VERMICOMPOST TEA GRANULES

MANURES

PRE-CONSUMER ORGANIC MATTER

WATER

RETURN RESIDUE MATERIALS

MICROBE WASHING TANK

VERMICOMPOSTING BINS

VERMICOMPOST

WORM CASTING (BIOLOGY)

MICROBIAL NUTRIENTS

VERMICOMPOST TEA BREWING TANK

VERMICOMPOST TEA

ACTIVATED CARBON

RETURN EXCESS LIQUID

MIXER (DRYING PROCESS)

BAGGING/PACKAGING

RETURN RESIDUE SOLIDS

CARBON SATURATION TANK

DESIACENTS

[Continued on next page]

Abstract: A method of making vermicompost in worm bins which are substantially open to the air, brewing the harvested vermicompost for 3 to 4 days, along with added nutrients, under aerobic, and optionally cool temperatures, to produce vermicompost tea. The vermicompost tea can be applied directly to soil or plants or can be used to saturate carbon based carrier granules to form vermicompost tea granules.
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VERMICOMPOST TEA GRANULES
SPECIFICATION

This U.S. patent application claims the priority of U.S. Provisional Application No. 60/536,364, filed on January 14, 2004, entitled “Vermicompost Tea Granules,” of the same inventors.

TECHNICAL FIELD

This invention relates to a novel method of making vermicompost using novel worm bins and further relates to the processing of the vermicompost to produce vermicompost tea and vermicompost tea granules.

BACKGROUND OF INVENTION

Compost and vermicompost tea produced by convention methods have a useful shelf life that is measured in hours after cessation of production. Compost tea must remain aerobic to support the life and propagation of beneficial microbes. Anaerobic conditions will kill flagellates and amoeba forms of protozoa, as well as beneficial fungi and nematodes. See The Compost Tea Brewing Manual by Dr. Elaine Ingham, 4th Edition (published by Soil FoodWeb Inc., Corvallis, Oregon, 2003, first published 2000). Therefore, the ability of producers of compost and vermicompost to sell their products to end-users or distributors is severely limited by time and distance.

The purpose of adding vermicompost tea’s beneficial microbes to soil is that it is the least costly method to re-supply soil with biomass that has been lost to pesticides, inorganic chemical fertilizers, erosion and soil mismanagement. The microbe mix in a vermicompost tea should include bacteria for the consumption of the nutrients, fungi for root protection, protozoa for bacterial feeding and conversion of nutrients to plant available forms, and nematodes for microbial regulation, root protection and nutrient supply. These microbes are continually destroyed by the activities listed above (application of pesticides, etc. …)
There exist various designs for worm cultivation, in order to produce the worm by-products, which are used in the brewing of vermicompost tea. For example, U.S. Patent No. 6,488,733 B2 (Kalra et al.) describes vermicompost tea produced from worm castings derived from sand-bottomed worm pits, a fairly common method of creating worm pits. Sand-bottomed worm pits or other pit worm beds do not allow the collection of worm castings from the bottom of the pit. Of necessity, castings are collected from the top, thereby including the less mature worm castings and even compost, which has not been processed by the worms. U.S. Patent No. 6,797,507 B2 (Hahn) suggests a worm bed filled with biomass, and requires removing the entire worm bed in order to collect the castings on the bottom.

U.S. Patent Application Publication No. US2002/0144658 A1 (Holcombe et al.) discloses an automated worm bin/worm castings production process. The features of this system include a gantry delivered food source to the worms. The worm castings are harvested via an automated scraping device that runs below the long worm bins that have perforated floors.

U.S. Patent Application Publication No. US2004/0096963 A1 (Hahn) describes a vermicompost brewing system where some aeration is provided, but the complete system and conditions for producing vermicompost differs from those required in the present invention.

SUMMARY OF INVENTION

The method of producing vermicompost tea according to the invention comprises: selecting compost materials, thermal composting the selected composting materials under well-aerated conditions, and producing vermicompost under well-aerated conditions, putting the vermicompost into suspension ("microbe wash phase"), and brewing the suspension together with a nutrient mix in a brewing tank under well-aerated conditions, preferably at cool temperatures. The microbe wash phase preferably lasts from 4 to 6 hours. The brewing phase lasts more than 24 hours, preferably from 3 to 4 days. The vermicompost tea can be used for foliar
applications. In a particularly preferred embodiment of the invention, solid carrier granules are soaked in the vermicompost tea and dried to produce vermicompost tea granules.

5 The worm bins used in the method of vermicomposting according to the invention are substantially open to the air. The bins are preferably open at the top, do not have solid bottoms, and sometimes have additional air vents on the sides. In an exemplary embodiment of the invention to produce worm castings, the bottoms of the worm bins comprise augers, which can be turned for harvesting worm castings and other constituents. In an exemplary embodiment for producing a high concentration of nematodes, the bottom of the worm bin comprises a series of pipes and the sides of the worm bin have screen air vents.

According to the method of the present invention, the beneficial microbes from vermicompost tea are transferred into a solid carrier granule that has a long-term shelf life (at least 3 months) and can be delivered by commercial mechanical drop and broadcast spreaders as well as seed planting equipment. The preferred solid carriers, according to the invention, are natural, carbon-based granules that have adsorbed the nutrients and beneficial microbes. These carbon based granules hold the nutrients and microbes in a form that when the granules are applied the soil, the soil will be inoculated with beneficial microbes and beneficial soil components. Granules are easier to apply to the soil than liquid applications. The granules also provide additional balancing and chelating benefits. A preferred carbon based granule is a blend of activated carbon and humate granules, preferably 60% activated carbon to 40% humate carbon. The highest blend should exceed 80% activated carbon to 20% humate carbon.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is an isometric, partial cutaway view of a worm compost bin according to the invention.

Fig. 2 is an isometric view of a worm compost bin according to the invention.

Fig. 3 is an isometric, partial cutaway view of a nematode-producing worm
compost bin according to the invention.

**Fig. 4** is a schematic of the method of producing vermicompost tea and vermicompost tea granules according to the invention.

5 **DETAILED DESCRIPTION OF INVENTION**

The present invention is direct to a novel method of producing vermicompost tea and vermicompost granules.

In a preferred embodiment of the invention, the production of vermicompost tea granules includes the following steps:

10 A. Selection of Compost Materials
B. Production of Worm Compost (Vermicompost)
C. Brewing of Vermicompost Tea
D. Selection of Carbon Granules
E. Treatment of Granules

15 **A. Selection of Compost Materials**

The compost is composed of organic, natural materials. It is preferred to use a wide variety of composting materials. The larger the variety of source materials, the greater the diversity of microbes which will be available and present in the vermicompost tea, or vermicompost tea granules of the present invention to meet the demands of plants placed upon the microbial life in the soil for disease protection and for available food resources. The quantity and diversity of the desirable microorganisms that are present in the produced vermicompost tea and vermicompost tea granules are derived from the compost. It is particularly preferred to use compost source materials indigenous to the area, or to the crops and plants, where the vermicompost tea or tea granules will be applied, in accordance to practices well known to those skilled in the art of composting, and/or the manufacture of compost tea, such as taught in *The Compost Tea Brewing Manual*. The variables in generating compost are the need for organic matter with carbon and nitrogen components, diversity of protein and sugar source materials, monitoring heat and moisture, and the
physical activity of turning the compost at appropriate times in order to provide oxygen to keep the compost aerobic – the turning also allows excess heat to escape.

The development of protozoa (including nematodes) is more dependent upon aerobic conditions and the presence of bacteria and fungi as food sources, than upon the specific beginning materials. Some materials produce more protozoa than others, such as straw is a good producer of protozoa, but hay is less of a producer. How to adjust the organic matter used in vermicomposting for specific soil types and crops, and based upon soil chemical analyses, are well known to those skilled in the art.

Although nematode inoculums are commercially available, these products are packaged in wet sponges, designed to be rinsed in water, and directly applied with water to soil or plant surface areas requiring treatment. These sponge deliverable species can also be released into compost and vermicompost tea brewing tanks by soaking and squeezing the sponges into the brew’s water or tea. Due to the 24 or less hours of brewing time for conventional vermicompost teas, these teas do not propagate the added nematode populations, they just serve as a carrier for the added nematodes.

The nematode-producing bin, as described in hereafter in Sec. 2.b, Example 3, creates a unique man-made environment for the propagation of nematodes. It is dependent upon several factors, of which we find the key ones to be:

A. The soil content should be primarily vermicompost, which is a highly microbial soil that is able to provide continual food sources for nematodes.

B. The addition of forest litter to recreate the surface soil conditions of a combination deciduous and conifer forests to simulate favorable growing conditions with good carbon and nitrogen containing microbial food sources. The nematodes feed on bacteria, fungi, protozoa and other nematodes.

C. The moisture content must be sufficient, requiring moist soil, to enable the movement of higher microbial forms and the passage and retention of oxygen throughout the nematode bin’s vermicompost holdings.
D. The developed soil structure requires sufficient size soil aggregates as to
provide ample numbers and sizes of pore spaces to permit the movement of
mites and micro-arthropods, which will control the development of the
nematode population. The more aerobic these conditions are, the better the
control will be over the development of undesirable nematode species.

E. The relative material application rates of food sources to the top of the
nematode bin requires a range of 3 to 6 times more brown leaf or brown
plant material than green leafy matter or composted materials.

The matching of starting composting materials to crop or area is not a critical
issue. The acquiring or blending of a large variety of source materials is one of the
two keys.

The first key is to gather the largest variety of source materials to insure that
the vermicompost deliverable at the end of the thermal and vermicomposting
processes contains, reasonably, the largest diversity of microbe species possible.

The second key issue is the balancing of types of materials. It is impractical to
measure exactly equal amounts of manures, brown source material (leaves, straw,
hay, paper and cardboard, as examples) and green materials (leafy vegetables,
horticultural waste such as discarded cuttings from greenhouses, pre-consumer
produce waster) to create an equal mix of 1/3 manure, 1/3 brown material and 1/3
green material as the starting compost mix. In fact, such measuring is too complex
and difficult to be practical. For example, to measure the beginning chemical and
geological structure of manures, (which will depend upon their ages, the conditions in
which they aged, the animal groups from which they come, and the food sources
which the animals consumes and excreted), then to biologically and chemically
compare these results to the results of the same analyses for the brown and green
materials, and then to adjust each set of findings based upon relative moisture content,
would be prohibitive in cost, and not worth the investment. The action step at the end
of this costly and time consuming process would be the addition of a small fraction of
additional material from one or two of the three source groups to create a “balanced”
beginning compost material. Approximately an equal amount of manure, brown and
green beginning materials is reasonable, (this ratio is also acceptable in the art), and
most practical.

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The preferred compost source materials include: manures, hay, alfalfa,
soybean, corn, waste coffee grounds, pulverized raw chicken eggshells, dead leaves
from deciduous trees, shredded newspaper, shredded cardboard, straw, hay, and pre-
consumer produce waste. The pre-consumer produce waste preferably includes
tomatoes, potatoes, bananas, apples, pears, lettuces, spinach, kale, radishes, daikons,
turnips, parsnips, onions, celery, melons, cantaloupes, plums, raspberries,
strawberries, blueberries, and other seasonal and year-round fruits and vegetables.
Neither meat products nor cooked fruits or vegetables are included. The selected
materials are gathered from farms, supermarkets and restaurants.

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B. Production of Worm Compost (Vermicompost)

The production of vermicompost has two phases, the Thermal Compost Phase
and the Vermicompost Phase. The first phase is the thermal compost phase.

EXAMPLE 1

1. Thermal Compost Phase

The Thermal Phase is required for all manures, materials potentially
contaminated  with manures, all materials potentially containing weed seeds, and all
materials known to contain seeds. The Thermal compost phase should be used for
materials will low water content relative to leafy vegetables and those materials that
are more fibrous or containing cellulose, as these materials require thermal activity to
accelerate their composting.

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The Thermal Compost Phase requires that all materials be heated to at least
135 degrees Fahrenheit and maintained at that temperature for at least 72 consecutive
hours. These temperatures are reached automatically through the natural microbial
process of composting. This level of continuous heat must be maintained in order to kill all weed seeds, human pathogens, as measured by the finding of any presence of *Escherichia coli* bacteria (*E. coli* is a good indicator of the presence or absence of human pathogens), and most plant pathogens. This heat level will not kill most of the beneficial microorganisms.

The Thermal Compost Phase requires that the compost maintain aerobic conditions. This means that oxygen must compose at least 18% of atmospheric gases at normal atmospheric conditions. Biological tests of the compost, should find less than 50 ciliates per gram of compost, as ciliates only survive in anaerobic conditions.

In a preferred embodiment of the invention, a funnel tank mixer [Zimmerman Farm Service, Inc., Bethel, PA, 14 feet long, 7 feet wide and 81 inches high] with a center-based auger is utilized for generating Thermal Compost. The auger is turned to mix the materials when the mixer is activated (turned on). When the motor to turn the auger is turned on, the clutch engaged and the auger turns, or mixes, the composting material. The determination as to when to mix the material is determined by the temperature at the center material. The temperature will be hotter if the manure is not aged (over 30 days) and is mixed with high sugar and protein materials such as hay and fruits. These mixtures usually require turning 3 times a day during the 2nd, 3rd, 4th and 5th days of the thermal composting process. Daily turning is usually required during days 6 through 12. Another factor is that the compost should be moist, and depending upon the ambient temperature and humidity, water may need to be added – particularly when the ambient air has low humidity. No standards of the humidity or temperature of ambient air have been established. If the thermal composting is not an in-vessel process, but is performed in piles or windrows, the pile or windrow should not exceed 7 feet in height or width. The process will take up to 90 days, requiring turning daily when temperatures reach 135 deg Fahrenheit, for at least 14 days continuously. Composters trained in the art will recognize these composting requirements. The auger provides adequate aeration to maintain aerobic conditions while mixing the compost so that all materials are held at the 135 degree Fahrenheit level for at least 72 consecutive hours.
By using a funnel tank mixer, the typical time for thermal composting is reduced to two weeks compared to the several months needed for this stage in conventional composting methods. Other in-vessel composting devices are commercially available from companies such as B.W. Organics (Sulfur Springs, Texas), which makes in-vessel composters ranging for 1 cu. Yd. to 96 cu. Yd. capacities. These units can be used as long as equivalent aerobic and temperature conditions are maintained.

2. Vermicompost Phase
   a. Red Wigglers Vermicompost

   EXAMPLE 2

   The vermicompost phase consists of adding thermal compost, as described above (that has been cooled to ambient temperature) and leafy green vegetable matter, such as lettuce, spinach, cabbage, and kale, to the worm compost bins for processing by the worms. Grass clipping should not be added to the worm bins or the thermal compost phase due to the potential presence of chemical pesticides and fungicides, unless it is known that they are clear of all chemical pesticides and fungicides. If the grass clippings are known to be chemical additive free, then they can be added to the thermal composting process, but they should be spread homogeneously throughout the compost mix so that they do not form clumps that adhere together and create anaerobic aggregates within the compost mix. The food resources for the vermicompost-producing, bottom-harvested worm bins are a relative balance of thermally composted materials and the combination of green leaf, brown leaf, (note that “brown leaf matter” is a component of “brown plant matter”), and shredded newspaper matter.

   The worms used in the vermicomposting phase are commonly known as “red wigglers”. The red wigglers consist of two species, the Eisenia fetida (Garden Gold, Washington, IL), found naturally in aged manures, and Lumbricus rubellus (Gollon Brothers, Steens Point, WI), found naturally in aged manures and old compost heaps. Sources for worms and instructions for worm composting are readily available (See, e.g., cityfarmer.org). In a preferred embodiment according to the present invention,
ten (10) pounds of worms were added per worm bin. The worms were initially gathered from decaying horse manure and decaying natural compost.

The worm compost bins as shown in Fig. 1 are particularly preferred. As shown in Fig. 1, the worm compost bins 1, 2 are open-bottomed and open-topped. The bins may be stacked as long as airflow is maintained. In the present example, there are approximately 30 inches between each stacked bin. In one embodiment of the invention, each bin is 6 feet long, 2 feet wide and slightly less than 15 inches high. These are external measurements. In a preferred embodiment of the present invention, the bottoms are covered with augers 20, which in this example are four, ¾ inch in diameter and 7 feet long pipes 3, 4, 5, 6 that have two 1 inch flat steel blades welded onto opposite sides of each pipes. When it is time to collect the worm compost 7, suitable collection containers well known to those skilled in the art are placed under, for example, worm compost bin 1, augers 20 are then turned, thereby causing the worm compost to fall into collection containers. A worm bin 2 that is used to compost green, leafy vegetables 8 also include side screened air vents 9, 10 on each end of the bin. Screened air vents should also be placed on the sides of each bin. The preferred screening material is any perforated plastic weed control material available in rolls at most retail lawn & garden supply stores.

An exemplary embodiment of the augers 20 in the worm compost bin is shown in Fig. 2. Each 3/4-inch metal pipes (3-6) is welded to two one-inch metal blades 21-26. The blades in this example are directly opposite one another. Other sizes of pipes and blades, as well as various configurations of blades are suitable as long as the aerobic conditions in the bin are maintained. The auger handle 30 is used to turn the auger to harvest the worm castings (vermicompost) from the bottom of each worm bin. The pipe and flat steel material used to make the blades are commercially available from most building supply or sheet metal fabrication stores. Although stainless steel would be preferred, its high cost may not warrant its use.
It takes approximately 90 days to get a worm bin fully productive, as the bin must fill with at least 6 inches of vermicompost before harvesting, otherwise, too much vermicompost will be removed at one time. The worm bins should be fed and harvested weekly, with the addition and removal of approximately 25 lbs of composting material being added and 20 lbs of castings being removed. The 5 lb. variance may be attributable to evaporation. The tops of the bins are left open to maximize the airflow through the bins. The bins are regularly tested for moisture and pH levels. The bins are kept moist, but not wet. The pH varies between 6.8 and 7.2, but usually stays at 7.0.

The stacked worm bins are designed to produce vermicompost, the castings from the red wiggler worms. These bins feature a bottom harvesting process. The food is fed on the top and the worms eat to the top, leaving their castings behind to pile toward the bottom. Most commercial vermicompost producers use worm pits lined with sand and saw dust. They harvest from the top using pay loaders or shovels. The known harvesting practices disturb the worms’ living environment. The vermicompost producing worm bins of the present invention do not disturb the worms’ living environment.

b. Nematode-enhanced Vermicompost

EXAMPLE 3

Fig. 3 shows a worm compost bin 11 for nematode breeding and contains a bottom structure 12 that increases airflow while retaining the soil and biomass above. For nematode production, screened air vents 27, 28, 29 on all four sides of the bin are preferred. Worm bin structure 11 is constructed using wooden support beams 13, 14, 15, 16, and 17. One-inch polyvinyl chloride (PVC) plastic pipes 18 spaced 2.5 inches apart. The sides 19 are made of ¾ inch indoor plywood covered in plastic sheetrock covering, of the type commercially available at any building supply, home improvement retailer, hardware or similar supplier.

The worm bin as exemplified in Fig. 3, with the air vents and a polyvinyl chloride (PVC) pipe bottom, creates vermicompost, but is designed to promote the
growth and increase the number of nematodes in the vermicompost. The nematodes are harvested in the vermicompost from the top of the bin. This process requires more worm separation processing after harvest than is required from harvesting from the bottom of the bins. This bin style is unique because the objective of this bin is to re-create the forest soil environment to help propagate beneficial nematodes. The bottom is open to allow a flow of oxygen into the soil and to drain excess water. The harvesting from this bin is from the top, where the nematodes reside near the surface. Worm bin designs, other than those shown in Figures 1 and 3, may be used as long as equivalent aerobic and temperature conditions are maintained.

The nematode bin is initially stocked with shredded newspaper, red wiggler worms, burrowing earthworms (to help create and keep good aerobic soil structure, which may include some “night crawlers”, as we are recreating the forest floor environment), thermal compost, leafy vegetable matter, and layered with approximately equal parts forest soil and fluff, which has been blended together. Then the entire surface is covered with a blend of brown plant matter, green leafy material and thermally composted material. Again, this mix should contain 3 to 6 times more brown plant matter than the combined composted and green leafy materials. (personal communication – Dr. Elaine Ingham)

Soil fluff is the soft textured material just below the fallen leaf material, before it fully becomes soil. The fluff area is where the highest concentration of nematodes will be found; moreover, forest fluff has the greatest diversity of nematode species (Paul Wagner, Soil Foodweb, personal communication). In a preferred embodiment of the invention, soils and soils fluff from deciduous and conifer forests are both used and are mixed. There is no specific pattern to the mix, but there is an attempt to balance the mixes. The conifer forest is more fungal in content that other forest soils, so although the fungal dominance is good, it is necessary to supply the nematodes with bacteria and fungi as their food sources. The combination of forest products and composting materials recreates a combination of deciduous and conifer forest soil.
After the initial stocking of the bin, the food sources are dead leaf matter, the worm bin food materials from thermal composting as described in Example 1 above and brown plant matter, (which is decaying leaf, bark, woody material), thereby creating the nematode production mix. The predominant additive is brown leaf and shredded paper to continually add carbon sources. The green leaf matter provides the nitrogen sources, but we keep the Carbon to Nitrogen ration above 20 to 1. Although not precisely measured, the application of materials to the nematode-producing bin is at least 20 parts soil, soil fluff, brown leaves and shredded paper to green leaf matter. Again, the overall topping should remain within the range of a low of 3 to 1 and at least 6 to 1 of brown plant material to the total of all other materials. Although no standards or requirements have been established, an application of 1 gallon of vermicompost tea is applied to the nematode bin every 90 days. At all times, the base of the nematode bin must contain at least 8 inches of vermicompost (worm castings). Small, dead branches, up to ½ inch in diameter and 6 inches in length, are added to the top of the nematode bin. As the casting increase, the small branches create aerobic spaces within the soil structure while also serving as a food source.

The production of vermicompost according to the invention requires that the microbial contents of vermicompost are reproducible and consistent in order that the brewing of vermicompost tea is also reproducible and consistent, and can be altered to produce custom blends as needed to meet customer, plant and soil needs. Vermicomposts consists of worm castings (the worm’s excretion that pass from the worm body after digestion) and composted organic matter. Appropriate worm compost and castings should contain active and total bacteria and fungi numbers within the desired range. Similarly the protozoa, nematode and bacteria to fungi ratios should conform within the desired guidelines of the testing and reporting process. Vermicomposts produced according to the invention are tested for active and total bacteria, fungi, protozoa and nematodes, as well as the bacteria to fungi ratios prior to proceeding to the production of vermicompost tea, at least until an established mix of starting materials is established.
The next step in producing vermicompost for use in the brewing of vermicompost tea is to separate the compost resulting from step a) “red wrigglers” and b) “nematodes” by particle size and to remove any worms that have been added to the compost by the augers. Larger size particles, those that will not fit through a 1/4” screen mesh and any worms are quickly returned to a worm bin. A commercially available worm separator (Rising Mist Commercial Harvester, Rising Mist Organic Farm, Bellvue, KS) is used according to manufacturer’s instructions to separate the worms and large particles from the compost.

After the removal of the larger particles and worm, the remaining vermicompost is a finely textured, microbial rich organic material consisting of worm castings and some organic compost.

C. Brewing of Worm Compost Tea

The brewing of vermicompost tea consists of two separate phases:

1. Microbe Wash Phase
2. Microbe Propagation Phase

The brewing of vermicompost tea is performed in commercially available brewers, which generally brew 100 gallon or 500-gallon batches. In one embodiment of the present invention, a 500-gallon microbe wash solution is then added to 750 gallons of fresh water or water containing recycled water from previous granule treatments to yield 1,250-gallon brews.

1. Microbe Wash Phase

EXAMPLE 4

The microbe wash phase is where the vermicompost material, which along with optional ingredients will be termed “Biology”, is placed into suspension. In a preferred embodiment according to the invention, the Biology consists of 80% vermicompost, 10% nematode vermicompost and 10% oat flour. The oat flour helps
to dry the vermicompost while simultaneously serving as a productive fungal food. The mixing of the Biology can be performed in the same tank as the one used for mixing the treated carbon granules and the desiccants as described in Example 7. The microbe wash phase requires the rapid circulation of the Biology in water to separate microbes from particulate matter that is larger than what would pass through a 20 mesh screen from the particulate matter (vermicompost) and place the microbes into suspension in the water along with the Biology that passes through the screen. This pump driven circulation of the Biology and water through a discharge valve at the bottom of the tank and then back into top of the tank serves to sufficiently break up clumps of Biology to place most of the Biology into suspension. Over 85% of the Biology is estimated to be placed into suspension in the microbe wash process. We also believe that most of the desired microbes are washed off the larger particulate matter directly into the water. The pump is an AMT (Royersford, PA) 2" Self-Priming 2hp, 115V, Single Phase. (USA Blue Book, item # 12756). In a preferred formula according to the invention, the amount of materials to be washed for a specific brew of vermicompost tea is as follows: 2 pounds of Biology, of which 1.6 pounds of worm castings and compost, also called vermicompost, (the product of step 2a), 0.2 pounds of oat flour and 0.2 pounds of nematode castings and compost, also called nematode vermicompost, (the product of step 2b) is used for every 10 gallons of vermicompost tea desired. For a 1,250-gallon brew, approximately 238 pounds of the product of step 2a along with approximately 12 pounds of the product of step 2b as discussed above would be used. The actual measurements of the amount of compost material used should be within plus or minus 5% of the weight of material required by this formula.

The Biology is then mixed into 5-gallon containers with enough water to create slurry of the material so that it will immediately go into suspension in a microbe wash tank. Commercially available fermentation tanks are suitable for use as a microbe wash tank.

In one example according to the invention, a 500-gallon microbe wash tank is utilized. Approximately 500 gallons of water, less the corresponding amount of
gallons equivalent to the volume of the added Biology in slurry form is added to the microbe wash tank. The tank can be used, with appropriate amounts of water to create microbe washes between 200 and approximately 500 gallons for amounts of Biology ranging from between 50 and 300 pounds of Biology. A larger microbe wash tank is not recommended unless the size of the pump is significantly expanded to provide sufficient turbulence to perform the microbe wash function. The 500-gallon microbe wash tank currently serves 1,000 to 2,000 gallon brew tanks where the propagation phase occurs. Brewing operations greater than 2,000 gallons per brew will require either larger microbe wash tanks than the 500-gallon size, or they will require multiple batches of microbe wash outputs. The microbe wash phase should require continuous circulation for turbulence ranging between a minimum of 3 hours and a maximum of 24 hours, with the ideal microbe wash time ranging between 4 and 6 hours. The preferred length of microbe wash time is 4 hours. The resulting microbe wash solution will have a slurry appearance.

The time range of 3 to 24 hours means that the microbes will sufficiently survive up to 24 hours, but the optimum microbe wash time frame is between 4 and 6 hours. As shown in the following Table 1, the total fungal biomass reached 6.53 µg/ml, after 4 hours without added nutrients. This measurement shows fungal growth of over 100% within 4 hours. This population is sufficient to provide an excellent basis for microbe propagation. The results of fungal growth after 4 hours were not measured, because the 4 hour results met standards sufficient to produce an exceptionally productive product.

Table 1

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Bacterial Biomass (µg/mL)</th>
<th>Total Fungal Biomass (µg/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wash 1 – 1 hr</td>
<td>912</td>
<td>3.09</td>
</tr>
<tr>
<td>Wash 1 – 2 hrs</td>
<td>1171</td>
<td>2.69</td>
</tr>
<tr>
<td>Wash 2 – 1 hr</td>
<td>854</td>
<td>4.07</td>
</tr>
<tr>
<td>Wash 2 – 2 hrs</td>
<td>720</td>
<td>5.39</td>
</tr>
<tr>
<td>Wash 2 – 4 hrs</td>
<td>730</td>
<td>6.53</td>
</tr>
</tbody>
</table>
Untreated, unchlorinated well water is the preferred water source for the microbe wash phase. In addition to the lack of chlorination, the water temperature of well water is relatively constant. The external air temperature surrounding the microbial wash tank does not appear to affect the microbial wash results.

Approximately 40% to 50% of the compost material added to the microbial wash tank appears to remain in suspension, although it is difficult to determine the amount of compost material that becomes a tank residue.

Unlike most prior methods of brewing vermicompost tea, the microbe wash and the microbe propagation phases do not take place in the same time period or tank. This means that no microbe nutrients, or only minor amounts of microbe nutrients are added to the microbe wash tank.

2. Microbe Propagation (Brewing) Phase

**EXAMPLE 5**

The microbe propagation phase is where the microbes are fed nutrients appropriate to make the desired vermicompost compost tea in a continually aerobic environment.

The beneficial microbes found in worm castings and compost grow faster and more effectively in aerobic soil than do harmful microbes in aerobic soil, if their living conditions are continually aerobic (at least 18% oxygen in the surrounding atmosphere). Whenever anaerobic conditions occur, the harmful microbes grow faster and more effectively in anaerobic soil and can destroy the beneficial microbes.

The restoration of aerobic conditions will not enable the destroyed species to regenerate. The diversity of species found in the vermicompost tea is directly related to the diversity of diseases from which the plants growing in the soil treated with the tea will be able to resist diseases and the diseases may even be suppressed by the beneficial microbes found therein. An important analysis of worm castings and compost is relationship between the size of the bacteria and fungi populations.
The following table from *The Compost Tea Brewing Manual*, p. 57, illustrates some of the preferred ratios of bacteria and fungi in relationship to different crops and soil types. The method of producing vermicompost tea according to the invention can be directed to result in the desired mix and ratio of bacteria and fungi.

Table 2

"The Kind of Tea Needed for Different Plants and Soil Types"

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Plant Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli, Cabbage, Kale (strongly bacterial)</td>
<td>Row Crops, Grasses, Annual Plants (slightly bacterial)</td>
</tr>
<tr>
<td>Need both bacteria and fungi to build good soil structure</td>
<td>Need mostly fungal activity, some bacteria to build soil structure</td>
</tr>
<tr>
<td>Sand</td>
<td>Need to improve bacteria significantly; some fungi needed</td>
</tr>
<tr>
<td>Loam</td>
<td>Need mostly bacteria to form micro aggregates and get nutrient cycling going</td>
</tr>
<tr>
<td>Clay</td>
<td></td>
</tr>
</tbody>
</table>
The microbe propagation phase occurs in a brew tank. Preferred tanks include round, flat bottomed, 1,100 and 1,200 gallon tanks. Conical tanks are recommended when the footprint size of the tank is a practical issue. An exemplary tank is the Norwesco 1,100 gallon tank, model 40070 or model 40081 (Norwesco, Inc., St. Bonifacius, MN). These tanks do not have motors or pumps included or inserted in the tanks. A circulating pump, such as the one used in the microbe wash can be used in the microbe propagation phase.

The quantity and mix of nutrient additives depends upon the bacteria to fungi ratio desired. However, the Nutrient Mix shown in Table 3 is appropriate for all but the extreme fungi to bacteria ratio brews. The control of the fungi to bacteria ratio, using the Biology and Nutrient mix, as described in this example, is best controlled by managing the length of the brewing time. As the length of time applied to the propagation phase increases, the number of fungi will increase, as will protozoa (which are predators of bacteria), and will act to reduce the growth or even the total number of bacteria. However, when significantly bacterial dominant or fungal dominant teas are desired, then the Biology should be as bacterial dominant or fungal dominant as possible. It is very difficult to produce a completely fungal dominant tea as fungi do not like to live in water and they are much slower to reproduce than bacteria. Nevertheless, it is most desirable to match the worm compost blend to that of the desired resultant tea.

The following table shows the quantity and nutrient formulae designed to meet the widest biological spectra of desired vermicompost teas. Each of the ingredients in the Nutrient Menu, with the exception of the powdered sugar is principally a fungal food. However, these foods have natural sugars and proteins that will also provide ample bacterial foods too. The quantities indicated are proportional to the amount of desired tea. The flour quantities can be safely increased up to twice the current proportional ratios to the powdered sugar to increase fungi and protozoa development. The increase of the humic acid or soluble kelp ingredients should result in a corresponding decline in the amount of total flour in the mix, with the change not to exceed more than a 50% decline in the total amount of flour. The flour types selected
for the Nutrient mix was determined by the diversity of proteins, sugars and their solubility. The flour must be consumed during the propagation process, yet the flour particles must become vehicles to which the fungi can attach during the propagation phase. This menu is selected based on the best available flours and prices that would enable the production of reasonably priced product.

Table 3
Nutrient Menu for Brewing Worm Compost Tea
(based upon a 1,250 gallon brewing)

<table>
<thead>
<tr>
<th>NUTRIENT</th>
<th>Quantity for 1,200 Gallon Brewing System</th>
<th>Quantity for 175 Gallon Brewing System</th>
<th>SUPPLIER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soluble humic acid (dry)</td>
<td>5.3 lbs.</td>
<td>12 oz.</td>
<td>Fertrell Inc., Bainbridge, PA</td>
</tr>
<tr>
<td>Soluble Acadian Kelp</td>
<td>4.6 lbs.</td>
<td>10 oz.</td>
<td>Fertrell Inc., Bainbridge, PA</td>
</tr>
<tr>
<td>Wheat Flour</td>
<td>1.8 lbs.</td>
<td>4 oz.</td>
<td>Echo Hill Country Store, Fleetwood, PA</td>
</tr>
<tr>
<td>Soy Flour</td>
<td>1.8 lbs.</td>
<td>4 oz.</td>
<td>Echo Hill Country Store, Fleetwood, PA</td>
</tr>
<tr>
<td>Rice Flour</td>
<td>1.8 lbs.</td>
<td>4 oz.</td>
<td>Echo Hill Country Store, Fleetwood, PA</td>
</tr>
<tr>
<td>Oat Flour</td>
<td>1.8 lbs.</td>
<td>2 oz.</td>
<td>Echo Hill Country Store, Fleetwood, PA</td>
</tr>
<tr>
<td>Powdered Sugar</td>
<td>1.2 lbs</td>
<td>1 oz.</td>
<td>Echo Hill Country Store, Fleetwood, PA</td>
</tr>
</tbody>
</table>

The brewing process requires a continual aeration of tea with and infused air. Most conventional (thermal and vermi-) tea brewing methods in the prior art suggest that the ambient temperature for brewing should be between 65 and 75 degrees F. The reason for this temperature range is principally related to the level of microbial
activity and oxygen levels in the water. In contrast, according to the method of the present invention, the external ambient temperature is not as much a factor in the quality of the tea. In fact, a preferred temperature is colder than 65 degrees. It is postulated that there is more oxygen in the water. When the temperature is colder, it is possible to optionally add up to 20% more nutrients to the brew, as the oxygen level will support more microbial growth. We do not use a specific ratio of temperature to amount of nutrients, but typically, under 45 deg F. up to 20% more nutrients are added.

Our test results have found that the optimum yield of fungi is achieved with a brew equal to or greater than 1,000 gallons cycle of 4 days, although as little 3 days yields high quality vermicompost tea. An analysis of the vermicompost tea produced after 4 days is shown in Table 4

<table>
<thead>
<tr>
<th>No. of Days Vermicompost Tea Brewed Before Sampling</th>
<th>Total Bacterial Biomass (μg/ml)</th>
<th>Total Fungal Biomass (μg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day</td>
<td>3200</td>
<td>1.67</td>
</tr>
<tr>
<td>2 days</td>
<td>4045</td>
<td>3.55</td>
</tr>
<tr>
<td>3 days</td>
<td>2637</td>
<td>5.85</td>
</tr>
<tr>
<td>4 days</td>
<td>2278</td>
<td>7.38</td>
</tr>
</tbody>
</table>

The vermicompost tea as produced in this example can be applied as a home or commercial foliar spray. Foliar application of vermicompost tea, where at least 80% of the foliage is sprayed has been shown to prevent disease and the harmful effects of pesticide drift. In addition, nutrient intake has also been increased.

D. Selection of Carbon Granules

The vermicompost tea granules according to the invention are best prepared by soaking solid carrier granules in brewed vermicompost tea for a period of time sufficient to saturate the granules with both the microbes and nutrients found in the
vermicompost tea. In a preferred embodiment of the invention, the solid carrier granules are a blend of activated carbon granules and humate granules.

Activated carbon granules provide the best adsorption properties for enabling the carbon granules to capture the microbes and the nutrients found in the vermicompost tea within the granules’ pore structures. The activated carbon is pure bituminous coal that has been burned so that all detectable impurities have been removed. It serves as a balancing agent once placed in the soil. The activated carbon granules retain plant nutrients with organic nutrients being retained at a 50 times greater rate than inorganic or synthetic nutrients. The nutrients are a continual food source for the bacteria and fungi, which in turn are food sources for protozoa, beneficial nematodes and microarthropods. When the food supply is variable, the carbon thus regulates the growth of microbes by adsorbing food excesses during feast periods (preventing overpopulation) and desorbing food during famines (preventing starvation). When microbes die, the carbon adsorbs toxins that may be emitted during decay. The carbon also adsorbs any antibacterial agents that may be secreted by a colony. The protozoa provide a major link between nutrients and the plants. The bacteria and fungi stabilize the nitrogen, sulfur and phosphorus in the soil, preventing the leaching of these nutrients into water tables or evaporation into the atmosphere.

Fungi are the most difficult microbes to adsorb in the carbon due to the structure of their hyphae. Consequently, humate carbon granules are also selected as part of the vermicompost tea granule mix. The humate granules serve as an adsorbent as well as a fungal food source. The humate granules provide a chelating effect upon the beneficial biomasses in the soil.

The blend of activated carbon and humate granules provides the soil and plants growing therein with the beneficial microbes that help protect the plant surfaces, the beneficial microbes that increase the amount of plant available nutrients in the soil while building a beneficial aerobic soil structure.
The minimum acceptable blend of activated carbon to humate carbon by weight prior to treatment is 60% activated carbon to 40% humate carbon. The highest blend should not exceed 80% activated carbon to 20% humate carbon. A preferred activated carbon is VRU-F3 activated carbon (Calgon Carbon Corporation, Pittsburgh, PA), made from bituminous coal. A preferred humate is Menefee Humate composed of granular sub-bituminous humic containing plant and animal residues (Fertrell Inc., Bainbridge, PA). Menefee Humate is mined by Menefee Mining Corporation in New Mexico. Menefee Humate contains more than 35% organic matter, a minimum of 35% humic acid and at least 35% available carbon and trace minerals.

E. Treatment of Granules

The treatment of the carbon granules consists of two phases:

1. Soaking Phase and
2. Drying Phase.

1. Soaking Phase

EXAMPLE 6

The Soaking Phase for activated carbon requires three days of continuous soaking in order to replace as much of the air left within the granules’ pores from the burning process that creates “activated” carbon (“the soaking period”), followed by the “curing period”.

The Soaking Phase may be conducted within a tank where vermicompost tea is continually re-circulated through the bed of activated carbon. In a preferred embodiment of the present invention, the Soaking Phase is conducted in a pallet tote tank (“Soaking Vessel”) where vermicompost tea is continually re-circulated through the bed of activated carbon. Preferred Soaking Vessels are constructed from 275 gallon, plastic pallet totes (4 feet wide by 4 feet long by 4 feet tall, 8 inch fill hole on the top and a 2” drain with a valve -- MD Packaging Solutions, Mt. Laurel, NJ).

Pallet totes are plastic tanks that have their own pallet base so that they can be moved by a fork-lift truck. The tanks used in this example have a discharge valve at the center bottom of the tank, emptying to the side of the tank. In a preferred
embodiment of the invention, the top of the tank is cut off and one-inch polyvinyl chloride (PVC) gussets are placed in the corners of the bottom of the tank. 50 mesh stainless steel sheets are cut to fit the bottom of the rectangular tanks and mounted on the gussets. The stainless steel mesh is designed to hold the activated carbon during the three (3) days of soaking and one (1) day of curing which together compose the soaking process.

The vermicompost tea produced during the microbe propagation (brewing) phase is pumped from the brewing tank over the top of the Soaking Vessel and removed from the Soaking Vessel through the discharge valve. The tea being removed is recycled back into the brewing tank, the tea is pumped back into the top of the Brew Tank. The tea in the Brew Tank is continually pumped back into the top of the Soaking Vessel throughout the Soaking Phase. The tea is re-circulated down through the activated charcoal in the Soaking Vessel by the force of gravity, back to the Brew Tank, then back through the activated charcoal in the Soaking Vessel over and over again for a soaking period of 2-4 days, preferably for 3 days. The same pump used in the microbe wash phase and the microbe propagation phase is used in the Soaking Phase. The pump is a single speed pump that moves approximately 40 gallons of tea per minute. The hoses used in this process are 2 inch and 3 inch hoses, with the intake of the pump requiring a 3-inch hose and the discharge requiring a 2-inch hose.

The wet soaked carbon/humate mixture remains in the Soaking Vessel for a curing period of not less than 4 hours or more than 24 hours. The optimal curing period in the Soaking Vessel is 8 hours.

E. Drying Phase

EXAMPLE 7

The Drying Phase is dependent upon ambient temperature and humidity. The method of drying the granules is to first complete the “curing” step in the Soaking Phase so that water and vermicompost tea is not visibly draining from the granules. Then the treated granules are mixed in a slow moving, tumbler where the rotation is set between 1 to 3 revolutions per hour, depending upon the initial weight of the
granules. For example, 1,100 pounds of dry, unsoaked activated carbon is soaked and then dried with 1,900 of Perdue pasteurized poultry manure, (the pasteurized poultry manure (PPM) is commercially available from Perdue Farms, Grain and Oilseed Division, www.perdue.com) and 800 pounds of Menefee humate to yield approximately 4,000 to 4,100 pounds of dry, vermicompost tea granules. The pasteurized poultry manure granules can be replaced by compost granules or mixed with compost granules at any proportion. Pellets do not work because their size and density per unit is much greater than the size and density per unit of the granules. The initial tumbler revolutions will be at 3 revolutions per hour rate due to the heavy weight of the mix and its imbalanced distribution of granular materials. As the pasteurized poultry manure and humate absorbs the excess tea, the revolutions will be dropped to 1 revolution per hour so as not to physically crush the drying carbon and moisture gaining pasteurized poultry manure and humate granules. This slow turning rate is designed to provide oxygen during the drying process, thereby keep aerobic conditions while not impairing the development of fungal hyphae which will be broken with too much physical disturbance. The finished product is mixed until it is dry. The Drying Phase then takes between 1 and 4 days to cure the granules, that is, to return to ambient temperature as the microbes slow their continuing propagation process as the moisture content declines.

The vermicompost granules and added matter (humate granules, poultry manure granules, and/or compost) are mixed in an portable electric mixer, a cement mixer, or a commercial tumble mixer, depending on the size of the batch being processed. In addition, the granules can be sized for different plant applications. If desired, the granules may be bagged, for example, polyester mesh bags that hold fifty pounds. Any and all home, nursery and commercial spreader, including drop and broadcast spreaders, as well as seed planting equipment can apply the granules. The complete system of creating vermicompost tea and granules according to the invention is shown in Fig. 4.
EXAMPLE 8 – Applications

Soybeans
Plant 20 pounds of vermicompost tea granules with enough soybean seeds to plant an acre of soybeans and apply one foliar application of vermicompost tea at the rate of 20 gallons per acre with 80% coverage of the foliage of each plant. This treatment should enable the plants to successfully resist Asian Rust disease and increase marketable yield by at least 20%.

Clay and Clay/Sand Soils
The application of vermicompost tea granules at a minimum rate of 200 pounds per acre over soil that currently holds standing, puddle water after a period of more than 8 hours after the completion of rainfalls of 1 inch or more will remediate sufficiently to no longer have standing water puddles after a period of 8 hours after the termination of the rainfall. The semi-annual application of the vermicompost tea granules at the same rate will perpetuate the newly aerobic condition of the soil, as long as fungicides, herbicides and pesticides have not been applied, or if applied, then a spray application of vermicompost tea at the rate of 20 gallons per acre within the 24 hour period following the application of the fungicide, herbicide or pesticide.

Pastures, Forage and Growing Fields
The application of vermicompost tea and vermicompost tea granules to pastures, forage growing fields, and grass fields will significantly reduce the incidence of weeds and grub infestations.

It is to be understood that many modifications and variations may be devised given the above description of the principles of the invention. It is intended that all such modifications and variations be considered as within the spirit and scope of this invention, as defined in the following claims.
CLAIMS

We claim:

1. A method for producing vermicompost tea comprising the steps of
   a) thermal composting compost material under well-aerated conditions;
   b) using the products of step a) to produce vermicompost under well-aerated
      conditions;
   c) placing the vermicompost of step b) into suspension;
   d) adding a nutrient mix to the suspension of step c); and
   e) brewing the suspension and nutrient mix for more than 24 hours.

2. The method of claim 1, wherein steps c and d take place under well-aerated
   conditions.

3. The method of claim 1, wherein step c) lasts from 4 hours to 6 hours and
   wherein step d) lasts from 3 days to 4 days.

4. A method for producing vermicompost tea comprising the steps of
   a) thermal composting compost material under well-aerated conditions;
   b) using the products of step a) to produce vermicompost under well-aerated
      conditions;
   c) placing the vermicompost of step b) into suspension and continuously
      washing the suspension under well-aerated conditions for from 4 hours to 6
      hours;
   d) adding a nutrient mix to the suspension of step c); and
   e) brewing the suspension and nutrient mix for 3 days to 4 days under well-
      aerated conditions.

5. The method according to claim 4, wherein the nutrient mix comprises
   fungal food.
6. The method according to claim 5, wherein the fungal food comprises grain flour, kelp and humic acid.

7. The method according to claim 4, wherein step e) is conducted at temperature equal to or less than 45 degrees Fahrenheit.

8. The method according to claim 4, wherein the vermicompost comprises nematode vermicompost.

9. The method according to claim 4, wherein step b) takes place in a worm bin, wherein the worm bin has an open top and non-solid bottom.

10. The method according to claim 9, wherein the worm bin has screened, side air vents.

11. A method of producing vermicompost tea granules comprising the steps of:
   a) soaking solid carrier granules in a vermicompost tea produced according to the method of claim 4 to produce a vermicompost-soaked solid carrier; and
   b) drying the vermicompost-soaked solid carriers.

12. The method according to claim 11, wherein the solid carrier granules are carbon based granules.

13. The method according to claim 11, wherein the carbon based granules are a blend of activated carbon granules and humate granules.

14. The method according to claim 11, wherein step a) lasts from at least two days to four days.

15. The method according to claim 10, further comprising the step of curing the vermicompost-soaked granules after step a).
16. A method of producing vermicompost tea granules comprising the steps of:
a) soaking carbon based granules in a vermicompost tea for 2 to 4 days to produce a vermicompost-soaked granules wherein the carbon based granules comprise:
from 60 to 80% activated charcoal and
from 20 to 80% humate carbon; and
b) curing the vermicompost-soaked granules for a period of not less than 4 hours or more than 24 hours; and
c) drying the vermicompost-soaked granules.

17. A solid carrier granule soaked with vermicompost tea.

18. The solid carrier granule according to claim 17, wherein the solid carrier is a carbon based granule.

19. A method of treating plants comprising applying the vermicompost tea of claim 4 by foliar spray or in vermicompost tea soaked granules.

20. A method of soil remediation comprising applying the vermicompost tea of claim 4 by foliar spray or in vermicompost tea soaked granules.