100% recycled paper in China

Send all Inquiries to:
Matt Powers
Matt@ThePermacultureStudent.com

Published and Distributed by PowersPermaculture123
ISBN: 978-1-7321878-9-4
website: www.RegenerativeSoilScience.com

Please Note: Just as food that nourishes one person causes an allergic reaction in another, the same concept of situational complexity applies to soils, water, microbes, contaminants, and more that is situationally complex. In this book, complexity is embraced with the understanding that every situation and biome is unique. The information in this book represents research from sources listed—it is an educational and informational resource and does not represent any agreement, guarantee, or promise by any party associated with the creation or editing of this book. The publisher, editors, and author are not responsible for any negative or unintended consequences from applying or misapplying any of the information in this book.

COMPOST

Compost is decomposed and stabilized organic matter – pure and simple. When we add compost to the soil, it is literally a SOM deposit. Compost is both biological mineralization and humification, creating a stable soil amendment while producing heat, CO_2, and H_2O. Carbohydrates are broken down into simple sugars, then organic acids and then simply CO_2, H_2O, and organic matter. Proteins are broken down into peptides, then amino acids, then NH_4 compounds, and finally into N_2 or ammonia. There are so many types of composting and with such a wide variety of ingredients to be combined, we've likely a lot still to discover and learn.

The efficacy of a compost pile is often determined by how ideal an environment it is for microbes. The typical compost is in the 20–30:1 C:N ratio range at its start and 10:1 C:N ratio by its completion, but you may raise the C levels for more fungal compost that breaks down over a longer time period or more N for faster CO_2 release though you also begin to lose N in the form of ammonia or N_2 at higher N levels. The surface area of the organic matter can often determine the speed of decomposition and the texture and quality of the final product – the more we chop and mince the organic matter being composted, the better the mature compost will be. Moisture levels need to be maintained in the 50–65% range – this is why folks water their hot composts but often never their mouldering composts (the fresh kitchen compost material is high in water and sugar).

Compost also is habitat and a medium of cultivation and transport for soil life: we can add life back to our soils with compost. Without compost, we can spend a lot of money on expensive biofertilizers that don't persist in the soil because they have no fuel, no habitat, and no reservoir of nutrients, electrons, and water to tap into. Compost is AMAZING in many ways, and it has been touted as a magic bullet solution to gardeners for years. Modern farmers have used it when possible, but overall, they've skipped it despite its long history of use because it was too expensive, too complicated for them to DIY at scale, or too uncertain as to whether it would truly benefit their bottom lines – there is research now showing that at least one type of compost has proven, exponential benefits and is worthwhile for farmers to utilize…

…But why the uncertainty?

When I interviewed Dr. Elaine Ingham, soil science and composting pioneer, in 2017, I was surprised to hear her explain how, even in the 1990's, compost was sometimes helping, sometimes hurting, and sometimes had no effect, and folks were puzzled by it. As with many things in mainstream science in the 80s and 90s, it was disregarded as anecdotal until research was sophisticated enough to navigate the space more adeptly. Even in recent years and months, our understanding of compost and soil in general is evolving. Aerobic, for instance, for many years was synonymous with safe or sterile despite facultative microbes playing central roles in all soils – most especially in the tropics but in all decomposition, all rain events, and especially in humid rainy climates, we will see microbes that can live in both realms. Aerobic also means lots of oxygen which means oxidization, losing nutrients, higher Eh, and higher nitrates which will all lean it towards the alkaline side of neutral though the organic matter levels will always try to act as a pH buffer pulling the pH towards 7.

What is the "Best" Compost?

There are many types of compost – many folks find it confusing which to choose to buy or make, and so they just choose what's easiest for them at the time. This does not always serve them well. If you give the wrong compost to a plant or soil, you can negatively affect everything you're trying to accomplish there. Compost is diverse – we can create alkaline, acidic, high N, low N, hot, or cold compost. Most commercial composts are cooked in large windrows at such a high heat that they are primarily structureless pancakes of organic matter with very little diversity in life: the majority of life and nutrients are lost above 141F°. New research has also shown that the longer we let compost sit and mature, the better it is: more life, greater diversity of life, more fungi, more humic compounds, and more clay-like soil structures that are more resistant to weathering and leaching. It is the epitome of *good things take time*. In nature, soils take millennia to form, so it makes sense that the longer we let something decompose, the more beneficial to the soil profile it will become.

Given the current research and information we have, the Johnson-Su or BEAM compost method is the best compost for large-scale soil building, net primary production (NPP), carbon sequestration, and soil remediation – it has the most biodiversity ever recorded and after one application raises SOM 0.24% every year for many years with a potential of 0.5%. It is made in a bioreactor composting system with chimneys of perforated PVC pipes for aeration. It's a "no turn" semi-static decomposition process that takes a year to accomplish. It is the opposite of the classic 18-day Berkeley Compost or standard 15-day Dr. Elaine Ingham Composting Method (though Elaine does recommend at least a week of undisturbed maturation for her 15 day piles to mature for an increase in fungal populations, but a week compared to a year in terms of biodiversity is truly dramatic).

We can emulate this composting method with our own miniature or to-scale bioreactors (see the recipe section further on) – and according to students learning from her right now, Dr. Elaine Ingham is adding chimneys to her own hot composts and only turning her piles twice. Adaptation is regenerative, and we all need to adapt the way we are composting for the biggest benefit to our soils, plants, ourselves, and our collective future.

That being said, you may want to shift pH out of a deeply acidic condition, to create sterilized organic matter (for seed starter soil in a greenhouse), to kill weed seeds, to destroy disease or pathogen infected biomass, to compost a chicken carcass, etc. These are important things to know how to do. You may also use the hot composting methods to jumpstart a pile and then slow it down with more carbonaceous material like Michael Phillips does for his orchard compost piles. I don't want to limit us by only sharing one form of compost. We can tinker, push, and pull things much further than we often realize, and *there is no "best" just what is best for you in that given situation and time.* We can do hot composts that turn out fungal and acidic, but it won't be the typical 1/3 browns, 1/3 greens, 1/3 manure 15-day process, so things aren't so cut and dry as "best" and "the rest". Everything has an effect and each is unique and has a range of possible expression especially when we consider ingredients.

Composts gas off CO_2?? The hotter the compost the more it loses volume – where does that volume go? It gets gassed off: we lose C, N, and more! Have you ever turned a pile and had it smell like ammonia? That's your N being lost. This is why cooler composting methods like EM® composting, mouldering, or the Johnson-Su method make such fantastic compost: they retain their nutrients! This is also why many longtime mouldering compost practitioners have a hard time switching to hot compost – they see all that work and question whether it is as good as their easier and longer term compost which takes little to no effort. That being said, you may want the CO_2 in your greenhouse or in your fields depending on your operation, and you may want piles that are high in N, so they gas off and shrink fast, or you may want a steady release. It depends on your goals and situation.

This is why some folks are saying compost piles are releasing greenhouse gas emissions because they are, and this is just one aspect of a bigger complex issue when we look at it scientifically. Because it gases off, it shrinks. Because it gases off, it loses nutrients. Because it's being aerated, oxygen is oxidizing nutrients and life, and the entire pile is shifting its Eh higher and higher, becoming more and more oxygenated, which means less and less nutrients that are bioavailable and more nitrates, so we are now looking at a wasteful practice that stresses our plants, costs them energy, and shifts our soil away from the ideal zone of health and nutrition. This is why Elaine Ingham is always trying to make her piles more fungal – to reverse the effects of aerobic composting.

COMPOST TYPES

Bacterial Compost – most kitchen composts are high in simple sugars, and they foster high bacterial populations. Most hot composts are turned regularly to control the heat, so they develop strong bacterial populations because fungi prefer static and no-till settings to myceliate. Bacterially dominant and regularly aerated compost piles tend to be alkaline because the microbial metabolites are regularly oxidized (higher Eh) – all organic N transforms into nitrates within hours in this scenario. We can use a bacterial compost as a starter for a more fungal pile though, so this method is not without its merit and use. We can also amend these piles with fungal foods to tip the balance towards a more fungal pile but aeration is aeration, and we lose and shift things when we do it excessively. This type of compost has been the most common and it's also why we have so much uncertainty, apprehension, and praise around it. Nitrates provide a growth boost and are easily leached out of the soil profile, so gardeners adding it into their early spring gardens see a big growth boost and then their plants shift to reproductive growth and, ideally, the amino acids from the soil biology from the compost still persist and help Ca uptake and largely those nitrates have been taken up by plants or leached away by that point, but if they aren't, if they are still there in abundance, you could get that sad situation where we have vigorous plants but no fruits and flowers (and high nitrates in leaves are unhealthy for us to eat). So, if those nitrates are all soaked up or washed out by the start of reproductive growth, it works even when it's not the "ideal" compost. This is why I don't want to demonize things: we can be creative and adapt, transform, and situationally apply all these solutions, but we have to be fully aware of the possibilities. That's why these composting types are listed in this book and that's why I go into complexity so often.

Fungal Compost – considered the holy grail by some composting aficionados, fungal dominant compost is highly sought after, and the higher the fungal count you have, the more people will want to know HOW you are doing it. Fungal compost is more acidic, so more nutrients are retained, there's more nutrient availability, and there's a lower Eh (so there's more energy). On top of the conditions they create and maintain, fungi alone

COMPOST INGREDIENTS

MATERIAL	C:N	N%	💧%
Compost	20–30:1	–	50–65
Grass Clippings	9–25:1	2.4	9–25
Shrub Trimmings	50:1	–	15
Alfalfa Hay	12–18:1	–	–
Legume Hay	16:1	2.5	15–19
Vegetable Wastes	11–19:1	2.7	87
Fruit Wastes	35–40:1	1.4	62–88
Oat Straw	48:1	1	–
Timothy Hay	58:1	0.8	–
Wheat Straw	128–150:1	0.3	–
Leaves	40–80:1	0.9	38
Oak Leaves	26:1	–	–
Pine Needles	60–110:1	–	–
Corn Stalks	60–73:1	0.6–0.8	12
Corn Cobs	56–123:1	0.6	9–18
Rice Hulls	121:1	0.3	7–12
Seaweed	5–27:1	1.9	53
Coffee Grounds	20:1	–	–
Turnip Tops	19:1	2.3	–
Whole Turnip	44:1	1	–
Mustard	26:1	1.5	–
Amaranth	11:1	3.6	–
Cabbage	12:1	3.6	–
Onion	15:1	2.6	–
Pepper	15:1	2.6	–

MATERIAL	C:N	N%	💧%
Tomato	12:1	3.3	62
Potato Tops	25:1	1.5	–
Whole Carrot	27:1	1.6	–
Red Clover	27:1	1.8	–
Chicken Manure	6–15:1	8	62–75
Cow Manure	11–30:1	2.4	67–87
Horse Manure	25–30:1	1.6	59–79
Pig Manure	9–19:1	3.1	65–91
Humanure	5–10:1	5–7	–
Urine	15–18:1	0.8	–
Goat Manure	32.6	1.6	–
Rabbit Manure	12:1	2.4	–
Duck Manure	27:1	0.8	–
Chicken Carcasses	5:1	2.4	65
Slaughter Waste	2–4:1	7–10	10–78
Blood	3:1	10–14	–
Fish Processing Waste	2.5–5	10.6	94
Sewage Sludge	5–16:1	2–6.9	72–84
Cardboard	400–563:1	0.1	8
Newspaper	170–850	0.06–0.14	3–8
Paper	100–800:1	–	18–20
Raw Sawdust	500:1	0.1	19–65
Rotted Sawdust	121:1	0.3	–
Hardwood Bark	223:1	0.2	–
Softwood Bark	496:1	0.1	–
Douglas Fir Bark	491:1	–	–
Wood Chips (Hard	450–820:1	0.09	–
Wood Chips (Soft	641:1	0.09	–

provide a vast array of benefits to almost all plants and all soils – it's really no contest when we compare compost types across settings and applications: we want more stable, efficacious, longterm, and nutritious compost. Fungal composts rely upon fungal foods: woody and high lignin biomass, complex carbohydrates, soluble kelp, fish and chitin hydrolysate, and humic acids.

Balanced or Neutral Compost – this is compost that approaches neutral i.e. pH 7 and has a 1:1 F:B. This is essentially ideal zone compost (ideal pH/Eh), and what the BEAM/Johnson-Su and modified Elaine Ingham compost methods are trying to do. These piles have just enough aeration or air present to keep it from going too acidic and anaerobic. You'd only really use this as a buffer or to maintain the perfect ideal zone soil you've developed. It's much harder to hit the neutral mark than it is to make something alkaline or acidic. Most often we are driving the soil in different directions, but once we arrive there, we have to maintain it, and that's why knowing what you want is key. You may have a blueberry farm and prefer your soils to be acidic and you'll need to maintain that pH, but most of us are gardening too, and we'll all want 6.5–7 pH and 400-450 mV Eh in our soils there, so we will all eventually seek specific compost to maintain and not disturb the soil balance we've already created regardless of what pH/Eh we are talking about (or you might instead focus on biofertilizers and foliar sprays to buffer and support your plants in creating the soil pH/Eh and SOM transitions themselves through seeds and photosynthesis which might save you time, money, and energy – it depends on what resources you have access to).

COMPOST INGREDIENTS

It's easy to fall prey to the math and the clean numbers of industrial composting formulas, BUT we have to remember that they are using much less diversity of inputs when making these calculations (this isn't municipal composting where it's a mix of everything and the goal is to err on the hot side to guarantee breakdown). Every C/N ratio and moisture percentage listed anywhere is a generalization, and it does not reflect the precise C/N ratios or moisture contents of actual materials which naturally fluctuate in their C/N ratios and moisture levels even among homogenous materials. This is why industrial composting operations do thorough testing to be precise with their large-scale compost operations: they dry out the material to calculate the moisture content over a 24 hr time period and they have tests done for the actual C/N ratios and N percentages of materials – being off with our calculations for acres of compost is expensive and time-consuming to correct. That being said, the beautiful thing about small-scale composting is it can be easily adapted on the fly, so even if you are winging it and using just your eyes, sense of smell, and sense of touch, you can fix things and still get good compost. There are also compost calculators online that are professional and others that are more generalized that will give you an idea of how close you are to that ideal 20–30:1 C:N ratio:

- Cornell's Compost Calculator requires moisture %, N%, C%, and weight but it gives individual C:N ratios of materials and the aggregate C:N ratio of the pile. It is the best professional compost calculator online that I've come across: http://compost.css.cornell.edu/calc/2.html

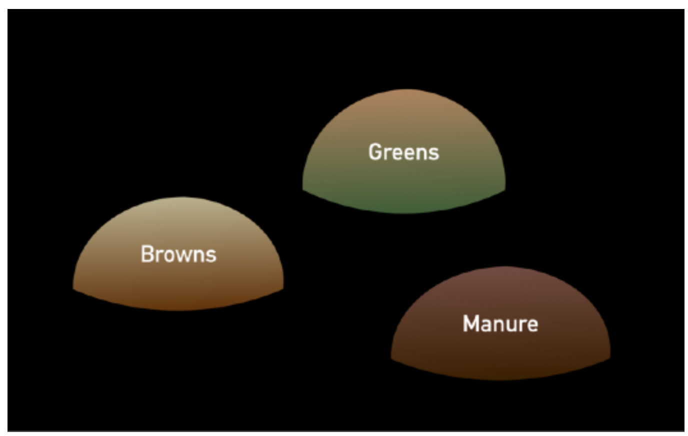
- Morning Chores Compost Calculator is a more simplified version of the Cornell's calculator. It only requires the "parts" of each ingredient in the pile and uses the generalized C:N ratios and skips moisture % to produce a generalized C%, N%, and C:N ratio: https://morningchores.com/compost-calculator/

If you are interested in calculating the moisture content yourself, you can follow the Cornell guidelines here: http://www.compost.css.cornell.edu/calc/moisture_content.html

If you are interested in running the entire series of equations yourself, you can also do that here – again, thanks to Cornell: http://www.compost.css.cornell.edu/calc/cn_ratio.html

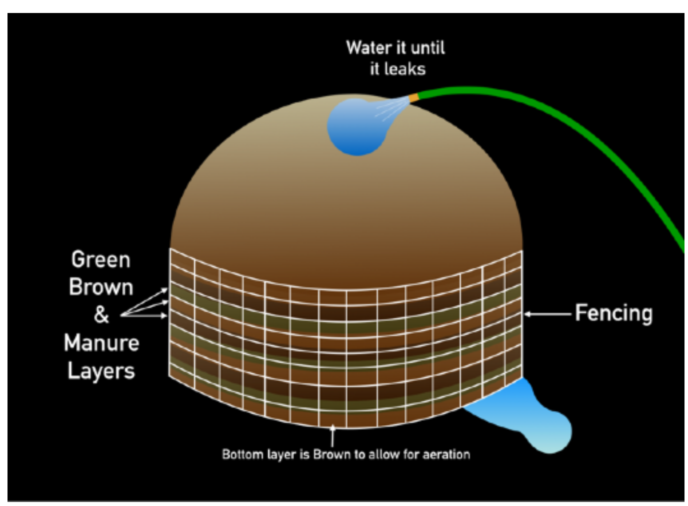
Seeds – seeds are all the focused energy of an annual plant captured in a small package. The seed contains everything a baby plant needs to start growing. Seen in this light, it's not a surprise that they are high in N.

Fruit & Flowers – fruits and flowers are high in phosphorous, nitrogen, and other essential nutrients as well as an immense amount of sugar and moisture if we are talking about most cultivated fruits from healthy plants – this causes them to breakdown quickly making them excellent additions to compost heaps. Fruit is also extremely high in microbial content since both flowers and then fruit are so often visited, so exposed, and are also the inoculation setting for the next generation of plants.



"Greens" = Growing Plants - These are plants that are harvested in the vegetative state, while they are still growing. They are high in bacteria, endophytes, simple sugars, carbohydrates, and easily broken-down cellulose.

Browns - these are plants that have gone to seed and they are mostly just standing, dried out carbon: cellulose and lignin.



High Lignin = Woody Materials - sticks, bark, branches, tough seed coats, tough husks, wood chips, logs, etc. It is of the forest and woody world that we create compost that supports those types of plants – it makes perfect sense and alignment.

Animal Manures – a critical compost reaction ignitor, it is often the sole ingredient in mouldering piles of manure at ranches or stables. Manures are high in nitrogen and other essential nutrients in organic compounds, but we often steer towards herbivore especially ruminant manures instead of predator manures due their extremely high N content and often high pathogen and viral counts though in hot composts they can be properly composted as can small animal carcasses, meat, bones, and other highly nitrogenous waste in small amounts.

Compost Starters – often manure is used to start composts, but fresh comfrey, alfalfa, or even chicken carcass can be placed at the center of a hot compost.

Humanure – a contentious topic, but an important one, humanure's benefit is contingent upon the health and diet of the person generating it and how it is composted. Ideally, humanure is composted at a high heat for a few weeks and then allowed to mature for an extended time period, often a year.

Dr. Elaine Ingham with a handful of material that is 6 days into composting.

COMPOST METHODS

Every method has a set or series of techniques associated with it. They all have their benefits, their range of possibilities, and their limitations. Some won't break down your wood, some won't do well with meat or dairy, but in this list you'll find solutions to turn it all into rich soil or soil amendments.

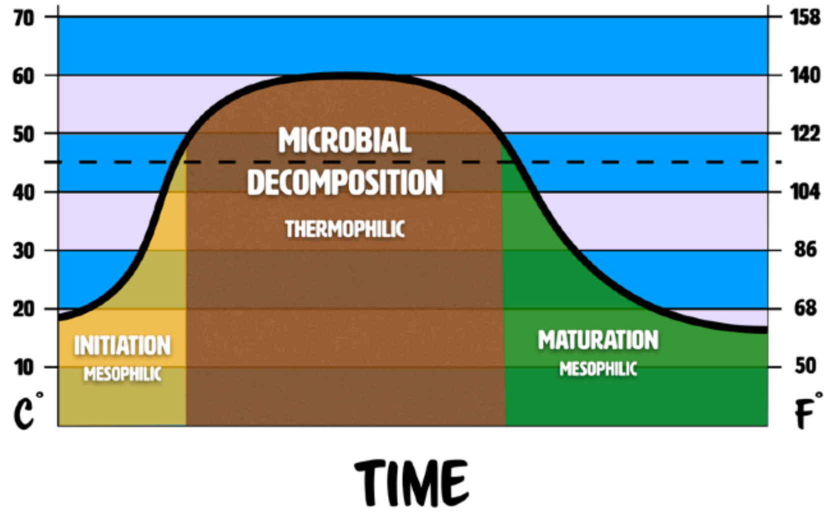
MOULDERING COMPOSTING

This is compost most of us prefer: you have a designated area that you dump organic matter and it decomposes. It may be in a pit, wooden frame, or even an old tub, but it's not something that is dealt with until it fills and sits for a long time. Mouldering compost piles take months (at least 3) and their specific nature is unique to the ingredients added, the climate, the surrounding soil and biodiversity above and below ground, the size of the biomass, their proportions, the amount of shade and light, whether or not it is covered and watered, and the amount of time given. What is clear is the longer we wait and the larger the size pile, the better it will be, and the graver our potential mistakes with ingredients and pile design, the more they'll be mitigated by that stretch of time. *Good things come to those who wait! And time heals all mistakes!*

MOULDERING COMPOST PREP

1. Find an area that is shady with good air flow
2. Ideally, dig a shallow pit or hollow into the land, but even if you don't do this, life will start to drag it down into the soil profile*
3. If desired, add a perimeter to the pit as you would for a raised bed but never make a bottom on your mouldering compost pile

4. Ideally, add a lid or tarp to cover your compost to trap moisture, protect microbes, and keep out most animals*
5. Fill the compost and then leave it alone as it breaks down (3 months or more)
6. Once it has broken down and shrunk into the earth, you can add more composting ingredients or dig up the compost and use it



For some folks doing this method attracts rats and other undesirable visitors in urban settings, etc. so use discretion and common sense.

THERMOPHILIC "HOT" COMPOSTING

Are you in a hurry? Do you have diseased plants you need to purge from your farm's ecosystem by burning them? Do you have manure with weed seeds in it? Do you have to compost everything under the sun and adhere to a national composting standard? Do you have a deadline? *Hot compost can help you.* Hot compost is relatively easy if you have the time to turn, monitor, and water a cubic meter or more of organic matter. At its most basic, thermophilic or "hot" composting is the decomposition of organic matter rich in N and C to generate a thoroughly decomposed SOM amendment.

Thermophilic composting is a way of decomposing organic matter to create a safe, pathogen-free, weed seed-free, parasite egg-free, and humus-rich soil amendment that is saturated with beneficial aerobic soil microbes and a broad spectrum of nutrients. Humus itself doesn't contain nitrogen or phosphorous; it is comprised of carbon compounds that are continuously breaking down into smaller, finer compounds. Hot composts are a quick process: if you aren't observing, measuring the temperatures within it, and turning the compost when it needs to be turned, you will lose fertility, nutrients, and time—it can also catch fire! It will also exhaust greenhouse gases into the environment instead of sequestering the carbon, nitrogen, and more.

For a compost to be effective, the ingredients must be as precise as possible. The initial pile by volume is made of a third brown organic matter (high carbon, dead, dried plant material that has already gone to seed), a third green organic matter (these are plant materials that haven't gone to seed, so they still contain enzymes, nitrogen, protein, and sugars—they can be dried or fresh), and a third manure or another nitrogen-heavy component. This even split is the ideal composition for a pile that is at minimum one cubic meter in size. The larger the pile is, the easier it will be for the microbes to go to work but the harder it will be to turn. Large operations use heavy machinery to turn their piles. (In the summer heat, smaller piles are possible).

Compost piles need more carbon when you use hotter manure sources to maintain the 20–30:1, C:N ratio. A pile that is a third chicken manure will have a higher nitrogen content than one that is a third cow manure simply because of the nature of the waste itself. Wood chips likewise contain more carbon than straw; they are higher in density. Hotter piles burn quicker and provide less compost as their end product, so if you notice yourself turning it more often, mix in some saw dust or well-shredded, dried plant material for more carbon to balance out the excess nitrogen. The heat is generated by microbial activity: first mesophilic and then peaking with thermophilic and then back to mesophilic. This plot structure form of biological turnover can have a very long tail as mentioned earlier with Johnson-Su composting, but typically, the gardener is eyeballing the pile in eager anticipation of the moment they can transfer it to the garden or compost tea bucket or barrel.

BOKASHI INGREDIENTS	AMOUNT
Bag of Wheat or Rice Bran	50 lbs (22.7 kg)
Biochar	Equal Parts to Bran
Water	4 gal (15 L)
EM-1® or Cuauhtemoc's Liquid Biofertilizer	2–6 oz (59–177 ml)
Molasses	2–6 oz (59–177 ml)

For perennial systems, a woody compost is ideal because it will require fungi to breakdown the wood lignin, and the resultant compost will be more fungal-dominant. If we add extra fresh cut grasses or weeds, we can easily create a bacterial-dominant compost which is ideal for establishing gardens in acidic soils.

DR. ELAINE INGHAM CLASSIC HOT COMPOSTING PREP

This is the standard 15-day Dr. Elaine Ingham Hot Composting Method

INGREDIENT	10 lbs (4.5 kg)	50 lbs (22.6 kg)	2,000 lbs (907 kg)
EM-1® OR CUAUHTEMOC'S LIQUID BIOFERTILIZER	4 tbsp (59 ml)	3/4 cup (180 ml)	1 gal (3.7 L)
MOLASSES	4 tbsp (59 ml)	3/4 cup (180 ml)	1 gal (3.7 L)
WATER	10 cups (2.4 L)	3–4 gal (11–15 L)	75–100 gal (284–378 L)
BRAN (CARBON SOURCE)	10 lbs (4.5 kg)	50 lbs (22.6 kg)	2000 lbs (907 kg)

1. Gather 1/3rd m^3 browns, 1/3rd m^3 greens, and 1/3rd m^3 manure.
2. Combine the ingredients in layers only a few inches thick at a time, starting with browns while wetting each layer as it is applied.
3. When complete, water it until it leaks and cover it with a tarp especially in more humid regions where precipitation is a factor but as well to keep in the heat during cooler times and moisture in drier areas.
4. Wait 3 days and then turn it every other day from thereafter, as long as it maintains a 131°F–140°F (55°C–60°C) temperature range. If it is too cool, either don't turn it as often, so it builds heat, or add more manure and possibly greens to speed up the reactions and resultant heat.
5. At day 15, let it rest at least a week or longer for fungal populations to rise before using
6. If you are testing your compost or doing the microscope work yourself, your goal is to have a minimum of 300 beneficial bacteria per microgram of soil, 10,000 flagellates and amoebae per gram of soil, and a few beneficial nematodes per gram of soil.

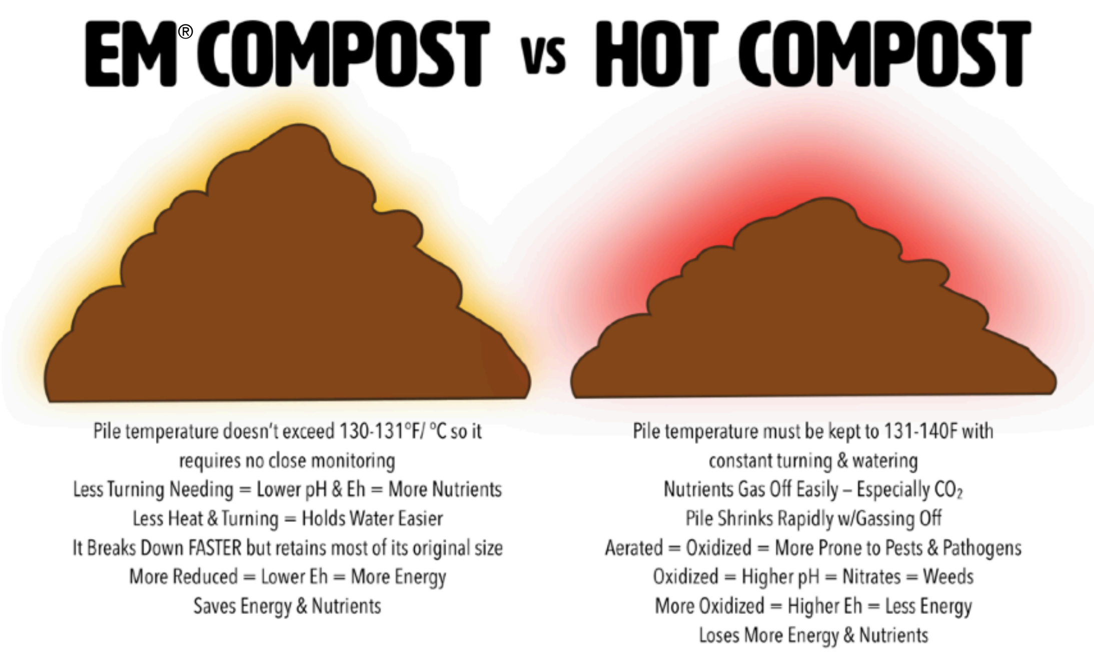
INGREDIENT	Amount
BONE MEAL	180 kg
FIG CAKE	300 kg
WATER	350 L
RICE BRAN	500 kg
MOLASSES	5 L
FISH MEAL	20 kg
EM	4 L

EM® COMPOSTING

This is a "warm" composting method – these are hot compost piles with a temperature governor and decomposition accelerant, so temperatures stay at or below 131˚F/55˚C and it breaks down faster and more efficiently while pathogens and putrefying agents are controlled. Because it doesn't reach the typical hot composting temperature range of 132˚F–140˚F, it doesn't gas off the carbon, nitrogen, and other nutrients. The pile shrinks less, breaks down more thoroughly, and requires less turning, but does not break down weed seeds and depending on how you do it, can take more time.

"Lactic acid bacteria, yeast, and phototrophic bacteria contained in EM® have the ability to ferment organic substances and prevent putrefaction. Therefore, for example, when making compost with EM®, putrefying bacteria will be suppressed and, due to the fermentation action of EM®, it is possible to manufacture compost with less turning than usual. Also, compost fermented by EM® is rich in amino acids and polysaccharides compared with compost produced by the usual methods. EM® prevents the production of ammonia during protein decomposition, metabolizing proteins in such a way that amino acids are produced instead. These amino acids can be directly absorbed by plants. Also, under normal circumstances, cellulose will be decomposed and broken down to form carbon dioxide. However, due to the fermentation action of EM®, low-molecular polysaccharides will be produced and these will be absorbed by microorganisms and plants. Generally, proteins are synthesized from nitrogen. However, if the plants can directly absorb amino acids from their roots, they can repurpose the energy that would have gone into producing amino acids and proteins, thereby producing fruit with more sugar."

– How EM® Works, EMROJapan.com (2016).



EM® COMPOSTING PREP

1. Prepare your compost pile as you would normally for a hot compost pile but let it fully drain and sit for a bit after it has been soaked through
2. Water it down with EM-1®(or Cuauhtemoc's Liquid Biofertilizer) at 1–2 liters per cubic meter and cover
3. Ferment for 6 weeks or turn pile once every week for 3 weeks
4. Water pile regularly with EM® to maintain 50-65% moisture and EM® activity
5. Use as a plant fertilizer or rich SOM amendment

BOKASHI EM® COMPOSTING

Bokashi means fermented organic matter, but more specifically it is organic matter inoculated with EM®. Bones, dairy, and anything organic can be digested by the bokashi EM® fermentation. It is commonly used on kitchen counters in Japan to digest organic matter of all kinds though its use is now spreading all over the world rapidly. Two weeks after it has fermented in the bucket, it can go into a hole in the ground and covered lightly for two more weeks, and after that, it is completely decomposed or nearly so. There are specialized bokashi buckets as well with a spigot on the bottom for EM®/Bokashi extract liquid!

There are many bokashi methods, but this first method using biochar is taught by Cuauhtemoc Villa in *The Advanced Permaculture Student Online* and slightly different from the TeraGanix recipe on their site. You can scale the Cuauhtemoc's biochar version of bokashi by just adding equal parts of biochar to bran (because it's much lighter than bran so you can't go by weight).

CUAUHTEMOC'S BIOCHAR BOKASHI PREP

1. Combine 1:1 biochar to bran or other organic matter (this can be compost, rice bran, insect frass, brewer's spent grains/beer mash, seabird guano, cow manure, worm castings, agricultural waste, nut husks, hulls, and more to add in unique biology)
2. Mix water with the molasses until it is dissolved
3. Add EM® to the molasses water and stir in
4. Combine all the ingredients and mix them until just moist all the way through: 25% moisture, so you can squish out just a bit of liquid when you squeeze the mix in a ball with your hands
5. Ferment the mix for 14–21 days with no air in a sealed barrel or black plastic bag. White mold is good, but green or black mold is bad and a sign of air getting in
6. You can then apply this to the soil or use it in a bucket system to digest your kitchen waste – including meat and dairy
7. Store wet for up to 2 weeks longer or dry it for long term storage – all storage must be in sealed airtight containers

TERAGANIX BOKASHI PREP

1. Mix water with the molasses until it is dissolved
2. Add EM® to the molasses water and stir in

3. Combine all the ingredients and mix them until just moist all the way through: 25% moisture, so you can squish out just a bit of liquid when you squeeze the mix in a ball with your hands
4. Ferment the mix for 14–21 days with no air in a sealed barrel or black plastic bag. White mold is good, but green or black mold is bad and a sign of air getting in
5. You can then apply this to the soil or use it in a bucket system to digest your kitchen waste - including meat and dairy
6. Store wet for up to 2 weeks longer or dry it for long term storage – all storage must be in sealed airtight containers

1 TON BOKASHI FARM FERTILIZER PREP

1. Mix water with the molasses until it is dissolved
2. Add EM® to liquid and stir well
3. Thoroughly mix fig cake, bone meal, fish meal, and rice bran
4. Combine liquid and "dry" ingredients and mix them until just moist all the way through: 25% moisture, so you can squish out just a bit of liquid when you squeeze the mix in a ball with your hands
5. Ferment the mix for 24 hrs covered with a tarp or vegetable fiber sacks to protect from the sun, wind, and rain.
6. Apply at a rate of 5 tons per hectare

TERRA PRETA COMPOSTING

There is a lot of debate and hearsay around terra preta. It's the source and inspiration for EM®, biochar, and bokashi. Passed word of mouth in off record conversations for decades, there is much confusion as to what actually led to the incredible rich and black soils of the Amazon – their stability in a tropical rainforest setting defies conventional understanding of soil science. It's clear terra preta is manmade as well, so this is something we can do again.

The first time I learned about EM®, biochar, and bokashi from Cuauhtemoc Villa, it was through the story of terra preta. Japanese researchers were studying terra preta from a microbiological perspective. They discovered that there were microbes in the soil maintaining it, and the biochar and broken clay shards were providing stable habitat for them. Michael Collins, one of Chez Panice's first farmers, went down to the Amazon to see what is happening today, and he saw large 1m wide clay pots being used to make *chicha*, the traditional corn beer, over burning pits with grandmothers inspecting the pots and spitting in each of them. These pots made from riverside clays (likely inoculated with PNSB) would often break or leak, dowsing the burning logs in yeast-rich, partially fermented corn broth. These pits become latrines, compost heaps, and dumps for the broken clay pots. The yeast and indigenous microorganisms worked together and formed stable, resilient habitat in those pits in the char and clay shards.

It's also reasonable to speculate that the LAB species could have come from sitting water and corn or corn rinse water of some other sort sitting for a few days, creating LAB, and that being used or being discarded into the pits, inoculating them without them even realizing it. In the rainforest, reactions happen fast, and it's logical that spoilage of materials was regular and led to dumping of failed attempts which led to the formation of LAB- and yeast-rich soils. The PNSB could have been indigenous or the concentrated manures could have eventually brought them into the ecosystem out of need for its role in the new behavioral pattern and ecological niche that opened up in a narrow facultative bandwidth (since the LAB and yeast hold the organic matter in a fermentation process of breakdown).

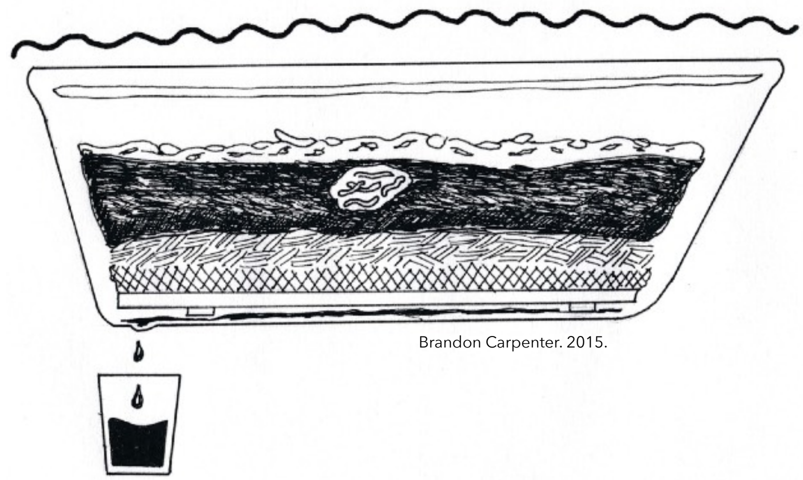
Overtime with this pattern expanding and becoming cultural to the region over generations, biochar, humanure, food waste, fermentation waste, LAB, & yeasts all combined in a facultative soil environment, allowing microbes to travel, communicate, and reproduce easily – creating more and more uniformity and transformation into a smoothly functioning consortium of microbes that maintain a very stable soil environment.

DIY TERRA PRETA COMPOST PIT PREP

1. Dig a pit 3–6 feet (1–2m) deep
2. Build a fire in the pit of uniformly sized fuel like sticks, branches, bamboo, or stalks – avoid large logs but you can have a few (but they'll be hugelkultur more than biochar if you do)
3. Let the fire reach the char stage fully (and ash just begins to form on the outside of the burning material)
4. Extinguish with EM/water mix until it is cooled off enough to stop steaming (I start with a low concentration but quickly switch to a heavier EM® mix to get it deeply into the char as fast as possible to fully inoculate it
5. Add your manure, kitchen waste, agricultural residues, or other biomass to compost, and water with EM/water as you layer it in
6. Biochar should not be crushed or forced down to the bottom but instead allowed to protrude through the layers of the compost vertically – if char breaks down too fully, dig out some of the char and mix it in as its own layer in the pit compost
7. Cover the pit with a cap of dirt and pat it down as a seal
8. Allow the pit to ferment for at least 1–3 months, but giving it a full year will create even more incredible soil

VERMICOMPOSTING

Using earthworms and compostable kitchen waste, we can create a bacterial–dominant compost of mostly worm castings (pH 7.8–8.6) that is potentially high in N, P, K, Ca, Fe, Zn, and Mn – it all depends on their diets. The gut pH of worms is typically 6.9, and their



Brandon Carpenter. 2015.

gut biome contains a consortium of bacteria: Bacillus, Enterobacter, Azotobacter, Pseudomonas, Klebsiella*, Aeromonas, Flavobacterium, Nocardia, Gordonia, Vibrio, Clostridium, Proteus, Serratia, and Mycobacterium. You can feed worms inoculated substrates, kelp, and insect frass to shift the castings to more fungal and acidic, but their digestion shifts things naturally more alkaline and bacterial (that's why they are a menace in forest systems not evolved for their presence). Together the worm juice (a leachate) and the worm castings themselves can be used to inoculate soils or to start a compost tea: just remember that the castings have worm eggs and we can spread composting worms into our ecosystems unknowingly and cause damage if we are not careful.

If indigenous earthworms are available, you can build a system that is very cheap and easy to build and maintain out of almost anything because it can have contact with the ground and be outside easily. A vermicompost bin can be as simple as 4 pallets attached to each other with a removable "trap" door on the bottom of one of them (make sure your pallets are safe and not toxic). You can also do a vermicompost trough or windrow that allow them to move laterally through the piles or trough. The general idea is to build a compost that shields the worms from light while it allows them to migrate upward or to the side to allow us to harvest their worm castings from below or to the side after they've left the area. We can also draw them to certain areas with their favorite foods like watermelon or any melon to allow us to remove castings without harming worms in pit worm composting situations (sometimes you do a pit compost and they show up!) Make sure to keep things cool and out of direct sunlight to keep the worms happy, and avoid feeding them citrus, hot peppers, onions, bones, meat, and garlic. Also avoid adding weeds since they don't breakdown weed seeds.

Sean Christopher Powers with a worm composting trough system. Photo by Sarah Powers (2020).

Termites, BSFL, and other insects are also great allies. Termites like ants farm fungi, and natural farmers are using the biology in their digestion to boost plant growth. Black soldier fly larvae (BSFL) create waste that is incredibly high in N and they themselves are very high in protein, so they make great bird feed, but they also break down food waste, produce high-N manure, and create a very unique compost. In the future, I'm sure we'll be partnering with more than just red wiggler worms (*Eisenia fetida*).

SIMPLE PALLET VERMICOMPOST PREP

1. Order, purchase local, or beg your friends for some composting worms (they're even on Amazon now)
2. Acquire 4 non-toxic pallets that are close enough in size and complete enough to hold a compost pile when they are nailed or screwed to each other in a square. Look up the stamp on the sides of the pallets online to know if they are toxic or not
3. Remove the 2 bottom section slats from 1 pallet

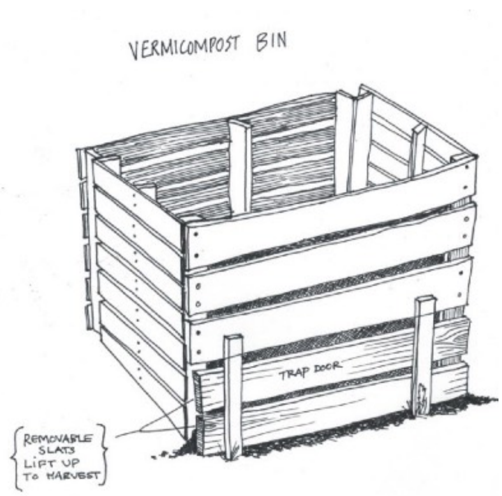


Image from *Worms at Work* by Crystal Stevens (2017).

4. Lightly screw the wood pieces back in to where they were using the nail holes as guides or create a removable section that is one piece with stabilizer sections like the image example (but remember you'll have to secure it somehow and still be able to remove it for access)
5. Add a layer of straw, grasses, or newspaper as a base layer
6. Add fresh cut plants, kitchen waste, coffee grinds, etc.
7. Introduce the worms
8. Cover with more grasses and straw and then cover with a tarp
9. Allow worms to do their work for ideally 3 months minimum
10. Harvest castings from below through the trapdoor and continue to add more compost ingredients from above – the pile will naturally shrink as it decomposes and is consumed
11. Use worm castings in the garden, vermicompost tea, biofertilizer creation, and in foliar sprays

GARBAGE CAN VERMICOMPOST PREP

Sean Christopher Powers with a worm composting garbage can system. Photo by Sarah Powers (2020).

1. Perforate the bottom of a garbage can or similar bin (can even be Tupperware or storage bins) – make the holes larger if the gap between the bins is large and make smaller if only worm juice is desired and the clearance between stacked bins or garbage cans is minimal
2. Put a spigot hole in another garbage can or similar bin and screw on a spigot for the worm juice
3. Add mesh like shade cloth to the bottom of the 2nd garbage can to keep castings from coming out through the worm juice spigot especially if you have a large gap and larger holes
4. Insert the perforated garbage can or bin into the spigot garbage can or bin (there should be some space at the bottom)
5. Acquire some composting worms – a few handfuls to start is all you'll need
6. Add grasses and straw to the base of the garbage can or bin
7. Add fresh kitchen waste, manure, grass cuttings, etc. to the can or bin loosely to leave plenty of air and space for worm travel
8. Add the composting worms
9. Cover with more grasses and straw
10. Place lid on trash can or bin
11. Keep in a cool, shaded spot out of direct sunlight
12. Allow worms to do their work for ideally 3 months minimum
12. Harvest worm juice as needed for compost teas, foliar sprays, or soil soaks
13. Harvest castings from below through the trapdoor and continue to add more compost ingredients from above – the pile will naturally shrink as it decomposes and is consumed
14. Use worm castings in the garden, vermicompost tea, biofertilizer creation, and in foliar sprays

STACKED BIN VERMICOMPOST PREP

Similar to the above prep, we can take it one step further: we can have nesting tupperware, storage bins, or even store-bought contraptions that allow us to have multiple levels of perforated stacked bins. You would start out just like the above system but then add perforated bins on top of each level over time and then as lower bins matured, they be removed for castings while the upper levels would retain the happily working worms. This can be indoors or outdoors if sheltered, but remember like all biology: they prefer having enough space and enough food.

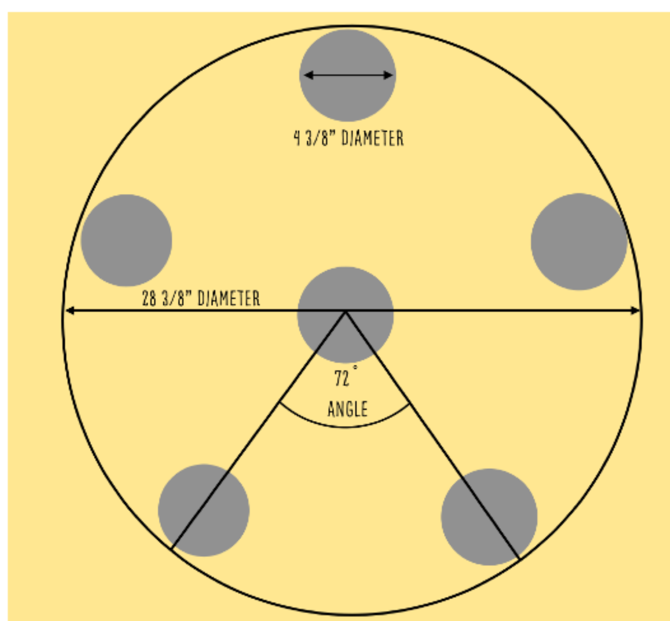
WORM JUICE COMPOST TUB PREP

1. Find an old tub or a waterproof container that allows liquid and air to pass through freely
2. Create a wooden or metal riser that everything can rest on and liquid can pass through
3. Add a layer of filtration on top of the riser like shade cloth mesh
4. Add a base layer of manure or fresh vermicompost with earthworm eggs or earthworms themselves
5. If your compost or manure lacks worms, acquire them and add them in at this point
6. Loosely add kitchen scraps on top mixed with freshly cut grasses
7. Once this tub is full, keep it covered and allow the worms to do their work for 3 months or more until it is all broken down and ready to be removed and added to the garden.
8. Once emptied, you can start the whole process over again

BLACK SOLDIER FLY LARVAE (BSFL) COMPOSTING

BSFL do not have the picky nature of earthworms, so the citrus, meat, etc. are all fair game for these organisms. They are also faster at breaking down organic matter than worms –a single larva will eat 200 mg of food waste a day and 1000 larvae will eat 1 kg (2.2 lbs) of food scraps a week. These larvae (or maggots) also scale to the size of the compost provided and mitigate toxins by bioaccumulating heavy metals like mercury in the food waste.

The key is to keep the system warm and dark and to put it away from the house: it will smell! Another interesting aspect is ramps can be added or the sides can be sloped on the compost container for larvae (maggots) to crawl out of the compost and into buckets or other catchment for chickens, fish, and other livestock to feed on. Large scale operations do not focus on capturing larvae for another purpose like feeding chickens but let the flies and larvae do their work continuously. Some systems allow flies to fly in and out while capturing larvae or keeping them contained to do their work.



Guide for cutting holes in the pallet platform and ground cloth mesh covering the pallet

SUPPLIES	TYPE	QUANTITY
LANDSCAPE OR GROUND CLOTH	woven and at least 5 oz. weight	3 pieces total: 13′ x 6′ 6′ x 6′ 6′ x 6′
WIRE RE-MESH	6″x6″ square 10-guage wire re-mesh (usually used for concrete reinforcement)	5′ x 12′ 6″
WIRE	Rebar Tie Wire	1 spools
SHIPPING PALLET	non-toxic and sturdy	1 pallet approx. 40″ x 48″ in size
PIPING	septic drain field piping	6 pipes total: 6′ x 4″
GARDEN HOSE	0.5″ hose	However long to reach your water source from the top of the bioreactor
IRRIGATION HOSE RING	0.5 hose – perforated every 4-5″ with 16″ inch holes and made into a ring with a T-hose fitting connector	7.5 of hose to form the ring
BIOMASS	Dairy manure, leaves/yard waste, and wood chips (3/8″ across or smaller)	1/3rd of each ingredient

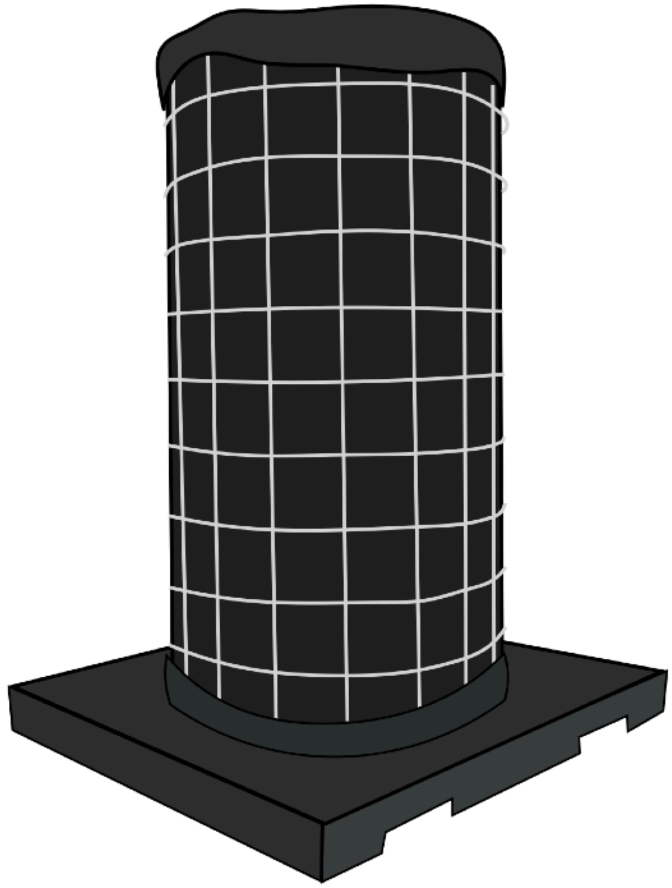
Other systems are fully contained and do not let the flies escape, keeping all of the flies inside the composter for the entirety of their 2 weeks of life. The dead flies also add concentrated nutrients to the compost but if one is trying to remediate the food waste of heavy metal they would want the flies to escape with their bioaccumulated toxins.

The resultant compost from their activities is very high in NPK, and the larvae are very high in protein, so they are excellent feed. The adults also don't bite, so they are ideal flies to have around for many reasons.

BSFL COMPOST PREP

1. Purchase or acquire from a friend BSFL
2. Find a warm area for your BSFL compost setup
3. Build or purchase a BSFL composting system: can be as simple as a partially covered bucket of food waste
4. Add food waste to the composting system
5. Add BSFL to the food waste
6. Continuously add food waste to the composter until it is full of fully digested compost
7. Empty the composter, preserving larvae for the next round or allowing adult flies to access the new food to start the process over again

8. Smell the compost – if it does not smell ready for the garden, apply EM/water dilution to the pile for 7–14 days of further composting or use the BSFL compost in IMO-5 prep

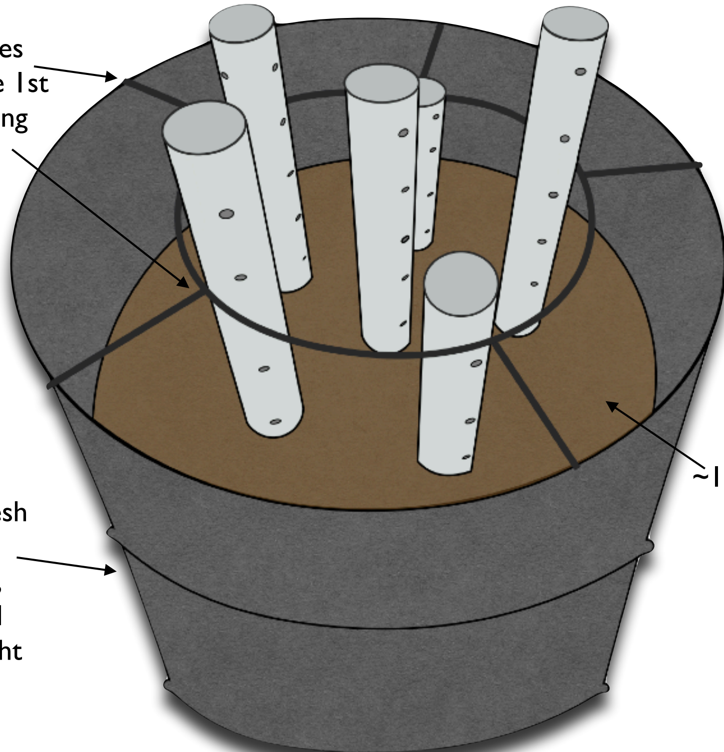


JOHNSON-SU "BEAM" COMPOSTING

It's a hot compost, but it's also a static compost. It's perhaps the most beneficial compost ever documented. Johnson-Su "BEAM" or Biologically Enhanced Agricultural Management compost is unique in its construction and results. Developed by New Mexico University professor Dr. David Johnson and his wife, Hui-Chun Su, this method requires a lot of upfront labor and then a year of waiting, but the bioreactor setup can be reused (though I've gotten feedback that the pallet used as the base is mostly digested by the end of the year.) Essentially, the Johnson-Su method is a large-scale and field-tested bioreactor composting method that is reliable, replicable, and consistent with its results. 375 gallons of material (approx. 1800 lbs) of material can fit into these bioreactors, and it turns into a clay-like SOM that is much more resistant to leaching, weathering, and biological degradation in the soil than typical compost. In many ways this is a product of time, static aeration, and fungal action, other composting methods don't take the full year, nor do they provide access to air within 12″ of any given point in the pile, and nor do they give fungi complete free rein. We can do smaller bioreactors than the 375 gal version Dr. Johnson uses and use different ingredients, but we must maintain those key attributes for similar results to be had.

	INGREDIENT	Amount
	1ST LAYER OF COMPOSTED OR FRESH MANURE (SEEDLESS)	1–2″ (2–5cm)
	NEWSPAPER OR CARDBOARD	1/4–1″ (1–2cm)
	2ND LAYER OF COMPOSTED OR FRESH MANURE	1–2″ (2–5cm)
	ORGANIC MULCH (STRAW, GRASS CLIPPINGS, RAMIAL WOOD CHIPS)	6–18″ (15–46cm)
	COMPOST	1–3″ (2.5–7.5cm)
	LIGHT SCATTER MULCH	0.25–0.5″ (0.6–1.3cm)

When analyzed, BEAM compost has an incredible diversity of microbes including some that have not been documented since Louis Pasteur himself was scanning the territory with his own microscope. There are P solubilizers, N fixers (free-living & symbiotic), metal oxidizers for all essential nutrients (and beyond), carbon monoxide oxidizers, pesticide degraders, phytochemical producers, xenobiotic producers, and antibiotic and antimicrobial producers. Quorum sensing, when microbiology begins to communicate and regulate their genes as a whole in relation to



population density, is incredibly high in the finished compost – these microbes work together efficiently and as a team. Incredibly, the carbon cycling abilities of this consortium of microbes is similar to photosynthesis in the healthiest plants: applications of Johnson-Su compost have led to 0.24% SOM increase annually with a potential for 0.51% increase annually, according to Dr. David Johnson and his research: that's 10.7 metric tons of C per year per hectare i.e. over 38,000 lbs of C per acre per year, but there's a potential for 37metric tons of C per hectare a year. With a cover crop growing in BEAM amended soils, Dr. Johnson was seeing 3186 g of dry biomass per m^2 a year and 777 lbs of N per acre per year. While an increase in fungal populations and activity in the compost correlates to more CO_2 release initially (from fungal respiration), the sequestration abilities of fungi mature over time, and while there's a documented 4x increase in carbon respiration, there's a 18x increase in SOM (soil carbon) and a 5x increase in microbial biomass.

"At 10.7 tons carbon per hectare per year increase, it only takes 40% of arable land on this planet to capture all anthropogenic CO_2 – so half a percent a year, we are looking at half that rate"

– David Johnson, EcoFarm Keynote 2018

Using only 1 application of the advanced BEAM compost on only 20% of the arable land, we would see ALL excess atmospheric carbon taken into the soil within 1 year – it's just that easy, but it requires time, effort, resources, and investment to make it happen.

JOHNSON-SU "BEAM" COMPOST PREP

You don’t have to create the same sized bioreactor, so please don’t be intimidated by the size and dimensions mentioned here, BUT you do have to maintain the length of time (a full year), the 12″ distance to open air from anywhere in the pile, the protection from light, and the static nature of the pile. You don’t have to have a metal form to hold your pipes while you fill your bioreactor, and you don’t have to make it as large. Ideally, all materials should be dried before composting and then shredded or chipped for maximum surface area. You don’t have to do the exact ingredients listed (it can be entirely leaves), but to get similar results, I’d stick with the original recipe. Once your materials are the proper size, soak them in water for 60 seconds to adequately wet them. This is similar to how some folks soak straw before using it. This type of composting method requires 70% or greater moisture levels for microbes to do their best: this is why an irrigation hose ring is used to irrigate the bioreactor daily for 1 minute a day.

DAY 1

1. Gather all the supplies and tools needed for construction
2. Create a cutting guide for the pipe holes using the diagram above
3. Cut holes in your pallet using your newly created guide to avoid cutting all the way through any planks – if you cut through any planks, use bricks or another support beneath them to maintain the integrity of your bioreactor. You can also reuse the guide over and over.
4. Using the guide, cut holes in a section of the 6′ x 6′ ground cloth and lay over the pallet
5. Sew the large landscape cloth, the 13′ x 6′ piece, to the wire re-mesh with tie wire
6. Roll the wire re-mesh and attached ground cloth and secure with tie wire every 6″
7. Fold excess ground cloth over the upper and lower edges (as seen in the diagram)
8. Acquire or cut 6 septic drainage 4″ pipes to 6′
9. Place the pipes in the holes in the bioreactor base
10. If you have a metal form for the pipes, you can place it on the top of the bioreactor and wire the pipes to the form (or have a helper hold them)

DAY 2

1. Gather pre-shredded and dried compost ingredients: 125 gal of dairy manure, 125 gal of yard waste, and 125 gal of wood chips – or you can use all yard waste or any combination of biomass that you have on hand as long as it is dried and pre-shredded with a ratio close to 20–30:1, C:N.
2. Thoroughly mix the ingredients or add in alternating buckets later on
3. Submerge ingredients in water for 60 seconds
4. Add wetted material to the bioreactor but don’t pack it because this can cause anaerobic pockets to form – this entire process can take time
5. Once the bioreactor is filled, connect the perforated irrigation ring hose with a T-hose connector to a longer garden hose connected to your water spigot and an automated timer
6. Set the automated watering timer to 1 minute per day
7. Cover the bioreactor with the final piece of ground cloth (6′ x 6′) to keep moisture levels high – tuck the corners into the re-mesh or secure one side with tie wire and tuck only one side

8. Let the thermophilic reaction begin
9. After 24 hrs, remove the perforated pipes and return the ground cloth cover
10. Let the compost sit another 3–6 days as it goes through the full thermophilic stage (145–165˚F)
11. Once temperatures have cooled to 80˚F, add earthworms
12. Allow compost to sit and mature for 9–12 months, ideally a full year since that is where there is a large microbial population jump
13. Apply as compost slurry, extract, seed coating, or top dressing

STATIC AERATED COMPOST

We can elaborate on the design concepts behind the Johnson-Su composting method: we can create static, semi-aerated compost piles. Perforated hoses usually used for pumping water can be used to provide air from inside or beneath compost heaps so they do not need to be turned. Perforated pipes can be added to piles as well to imitate the Johnson-Su method – these could be freeform piles, fenced columns, compost boxes, or even pits. The idea is to keep things still and still allow air to reach within 12″ of all areas within the pile (air can penetrate up to 12″ of soil easily. Feel free to modify and experiment with this concept.

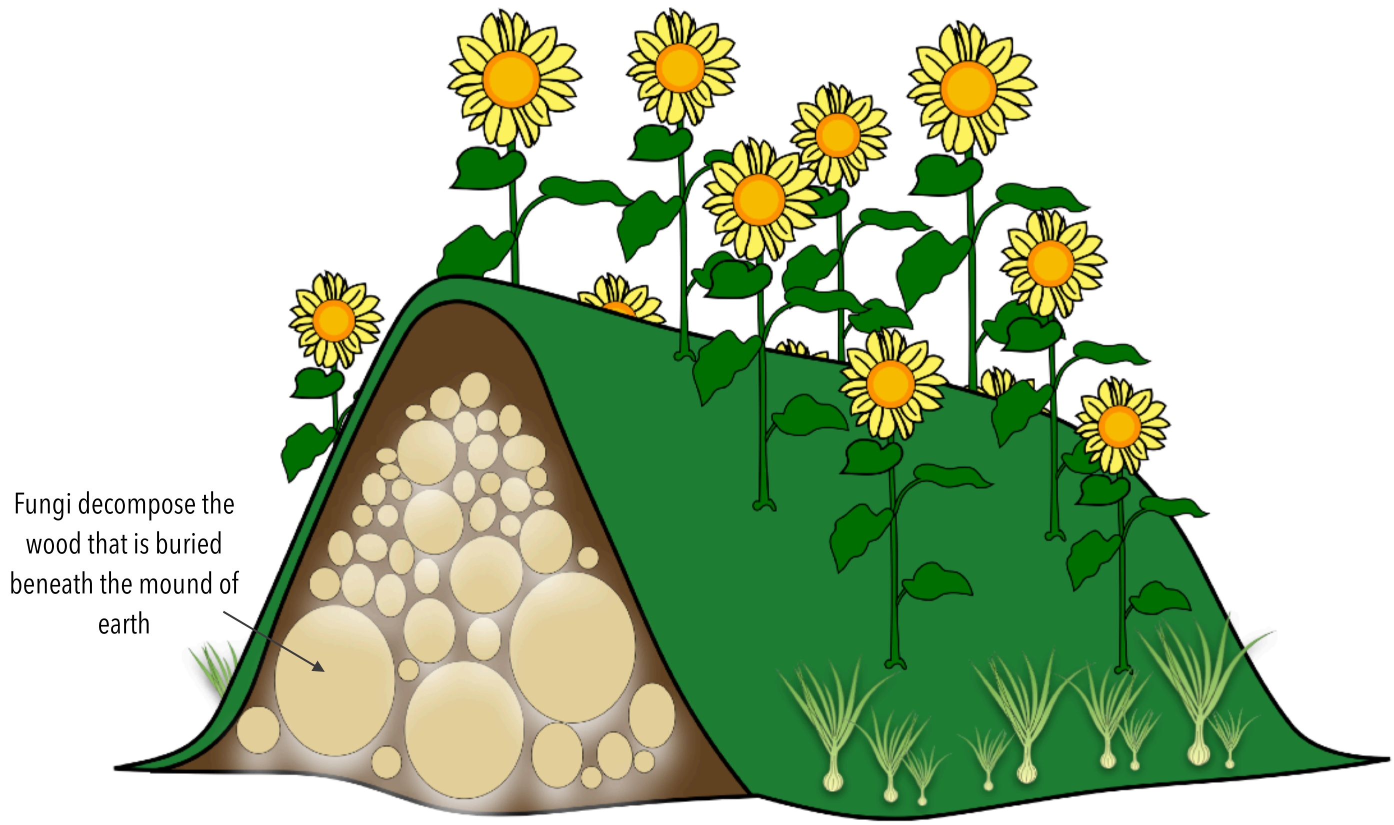
"WOODY" JEAN PAIN COMPOSTING

Jean Pain was a Frenchman who used woody compost heaps in numerous ways: to heat his home and his water, to fertilize his gardens, and to power his truck. His simple ingenuity captured the methane from the compost as it gassed off for his vehicle and cooking range, used the heat from the pile to heat water for using in the kitchen, bathroom, and radiators, and then used the rich compost at the end of the decomposition in the garden. Instead of burning the fuel wood, perpetually choking the countryside around him, Jean Pain slowly released the potential inside of the wood to create numerous, stacked benefits.

BASIC JEAN PAIN COMPOSTING PREP

This is a great fungal compost especially for orchard applications

14. Gather a variety of woody yard waste or trimmings – 8mm or less in diameter only or pre-chipped
15. Submerge woody brush and trimmings in water for several days – use a weight on top to press it down
16. Gather wetted material into a pile for 3 weeks – let sit and allow fermentation to begin
17. Shred the material with a pitch fork or use a chipper/shredder (or if pre-shredded or chips, skip this step)
18. Build a new triangular pile, 2m 20cm at its base and 1m 60cm at it's peak – loosely, with plenty of air
19. Cover the entire pile carefully with a 2cm cap of earth, sand, leaf mould, or old compost
20. Cover the pile with a tarp or with a thick layer of boughs to keep out the rain, sun, wind, and snow
21. Let pile mature for 90 days – it will first go through a thermophilic stage
22. Cut into the pile and test the compost: if a woody piece resists pressure, it is not ready, but if woody pieces crumble when pressed in our fingers, it is ready! If the pile is dry and the woody pieces unfinished, wet the pile and let it compost longer (check it again in 30–60 days).
23. Apply woody compost in orchards, food forests, and even the garden for strong fungal activity and rich soil



Inspired by Sepp Holzer and Permies.com's hugelkultur diagrams

SHEET MULCHING

Sheet mulching is an easy and effective way to turn a lawn into a garden or build up rather than dig down when we don't even have dirt to transform into soil. It's also a great way to deal with waste products like newspapers and cardboard though any paper or even ramial wood chips will do. It is a mulch to cover the soil, a way to smother weeds, and a form of in-situ composting. Remember: the ingredients and amounts depend on your site, climate, and available resources — and everything has a different effect: an inch of chicken manure is very different than an inch of rabbit manure. You may end up with an imbalanced or over-fertilized soil if you are not careful, so consult the C:N ratio chart to build a DIY sheet mulching recipe that is 20:1 C:N or slightly higher in N for faster breakdown in situ.

SHEET COMPOSTING PREP

24. Aerate the soil, chop and drop the plants in place, and prepare the area for the sheet mulch
25. Soak all ingredients to begin with and use what you can
26. Add a manure layer first then newspaper or cardboard followed by a 2nd manure layer
27. Add mulch – shredded and/or chipped biomass: ideally a cover crop or green manure biomass for fast break down
28. Add compost
29. Scatter light mulch on top

30. Allow 30–90 days for soil to compost in place and mature. This process can be sped up by watering in EM®, adding high N manure, adding fresh, high N organic mulch, adding comfrey, adding biochar to the organic mulch layer, and spraying the initial mixture down with compost tea

HUGELKULTUR

Hugelkulturs build soil quickly by imitating deadfall in a forest. Associated often with Austria's Sepp Holzer, hugelkulturs are mound-cultures in translation: you mound dirt on top of a wood pile which speeds up decomposition of the wood and feeds and heats the plants growing on the mound. This is also a great way to compost without losing by-products into the atmosphere, especially if it is too hot: hugelkulturs work like a contained compost where the plants, soil, and soil life intercept the released forms of nitrogen and carbon. Water is also held extremely well by the punky, fungi-inoculated wood inside the mounds. These kinds of earthworks could be used to build back the soil in the forests of the Western United States and many other degraded landscapes worldwide. They can be used as firebreaks and areas to replant the new polycultures.

Hugelkulturs generate fungal-dominant soil. They are great for large-scale and small-scale annual and perennial plantings. Hugelkulturs are a great alternative to burning and an easy way to build more soil with excess woody materials – similar to the Jean Pain capped woody compost pile, Sepp Holzer usually sets them up in slightly off contour windrows.

In sandy soils, the wood should be sunken into the earth. In soils with more clay, semi-sunken or even on top of the surface is viable. How deeply or not deeply embedded is also dependent on the context – if you are on a

INGREDIENT	AMOUNT
Bacterial Compost	2.5–7 kg (5–15 lbs)
Soluble Cold-Water Kelp	250 g (4 oz)
FPJ/FFJ/EM/Fish Emulsion	30 ml (1 oz)
Molasses	30 ml (1 oz)

INGREDIENT	AMOUNT
Fungal Compost	2.5–7 kg (5–15 lbs)
Soluble Cold-Water Kelp	250 g (4 oz)
Fish Hydrolysate	250 g (4 oz)
AMF or ECM Inoculant	120 g (8 tbsp)

INGREDIENT	AMOUNT
Balanced Compost	2.5–7 kg (5–15 lbs)
Soluble Cold-Water Kelp	250 g (4 oz)
Fish Hydrolysate, soybean meal, feathermeal, oatmeal, or fruit pulp	30 ml (1 oz)
Humic Acids	30 ml (1 oz)

*In very small amounts, OHN, humic acids, yeast, soybean meal, feathermeal, oatmeal, fruit pulp, and fruit juices can also all be added to feed the fungal tea

These are adaptations of compost tea recipes from *The Compost Tea Brewing Manual* by Elaine Ingham, 2014.

slope or get a lot of rainfall, you will want to bury the wood at least enough to give it a stable resting point in case of flooding. Wood floats, so hugelkulturs on undisturbed hardpan in flooding events have been known to float and then roll downhill, which is dangerous.

Above all hugelkulturs are a waste management strategy for putting an abundance of woody material to productive use and should not be a strategy for building gardens from scratch. It is much easier to sheet mulch with already processed woody material wastes that we have in abundance, such as paper and cardboard, without cutting down more trees.

HUGELKULTUR PREP

1. Soak the woody biomass overnight or for several days
2. Dig down and remove the topsoil from the area you want to put the hugelkultur – set aside for later
3. Dig down further 10–30cm or more – set aside this soil separately for later
4. Arrange woody biomass large to small, bottom to top in a pile, but feel free to use smaller pieces to fill in the gaps created by larger pieces
5. Mix soil in-between all wood pieces (handfuls of biochar can also be added)
6. Cover the wood pile completely with the 2nd soil pile
7. Apply the topsoil to the mound and cover up any remaining woody biomass exposed – add more soil if necessary
8. Apply compost, seed, and a scatter mulch
9. Drench the soil water + compost tea, biofertilizers like *rhizobium*, *rhizophagus intraradices & azospirillum brasilense*, and/or EM
10. Water and replant when needed but eventually the breakdown will ideally provide all the water the plants will need (3–5 years into the process) and if you plant self-seeding annuals or perennials, you won't even have to plant again

COMPOST TEAS

Dr. Elaine Ingham's Compost Tea Recipes

An excellent way to scale up the microbes from our highest quality composts whether thermophilic, vermicompost, Johnson-Su, IMO-4, etc. Just remember all these teas are actively aerated in a 55 gal barrel for only 24–48 hrs in warm temperatures (and longer in cold temperatures), the amount of compost added depends on quality, and then they only keep for around 8 hours, and then they begin to lose vitality. Use an air pump that is equal to the amount of water you're using and stone you can clean. Transform soils and revitalize plants with a liquid inoculation of beneficial biology, enzymes, amino acids, phytohormones, and more! Teas can change pH/Eh significantly - there are even studies showing that it can shift soils by 10 mv.

APPLICATION

- Use as foliar spray, coating at least 70% of plant surfaces, 50 L per hectare (5 gal per acre) – use water as a carrier to spread out the compost tea over the full hectare or acre but don't try to dilute it, just match it to your sprayer's regular volume of output per acre or hectare. Gardeners can use undiluted at a rate of 1 L (0.25 gal) of tea per plant starting at the seedling stage or in regular watering diluted 2:1 or 4:1.
- Use as a soil soak, 200 L per hectare (20 gal per acre)

COMPOST TEA ANALYSIS

Beneficial compost has ranges for its bacteria, fungi, protozoa, and nematodes. There's also certain actors that are red flags for anaerobic and pathogenic conditions like ciliates, so breakout your 400x microscope and dilute your soil sample 1:5 in clean water and start counting microbes!

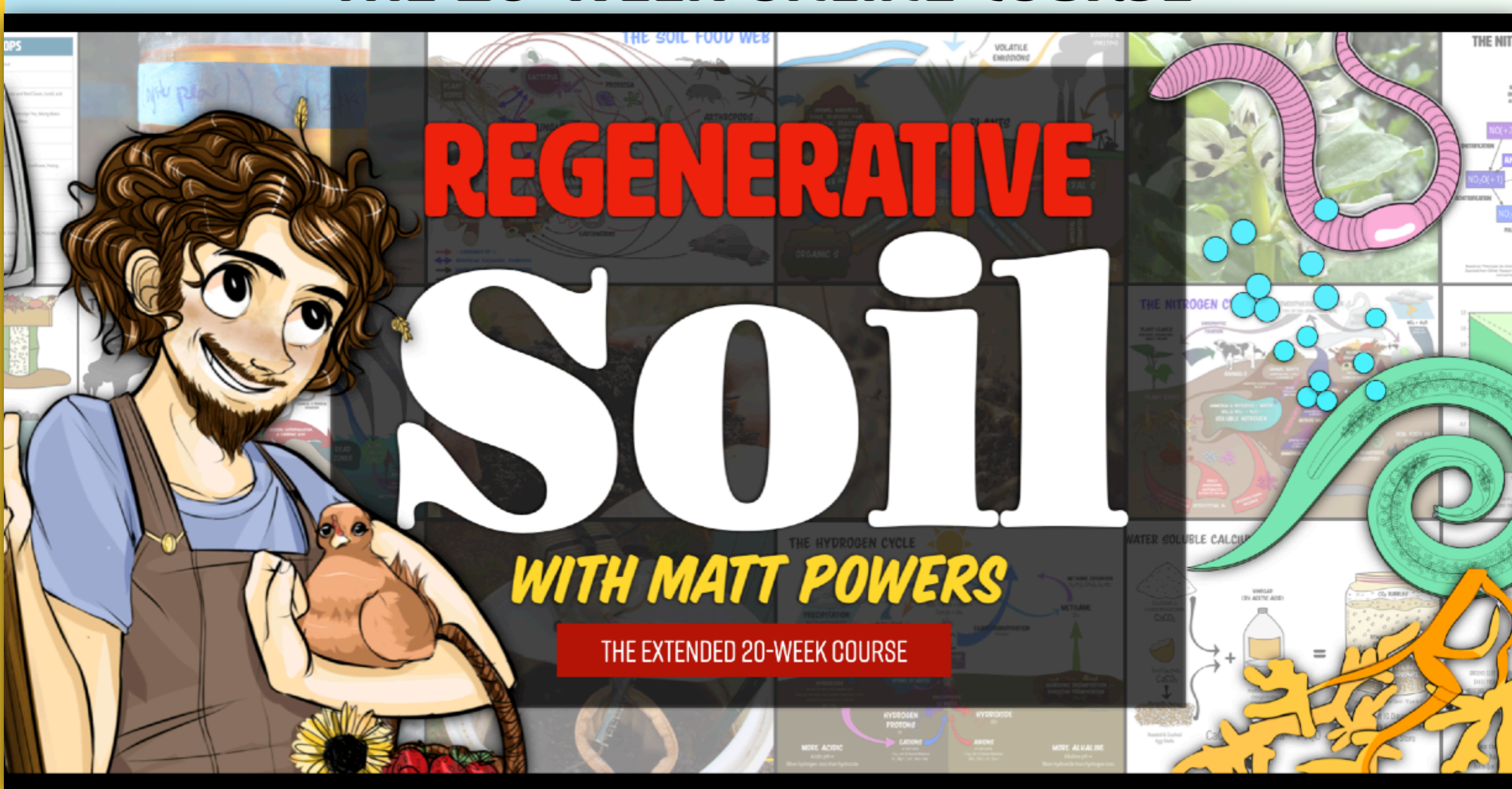
- 100's–1000's of bacteria per field of view
- 1 or more strands of mycorrhizal fungi every 5 fields
- 1 or more beneficial protozoa (amoebae or flagellates) every 5–10 fields
- 1 beneficial nematode per drop of soil water

HUMIC SUBSTANCES = COMPOST EXTRACT

Commercially acquired humic and fulvic acids are separated from each other using centrifuges in an N_2 atmospheric condition where they adjust the pH to coagulate the humic acids (even down to pH 1). This is an intense process energetically and biologically catastrophic, so it reduces a lot of the functionality and holistic benefits that complete humic substances from compost can offer. That being said, humic acids and fulvic acids do have functional uses individually and produce beneficial effects.

1. Run water gently through a compost heap (or IMO or Bokashi pile)
2. The dark water that passively leaks out of the pile is rich in humic acids of all sizes (humic and fulvic)
3. Use as a substitute for store bought humic powders and solutions

THE 20-WEEK ONLINE COURSE



"THIS IS A COURSE THAT TAKES THE BEST OF ALL THE GREATEST MINDS IN THE WORLD OF SOIL REGENERATION AND PUTS THEM INTO ONE UNDERSTANDABLE COURSE THAT MAKES SENSE."
- MIKE GARCIA,
AWARD WINNING LANDSCAPER & FOUNDER OF ENVIROPONDS

"I HAD DOUBTS ABOUT WHETHER I WOULD MANAGE ON THIS COURSE BECAUSE I HAVE ALWAYS BEEN INTIMIDATED BY SCIENCE AND THIS HAS BEEN SUCH A NON-THREATENING, UPLIFTING WAY OF LEARNING. **SO THANK YOU SO MUCH, TRULY."**
- CHRISTINA FERNANDES

- Get Past the One-Size Fits All Thinking in Soil Science & Management
- **Navigate, Understand, and Connect the Soil Biology, Chemistry, Minerals, Plants, All the Cycles, & All the Climates & Soil Types**
- Learn HOW to Solve Problems & Tailor Soil to Your Goals & Plant's Needs
- **Learn How to Build, Remediate, Restore, & Regenerate Your Soil**
- Learn How to Grow Pest & Disease Resistant Plants
- **Learn How to Use a Microscope to Understand & Evaluate Your Soil**

YOU CAN GROW INCREDIBLE FOOD, OVERCOME CHALLENGING SOILS, AND MAKE THE WORLD A BETTER PLACE ALL AT THE SAME TIME.

WWW.REGENERATIVESOILSCIENCE.COM