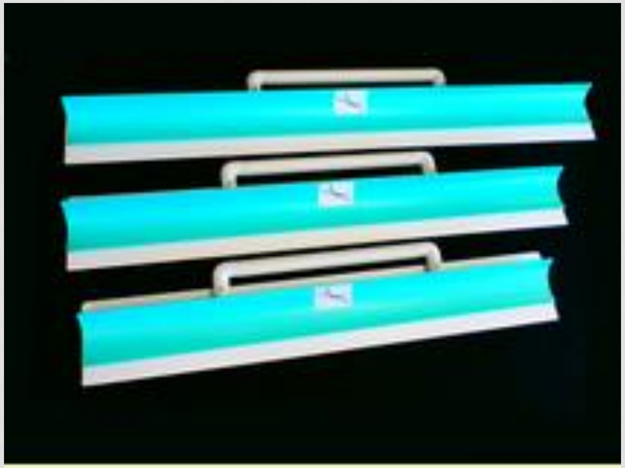
INFINITE VERMICAST SOLUTIONS

MAGEN KEGLEY, TAYLOR CONLEY, GUY BARKER, MATT GALLAGHER

ABOUT THE CLIENT

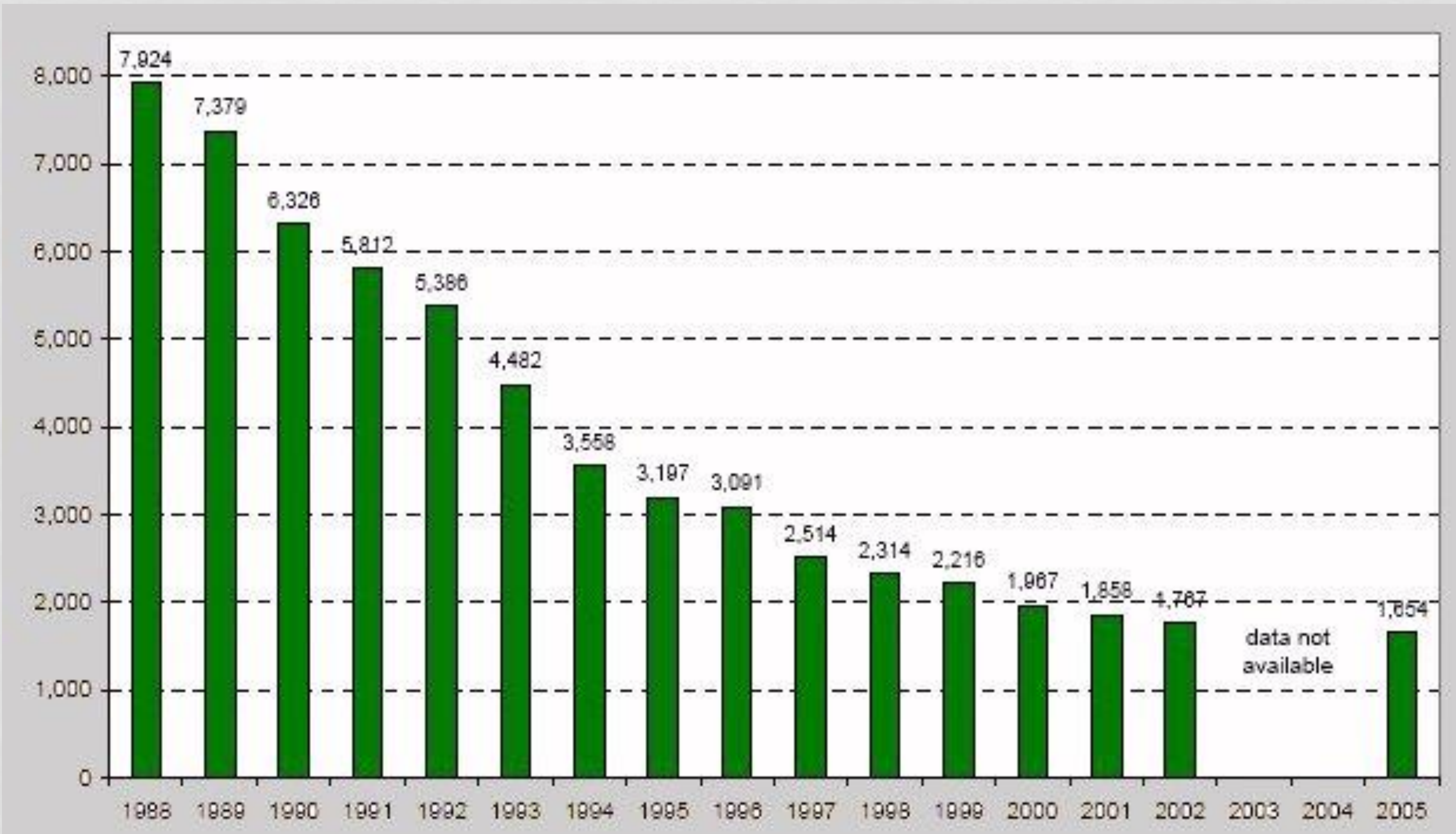
- Dale Robinson
  - Inventor of The Big Squeegee
    - http://www.bigsqueegee.com
    - Runs business out of Lawton, OK
  - Looking to innovate vermicomposting systems by making them continuous



Bigsqueegee.com

WHAT'S THE PROBLEM?

Decreasing number of landfills since 1988



Source: Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2005, EPA, page 14)

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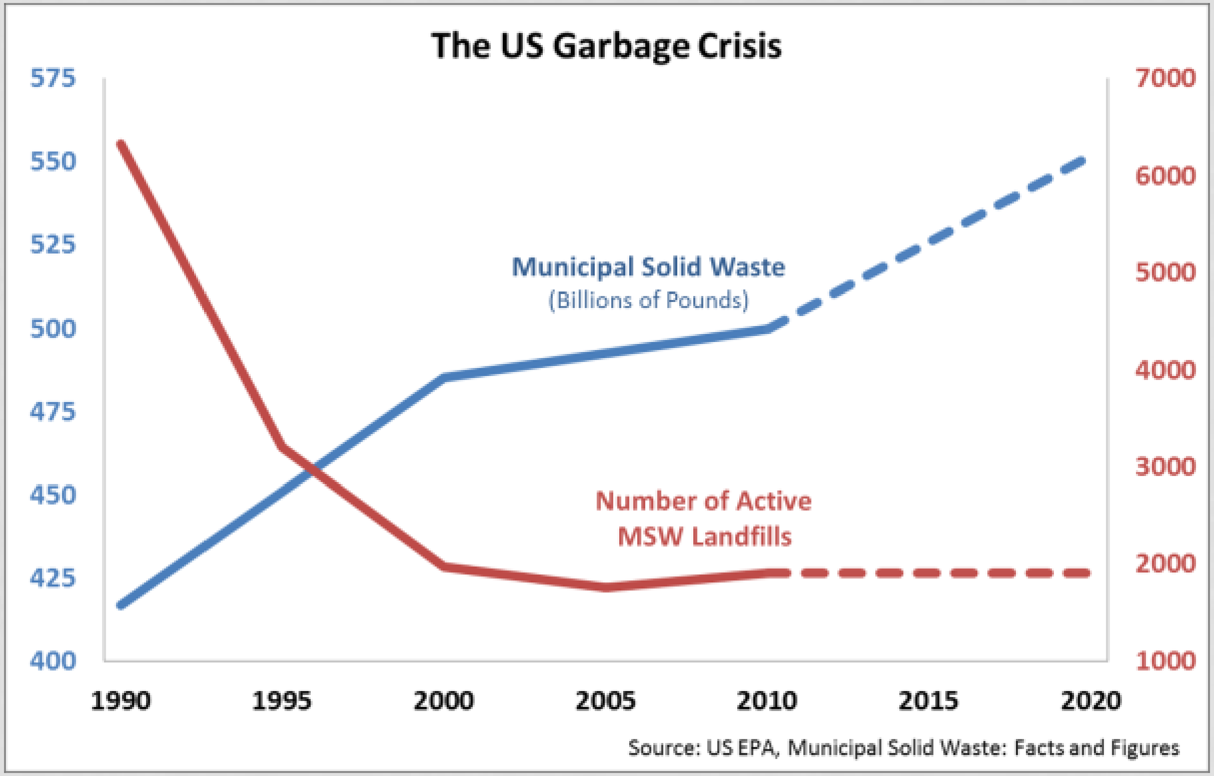
LANDFILLS

- According to the EPA, America produces 254 million tons of trash a year.



LANDFILL COMPOSITION

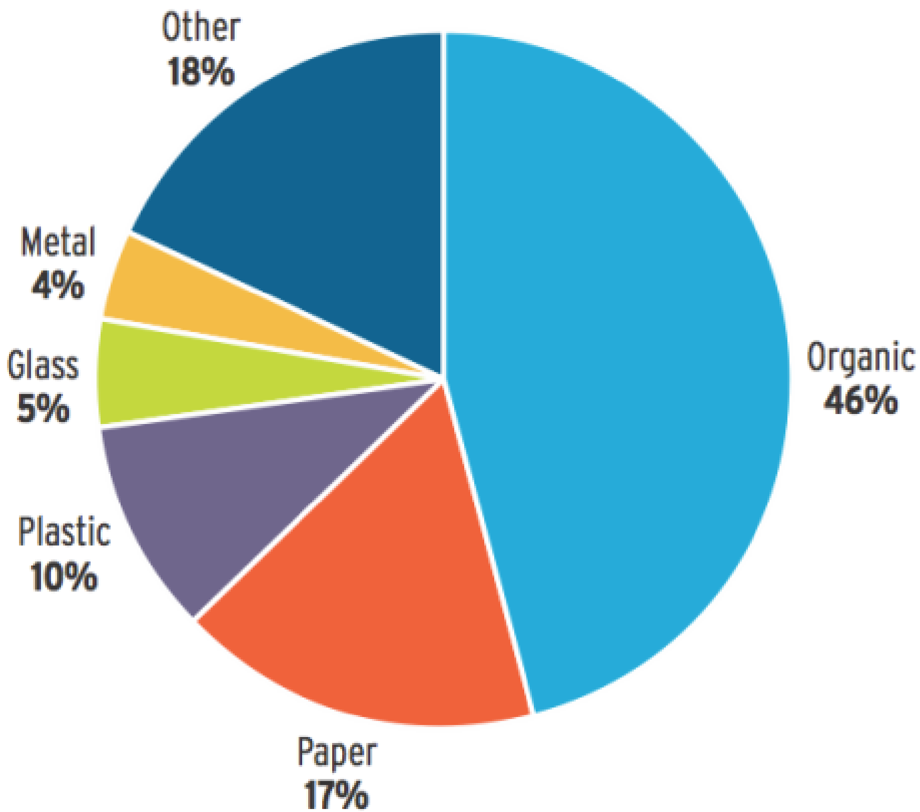


FIG. 7
Global Solid Waste Composition

http://cdn.theatlantic.com

STATISTICS

- Every year, **40%** of the food generated by Americans is wasted. (https://www.nrdc.org/food)
- 34 million tons of food scraps
- Historically, food scraps were separated from garbage and used as pig food, but today it ends up in the trash.

https://www.google.com/search?q=landfills

SOLUTION

- **Composting**

Large amounts of organic waste can be turned into nutrient-rich substance capable of repurpose.

https://www.google.com/search?q=compost+pile&

https://www.google.com/search?q=compost

COMPOSTING

- Typically the organic material is decomposed using microorganisms
- However, there is a faster way-

Vermicomposting

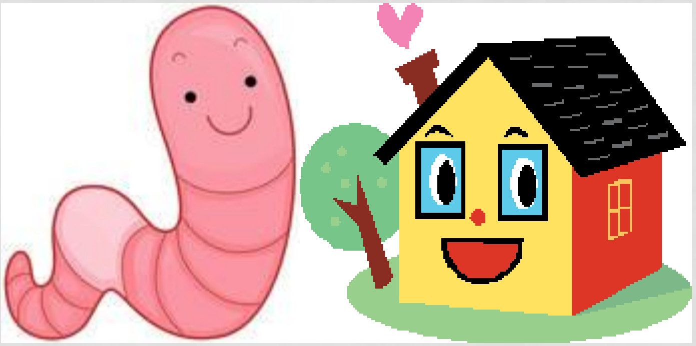
BACKGROUND

- **ver·mi·com·post·ing** [ˌvərməˈkämpōstiNG] NOUN, the use of earthworms to convert organic waste into fertilizer.
  - Vermicomposting." Oxford University Press, n.d. Web. 6 Nov. 2015.

- Vermicomposting is an effective and beneficial way to reduce the amount of trash that is being dumped into landfills every day

OBJECTIVES

- Create a continuous, flow-through vermicast system
- Worm excretions are a useful form of topsoil and fertilizer that can grow better food
- Design will be small enough for an "everyday" person to use



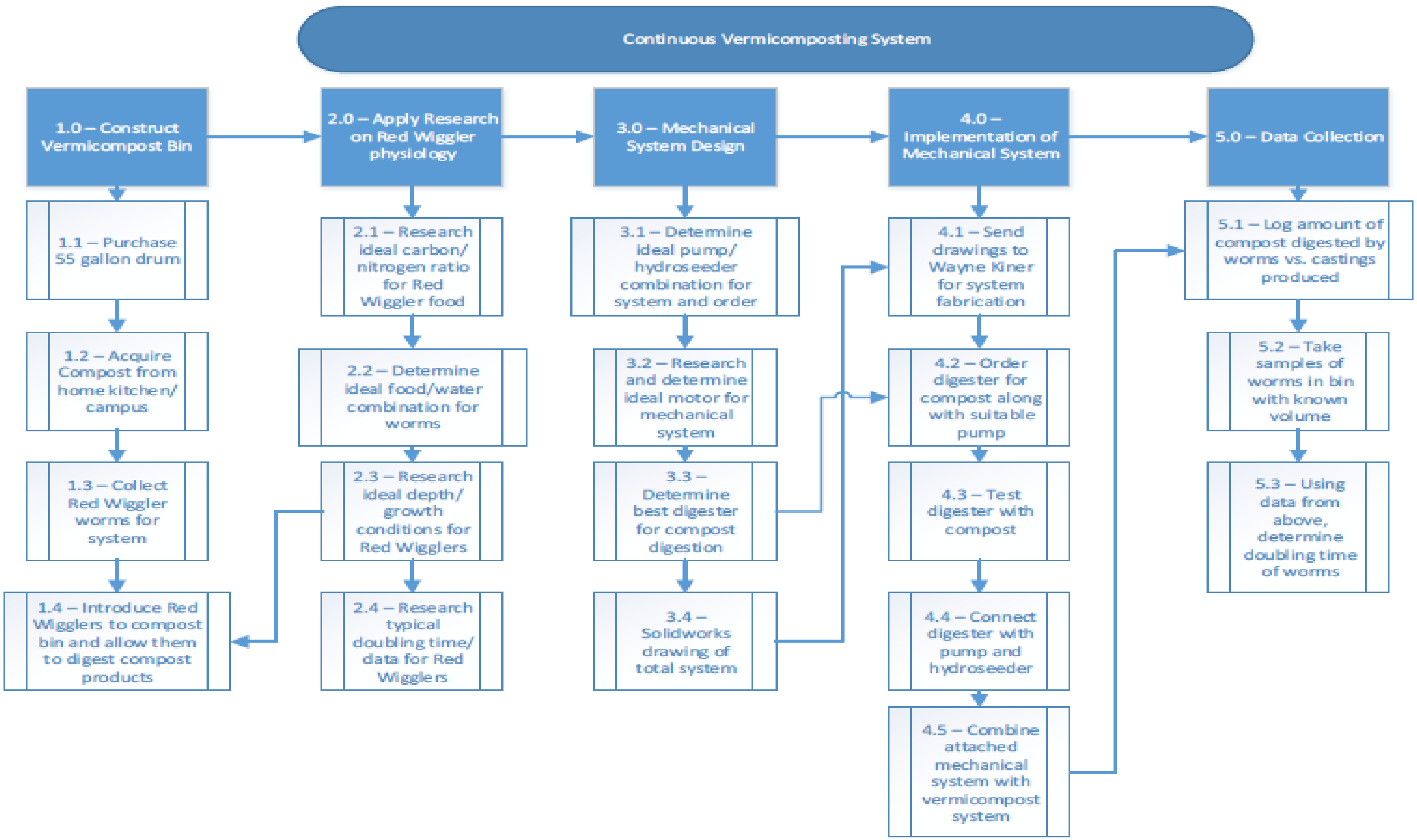
SCOPE

- Design is expected to deliver food to flow through system
- Best species of worm will be determined from research
- Data on worm doubling time and food consumption will be taken

TASKS

- Our main task will be the construction of the flow-through bin
- Worms must consume a certain amount of food before tests can be done on the flow-through bin
- A "food spraying" implement will be designed and constructed as the food delivery system for the worms

WORK BREAKDOWN STRUCTURE



DESIGN CONSIDERATIONS: FLATBED

- Flatbed “box” system
  - Blade runs back and forth across box and scrapes castings off

FLATBED PROS

- Effective flow-through system
- Used by many large-scale industrial vermicomposting systems
- Large surface area provides more room for worm volume

FLATBED CONS

- Difficult to fit into small, domestic settings
- Laterally moving blades require more power
- More problematic to evenly distribute compost
- Larger amounts of water needed for more surface area

DESIGN CONSIDERATIONS: MANUALLY FED CYLINDER

- Cylindrical column where food and water are added together
- As worms digest compost, castings move to the bottom
  - Employs "flow-through" design
- Currently widely used as a domestic design for vermicomposting

MANUALLY FED CYLINDER PROS

- Good size for every-day households
- Flow-through system
- Easy to control parameters

MANUALLY FED CYLINDER CONS

- Manual removal of castings
- Food not pre-digested takes longer to process into castings
  - Increases chances of anaerobic digestion by microbes
- Food and water added separately = more work

SECURITY

- Secure and private work and construction environment
- Unaltered ambient conditions for worms to ensure proper data collection
- Protection of public from potentially hazardous parts
- Usage of non-invasive worm species

BAE 1012 CONTRIBUTIONS

- Research on species physiology and ideal conditions for vermicomposting

- Research on mechanical specifications of hydroseeder sprayers and ideal material composition of semi-solid spraying

DELIVERY

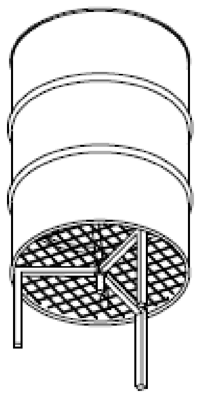
- The final product must be a sustainable, continuous, flow-through bin that digests and delivers food to worms
- Research on why the specific worm species that was chosen will also be presented
- Doubling time and food consumption will demonstrate efficiency of system

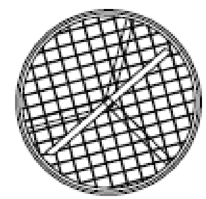
WORM BIN DESIGN CONSIDERATIONS

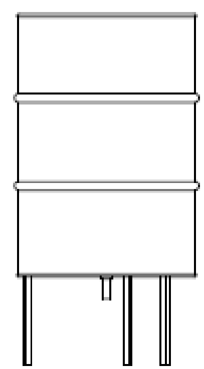
- Marry efficiencies of flat bed & fed cylinder
- Increase efficiency spatial use
  - Increase bin depth
    - For gestation & curing period of eggs & castings
  - Produce an immediately usable product
- Eliminate the need for propagation trays or worm harvesters

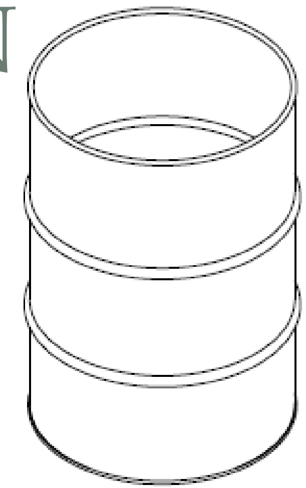
Jet 3600 series worm harvester

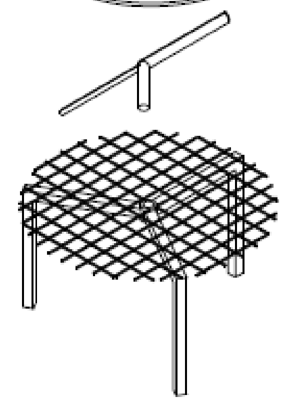
INITIAL DESIGN











		UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
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			CHECKED			TITLE: Prliminary Drawing of Worm Bin for Infinite Vermicast Solusions
			ENG APPR.			
			MFG APPR.			
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
		MATERIAL	COMMENTS:			SIZE A DWG. NO. Worm_bin REV
NEXT ASSY	USED ON	FINISH				
APPLICATION		DO NOT SCALE DRAWING				SCALE: 1:24 WEIGHT: SHEET 1 OF 1

HYDROFEEDER DESIGN CONSIDERATIONS

- Increase Loading efficiency and cut down on man power
- Avoid loading bins by
  - Hand
  - Small commercial equipment (skid-steer)
- Combine the feed and moisture control system
  - While maintaining appropriate DO (dissolved oxygen) levels

INITIAL DESIGN OF HYDROFEEDER

VERMICULTURE

- Worms chosen were Red Wigglers
- Optimal growth temperature between 55-77°F (13-25°C)
- Bed depth will be around 6-10”
- Aerobic environment required
- Expected to live 2-3 years

FOOD FOR VERMICULTURE

- Cellulosic material will be used to feed worms
  - Newspapers, fruits and vegetables, coffee grounds, and "coco-coir" will be used as feedstock
- Ammonia-rich compounds (manure and urine) needs pre-treatment
- Expected to eat their weight in food
- Pre-digested food aids in casting-producing efficiency

DEALING WITH POPULATION GROWTH

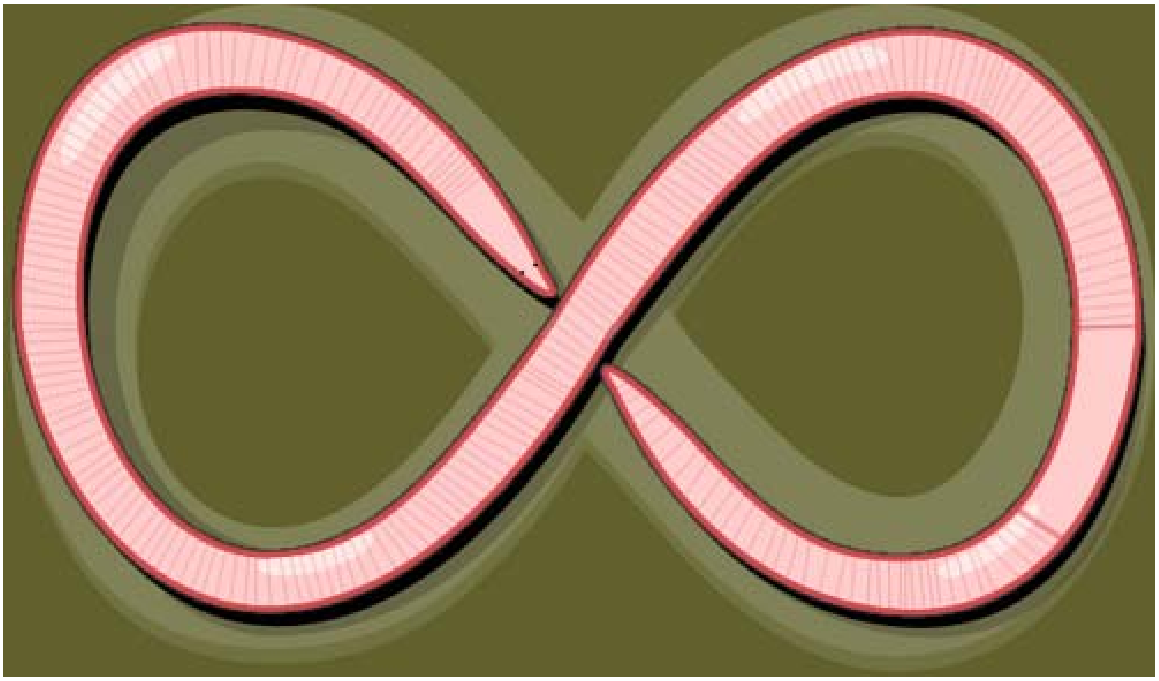
- Doubling time of Red Wigglers expected to be 60 days
- Over time, worms will reach “critical mass”
- Manual harvesting of worms to continue growth
  - Use as bait or feed – provide extra business
- Considered a “maintenance” aspect of the system

COMPOST THAT CAN NOT BE USED

- Dairy products and meats
- Non-biodegradable products (plastics)
- Cat litter
- Non-treated manure and urine

PERFORMANCE

- Duties already performed:
  - Research of vermiculture and worm physiology
  - SolidWorks drawing of potential system design
- Duties to be carried out:
  - Order parts and materials for bin construction
  - System set-up and construction
  - Fill bin/bed with compost and worms
  - Test system with digester and food sprayer
  - Collect necessary data



INFINITE VERMICAST SOLUTIONS
Established 2015

Final Project Report – April 28th, 2016

Guy Barker
Taylor Conley
Matthew Gallagher
Magen Kegley

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Introduction to the Problem

Problem Statement

This project includes the design and implementation of an innovative continuous vermiculture system. To achieve this, our team will study the habitat and physiology of various worms to develop the proper feeding and nutrient system. A digested waste delivery and casting harvesting system will be developed based off of our research.

Statement of Work

Background

More and more precious land space is taken up every year by the spreading of landfills, caused by increased consumer wastes. However, a large amount of the trash that is carelessly thrown away can be transformed into nutrient-rich silage via composting. Although composting is beneficial, it lacks efficiency since decomposition must be performed by microorganisms. An alternative and faster method to accomplish the degradation of organic materials is by adopting a vermicomposting system, which introduces worms to the compost area. Worms, when utilized in the proper conditions and when fed biodegradable wastes, can efficiently break down a variety of materials in order to reduce the number and size of landfills all over the world.

The customer, Mr. Dale Robinson, proposed that a continuous, flow-through worm bin can be designed so that even the busiest person would be able to take advantage of the benefits that result from vermicomposting. The customer requires that the team design and develop the technology for a continuous flow-through vermiculture system that will treat organic wastes and harvest digested Red Wiggler worm castings. The flow-through system will implement a flooding technique in order to address issues of aeration. This system will aid in reducing landfill wastes from kitchen and industrial settings, while providing a nutrient-rich topsoil that can be used to grow high quality crops and produce.

This project is similar to a continuous conveyor vermiculture system because it utilizes a continuous automatic worm castings collection system. Although it does not utilize a mechanized conveyor system, the pitched filtration system allows for separate worm tea and casting harvests. The system also will be designed including a digester that will allow for a higher efficiency for the total process due to the initial digestion of the organic waste. Although there are no specific regulations for vermicomposting, a permit is required for composting if the process reaches commercial scale.

Objectives

The objective of this project is for the Infinite Vermicast Solutions team of Oklahoma State University to design a fully integrated, flooded, flow-through vermicomposting system that includes a digester that will increase the efficiency of the process as a whole. Testing will include research on the best breed of worm to exploit in the flow-through bins for the North-Central Oklahoma ecosystem where the experimentation and fabrication will take place. Experiments will be conducted in order to determine ideal water to food ratios based on the growth of worms in the individual systems, as well as moisture contents of worm castings and proper sieve sizes for the filtration of castings and tea.

By utilizing a continuous system, it will be easier for consumers of the product to reduce waste in landfills, and introduce a way for the consumer to be self-sustaining by providing fertile soil for produce growth. Goals that lie within this objective are to make the design take up as little space as possible, as well as utilizing materials that are inexpensive and easy to find. The system should emphasize effectiveness of breaking down organic wastes as well as ease of use by the operator. Preferably, the total system will cost $1,000 or less, but the client has noted that this is not a firm limit.

Scope

Mr. Robinson of The Big Squeegee© expects a flow-through vermiculture bin design that includes a process of digestion prior to the delivery to the worm beds. Therefore, by employing a system that includes a sprayer that delivers the food to the worms in a pre-digested form, the worms will constantly be at the top to consume the food. To determine the most suited breed of worm for the bin, data on the preferred depth of each breed will be researched. Data will be collected on the doubling time of the specific species of worm as well as the expected daily food consumption.

A possible limitation of the designed bin could be the growth of worms within the bin. A future aspect of the project that may arise is implementing supplementary aspects of the bin with the ability to separate the large worms from the smaller worms for use as fish bait and poultry feed. This process would be very tedious and time consuming, since there is no known or affordable technology to distinguish the two worms; there is little design in the process of separating worms. Other limitations that might arise during testing is being able to determine the location of the worm "nursery" area and if it would be effective separate from the worm feeding area.

Tasks

Our customer is requiring that we design and develop the technology for a continuous flow-through vermiculture system in order to treat organic wastes and to harvest digested worm castings and tea. The castings can then be transported and used as nutrients for crops. A filtration system will be developed in order to separate the worms from the castings. After the flow-through system is flooded by the digester, the residual fluid or "worm tea" will be separately harvested.

An important requirement is to research and verify the biological specifications of the worms, and more specifically, the most desirable conditions for the utilized worms. We must find an ideal depth for proper growth and activity for the worms, and their dietary habits must also be researched in order to determine the waste delivery system. Our vermiculture unit should be able to maintain a certain ideal volume for each individual worm in order to maximize the composting process. Ultimately, we are required to design and manufacture a prototype for a continuous waste management and composting unit utilizing vermiculture.

Table 1 below shows the tasks to be completed during the project and the corresponding estimated completion date of each task. The following section gives a brief summary of the details involved in completing the task.

Table 1. Task List and Completion Dates		
Task Number	**Work Milestones**	**Projected Completion Date**
Task 1	Review Customer Order	10/14/15
Task 2	Preliminary Design Modeling	10/27/15
Task 3	Preliminary Design Report Draft	11/13/15
Task 4	Preliminary Design Final Report	11/23/15
Task 5	Preliminary Design Presentation with Client	12/3/15
Task 6	Experimentation and Testing Begins	2/1/16
Task 7	Experimentation and Testing Ends	3/20/16
Task 8	Manufactured Prototype	4/1/16
Task 9	Prototype Testing	4/21/01
Task 10	Final Design Presentation with Client	4/28/16

Task 1 – Review Customer Order

This includes preliminary reviews of the presented project. These reviews include literature reviews, patent searches, biological specifications of the worm type used, engineering specifications of materials within the system, analysis of customer requirements, and detailed problem statement formation. This also concludes design of company name, mission statement, and logo.

Task 2 – Preliminary Design Modeling

This includes the modeling of the preliminary design utilizing SolidWorks. This includes a conference call with applications and extension engineers, engineers within the department of Biosystems & Agricultural Engineering, the client, and the contractors in order to present initial ideas and gain valuable guidance and feedback.

Task 3 – Preliminary Design Report Draft

A preliminary design report draft is submitted to Dr. Paul Weckler on the progress of the project.

Task 4 – Preliminary Design Final Report

A corrected version of the preliminary design report draft is submitted to Dr. Paul Weckler on the progress of the project.

Task 5 – Preliminary Design Presentation with Client

The contractors will present the progress of the project and the prototype to the client and associated engineers. Throughout the presentation, those in attendance will offer critiques and suggestions on the feasibility of the current design and possible changes that could be made to benefit the system.

Task 6 – Experimentation and Testing Begins

Experimentation and data collection on optimal water to food ratio, worm tea recycle benefits, and proper sieve size for the filtration of worm castings and tea will be conducted during this period.

Task 7 – Experimentation and Testing Ends

Experimentation and data collection on optimal water to food ratio, worm tea recycle benefits, and proper sieve size for the filtration of worm castings and tea will conclude.

Task 8 – Manufactured Prototype

The manufactured prototype is assembled in order to begin testing the system.

Task 9 – Prototype Testing

This concludes the testing period of the manufactured prototype at the Bioenergy Laboratory and data is taken to determine effectiveness of the system.

Task 10 – Final Design Presentation with Client

The contractors will present the findings of the project and the final prototype to the client and associated engineers at 2:00 PM, 28 April 2016, in the Seretean Wellness Center at Oklahoma State University. This will be followed by demonstrations of the prototype

Work Breakdown Structure

Figure 1 listed below is a summary of the work break down involved for the completion of the project.

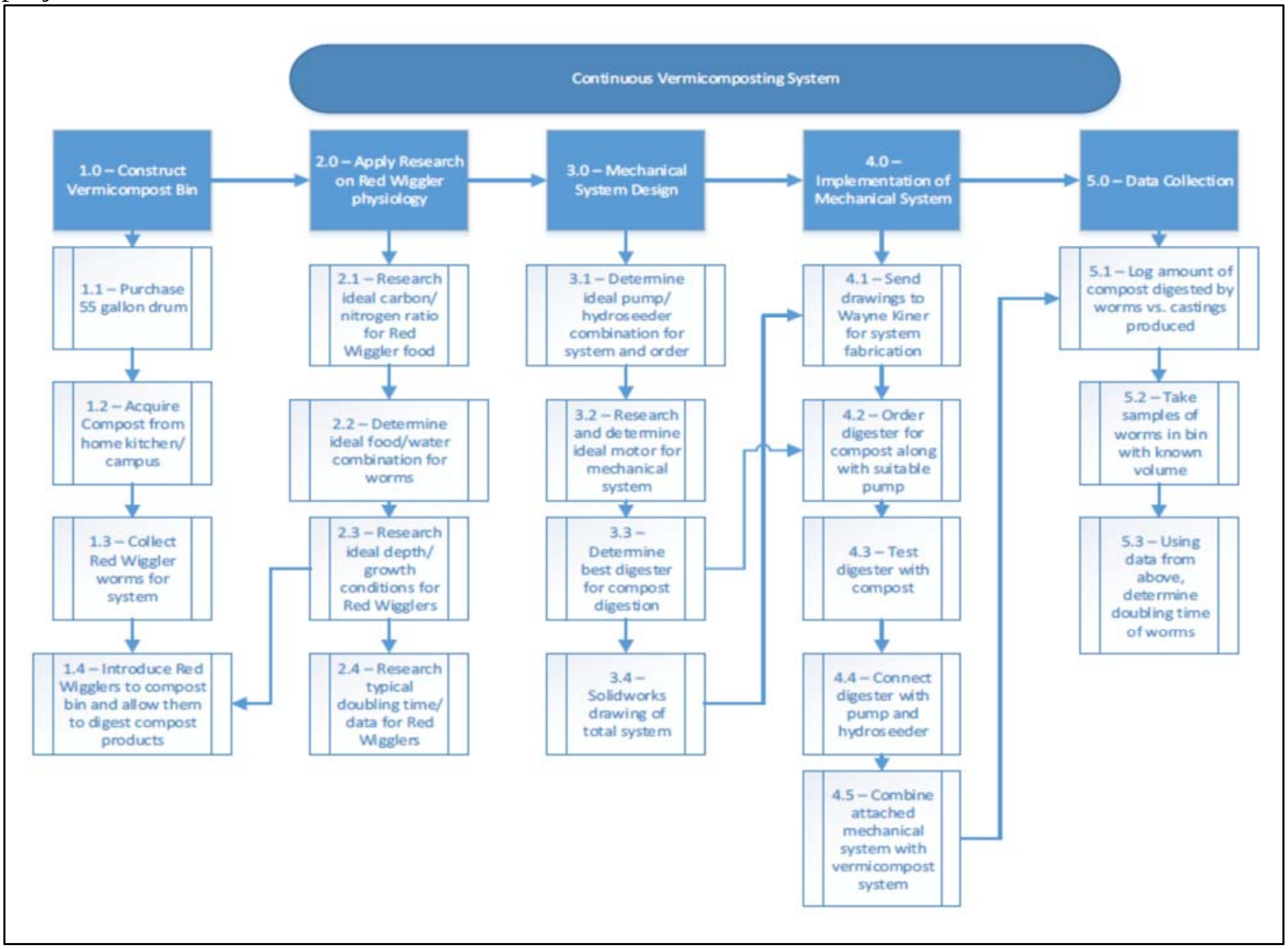

Figure 1. Work Breakdown Structure for Completion of Vermiculture flow-through Project.

Delivery

We are to deliver a continuous worm bin with an automated feed delivery system. The designs will be delivered via a presentation in Ag Hall, 3 December 2015 at 1:45 PM; location will be Agricultural Hall 210, Stillwater, Oklahoma. Prototypes of both the bin design and hydrofeeder system will be delivered and demonstrated 28 April 2016 at 2:00 PM at the Seretean Wellness Center at Oklahoma State University, Stillwater, Oklahoma. No governmental documentation of receipt is necessary.

Government Involvement

Furnished Property, Material, Equipment, or Information (GFP, GFM, GFE, or GFI):

Since this project is being designed and constructed on land grant university property, the area where it will be built belongs to the government. The specific location of the worm-bin will be at the Oklahoma State University Bioenergy Annex off of Marvista St. in Stillwater, OK. Material will be purchased by the contractor using Mr. Robinson's provided budget of $1,000.

Security Considerations

There are multiple security considerations to accommodate on this project. The first concern is who has access to the vermiculture bins. The team will be designing and testing a new system of continuous vermiculture processing. The design setup should be kept out of public eye as to avoid premature or unlawful replications.

The second concern for housing the bins in a securely monitored location is the safety and well-being of the worms. The team will be altering and testing different parameters on the bins to ensure the most efficient setup. The monitoring process will be based upon the success rate of the worms and their produced castings. If unauthorized persons enter the work space and purposely or accidentally change any conditions in the worm's environment, the testing outcomes will be flawed. The team may be unaware of the intruder's actions and deem the setup flawed when in reality it was due to the outsider's alterations.

A variety of parts will be assembled during the construction of the continuous vermiculture setup. Some of these parts will either be small in size, valuable, or dangerously sharp. The setup location shall be limited from the public to ensure no parts are lost, stolen, or damaged. The isolation will also ensure no public entities are injured on exposed unfinished pieces.

Permission to access the facility responsible for housing the project will be granted to all team members. This will be approved by Dr. Doug Hamilton of the Oklahoma State University Biosystems and Agricultural Engineering Department. His contact information is 226 Agriculture Hall, Stillwater, OK, (405) 744-7089, dhamilton@okstate.edu.

Failure Modes

As with any project, there is a certain risk associated with the failure of the system. Some of these failures may be minor and only need a small part replacement, while other failures may be of monumental significance that could lead to human injury or even death. It is of extreme importance to know the failures associated with any project. It is a good idea to list the failures along a gradient scale that lets you know how important the failure is to the system. The minor failures associated with this project are the paint types used on the system. The paint is in place to ensure that the worm substances do not rust or corrode the bin. The paint should be strong enough to resist corrosion and scraps. However, if the paint were to peal or get scraped, the structural integrity of the system would still hold true. If no paint were on the bin, if could possibly be years before any permanent damage was caused to the bin.

The next failure to consider is the motor size of the garbage disposal used. This failure is of significant importance. The garbage disposal is responsible for preparing the food to be added to the worm bed. If the motor is not large enough to handle and shred the amount of food being added to the system, then no food will make it to the bin. If the disposal breaks, one would have the tear the food up by hand which would use a lot of man power and hours. If whole food is added to the bin, you risk the food heating up and going into anaerobic conditions. The heat involved in this process will kill your worms. If your garbage disposal cannot handle the food load, you risk ruining the workings of the entire system.

A failure of medium significance is the workings of the hydrofeeder. The hydrofeeder is responsible for transporting the food and water from the digester to the worm bin. If the hydrofeeder fails and stops working, this does not affect the integrity to the workings of the system. If the hydrofeeder stops working, the food and water could be ladled out of the digester and manually added to the worm bin. The process would be inconvenient, but you would not need to stop the decomposition of the worm beds in order to fix the problem.

The next failure to consider is the size of the screens used and the strength of the screen used. These parameters are also of great importance. If the screen cannot support the load of the castings, you risk having your screen tear. If the screen tears, the castings, food, and worms will fall through the system onto the floor. This may not be a mechanical failure, but a tear in the screen would deem the system useless.

The same goes true for the size of the screen. If the size of the screen is too large, it would act the same as if there were a tear in the screen. However, the failure significance can be downgraded if the size if the screen were too small. If the screen size were too small, the castings would not be able to flow through the system. In this case, the system would no longer be a continuous vermiculture system. However, the system would not be deemed totally useless. You could use the bin as a batch process until plans were made to increase the size of the screen.

Other failures to be considered are operation failures. It needs to be made clear to the operator that only foods that the worms can eat should be added to the system. Also, the water content of the soil needs to be maintained to ensure the survival of the worms in the system. If the worms die, then the system has failed.

Travel

A preliminary visit was made in October 2015 to Mr. Dale Robinson’s facility based out of Lawton, Oklahoma. After speaking with Mr. Robinson and touring his facility, no additional visits were required. The contractors will travel to the Bioenergy Annex laboratory facilities west of the Oklahoma State University campus in order to conduct their experiments and tests.

Special Material Requirements

- Provided space in the Bioenergy Annex
- Worms (Red Wigglers) provided by Dr. Doug Hamilton

Place of Performance

The project will be housed in the Bioenergy Annex belonging to the Biosystems and Agricultural Engineering (BAE) Department of Oklahoma State University. The location of the annex, shown in Figure 2, is Marvista St, Stillwater, OK, 74074. All construction and setup testing, either on the worms or the design features, will be made in this location.

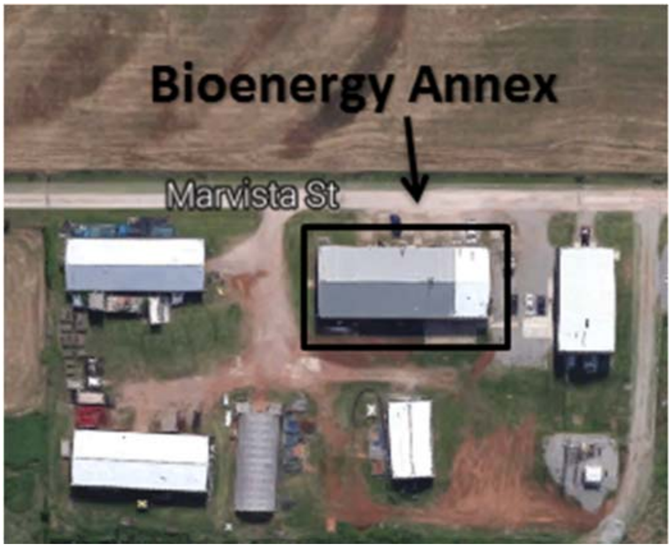

Figure 2. Bird's-Eye View of Bioenergy Annex in Stillwater, OK.

Project parts will either be ordered from exterior companies or fabricated at the BAE Research Laboratory Machine Shop. Initial contact will be made through Wayne Kiner, BAE Research Laboratory Manager. His contact information is 116 BAE Lab, Stillwater OK, 404-744-5428, wayne.kiner@okstate.edu.

Period of Performance

This project was introduced to the team at the beginning of September 2015. The initial face to face meeting with the client was on 18 September 2015. Upon acceptance of the project, the team began reviewing the customer's order and designing first draft plans of the system setup. Through the months of September and October, the team collected copious amounts of research materials and familiarized themselves with the background of vermiculture. By the end of October, a SolidWorks drawing of the system setup was constructed. The following steps will be taken to complete the project: Parts and material will be ordered at the beginning of November. Customized parts will be fabricated during this time period. After attainment of the bin, it will be sent out for powder coating to avoid corrosion. When all parts have been gathered, assembly of the system setup will begin by the end of December/beginning of January. At the time, a presentation will be given during the first week of December to update the client and application engineer about the status of the project.

At the beginning of February, the team began filling the bins with bedding and compost material. After completion, the worms were introduced to the system. Water to food ratio testing was completed and worm tea was recycled to provide analysis about its nutritional value. The testing process took 3 weeks. The month of April was used to analyze the test results and assess any problematic features of the bins. All problems were resolved by mid-April. A final presentation including all design features, testing, and results will be given to the client, application engineer, professors, and approved audience on 28 April 2016. The final product of a continuous vermiculture system will be delivered to the client the first week of May signifying thus, project complete.

Technical Analysis and Market Research

A system that provides a solution to a continuous vermiculture system is a patented slow-moving conveyor system that automatically applies thin layers of organic wastes to a bed of worms. The conveyor moves the digested biomass into separate bins while keeping the worms on the conveyor system. This allows for worms to work both at a high activity level and for the system to be continuous. Durability issues that come along with the system are the eventual corrosion of the conveyor system and the replacement of items related to it. Chains and belts would have to be replaced often due to the introduction of a wet environment to the metal parts. The system is quite reliable because of the relative simplicity of the design, as long as the mechanical aspects remain functioning. The dangers that exist within this system are finger pinching in the gears and belt mechanism. Also, the wet "worm tea" might form a slippery area around the system. As far as maintenance requirements, the bin that collects the castings must be manually emptied and taken away. The parts, as mentioned earlier, must be replaced when necessary to prevent rusting and corrosion in the wet environment. The conveyor belt system overview can be viewed in Figure 3.

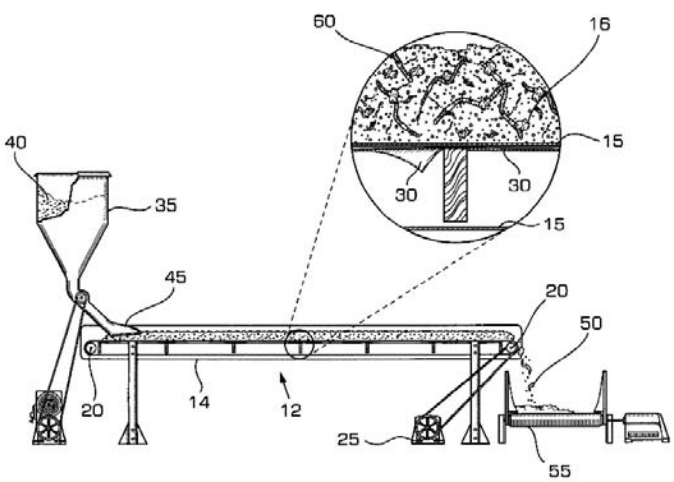

Figure 3. Conveyor vermiculture system. Patent ID US 6223687 B1.

Another process that holds similar solutions to components needed within a continuous vermiculture system digests sewage material, then distributes it among a bed of worms. The system treats sewage waste to optimize it for worm digestion, and heats or cools it before feeding it to worms. The system poses a few hazards since it contains grinding pumps, heating and cooling coils, and raw sewage. Therefore, those maintaining it should be properly trained to replace the necessary parts. Corrosion over a few years could also become an issue in durability, because the pipes and holding tanks most likely have steel or metal components. It is reliable for properly digesting and distributing the sewage material onto the vermiculture beds, as long as the heating and cooling coils do not exceed the required temperatures, which could cause a lack of efficiency or even death among the worms. The pipes and temperature coils must be maintained, as well as the correctional fluid that adjusts pH, electrical conductivity, and percent solids. The logical flow of the sewage treatment and distribution can be viewed in Figure 4.

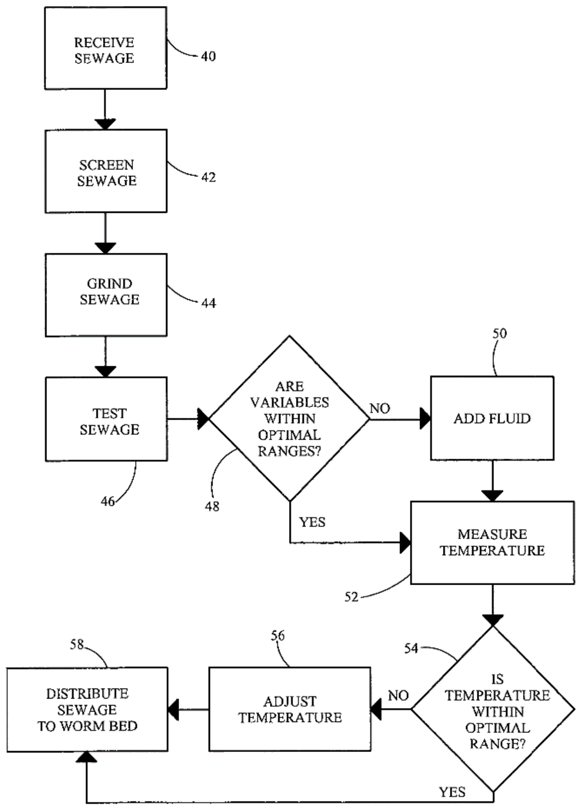

Figure 4. Flow chart of sewage treatment from patent number US 7141169 B2.

Existing Patents

An extensive research was conducted to find similar continuous vermiculture systems currently holding a patent. The patents researched are summarized below and can be found in the references section.

Patent ID US 8919282 B2: Published on December 30, 2014
http://patft.uspto.gov/netacgi/nph-Parser?Sect2=PTO1&Sect2=HITOFF&p=1&u=/netahtml/PTO/search-bool.html&r=1&f=G&l=50&d=PALL&RefSrch=yes&Query=PN/8919282
This is a patent for a continuous vermiculture system that feeds a slurry of organic food waste and probiotic through a continuous irrigation system that floods the beds of worms. This is relevant because it provides an idea for mechanized flooding of the worm beds with an added component of nutrient-rich organic materials.

Patent ID US 6576462 B2: Published on June 10, 2003
http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&u=%2Fnetahtml%2FPTO%2Fsearch-adv.htm&r=12&f=G&l=50&d=PTXT&p=1&S1=%28%28vermiculture+AND+continuous%29+AND+compost%29&OS=vermiculture+AND+continuous+AND+compost&RS=%28%28vermiculture+AND+continuous%29+AND+compost%29
This is a patent for a rectangular container fabricated specifically for the composting of animal and household waste using vermiculture. The bins are painted specifically to absorb sunlight on the front end and cover (black) and to reflect sunlight on the opposite end (white). Compost is extracted via an opening adjacent to the base of the container. This is a very simplified and small vermiculture composting unit that uses the temperature gradient to draw in new oxygen and cool the increasing temperatures within the bin due to respiration. The manipulation of sunlight in order to maintain an ideal temperature within the containers could greatly assist our project.
Patent ID EP 0196887 A2: Published on October 8, 1986
https://www.google.com/patents/EP0196887A2?cl=en&dq=continuous+vermiculture&hl=en&sa=X&ved=0CCoQ6AEwAmoVChMIwpykx5ikyAIVhZENCh2WjA3R
This is a patent for the use of a breaker bar unit to extract the base layer of the finished compost within a unit with a perforated floor. As it separates the completed compost at the bottom of the container, it does not disrupt the worms that are near the top of the bin. This can also serve to harvest worms for the marketable venture of protein-rich feed for pig, poultry, and fish farming. Ultimately, this provides an idea for the mechanized extraction of compost after the waste products are broken down and excreted by the worms.
Patent ID WO 2002046127 A2: Published on June 13, 2002
https://www.google.com/patents/WO2002046127A2?cl=en&dq=continuous+vermiculture&hl=en&sa=X&ved=0CEYQ6AEwBmoVChMIwpykx5ikyAIVhZENCh2WjA3R
This is a patent for composting organic waste using a thermophilic vermiculture system in order to produce worm castings. This is a very similar system to what we are trying to implement in this project, but does not give many specifics on the technology used. This is still helpful because it describes the process and necessity of this type of system.
Patent ID US 6223687 B1: Published on May 1, 2001
http://www.google.com/patents/US6223687
This is a patent for a conveying system in which a thin layer of biomass is moved along a layer of worms in order to increase their activity. This creates a continuous open system and maintains efficiency due to increased spatial awareness from the worms. The beds can then be stacked in order maximize this efficiency. This is likely a system that would greatly exceed our budget, but it is helpful because it provides insight into spatial efficiency and the continuous process we are seeking to develop.
Patent ID US 7141169 B1: Published on November 28, 2006
http://www.google.com/patents/US7141169
This is a patent for the digestion and distribution of raw sewage among the bed of worms. The system controls the temperature of the waste before its dispersal among the worms through simple heating and cooling coils. While this may be slightly too intensive for our project, it provides insight about the importance of temperature control, maintenance of equipment, and the process of digestion prior to the flooding of the containers.
Patent ID US 8642324 B1: Published on February 4, 2014

http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=6&f=G&l=50&co1=AND&d=PTXT&s1=vermiculture&OS=vermiculture&RS=vermiculture

This is a patent for an innovative vermiculture container. The walls are so shaped as to compress the processed organic matter and to allow an effective means of loading the container with the waste. The "discharge apertures" allow for the removal of castings and compost and a base lid releases these materials. This is a very advanced container that can provide insight into the importance of the design of the receptacles.

Customer Requirements

Our customer, Mr. Dale Robinson, is requiring that we design and develop the technology for a continuous flow-through vermiculture system in order to treat organic wastes and to harvest digested worm castings. The castings can then be transported as nutrients for crop usage. A filtration system will be developed in order to separate the worm tea from the castings. After the flow-through system is flooded by the digester, the residual fluid or "worm tea" will be separately harvested and can be utilized in similar applications to the castings.

An important requirement is to research and verify the biological specifications of the worms, and more specifically, the most desirable conditions for the utilized worms. We must find an ideal depth for proper growth and activity for the worms, and their dietary habits must also be researched in order to determine the specifications for the waste delivery system. Our vermiculture unit should be able to maintain a certain ideal volume for each individual worm in order to maximize the composting process. Ultimately, we are required to design and manufacture a prototype for a continuous waste management and composting unit utilizing vermiculture.

Quantitative Engineering Specifications

The initial continuous flow-through system was to be made utilizing a 55-gallon drum as the compost bed where the worms will be located. This bin diagram mockup, rendered through SolidWorks, is shown in Figure 5 and Figure 6. The new, 16 cubic foot square bin can be found in "Generation of Design Concepts". A three-quarter horsepower garbage disposal will be used as the digester for the provided organic waste. The chopped up food waste will be combined with water and will be used to flood the bin using a sprayer. A hydroseeder will be used in order to flood the bins with the waste material and water solution. The specifications for a Finn and Reinco model hydroseeder is listed in Table 2. A relay switch will be used to activate and deactivate the hydroseeder.

A venturi tube can be used to oxygenate the organic waste solution prior to flooding the container to avoid the mixture from becoming anaerobic. This is exceptionally important when trying to maintain the dissolved oxygen content of a waste slurry similar to the one used in this process. However, in the case of this prototype, a Venturi tube will be inserted into the slurry tank to oxygenate the food and water source to maintain an aerobic feeding process in order to prevent the growth of anaerobic fungi and bacteria.

Figure 7 and 8 depicts the mobile base of the bin. Figure 9 shows the hopper used to add food to the garbage disposal. This allows for easy movement and transportation of the bin even when it is full of worms and castings. Figures 10 and 12 show the two sieves used to separate the castings from the tea. The size of these mesh screens were tested and more data can be found under “Validation and Testing” below.

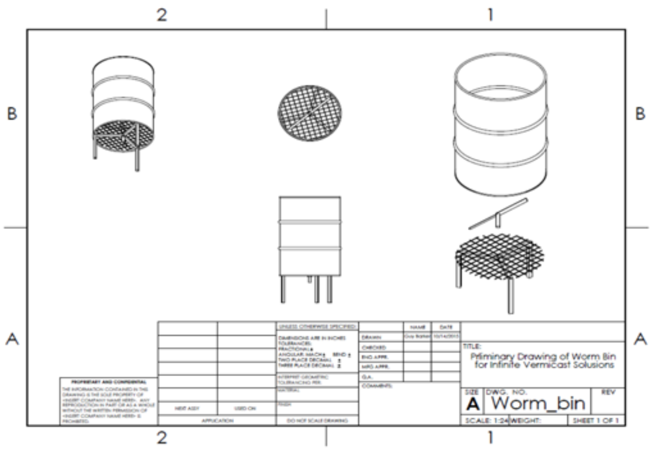

Figure 5. SolidWorks rendering of initial bin.

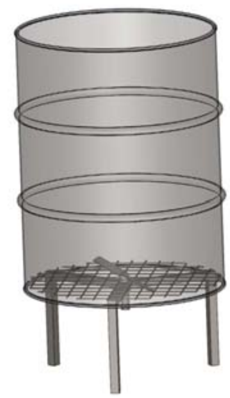

Figure 6. SolidWorks rendering of initial bin.

Table 2. Engineering specifications for Finn and Reinco model hydroseeder.			
FINN:	MODEL T170	MODEL T30	MODEL T60
NOZZLE SIZE			
TANK SIZE	1500 GALLONS	281 GALLON	500 GALLON
PRESSURE	320 GPM @ 115 PSI	65 GPM @60 PSI	65 GPM @ 75 PSI
MATERIAL VOLUME: GRANULAR SOLIDS	5000 LBS	500 LBS	1550 LBS
MATERIAL VOLUME: FIBER MULCH	750 LBS	100 LBS	200 LBS
DISCHARGE DISTANCE	200 FEET	70 FEET	90 FEET
	MODEL T75	MODEL T90	MODEL T120
NOZZLE SIZE			
TANK SIZE	700 GALLON	800 GALLON	1000 GALLON
PRESSURE	135 GPM @ 65 PSI	170 GPM @ 100 PSI	170 GPM @ 100 PSI
MATERIAL VOLUME: GRANULAR SOLIDS	2333 LBS	2500 LBS	3200 LBS
MATERIAL VOLUME: FIBER MULCH	350 LBS	400 LBS	500 LBS
DISCHARGE DISTANCE	150 FEET	180 FEET	180 FEET

REINCO:	HG-13GX3	HG-10GX3
NOZZLE SIZE		
TANK SIZE	1550 GALLONS	1200 GALLONS
PRESSURE	400 GPM @ 70 PSI	450 GPM @80 PSI
MATERIAL VOLUME: GRANULAR SOLIDS	3000 LBS	2500 LBS
MATERIAL VOLUME: FIBER MULCH	650 LBS	500 LBS
DISCHARGE DISTANCE	130 FEET	130 FEET

Figure 7. SolidWorks rendering of bin stand.

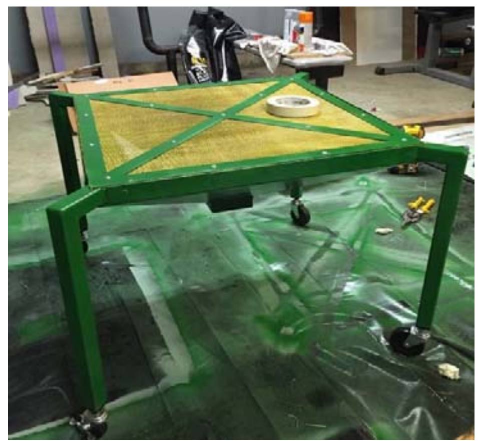

Figure 8. Final prototype bin stand.

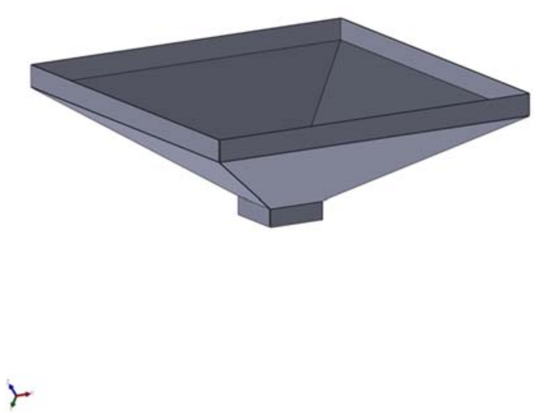

Figure 9. SolidWorks rendering of hopper.

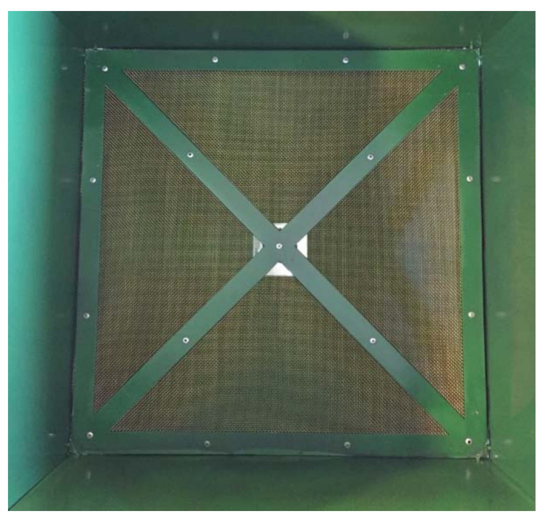

Figure 10. Final prototype hopper.

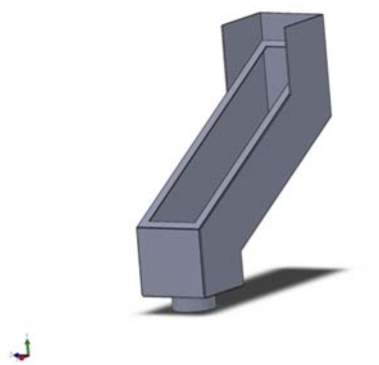

Figure 11. SolidWorks rendering of sloose.

Figure 12. Final prototype sloose.

Selection of Design Concept

At the end of the first semester, it was decided that a separate "hydrofeeder" with a digester attachment would be constructed, as well as a flow-through vermicomposting bin with a rotating blade at the bottom to scrape off the compressed worm castings. However, it was noted that this did not meet the client's requirement for a worm tea collection system that is separate from the worm casting collection. Taking this into account, a new worm bin was designed that had a different type of outlet from the rotating blade on top of a screen. The new vermicomposting system would still contain the separate digester/hydrofeeder system that can be sprayed into the worm bin, but the worm bin itself was slightly changed. The outlet for the new system funneled down the worm waste (worm tea plus worm castings) to a two-path outlet; one side contained a screen, and a separate path was clear. With the implementation of a screen that is small enough to filter out worm casting particles, a pure worm tea can flow through the vertical path, while worm castings will be forced out the alternate channel. The newly designed worm bin can be viewed in Figure 23 and 24.

Three experiments were performed during the project in order to establish working specification for the bin. The three experiments were a water to food ratio test, a sieve size screen test, and a recycled worm tea test. The three tests will be discussed in detail below. Before testing began, the first step was to make the selection of worm type that would be used.

There are over 2,700 types of worms on the planet, but not all of these worms are suitable for vermicomposting. A vermicomposting worm must be able to adapt to warmer temperatures, live in crowded conditions, and live amongst organically rich waste materials. There are a handful of earthworms that are suited for such elements.

For this project, the Infinite Vermicast Solutions team chose to use the ***Eisenia Fetida*** worm. This worm is more commonly known as the Red Wiggler. Other known names for it are the Red Worm, Brandling Worm, Manure Worm, and Tiger Worms. This worm has so many different names because it comes in a wide variety of colorations and sizes. The type of worms used throughout the project as seen in Figure 13.

Figure 13. *Eisenia Fetida* worms used in Infinite Vermicast Solutions composting bin.

The Red Wiggler is an ideal composting candidate because it is incredibly versatile. It has a high temperature tolerance ranging between 32 degrees Fahrenheit and 85 degrees Fahrenheit. This wide temperature tolerance is perfect for composting bins. The Red Wiggler is also a prolific breeder, and is prone to eating highly organic material as well as the microbes that feed on decomposing organic material (Compost, 2012).

There are two reasons as to why having a high temperature tolerance worm is important. Composting bins will naturally start off at cooler temperatures when “fresh” kitchen scrap food is added. As the food begins to degrade, the temperature will start to rise as the microbes in the compost pile begin to eat the food and release heat energy. The second reason that it is important for the worms to be able to adapt to varying temperatures is because vermicomposting should be able to be used by everyday consumers stretching across the globe. This wide range of consumers will have differencing natural climates.

The benefit of using Red Wigglers in composting bins is that Red Wigglers are able to consume a wide variety of matter. They can eat kitchen scraps, leaves, grass clippings, manure in the proper limited amount, and a wide variety of other material. As well as eating a wide variety of food products, they can also eat microbes. This is a critical characteristic because composting bins will naturally have microbes. As food sits out in the open, bacteria will multiply on the surface and begin to decompose the food. There will be a prolific amount of bacteria in a composting pile, but since the Red Wigglers are able to consume the microbes, it will cause no harm to their system. One might ask the question of why the use of worms is needed if microbes will naturally decompose food. It is true that microbes decompose food, but worms can do it at a substantially greater rate, and thus achieve a higher turnover rate for composting fertilizer produced.

Another added benefit of using Red Wigglers is their prolific breeding rate. If your goal is the quickly decompose material into organic fertilizer, than you want a substantial amount of worms working on the process. The benefit of using Red Wigglers is that you can buy an initial batch and they will quickly multiply and can be used to fill other bins if desired. Red Wigglers lay 3 to

4 cocoons per week. The cocoons take anywhere between 32 to 73 days to hatch. The newly hatched worms will take around 60 days to fully mature. An added benefit of using Red Wigglers is that they self-regulate their population. As the worm population increases within the bin, it will reach a maximum carrying capacity based on the environment. When the worms reach this maximum, their population will plateau at a stable level and remain at this level unless the bin is expanded. For this reason, the worms will never need to be harvested or thinned out from the bin.

In summary, *Eisenia fetida* or “Red Wigglers” were chosen as the worms to be used in our tests. Specifications for the red wigglers can be seen above in Table 3. As can be seen, red wigglers live in a very neutral environment that is easily maintained, and one pound of worms can fit into just one square foot of space. One pound of red wigglers is estimated to digest anywhere from 0.25-0.5 lb of food daily. Therefore, in a cubic foot, up to 6 lb of food waste can be composted, which is greater than the estimated 4.3 lb of waste generated per person, per day. Due to their high productivity and low maintenance, it was decided that the *Eisenia fetida* was the best composting worm choice for our system.

Table 3. Ideal environmental conditions and physiological traits of the *Eisenia fetida*.

Temperature (°F)	pH	Depth (in.)	Space	Reproduction Rate	% Moisture	Do not feed:
55-75	7.0	42594.00	1 ft^2/1lb	Cacoons produed in 3-4 Weeks	40-60	Meat, Dairy, Cooking Oil, Human Waste

Before the flow through bin could be built on this project, varying aspects of data needed to be collected based on the Red Wigglers. The first area that was researched was how much water to give the worm beds. Worm bodies are made primarily of water, and travel through the soil by using a film covering their body. For this reason, water needed to be added to the composting bins. Red Wigglers prefer to live in 50 to 90% moisture. It was important to add enough water to the bins for the survival of the worms, but not so much water that the bed becomes depleted of oxygen. If too much water is added, the compost can go anaerobic and begin to produce a strong foul odor. You will also run the risk of the worms drowning.

The second parameter to be measured during the project was the possibility of recycling the “worm tea”. As food decomposes in the bins and water is added to the bins, a substance known as Worm Tea will leak out of the bottom of the bins. As water is added to the top of the bins and slowly filters its way down the bin, it collects the nutrients from the food in the bin. The worms processing the food and expelling the food as castings also adds nutrients to the passing water. This liquid is often used as liquid fertilizer because of the amount of nutrients that is contains. Since we chose to water the worms every day, we felt as though we might be leaching the contents out of the container. We wanted to determine if we could collect the worm tea coming out of the bin and reuse it to water the top of the bin the next day. A test was conducted to determine if recycling the worm tea increases the nutrients in the expelled worm tea.

The third parameter that was measured in this project was the screen size needed to retain the worm castings. As worms decompose their food source, they produce castings that become pushed to the bottom of the bin. The goal of the screen is to be large enough that it allows castings to fall out of the bin, but small enough that it can retain the coconut coir and worms. A secondary screen is also used to separate the castings from worm teas.

Validation and Testing

Water Content Test

To test the amount of water to add to the bins, a serious of ratio tests were performed on the worms. The test was conducted by using giving six samples of worms the same amount of food, but different amounts of water. The six ratios that were used were half the amount of water to food (1:2), the same amount of water to food (1:1), twice the amount of water to food (2:1), and continuing the trend up until five amounts the water to food (3:1, 4:1, 5:1). This was done by using cylinder tubes, 6 inches high with a 3 ¾ inch diameter. The tubes are shown in Figure 14. Five replicates were performed of each test. An average was taken of each test to minimize natural variations in the data. Each cylinder was fit with a screen on the bottom of the tube to allow the water to flow through the tube, but to hold the soil material inside of the tube. Each tube was filled ¼ of the way up with bedding material. For our tubes this was approximately 70 grams. The bedding material of our chose was coconut coir. Fifteen grams of worms was added on top of the bedding. This was based on the fact that Red Wigglers prefer a density of one pound of worms per half gallon of bedding. The worms used in the experiment are shown in Figure 15. The amount of food added was equal to the amount of bedding added, 70 grams. The amount of water added was based on the amount of food added according to the proper ratios. So the amount of added water was 35g, 70g, 140g, 210g, 280g, and 350grams. Food was added to the bins once a week. Water was added to the bins every day. The test was run for three weeks. At the end of the third week, the containers were dumped out and the worms were extracted from the castings. The mass of the worms at the end of the three weeks was compared to the mass of worms initially added. The bins were kept in a well-insulated thermal room. The average temperature of the room was kept around 70 degrees Fahrenheit.

The food used to feed the worms was a mixture of coffee grounds, paper, kitchen scraps, and spent grains from a local brewery. Red Wigglers prefer a Carbon to Nitrogen ratio of 50% in their food sources. The C: N ratio of the food added to the bins in shown below in Figure 16.

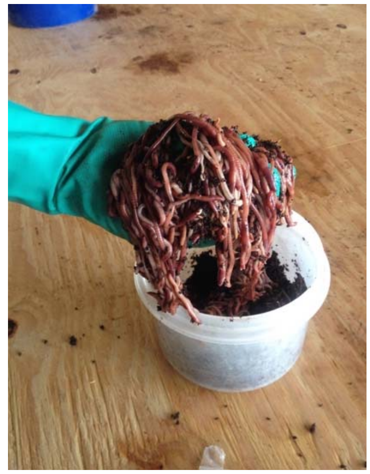

Figure 14. Testing bins for experimentation. Figure 15. Red Wigglers used in experimentation.

Compost Mix Calculator

Choose a material. Enter a cubic foot measurement. Press TAB. The Total C:N ratio for your recipe will appear.

Aim for a TOTAL C:N RATIO of 30. (25-30 is good. 20-40 is OK.)

Material	CuFt	LbWet	%H2O	available %C	%N	available Lb C	Lb N	available C:N
Vegetable Waste 11:1	.0004	0.02	87	34.75	3.2	0	0	10.86
Coffee Grounds 14:1	.0008	0.04	80	27.46	2	0	0	13.73
Fruit Waste 32:1	.0001	0.01	80	44.52	1.4	0	0	31.8
Straw Wheat 53:1	.009	0.08	12	21.06	0.4	0.01	0	52.66
					TOTALS:	0.02	0	32.33

For a total C:N Ratio of 32:1 mix
.0004 part(s) Vegetable Waste
.0008 part(s) Coffee Grounds
.0001 part(s) Fruit Waste
.009 part(s) Straw Wheat

Figure 16. Estimated Carbon to Nitrogen Ratio of food slurry utilized in testing.

Worm Tea Recycle Test

To conduct this experiment, the same containers were used that were used in the ratio test. The same proportions were also used; 70g of coir, 70g of food, and 15g of worms. The amount of water used was determined how much water was needed to produce an expulsion of water at the bottom of the container. The water was poured into the top of the container each day for six consistent days. A collection of water was taken each day from the worm tea and sent to a water processing lab. Figure 17 shows the setup of the recycle test. The amount of Nitrogen, Phosphorous, and Potassium was measured in each sample. To keep all parameters as constant as possible during the six day period, an air stone was added to the bottom of the container that held the worm bin. This stone aerated the worm tea that would be recycled the following day. Aerating the worm teas made sure that the oxygen was not depleted from the water. If the water became depleted of oxygen, it could alter how it affects the production rate of the worms working in the soil. This could thus alter the amount of nutrients being expelled into the soil.

Figure 17. Setup of worm tea recycle test.

Sieve Test

To determine the appropriate screen size to be used in the final product bin, a wet-sieve particle size analysis was performed on the produced castings. The castings used in this test were the castings that were produced as a result of the three-week ratio test. The sieves sizes used were ¾ in, 5/16in, #5, #10, # 18, # 40, #60, #120, #230.These sizes correspond to differing screen size openings. The sizes will be shown in the results sections. An example of the sieves used are shown in Figure 18. Three replicates of the particle size analysis test were conducted. Moisture content was taken on each sample. The sieves were stacked on top of each other from larger sieves size opening at the top to smallest sieves size opening at the bottom. The castings sample was put in the top sieve and allowed to pass all the way until the bottom size. Water was used to help push the castings along. The portion retained in each sieve was weighed and oven dried for 24 hours. ASTM (American Society for Testing and Materials) practices were used.

Figure 18. Example of differing sieves sizes used during casting size test.

Testing results

Water Content Test Results

The parameter being measured in the water-ratio test was how the amount of water added to each bin affected the growth in mass of the worms in each bin during the three-week time period. The dependent variable was the rate of change in the mass of the worms. The independent variable was the ratio of water added. Statistical software called SPSS was used to analyze the results. An ANOVE or analysis of variance was performed on the data. The initial hypothesis H_o was that there would be no difference among the means of the worm rate of growth between the differing water ratio tests. The alternate hypothesis H_a was that there will be a difference among the means of the worm's rate of growth between the water ratio tests. The level of significance used in the test was 0/05. This means that there was a 5% allowable difference between the testing data due to natural error. This allows means that any difference between the means of the worm mass was made with 95% certainty that the difference was caused by a specific factor. In our case, the factor was the amount of water added. Figure 19 and 20 show the results of the analysis.

Ratio	Ratio	Mean Difference
.0	1.0	-9.320000000000100*
	2.0	-10.920000000000101*
	3.0	-9.500000000000100*
	4.0	-6.220000000000102*
	5.0	-6.260000000000103*

Figure 19. Comparison of 1:2 (half the amount of water) to the full water ratio tests.

1.0	.0	9.320000000000100*
	2.0	-1.600000000000101
	3.0	-.180000000000100
	4.0	3.100000000000100
	5.0	3.060000000000099

Figure 20. Comparison of 1:1 ratio to the other ratios.

The ANOVA program prohibits the use of ratio as a label so the label 0-6 was used to label the test. The 0 corresponds to the 1:2 ratio tests. The 1 corresponds to the 1:1 tests and continued so forth. The ANOVA performed a t-test on the data. A t-test is a statistical test that uses math functions to compare the probability of an event occurring. If the ANOVA program detects a meaningful difference between the numbers, it puts a star besides the mean difference of the data. The way to read the output results is by first noticing what number is out front. We can see that 0 is out front and the rest of the numbers are to the right. This means that 0 was compared against all the other numbers. We can see when looking at Figure 19 that there is a star next to all of the mean differences. This means that there was a statistical difference between the 0 test compared to all the other tests. However, when looking at Figure 20, we see that the 1 test was compared to all the other tests. The only star that appears in this test is next to the 0 test. The same test was conducted for all of the ratios. The 2 was compared against all the other tests and so forth. The resulting conclusion is that the 0 test was the only test that held a statistical difference. A star appeared next to all of the results of the 0 test because it was statistically different than all the other tests. A start only appeared next to the 0 mean of the 1 test again 0 was the only test that held a statistical difference. To explain what these results mean, this means that the 1:2 ratio of water was the only ratio of water that made any difference to the growth rate of the worms. The 1:2 ratio corresponds to half the amount of water added to the test as food. So in conclusion, the worms mass continued to increase as long as the worms had water. A larger amount of water added to the worms did not negatively affect them. However, the growth rate of the worms was negatively affected by a depletion of water. So if the worms are deprived of water, they will not continue to grow.

Even though a surplus of water did not negatively affect the growth rate of the worms, we dumping out the castings, we could visibly see a difference between the amounts of decomposition in the added food source. Since all the parameters were measured before they were added to the bin, we were able to subtract out the worms, coconut coir and other variables in order to give a rough estimation of how much food source remained. An ANOVA was performed on this data. Figure 21 shows the results of that test.

(I) Ratio	(J) Ratio	Mean Difference (I-J)
.0	1.0	3.652400000000086
	2.0	-4.494400000000092*
	3.0	8.412800000000097*
	4.0	12.602800000000105*
	5.0	7.869600000000104*

Figure 21. ANOVA results of decomposition between remaining food in bins.

When viewing Figure 21, we can see that there are stars next to test 2-5. This means that there was a statistical difference between the amount of food remaining in the bins when compared to the 0 and 1 ratio test. From this we can conclude that while adding more water to the bins does not affect the growth rate of the worms, it does however affect the decomposition rate of the food. Reasons for this could be that the worms were having to work extra hard to eat the food since it was flooded in water and that they were not able to eat it at the same speed and in the lower water ratio tests. Other reason are that worms breath through their skin and they could have been taking in so much water that they just were not able to hold any food and so slowed their rate of eating. The result is that a water ratio of 1:1 should be used.

Worm Tea Recycle Test Results

The worm tea was recycled for a total of 5 days. The result after day 5 was that no worms remained in the bin. The worms either escaped or had died. The results of each days worm tea will be analyzed to explain why this happened. Table 4 shows the results of each day.

Table 4. Nutrient values of recycled worm tea.

Water soluble elements				
Sample	NH4-N	NO3-N	K	ICAP-P
Day	ppm	ppm	ppm	ppm
1	26.29	0.10	160.8	15.73
2	3.57	0.05	170.3	15.35
3	13.61	0.09	145.4	13.90
4	24.53	0.19	240.9	25.56
5	28.21	0.16	256.8	28.31
6	89.15	0.19	433.0	69.66

The NH4-N column in Table 4 is the ammonia part of the nitrogen in the worm tea. The NO3-N is the nitrate part of nitrogen. The K column is the potassium and the ICAP-P is the phosphorus. All of the data was given in concentrations of parts per million. When looking at the data for each day, we can see that day two was drastically smaller than day one. When the food and worms were first put in the bin, the food and worms both had a thin layer of slim on them. The food also had some liquid in it. When water was washed over the freshly added food and worms, the nutrient sin the slim were washed into the bucket. That is the reason for the spike in the data on day one. Ammonia and nitrate can both be volatized off and evaporated into the air when exposed to the air. Since such a large amount of ammonia was washed into the tea, a large portion of it was able to be volatized off through the day. This explains the drastic decrease in the concentration of the ammonia on day two. The data after day two were the results from the worms decomposing the food and not from the initial slim on the food. The K and P values did not decrease on day two because they act like a salt and cannot be evaporated.

The worms either died or escaped at the end of day five because of the K value. The potassium acts as a salt and will continue to increase. As the salt increase, the water becomes very salty and course. Worm bodies are very soft and harsh rough water can actually scrape and harm their bodies. However, we see that as the days go on, there is a concentration of nutrients. The tea should be recycled until the nutrients reach a plateau. For this experiment, the first plateau to be reached was at day four by the nitrate. At day four the concentration remains very similar for day five and day six. This is also the day that most compares to a liquid fertilizer such as miracle grow.

Sieve Test Results

The results of the sieve test performed on the worm castings can be seen in Figure 22. The castings were put through eight different sieve sizes. In order to separate the castings from the worm tea at the bottom side of our final design bun, we wanted to know what was the smallest size castings that the worms could produce. This is the plateau region on the graph that occurs at the 85% marking. At this region the castings corresponds to a grain size of 0.250 mm. The next screen size needed was to separate the food source from the castings. We chose to use the increasing region on the graph. At this point during the sieve test is where the large chunks of organic material were being separated from the castings. This screen size corresponded to a grain size of 1mm.

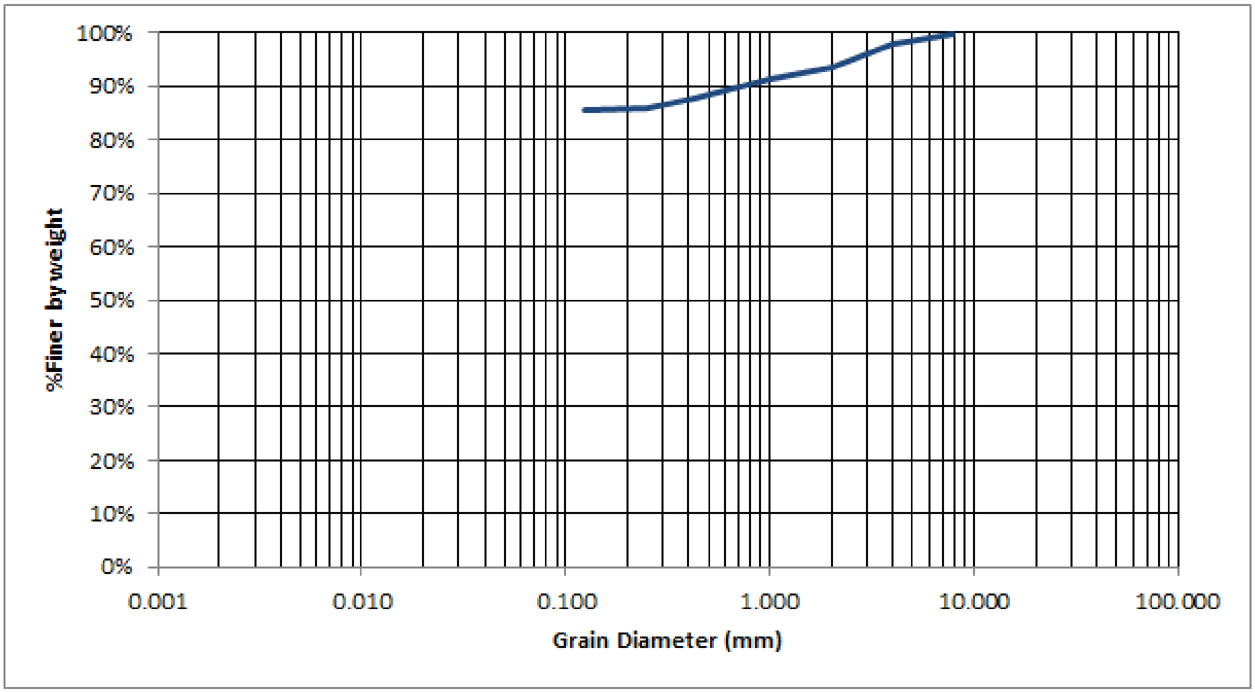

Figure 22. Graph of grain size of castings.

Environmental/Global Impact of System

The Infinite Vermicast Solutions group is seeking to create a sustainable, continuous flow-through vermiculture system that could have an immense impact on society as a whole. This system would allow for clean organic waste treatment by utilizing effective species of worms to create a compost that could be used as fertilizer in gardens and agricultural pastures. This design could be implemented in globalized communities that have poorly or underdeveloped waste treatment systems in order to increase the production of farmland or provide feed and bait to different species of animals and fish. Due to its relatively small budget, this design by IVS can be implemented to reduce landfill waste and produce fertilizer by utilizing efficient and reliable organisms in a wide array of global societies.

Generation of Design Concepts

The first design that was considered was a flatbed "box" system for the vermicompost system. In this system, the worms and compost would be distributed in a semi-shallow (6-10") bin with the worms evenly distributed throughout. A blade would run lengthwise along the screen underneath the boxes to collect the compost as it moves to the bottom and is pushed out. Compost would have to be added manually to the top of the bins, as would water for moisture. This type of system is widely utilized for commercial aspects of vermicompost system.

However, based off of the client's requirements, this design would not work for a flow-through system. The rectangular set-up of this design makes it difficult for even distribution of compost and nutrients, as well as water and the worms themselves. A shallow, rectangular bin is also less convenient for the domestic use of a vermicompost system, since it is bulky and more time-demanding than the average person would be able to manage. A rectangular bin is more useful for vermiculture systems where the worms are harvested for bait and feed.

Another design concept that was considered is similar to the one that was decided on. A deep, circular bin would be utilized, with a flow-through system where compost would be added to the top of the bin and worms would be introduced to the system. As castings are formed they travel to the bottom of the bin, food is manually loaded to the top of the system, while water is loaded via water hose. Castings are then separate from the worm bedding and compost by sinking to the bottom of the cylindrical system, and can then be harvested out of the bottom. However, although this system is a flow-through design, it is not as continuous as it could be. To improve the design of the cylindrical system, a better casting harvesting system can be considered, as well as a new food delivery design.

The chosen prototype by the end of the first design period was based off of this one, with a 55-gallon drum serving as the bin, and instead of the compost being manually added into the bin separately from the water, the compost will be digested with the needed amount of water and concocted into a slurry, then sprayed onto the top of the bin. With a sprayer, the distribution of the compost and nutrients are more controlled. Also, a rotating blade is added to the bottom of the barrel to scrape off the castings as they are produced by the worms. A collection bin will be place below the vermicomposting bin to hold the castings as they are produced.

Once drafting of the design began, it was quickly discovered that the rotating blade added unnecessary complications, and the client was also requiring that the system have an implement that would separate the worm castings from the "worm tea", so the bin that was to be constructed was redesigned. While the design of the feeding system remained the same, the bin outlet would have two paths. One path is made for solids, while the other path is where the "worm tea" is to drain out. The vertical path will draw the worm tea out the bottom of the system with a proper screen size to act as a filter and block the castings from exiting. The castings will then go out the second path, therefore separating the two. With the worm tea already separated from the castings, each one can be separately used/marketed. The benefits of separating worm tea from the castings is that it can be sprayed as a fertilizer source in lieu of commercial plant growth sprays, i.e., MiracleGro. If the castings and tea came out as one product, the ammonia and other nutrient concentrations would potential be too high, which would in fact hinder the growth of plants. By spraying it on separately, the concentrations going onto the plants can be controlled.

The feeding system that was implemented contains a compostable material input hopper that funnels the waste toward a garbage disposal. The garbage disposal then “digests” the food and mixes it in with water that pre-exists in the digestion tank where the food slurry is stored. In order to prevent anaerobic processes from occurring, the slurry had to be oxygenated in some way, so it was decided that a Venturi tube was to be inserted into the tank. A centrifugal “spa” pump was attached to the outlet of the tank with flexible tubing, and a sprayer nozzle was attached to the end in order to deliver the food stream to the worm bin. The digestion system was set up on a cart on wheels for ease of mobility in the case of multiple bins to feed. By making the feeding process separate from the construction of the worm bin itself, it allows the digester/feeding system to be separately marketable from the worm bin. The final bin product and hydrofeeder can be seen in Figure 23 and 24.

Figure 23. Final Bin Prototype.

Figure 24. Final Hydrofeeder Prototype.

Project Schedule

A timeline of the projects schedule is shown below in Figure 25.

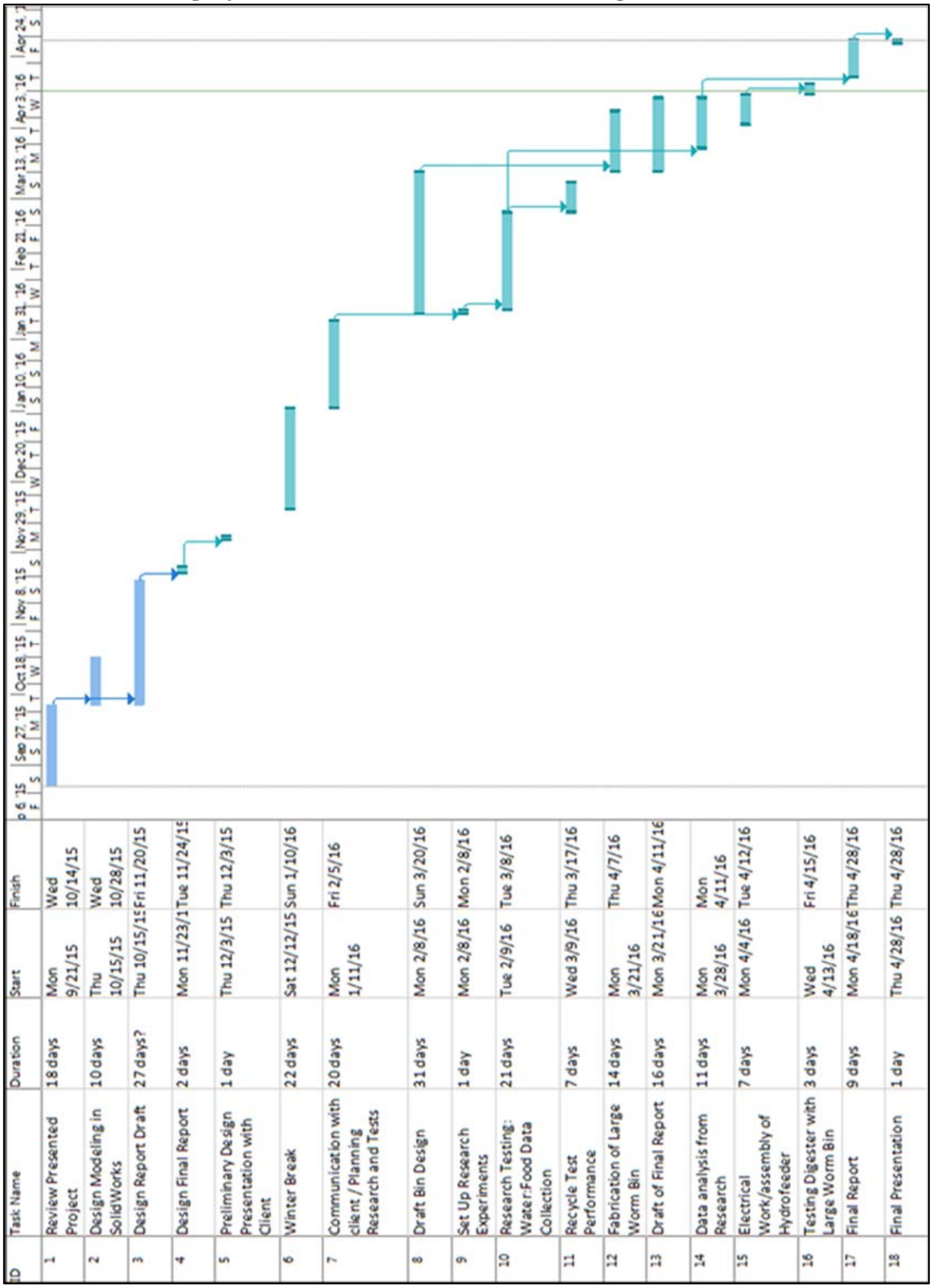

Figure 25. Gantt Chart for Project.

Financial Analysis

Proposed Budget

Table 5. Proposed budget for project.

Worm Bin Parts List & Prices			
Part	**Quantity**	**Price**	**Details**
Drum	1	$ 100.00	
Square steel tubing	13'	$ 26.00	1 X 1 X 11 GA (.120 wall) A513 Square Steel Tube
22" Mower blade	1	$ 15.00	
Taper bearing	1	$ 16.33	Taper Roller Bearing Cone, 0.750 Bore In
3/4" shaft	1	$ 11.00	
Worms (Red Wigglers)	n/a	n/a	
Expanded metal	1	$ 11.00	
Hydroseeder pump	1	n/a	
Digester drum	1	$ 50.00	
Timer for motor & blade rotation	1	$ 20.00	
Motor	1	n/a	
Paint/powder coating	1	$ 30.00	
System Fabrication Labor	$15/hr (? Hrs)	$ -	
Tentative Budget		$1,500.00	

Actual Budget

While there is no provided data on the exact purchases made like Table 4 above, the final bill for this design was $575.39; this is significantly lower than our proposed budget and proves that this system is not only effective, but economical.

Owner's Manual

- <u>Section 1.0 – Setup of Worm Bin</u>
  - 1.1 – Test run of system
    - *Materials*:
      - Top soil and/or worm castings (10 lb total)
      - Garden Hose connected to water valve
    - Layer loose topsoil and/or commercial worm castings into the bottom of the bin
    - Use hose to completely flood the soil/castings mixture, keeping an eye on the outlet
    - Excess water should drain out of the angled outlet site, while solids drain out of the straight outlet site
    - Rinse bin of topsoil and/or castings until it is empty
  - 1.2 – Integration of worm bed into bin
    - *Materials*:
      - Loose Coconut coir (20 lb)
      - Garden hose connected to water valve
      - 1.5 kg of "red wiggler" worms

        - Layer the coconut coir on the bottom of the worm bin
        - Spray the coconut coir with hose until it is completely saturated with water (water should come out the liquid outlet of bin)
        - Place worms on top of coconut coir bedding once water is fully absorbed into coir
- Section 2.0 – Set up of Digester/Feeder
    - 2.1 – Initial run of the digester
        - *Materials:*
            - Digester/Feeder System
            - Wall outlet within proximity
            - Water hose
        - Fill the digester up approximately ¼ of the way with water
        - Plug the Digester into the nearby wall outlet
        - Switch the power button to the "ON" position (located on black box)
        - Water should pump through system – if not, contact Support
- Section 3.0 – Using the Digester with the Worm Bin
    - 3.1 – Digestion of food/waste material
        - *Materials:*
            - Waste material to be composted
            - Digester/Feeder System
            - Water Hose
        - Continue to fill up the digester to 1/3 of the way full
        - Toss the waste material into the digester system
        - Plug the digester system in and power on
        - Food should be drawn into the pump system and recirculated back through – if not, contact Support
    - 3.2 – Spraying waste into worm bin
        - *Materials*:
            - Digester system with pre-digested food (See Sec. 3.1)
            - Worm bin from Sec. 1.2
        - Turn the digester system on
        - Once good circulation throughout system is achieved, use nozzle to spray digested material into worm bed
        - Spray until about 2 in. of digested material is on the worm bed, or until waste material has run out (whichever occurs first)
- For Support, contact Infinite Vermicast Solutions at: (614)-256-2361 or taylor.conley@okstate.edu

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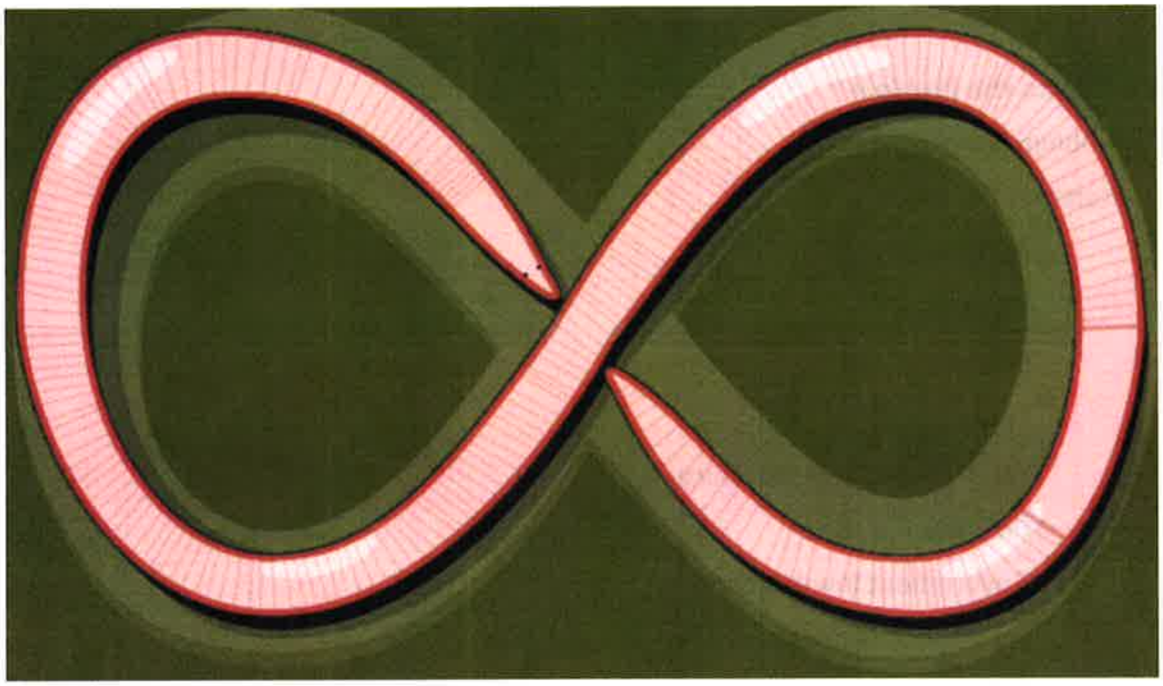
Gurav M. V. and Pathade, G. R. 2011. Production of Vermicompost from Temple Waste (Nirmalya): A Case Study. *Universal Journal of Environmental Research and Technology.* Volume 1, Issue 2: 182-192.



INFINITE VERMICAST SOLUTIONS

Established 2015

Fall Project Report - December 3rd, 2015

Taylor Conley

Magen Kegley

Guy Barker

Matthew Gallagher

Introduction to the Problem

Problem Statement

This project includes the design and implementation of an innovative continuous vermiculture system. To achieve this, our team will study the habitat and physiology of various worms to develop the proper feeding and nutrient system. A digested waste delivery and casting harvesting system will be developed based off of our research.

Statement of Work

Background

More and more precious land space is taken up every year by the spreading of landfills, caused by increased consumer wastes. However, a large amount of the trash that is carelessly thrown away can be transformed into nutrient-rich silage via composting. Although composting is beneficial, it lacks the efficiency since all of the decomposition must be performed by microorganisms. An alternative and faster method to accomplish the degradation of organic materials is by adopting a vermicomposting system, which introduces worms to the compost area.

The customer, Dale Robinson, proposed that a continuous, flow-through worm bin be designed so that even the busiest person would be able to utilize benefits that results from vermicomposting. The customer requires that the team design and develop the technology for a continuous flow-through vermiculture system that will treat organic wastes and harvest digested Red Wiggler worm castings. This system will aid in reducing landfill wastes from kitchen and industrial settings, while providing a nutrient-rich topsoil that can be used to grow high quality produce.

This project is similar to a continuous conveyor vermiculture system[i] because it utilizes a continuous automatic worm castings collection system. However, the system that will be designed includes a digester that will implement a higher efficiency for the total process. Although there are no specific regulations for vermicomposting, a permit is required for composting if the process reaches commercial scale[ii].

Objectives

The objective of this project is to design a fully integrated flow-through vermicomposting system that includes a digester that will increase the efficiency of the process as a whole, as well as research and collect data on the best breed of worm to exploit in the flow-through bins. By utilizing a continuous system, it will be easier for consumers of the product to reduce waste in landfills, and introduce a way for the consumer to be self-sustaining by providing fertile soil for produce growth. Goals that lie within this objective are to make the design take up as little space as possible, as well as using materials that are inexpensive and easy to find. Preferably, the total system will cost $1,000 or less, but the client has noted that this is not a firm limit.

Scope

Mr. Robinson of The Big Squeegee© expects a flow-through vermiculture bin design that includes a process that digests the food before it is delivered to the worm beds. The design is also expected to have separate areas for the worms to lay eggs and eat the food. Therefore, by employing a system that includes a sprayer that delivers the food to the worms in a pre-digested form, the worms will constantly be at the top to consume the food. To determine the most suited breed of worm for the bin, data on the

Table 1. Task List.

* Completion Dates are tentative and subject to change

4.1 Task 1 – Review Customer Order

This concludes preliminary reviews of the presented project. These reviews include literature reviews, patent searches, biological specifications of Red Wigglers, engineering specifications of materials within the system, analysis of customer requirements, and detailed problem statement formation. This also concludes design of company name, mission statement, and logo.

4.2 Task 2 – Preliminary Design Modeling

This concludes the modeling of the preliminary design utilizing SolidWorks. This includes a conference call with applications and extension engineers, engineers within the department of Biosystems & Agricultural Engineering, the client, and the contractors in order to present initial ideas and gain valuable guidance and feedback.

4.3 Task 3 – Preliminary Design Report Draft

A preliminary design report draft is submitted to Dr. Paul Weckler on the progress of the project.

4.4 Task 4 – Preliminary Design Final Report

A corrected version of the preliminary design report draft is submitted to Dr. Paul Weckler on the progress of the project.

4.5 Task 5 – Preliminary Design Presentation with Client

The contractors will present the progress of the project and the prototype to the client and associated engineers. Throughout the presentation, those in attendance will offer critiques and suggestions on the feasibility of the current design and possible changes that could be made to benefit the system.

4.6 Task 6 – Manufactured Prototype

The manufactured prototype is assembled in order to begin testing the system.

4.7 Task 7 – Prototype Testing

This concludes the testing period of the manufactured prototype at the Bioenergy Laboratory and data is taken to determine effectiveness of the system.

4.8 Task 8 – Final Design Presentation with Client

The contractors will present the findings of the project and the final prototype to the client and associated engineers.

Security Considerations

There are multiple security considerations to accommodate on this project. The first concern is who has access to the vermiculture bins. The team will be designing and testing a new system of continuous vermiculture processing. The design setup should be kept out of public eye as to avoid premature or unlawful replications.

The second concern for housing the bins in a securely monitored location is the safety and wellbeing of the worms. The team will be altering and testing different parameters on the bins to ensure the most efficient setup. The monitoring process will be based upon the success rate of the worms and their produced castings. If unauthorized persons enter the work space and purposely or accidentally change any conditions in the worm's environment, the testing outcomes will be flawed. The team may be unaware of the intruder's actions and deem the setup flawed when in reality it was due to the outsiders alterations.

A variety of parts will be assembled during the construction of the continuous vermiculture setup. Some of these parts will either be small in size, valuable, or dangerously sharp. The setup location shall be limited from the public to ensure no parts are lost, stolen, or damaged. The isolation will also ensure no public entities are injured on exposed unfinished pieces.

Permission to access the facility responsible for housing the project will be granted to all team members. This will be approved by Dr. Doug Hamilton of the Oklahoma State University Biosystems and Agricultural Engineering Department. His contact information is 226 Agriculture Hall, Stillwater, OK, (405) 744-7089, dhamilton@okstate.edu.

Travel

The contractors have decided that there is no applicable reason to visit Mr. Dale Robinson's facility. After speaking with him and viewing the pictures of his operation, they do not see any benefit in viewing the facility or current process. The contractors will travel to the Bioenergy Annex laboratory facilities west of campus in order to conduct their experiments and tests. Upon completion of the design process, it would be of assistance to travel with Dr. Hamilton to meet with Mr. Cunningham and Dr. Lake to discuss possible ideas and the feasibility of the process design.

Special Material Requirements

- Provided space in the Bioenergy Annex
- Worms (Red Wigglers)
- For the purposes of our project and its exposure to potential corrosive materials we will need to powder coated the materials in the drum and potentially use stainless steel for the bearings.

Place of Performance

The project will be housed in the Bioenergy Annex belonging to the Biosystems and Agricultural Engineering (BAE) Department of Oklahoma State University. The location of the annex, thus deemed as a laboratory, is Marvista St, Stillwater, OK, 74074. All construction and setup testing, either on the worms or the design features, will be made in this location.

Technical Analysis and Market Research

A system that provides a solution to a continuous vermiculture system is a patented slow-moving conveyor system that automatically applies thin layers of organic wastes to a bed of worms. The conveyor moves the digested biomass into separate bins while keeping the worms on the conveyor system. This allows for worms to work both at a high activity level and for the system to be continuous. Durability issues that come along with the system are the eventual corrosion of the conveyor system and the replacement of items related to it. Chains and belts would have to be replaced often due to the introduction of a wet environment to the metal parts. The system is quite reliable because of the relative simplicity of the design, as long as the mechanical aspects remain functioning. The dangers that exist within this system are finger pinching in the gears and belt mechanism. Also, the wet "worm tea" might form a slippery area around the system. As far as maintenance requirements, the bin that collects the castings must be manually emptied and taken away. The parts, as mentioned earlier, must be replaced when necessary to prevent rusting and corrosion in the wet environment. The conveyor belt system overview can be viewed in Figure 1.

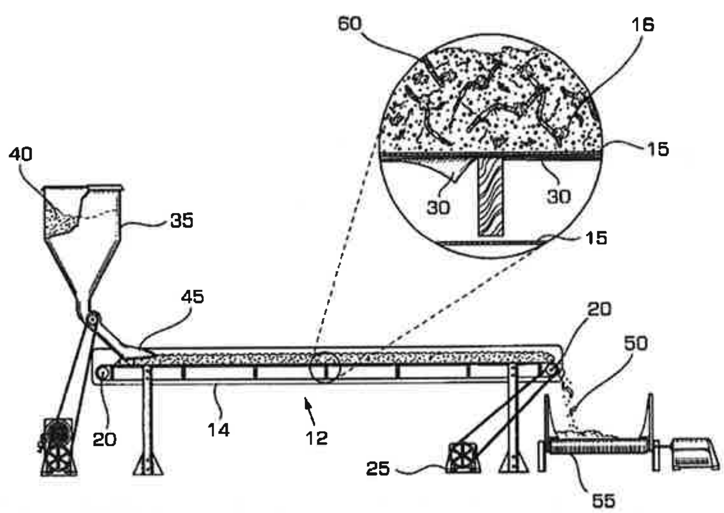


Figure 3. Conveyor vermiculture system. Patent ID US 6223687 B1.

Another process that holds similar solutions to components needed within a continuous vermiculture system digests sewage material, then distributes it among a bed of worms. The system treats sewage waste to optimize it for worm digestion, and heats or cools it before feeding it to worms. The system poses a few hazards since it contains grinding pumps, heating and cooling coils, and raw sewage. Therefore, those maintaining it should be properly trained to replace the necessary parts. Corrosion over a few years could also become an issue in durability, because the pipes and holding tanks most likely have steel or metal components. It is reliable for properly digesting and distributing the sewage material onto the vermiculture beds, as long as the heating and cooling coils do not exceed the required temperatures, which could cause a lack of efficiency or even death among the worms. The pipes and temperature coils must be maintained, as well as the correctional fluid that adjusts pH, electrical conductivity, and percent solids. The logical flow of the sewage treatment and distribution can be viewed in Figure 2.

http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&u=%2Fnetahtml%2FPTO%2Fsearch-adv.htm&r=12&f=G&l=50&d=PTXT&p=1&S1=%28%28vermiculture+AND+continuous%29+AND+compost%29&OS=vermiculture+AND+continuous+AND+compost&RS=%28%28vermiculture+AND+continuous%29+AND+compost%29

This is a patent for a rectangular container fabricated specifically for the composting of animal and household waste using vermiculture. The bins are painted specifically to absorb sunlight on the front end and cover (black) and to reflect sunlight on the opposite end (white). Compost is extracted via an opening adjacent to the base of the container. This is a very simplified and small vermiculture composting unit that uses the temperature gradient to draw in new oxygen and cool the increasing temperatures within the bin due to respiration. The manipulation of sunlight in order to maintain an ideal temperature within the containers could greatly assist our project.

Patent ID EP 0196887 A2: Published on October 8, 1986

https://www.google.com/patents/EP0196887A2?cl=en&dq=continuous+vermiculture&hl=en&sa=X&ved=0CCoQ6AEwAmoVChMIwpykx5ikyAIVhZENCh2WjA3R

This is a patent for the use of a breaker bar unit to extract the base layer of the finished compost within a unit with a perforated floor. As it separates the completed compost at the bottom of the container, it does not disrupt the worms that are near the top of the bin. This can also serve to harvest worms for the marketable venture of protein-rich feed for pig, poultry, and fish farming. Ultimately, this provides an idea for the mechanized extraction of compost after the waste products are broken down and excreted by the worms.

Patent ID WO 2002046127 A2: Published on June 13, 2002

https://www.google.com/patents/WO2002046127A2?cl=en&dq=continuous+vermiculture&hl=en&sa=X&ved=0CEYQ6AEwBmoVChMIwpykx5ikyAIVhZENCh2WjA3R

This is a patent for composting organic waste using a thermophilic vermiculture system in order to produce worm castings. This is a very similar system to what we are trying to implement in this project, but does not give many specifics on the technology used. This is still helpful because it describes the process and necessity of this type of system.

Patent ID US 6223687 B1: Published on May 1, 2001

http://www.google.com/patents/US6223687

This is a patent for a conveying system in which a thin layer of biomass is moved along a layer of worms in order to increase their activity. This creates a continuous open system and maintains efficiency due to increased spatial awareness from the worms. The beds can then be stacked in order maximize this efficiency. This is likely a system that would greatly exceed our budget, but it is helpful because it provides insight into spatial efficiency and the continuous process we are seeking to develop.

Patent ID US 7141169 B1: Published on November 28, 2006

http://www.google.com/patents/US7141169

This is a patent for the digestion and distribution of raw sewage among the bed of worms. The system controls the temperature of the waste before its dispersal among the worms through simple heating and cooling coils. While this may be slightly too intensive for our project, it provides insight about the

Customer Requirements

Our customer is requiring that we design and develop the technology for a continuous flow-through vermiculture system in order to treat organic wastes and to harvest digested Red Wiggler worm castings. The castings can then be transported to a growth bin that would provide nutrients to a certain crop. A filtration system will be developed in order to separate the worms from the castings. After the flow-through system is flooded by the digester, the residual fluid or "worm tea" will be separately harvested.

An important requirement is to research and verify the biological specifications of the worms, and more specifically, the doubling time of the species. We must find an ideal depth for proper growth and activity for the Red Wigglers, and their dietary habits must also be researched in order to determine the waste delivery system. Our vermiculture unit should be able to maintain a certain ideal volume for each individual worm in order to maximize the composting process. Ultimately, we are required to design and manufacture a prototype for a continuous waste management and composting unit utilizing vermiculture.

Quantitative Engineering Specifications

The continuous flow-through system will be made utilizing a 55-gallon drum (the bin diagram mockup, rendered through SolidWorks, is shown in Figure 5) as the compost bed where the worms will be located. A three-quarter horsepower garbage disposal will be used as the digester for the provided organic waste, which will then be used to flood the bin using a sprayer. A hydroseeder (specifications for Finn and Reinco hydroseeders listed in Table 2) will be used in order to flood the bins with the waste material and water solution. A relay switch will be used to activate and deactivate the hydroseeder. The air pump and porous air stone can be used to oxygenate the organic waste solution prior to flooding the container. A thermistor will be used during the testing process to record the optimal temperature of the worm bin as it fluctuates due to aerobic digestion.

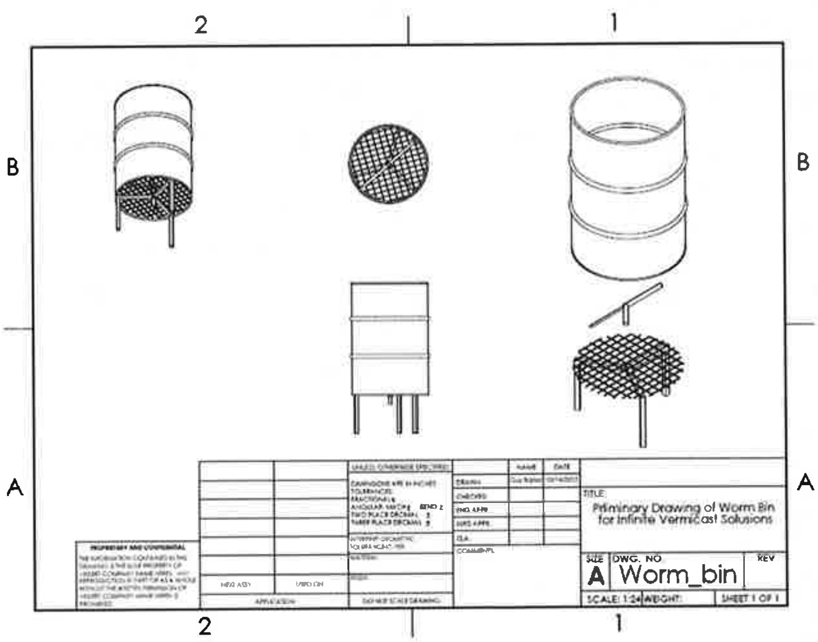


Figure 5. SolidWorks rendering of bin diagram.

Environmental/Global Impact of System

The Infinite Vermicast Solutions group is seeking to create a sustainable, continuous flow-through vermiculture system that could have an immense impact on society as a whole. This system would allow for clean organic waste treatment by utilizing effective species of worms to create a compost that could be used as fertilizer in gardens and agricultural pastures. This design could be implemented in globalized communities that have poorly or underdeveloped waste treatment systems in order to increase the production of farmland or provide feed and bait to different species of animals and fish. Due to its relatively small budget, this design by IVS can be implemented to reduce landfill waste and produce fertilizer by utilizing efficient and reliable organisms in a wide array of global societies.

Generation of Design Concepts

The first design that was considered was a flatbed "box" system for the vermicompost system. In this system, the worms and compost would be distributed in a semi-shallow (6-10") bin with the worms evenly distributed throughout. A blade would run lengthwise along the screen underneath the boxes to collect the compost as it moves to the bottom and is pushed out. Compost would have to be added manually to the top of the bins, as would water for moisture. This type of system is widely utilized for commercial aspects of vermicompost system. However, based off of the client's requirements, this design would not work for a flow-through system. The rectangular set-up of this design makes it difficult for even distribution of compost and nutrients, as well as water and the worms themselves. A shallow, rectangular bin is also less convenient for the domestic use of a vermicompost system, since it is bulky and more time-demanding than the average person would be able to manage. A rectangular bin is more useful for vermiculture systems where the worms are harvested for bait and feed.

Another design concept that was considered is similar to the one that was decided on. A deep, circular bin would be utilized, with a flow-through system where compost would be added to the top of the bin and worms would be introduced to the system. As castings are formed they travel to the bottom of the bin, food is manually loaded to the top of the system, while water is loaded via water hose. Castings are then separate from the worm bedding and compost by sinking to the bottom of the cylindrical system, and can then be harvested out of the bottom. However, although this system is a flow-through design, it is not as continuous as it could be. To improve the design of the cylindrical system, a better casting harvesting system can be considered, as well as a new food delivery design.

The final design that was designed was based off of this one, with a 55-gallon drum serving as the bin, and instead of the compost being manually added into the bin separately from the water, the compost will be digested with the needed amount of water and concocted into a slurry, then sprayed onto the top of the bin. With a sprayer, the distribution of the compost and nutrients are more controlled. Also, a rotating blade is added to the bottom of the barrel to scrape off the castings as they are produced by the worms. A collection bin will be place below the vermicomposting bin to hold the castings as they are produced.

Proposed Budget

Worm Bin Parts List & Prices			
Part	**Quantity**	**Price**	**Details**
Drum	1	$ 100.00	
Square steel tubing	13'	$ 26.00	1 X 1 X 11 GA (.120 wall) A513 Square Steel Tube
22" Mower blade	1	$ 15.00	
Taper bearing	1	$ 16.33	Taper Roller Bearing Cone, 0.750 Bore In
3/4" shaft	1	$ 11.00	
Worms (Red Wigglers)	n/a	n/a	
Expanded metal	1	$ 11.00	
Hydroseeder pump	1	n/a	
Digester drum	1	$ 50.00	
Timer for motor & blade rotation	1	$ 20.00	
Motor	1	n/a	
Paint/powder coating	1	$ 30.00	
System Fabrication Labor	$15/hr (? Hrs)	$ -	
Tentative Budget		$1,500.00	

United States Patent **6,576,462**
Thompson **June 10, 2003**

Vermiculture composting device

Abstract

The present invention relates to a composting device for composting organic waste, specifically animal and vegetable household waste. The device consists of a container having four rectangular sides, a base and a removable, reversible cover. The container is provided with a sealable ***compost*** extraction opening disposed on a front side of the container near the base. Ventilation openings are provided in the sides. One surface of the cover and front side of the container is painted dark to absorb sunlight and heat the interior chamber defined by the container. The opposing side of the cover is painted white to substantially reflect sunlight. The cover is removed and waste is added to the container through the top. Worms and microorganisms provide a way for degrading the waste into ***compost,*** which is removed through the extraction opening adjacent to the base for recycling. The temperature in the ***compost*** may be adjusted by increasing or decreasing absorption of sunlight. The temperature gradient thus formed in the container draws air through the ventilation openings and into the container to provide ventilation for the composting waste. In one embodiment, the composting device is provided in the form of a kit for home assembly.

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Family ID: **25130628**
Appl. No.: **09/783,861**
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Current U.S. Class:	**435/290.1**; 435/290.4; 435/810
Current CPC Class:	A01K 67/0332 (20130101); C05F 17/0009 (20130101); C05F 17/0205 (20130101); Y02W 30/43 (20150501); Y10S 435/81 (20130101)
Current International Class:	A01K 67/033 (20060101); A01K 67/00 (20060101); C05F 17/00 (20060101); C05F 17/02 (20060101); C05F 009/02 ()
Field of Search:	;435/290.1,290.4,810 ;71/8-10

4. The kit of claim 3 further comprising a third rectangular sheet of building material adapted to form a base for said container.

5. The kit of claim 4 further including handles for said door.

6. The kit of claim 5 further including a locking bar adapted for rotatable attachment to said container.

7. The kit of claim 3 further comprising worms of a species adapted for survival when exposed to climatic conditions corresponding to a particular geographic area.

8. The kit of claim 7 further comprising an inoculum of microorganisms operable for biodegrading organic waste material.

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

A composting device for the biodegradation and recycling of household waste and, more particularly, organic kitchen waste.

2. Prior Art

Organic waste recycling methods in which organic waste such as kitchen waste and newspaper are deposited into a composting container are well known in the art. Composting devices normally provide interim storage for such waste and provide and maintain environmental factors, including moisture, air, warmth and certain bacteria and worms (such as Eisenia foetida, Eisenia hortensis or Eudrilus eugeniae) and other wormlike organisms. The organic material is composted or digested to produce a pleasant smelling, uniform, well granulated ***compost*** that can be recycled as a plant food. Such devices are, in essence, bioreactors, wherein waste feed stock is converted into a desired product (***compost***) which may be inexpensively removed from the bioreactor for distribution, most preferably in a ***continuous*** process.

Numerous composting devices have been patented and are disclosed, for example, in U.S. Pat. No. 5,185,261 to Warrington, U.S. Pat. No. 5,413,934 to Fischer, U.S. Pat. No. 5,285,534 to Criss, U.S. Pat. No. 5,741,344 to Warkentin and U.S. Pat. No. 6,103,124 to Inoue. However only a few claim the ability to process ALL kitchen wastes. Unfortunately, these earlier art devices possess inherent deficiencies which have prevented them from becoming popular with consumers. There is a continuing need for a composting device that is inexpensive, easy to operate and adapted for home use.

SUMMARY

It is a first object of the invention to provide a device operable for converting organic kitchen waste into ***compost***.

FIG. 2 is a side elevational view of a ***vermiculture*** composting device in accordance with the present invention.

FIG. 3 is a rear perspective view of a ***vermiculture*** composting device in accordance with the present invention.

FIG. 4 is a side elevational view of a ***vermiculture*** composting device in accordance with the present invention with the side panel removed to show the flow pattern of the contents of the device.

FIG. 5 is a plan view showing the unassembled components of the device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A composting device 10 in accordance with the present invention is shown in top, front perspective view in FIG. 1. The composting device 10 includes a rectangular container 11 having a a removable cover 12, a front panel 13, with a removable extraction door 20, a right side panel 14, a left side panel 15, a rear panel 16, and an optional base 17. The panels comprising the device are preferably 0.5 inch thick five ply AB Exterior grade plywood or equivalently robust composite. The removable cover 12 measures approximately thirty three inches by twenty three inches. This cover 12 is epoxy resin sealed and is painted with a dark colored paint on one surface and a light or white paint on the other.

The front panel 13 measures approximately thirty inches high by thirty two inches wide and is epoxy resin sealed and painted a dark color on its exterior surface. This front panel 13 includes a galvanized steel angle iron 13a attached to its superior, uppermost edge with galvanized steel bolts 21. The front panel 13 inscorporates an extraction opening 19, which is sealed by a removable door 20. The door 20 has two reinforcing stringers 20a and 20b which also act as handles for removing the door 20, as well as stops for the pivoting locking bars 13e, 13f, 13g, and 13h. The front panel 13 also includes a two inch by two inch reinforcing stringer 13b secured to its inside surface above the extraction opening 19. In addition, two spacers 13c and 13d provide anchorage for the locking bars 13e, 13f, 13g, and 13h, and also provide said locking bars sufficient clearance from the front panel 13 in order that they may pivot about their anchor points. The door 20 may be independent or hinge-attached to the front panel 13. A number of ventilation orifices 22 are spaced over this panel's surface. The front panel 13 is assembled with the side panels 14 and 15 and held in place with hot dipped galvanized steel bolts 24, washers 25, and nuts 26.

The right side panel 14 measures approximately thirty inches high on its front edge, thirty three inches high on its rear edge, and twenty two inches wide. It is epoxy resin-sealed and painted a variable color on its exterior surface. Five two inch by two inch wood stringers 14a, 14b, 14c, 14d, and 14e are glued and nailed to its periphery and to a point approximately ten inches superiorly from its inferior (lowest) edge. There are a number of variably dimensioned apertures 22 and 23 disposed in the side panels of the bin 10 for ventilation. The left side panel 15 measures approximately thirty three inches high on its rear edge, thirty inches on its front edge, and twenty two inches wide. The panel 15 is sealed with epoxy resin and painted a variable color on its exterior surface. Five two inch by two inch wood stringers 15a, 15b, 15c, 15d, and 15e are glued and nailed to its periphery and to a point approximately ten inches superiorly from its inferior edge. A number of variably dimensioned apertures 22 and 23 perforate its surface.

The rear panel 16 measures approximately thirty three inches high by twenty two inches wide. It is family of four), the five-gallon pail is emptied into the top of the ***compost*** bin. Approximately two and one-half gallons, or a half-bucket, of garden soil is then spread over the top of the waste in the bin. An equivalent amount of shredded newspaper bedding, or ***compost*** taken from the extraction opening of the bin may be used in place of garden soil to cover the waste. Covering the wastes allows the microbes and worms access from all sides and prevents flies from entering or odors from developing.

Clean-up consists of putting the one gallon kitchen-based container in the dishwasher nightly and garden-hose-spraying the five gallon bucket weekly. This entire process takes less time than is required for adding compostable material to prior art devices. I believe this process/device to be more time-efficient than putting kitchen wastes down the sink macerator (and certainly more conservative of precious potable water inasmuch as each pound of kitchen waste macerated requires co-disposal of seven gallons of fresh water.) The device and process of the present invention is cost-effective when compared to the financial burdens of expanding and operating wastewater treatment plants or land fills. Finished ***compost*** can easily be periodically shoveled from the large extraction opening and used to replenish/enhance soil fertility in the local landscape.

This device allows ***continuous*** composting of kitchen wastes as the result of a unique modified vertical flow of the chamber contents: the reinforcing stringer attached to the inside of the front panel acts as a baffle. This baffle diverts the flow of composting waste and bedding from a straight vertical flow to a `J` curve flow. This unique flow allows more complete waste composting while maintaining a compact vertical dimension for the device. Thus the present ***compost*** bin operates with a ***continuous*** flow pattern to produce a nutrient-rich soil product in a short period and without odors or fuss. Because of the novel proportions of my device, the worms may migrate within the chamber to microclimate regions where conditions are optimum for their physiology. For example, if waste such as a liquid vegetable oil marinade is added in significant volume (one or two quarts) this oil would normally smother earth worms. In devices with smaller volumes, the worms would have no place to escape. The worms prefer an oil substrate. With my device, the worms can move vertically a sufficient distance to safety, then feed upon the oil from the periphery.

My device demonstrates `thermal advantages` over prior art devices. During hot periods of the day, the bedding/***compost***/wastes may overheat in other devices exposed to direct sunlight. This overheating may occur despite ventilation openings (which I believe my invention utilizes more efficiently due to its unique ability to develop a `stack effect` updraft). With my device, should overheating occur, the worms can migrate vertically and/or horizontally to cooler microclimate regions within the bin chamber. The ***vermiculture*** composting bin has been designed with attention to small details that ensure convenience and durability. The galvanized steel angle iron at the top of the front panel serves the dual role as panel reinforcement and shield. When the user is shoveling soil and/or ***compost,*** some soil or ***compost*** frequently adheres to the shovel blade. The angle iron provides a convenient device upon which to tap the shovel in order to remove adherent materials.

The present ***compost*** bin has been engineered to be `bullet resistant`. It may operate efficiently for generations. My prototype device has functioned well for more than two decades. My vermicomposting bin has successfully recycled all of the kitchen waste produced by my family of four, as well as the periodic "shock loads" associated with holiday parties and fishing adventures. I believe that this device and its process have achieved a mastery of the science of kitchen waste recycling.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made

United States Patent **8,919,282**
Jardine **December 30, 2014**

System and method for continuous vermiculture cycle

Abstract

A method for continuous vermiculture is provided. The method includes providing a continuous vermiculture culture system. The continuous vermiculture culture system includes at least one culture member that is fluidly connected to an irrigation system. After preparing a feeding solution, a volume of the feeding solution is then infused into the at least one culture member via the irrigation system. The steps of providing a feeding solution and infusing a volume of the feeding solution into the at least one culture member via the irrigation system are optionally repeated to promote formation of culture-grade soil and plant growth within the at least one culture member.

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Family ID: **46314966**
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Filed: **December 23, 2011**

Prior Publication Data

Document Identifier	Publication Date
US 20120234244 A1	Sep 20, 2012

Related U.S. Patent Documents

Application Number	Filing Date	Patent Number	Issue Date

RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/426,682, filed Dec. 23, 2010, which is hereby incorporated by reference in its entirety for all purposes.

Claims

Having described the invention, the following is claimed:

1. A method for continuous vermiculture comprising: (a) providing a continuous vermiculture culture system, the continuous vermiculture culture system comprising at least one culture member, comprising at least one earthworm, that is fluidly connected to an irrigation system; (b) preparing a feeding solution, wherein the feeding solution comprises organic food waste; (c) infusing a volume of the feeding solution into the at least one culture member via the irrigation system; and (d) optionally repeating steps (b) and (c) to promote formation of culture-grade soil and plant growth within the at least one culture member; wherein said step of preparing a feeding solution further comprises the step of placing an amount of organic food waste into a device for decomposing the organic food waste into a liquid effluent.

2. The method of claim 1, wherein said step of providing a continuous vermiculture culture system further comprises providing the irrigation system including: at least one source of the feeding solution; at least one primary fluid line connected to the at least one source; at least one junction member connected to the at least one primary fluid line; at least one secondary fluid line connected to the at least one junction member; and at least one tertiary fluid line that extends between, and is fluidly connected to, the at least one culture member and the at least one secondary fluid line.

3. The method of claim 1, wherein the at least one culture member comprises a mesh enclosure that surrounds a filler material and the at least one earthworm.

4. The method of claim 3, wherein the filler material further comprises soil, seeds, and at least one of coconut shavings and probiotic.

5. A method for forming culture-grade soil that facilitates plant growth, comprising the steps of: decomposing an organic waste material into a liquid feeding solution; infusing a portion of the liquid feeding solution into a medium, wherein the medium comprises an earthworm; and forming the culture-grade soil based on the earthworm consuming at least a portion of the liquid feeding solution; wherein decomposing organic waste material into a feeding solution comprises placing an amount of organic food waste into a device for decomposing the organic good waste into a liquid effluent.

Description

TECHNICAL FIELD

vermiculture system in FIG. 2;

FIG. 3B is a cross-sectional view taken along Line 3B-3B in FIG. 3A;

FIG. 4 is an image showing the continuous vermiculture system in FIG. 2 before initial seeding;

FIG. 5 is an image showing organic crops about 6 weeks after seeding in the continuous vermiculture system of FIG. 4; and

FIG. 6 is an image showing the organic crops in FIG. 5 about 10 weeks after seeding in the continuous vermiculture system of FIG. 4.

DETAILED DESCRIPTION

The present invention relates generally to a system and method for processing organic waste into a liquid solution to grow organic crops, and more particularly to a continuous vermiculture system and related cycle for producing culture-grade soil and growing plants. As representative of one aspect of the present invention, FIG. 1 illustrates a method 10 for a continuous vermiculture cycle for producing culture-grade soil and/or growing organic crops. The present invention harvests the regenerative power of nature by converting consumable organic waste (e.g., food waste) by-products into lush organic growth. Unlike conventional vermiculture systems and methods, which are eventually depleted of the minerals and nutrients needed to sustain the earthworm inhabitants, the present invention supplies earthworms with a liquid effluent of organic waste by-products so that the earthworms continuously create the needed nutrients to grow lush organic crops in any environment.

In one aspect of the method 10, a continuous vermiculture system 30 (FIG. 2) is provided at Step 12. The continuous vermiculture system 30 comprises at least one culture member 32 that is fluidly connected to an irrigation system 34. The irrigation system 34 generally comprises the following components: at least one source 36 of a feeding solution; at least one primary fluid line 38 that is fluidly connected to the source of the feeding solution; at least one junction member 40 that fluidly joins the primary fluid line and at least one secondary fluid line 42; and at least one tertiary fluid line 44 that is fluidly connected between the culture member and the secondary fluid line. Additional or optional components of the irrigation system 34 can include one or more pumps 46, one or more pressure gauges (not shown), one or more fluid flow control switches (not shown) (e.g., timed valves), one or more fluid flow sensors (not shown), one or more fluid quality sensors (not shown), and one or more central fluid flow controllers (not shown) for automated and/or centralized control of the continuous vermiculture system 30.

The source 36 of the feeding solution can include any device or structure (e.g., a vat or tank) capable of holding a volume of feeding solution (described in more detail below). The feeding solution is supplied to the source 36 via a conduit 37 that is fluidly connected to a device or system 39 capable of generating the feeding solution. Alternatively, the feeding solution can be manually supplied to the source 36 (e.g., by loading a pre-determined volume into the source as needed). In one example of the present invention, the device or system 39 can comprise a commercially-available food waste decomposer, such as the ORCA GREEN bioreactor (Orca Green, LLC, Marietta, Ga.). Other examples of devices and systems for decomposing organic food waste into a liquid effluent are known in the art. The device or system 39 is capable of decomposing organic waste (e.g., food waste, organic crop waste, lawn clippings, bark, leaves, branches, etc.) into a liquid effluent, which can then be fortified with one or more additives to form the feeding solution. Prior to supplying the source 36, for lines can be connected to one or more of the culture members. The tertiary fluid lines 44 can have any length and diameter desired. In one example of the present invention, the tertiary fluid lines 44 can have a diameter that is less than the diameter of the secondary fluid line 42 to provide increased fluid pressure within each of the tertiary fluid lines.

As shown in FIG. 2, the first end 48 of each of the tertiary fluid lines 44 partially extends into each of the culture members 32. Positioning the first end 48 of each of the tertiary fluid lines 44 in each of the culture members 32 helps facilitate widespread delivery of the feeding solution within the culture members. It will be appreciated, however, that the first end 48 of each of the tertiary fluid lines 44 may be flush-mounted to each of the culture members 32. Additionally, it will be appreciated that the tertiary fluid lines 44 can be fluidly connected to each of the culture members 32 in any desired pattern or configuration (e.g., symmetrically or asymmetrically spaced apart).

Referring to FIGS. 3A-B, each of the culture members 32 generally comprises an elongate mesh enclosure 52 that is formed from a mesh or netting-like material and includes a filler material 54 surrounded by the mesh enclosure. Each of the culture members 32 has a tube-like configuration defining a longitudinal axis LA and a longitudinal cross-section LC. The longitudinal cross-section LC can resemble any closed shape, such as a circle, a non-circle (e.g., an oval), and/or a polygon (e.g., a triangle, rectangle, square, hexagon, the shape of the letter "D", etc.). The particular dimensions of the culture members 32, such as length, width, cross-sectional area, etc., can be varied as needed. That is, the dimensions of one or more of the culture members 32 can be scaled up or down depending upon the particular application of the continuous vermiculture system 30.

The material used to form the mesh enclosure 52 can be fabricated from a flexible netting material, which can be woven, sewn, knitted, welded, molded, and/or extruded, etc. One example of a mesh enclosure 52 that may be used to form the culture members 32 is disclosed in U.S. Pat. No. 7,226,240 to Tyler, the entirety of which is hereby incorporated by reference. Briefly, the material used to form the mesh enclosure 52 can be biodegradable, such as cotton, a natural fiber, UV-sensitive plastic, and/or biodegradable polymer (e.g., starch) that can biodegrade at a predetermined rate. Alternatively, all and/or any portion of the material used to form the mesh enclosure 52 can resist biodegradation. For example, the material can be fabricated from plastic, UV-inhibited plastic, polyester, polypropylene, multi-filament polypropylene, polyethylene, LDPE, HDPE, rayon, and/or nylon. The material used to form the mesh enclosure 52 can be of any diameter and/or thickness. The material can have any mesh opening pattern, such as diamond, hexagonal, oval, round, and/or square, etc. Any number of mesh enclosures 52 can be coupled together in a process called "sleeving" to form a continuous mesh tube (and/or mesh sheet, not shown) of any size.

The filler material 54 can partially or completely fill each of the culture members 32. The filler material 54 can include one or a combination of materials, such as compost, composted products, mulch, sawdust, soil, gravel and/or various other organic and/or inorganic substances. As shown in FIG. 3B and described in more detail below, the filler material 54 includes one or more earthworms 56. Advantageously, the earthworms 56 can continuously create and replenish the nutrients needed for sustainable plant growth.

The filler material 54 can comprise any of a number of materials including, but not limited to, compost, composted organic materials, organic feedstocks, composted products, mulch, wood shavings, lime, clay, pea gravel, gravel, sand, soil, wood chips, bark, pine bark, peat, soil blends, straw, hay, leaves, sawdust, paper mill residuals, wood wastes, wood pellets, hemp, bamboo, biosolids, coconut fibers, coir, wheat straw, rice straw, rice hulls, corn husks, corn, grain, corn stalks, carbon dioxide are produced. The liquid effluent (or feeding solution) is then collected and prepared for further use.

At Step 18, the feeding solution is fed into the irrigation system 34. As indicated by the arrows in FIG. 2, the feeding solution is flowed through the source 36 via the primary fluid line 38 into the junction member 40, through the secondary fluid line 42, and then into each of the culture members 32 via the tertiary fluid lines 44. The rate and amount of the feeding solution delivered to the culture members 32 can depend on a number of factors including, but not limited to, the size and number of culture members, the type of organic crop(s) being cultured, the dimensions of the primary, secondary and tertiary fluid lines 38, 42 and 44, and the climate or environment in which the continuous vermiculture system 30 is located. For example, an arid environment may require a greater flow rate to prevent the filler material 54 from drying out.

The feeding solution can be flowed through the irrigation system 34 continuously and/or intermittently. The continuous vermiculture system 30 can be configured as a closed-loop system so, for example, the feeding solution is continuously flowed therethrough. Alternatively, the continuous vermiculture system 30 can be configured so that a desired amount of the feeding solution is delivered to one or more of the culture members 32 at specific time intervals. The feeding solution can be flowed through the irrigation system 34 via one or more pumps 46 or via a gravity-based mechanism (not shown). The feeding solution can be delivered to the culture members 32 one at a time, all at once, or a combination thereof (e.g., in a select pattern).

If it has not been done so already, one or more seeds of a desired plant (or plants) can be planted within each of the culture members 32 (FIG. 4). At Step 20, the culture members 32 are cultured by exposing the culture members to an appropriate amount of light and then infusing the appropriate amount of feeding solution into the culture members. Depending upon the type of plant(s) being cultured, all or only a portion of one or more of the culture members 32 can be exposed to partial or complete sunlight, for example. As shown in FIGS. 5-6, the culture members 32 are then cultured for an appropriate period of time until lush organic crop has been successfully cultured. At Step 22, the cultured organic crop can be harvested and consumed and/or converted into other non-food products, such as soaps, oils, medicines, etc.

After the organic crop is harvested and consumed, any organic waste (e.g., food waste and/or organic crops) can be disposed of at Step 24. To complete the virtuous cycle of the present invention, the organic waste can be recycled (Step 26) by depositing the organic waste into any device or system capable of decomposing the organic waste into a liquid effluent (feeding solution). Beginning at Step 14, the method 10 can then be repeated to once again culture organic crop that is ready for consumption. Not only are lush, healthy plants generated by the method 10, but so too is culture-grade soil that can be reused with the present invention or exported for other uses. Moreover, by generating a feeding solution from organic waste (e.g., organic food waste) to sustain the population of earthworms 56 in each of the culture members 32, the nutrients in the filling material are continuously regenerated to promote sustained and continuous plant growth.

From the above description of the invention, those skilled in the art will perceive improvements, changes and modifications. For example, other additives that can be included within the filler material 54 include fertilizers, pre-emergents, herbicides, nutrients, minerals, insecticides, pesticides, admixtures, aggregates, flocculants, polymers, chemical binders, and/or water absorbers, etc., chosen to enhance plant life. Additionally, it will be appreciated that the term "organic" as used herein is not restricted to "organically-certified" products or produce (as defined by the USDA, for example);

Vermicomposting system
EP 0196887 A2

ABSTRACT

A composting plant e.g. for use in vermiculture, comprises a cruciform-type breaker bar unit 16 (Figure 4) for moving the bottom layer of compost through the perforated floor of the plant. Alternative designs of breaker bar unit are also described.

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Publication type	Application
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Inventors	James Stanley Price, 4 More »
Applicant	National Research Development Corporation
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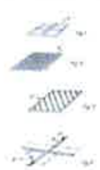
Patent Citations (2), Referenced by (16), Classifications (4), Legal Events (6)

External Links: Espacenet, EP Register

IMAGES (6)






DESCRIPTION

[0001] The present invention relates to a solids discharge device and in particular, but not exclusively, to one for discharging friable and/or particulate material from a container e.g. as part of a vermicomposting system for commercial scale vermiculture.

[0002] Whilst the aim of vermicomposting is the improvement of wastes into a useful or marketable product, the production of worms is another result of the process as these have a high protein content and when separated from the processed waste, can be used as a feed additive, e.g. for fish farming, or for pigs or poultry.

[0003] To date, two production systems have been in use. The simplest is a batch system where a quantity of waste is inoculated with worms and left until the waste has been broken down. The more successful system, however, is a cumulative-batch layer-fed system. Here a smaller quantity of waste is inoculated with worms and as it becomes broken down another and successive layers are added. In both systems, waste and worms are 'harvested' in one operation when the whole is removed and another batch is then started.

[0004] Machines are already known which use one or more augers for discharging compost from a compost bin but such arrangements are expensive for large-area bins and also less than satisfactory in a vermicomposting system, for example, where, ideally, worked material should be extracted from the lowermost layers of the charge with only negligible disturbance of the upper worm-containing layers of material.

[0005] On-farm (non-worm) composting is also being considered, and here the possibilities contemplated at present are the use of expensive screw-auger discharge vessels or simple in-pile composting. The latter option tends to give an inconsistent product but the expense involved in the former makes it inappropriate.

[0006] In addition, problems are often experienced in obtaining slow, even feed of other difficult solids which display severe bridging, e.g. moist soils in soil processing lines, etc. Commonly used equipment

CLAIMS (10)

1. A discharge device comprising a container having an apertured floor, one or more material-displacing members engaging with or lying adjacent to the upper surface of the floor, and drive means for moving the one or more members bodily across the floor thereby to urge material in the container downwardly through the apertures in the floor.

2. A device as claimed in Claim 1 in which the container is square or rectangular when viewed in plan, and the one or more material-displacing members comprises an elongate member lying parallel to the length or width dimension of the container, the drive means being operative to move the elongate member in directions parallel to the other of these two dimensions.

3. A device as claimed in Claim 1 or Claim 2 in which the material-displacing member includes one or more vertical tines, each tine is apertured and the device includes aerating means for supplying air to these apertures.

4. A device as claimed in any preceding claim in which said elongate member comprises a first such member and the one or more material-displacing members includes a second elongate member arranged at right angles to the first member.

5. A device as claimed in any preceding claim in which the drive means comprises a winch or chain and sprocket system or one or more rams or other linear activators.

6. A vermicomposting system incorporating a discharge device according to any preceding claim.

7. A continuous vermicomposting apparatus as claimed in Claim 6 comprising a container for a charge of worm-containing waste material, feed means for adding further amounts of said material to the top of

[0032] Conveniently, the apparatus includes feed means operative to break up lumps in a supply of unprocessed material before loading it onto the upper surface of the charge.

[0033] Conveniently, the apparatus includes means for watering the upper layers of the charge.

[0034] Conveniently, the apparatus includes enclosure means operative to prevent overwetting of the charge by rain when the apparatus is installed in the open air and to discourage the excessive evaporation of water from the charge in dry conditions.

[0035] It is to be noted that the term 'apertured' as used above and in the claims is to be broadly interpreted as describing any non-continuous floor for the container, i.e. any floor not wholly closing off the bottom end of the container.

[0036] The invention further includes a bedding system for animals, or a feed hopper, when incorporating a discharge device according to the present invention.

[0037] According to another aspect of the present invention, a continuous vermicomposting apparatus comprises a container for a charge of worm-containing waste material, feed means for adding further amounts of said material to the top of the charge and discharge means according to the present invention for removing from the bottom of the charge quantities of the material processed by the worms in the container.

[0038] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which:-

Figures 1, 2 and 3 are perspective views of different designs of apertured floor for use in a vermicomposting system;
Figure 4 is a perspective view of a cruciform unit for displacing material through the apertured floors of Figures 1 to 3;
Figures 5 and 5a show alternative drives for moving the unit of Figure 4 from end to end of a container;
Figure 6 is a vertical section of one or other of the material-displacing members used in the unit of Figure 4, and Figure 6a shows a similar section of an alternative design;
Figure 7 shows an alternative design of soil-displacing unit to that shown in Figure 4;
Figure 8 shows a modification of the design of Figure 7;
Figure 9 illustrates how the invention may be applied to a bedding system for animals;
Figure 10 shows a schematic vertical section through a first embodiment of the apparatus in accordance with the present invention;
Figure 11 shows a schematic perspective view of a first discharge device for use in the apparatus of Figure 10;
Figure 12 is a vertical section of part of an alternative discharge device to that shown in'Figure 11;
Figure 13 is a schematic side view of a feed hopper for use with materials that display severe bridging;
Figures 14 and 15 are respectively side and end views of an underfloor collection scaper for use with the apparatus of the earlier Figures, and
Figure 16 is a schematic perspective view of a drive system for use in some embodiments of the invention.

[0039] Thus referring first to Figures 1 to 3, these show three alternative designs of apertured floor for the container of a continuous vermicomposting system, namely a grid 10 (Figure 1) a mesh 12 (Figure 2), and a slanting bar construction 14 (Figure 3). In all these designs, the spacing between adjacent floor members (measured perpendicularly to these members) would typically be of a value of from 75 mm up to 200 mm, say.

[0040] Figure 4 shows a simple form of breaker bar unit 16 comprising two elongate members 18, 19 arranged in a simple unbraced cruciform construction.

[0041] Lugs 21, 22 extending upwardly from member 18 allow the construction to be pulled in a direction parallel to this member across the floor of the container.

[0042] The cross-member 19 is dimensioned so as to span or substantially span the container and the length of member 18 is preferably not less than about two thirds of the length of member 19.

[0043] In the illustrated embodiment, in fact, the separation l of each lug 21, 22 from the adjacent edge of cross-member 19 was designed to be not more than one third the length w of the member 18.

[0044] As illustrated in the drawing, both members 18, 19 incline upwardly at either end e.g. at about 30° to the horizontal.

[0045] Turning now to Figures 5 and 5a, these show alternative designs of drive system for use in a layer composting system of, say, 50 to 75 square metres (corresponding respectively to containers of 20 metres to 30 metres length, say). In significantly smaller systems e.g. containers of 4 to 9 square metres area, a simple hydraulic ram or similar linear activator may be employed e.g. as shown in the arrangement of Figure 3 to be described hereinafter. A modified ram or linear activator system may be used to drive intermediate size soil-displacement units, such as shown, for example, in Figures 8 to 10 still to be described in detail below. One example of thiks latter type of drive system will be hereinafter described with reference to Figure 16.

[0046] Returning now to Figure 5, the drive system 24 comprises, in essence, a winch 26 and idler pulley 27, one at either end of the container 29. A steel cable 31 attached to lug 21 passes around the winch 26 and then underneath the container floor 33 and back around the idler pulley 27 for attachment to the second lug 22. In the drive system 35 of Figure 5a the steel cable 31 is replaced by a chain 37 and the winch 26 and idler pulley 27 are replaced by a sprocket drive 39, 40. In alternative drive systems (not shown), both rotary supports can be driven.

preferably provided as a safeguard to water the upper layers of waste 114 should conditions require. In the event of excess water being provided, this can freely drain through the floor mesh of the container.

[0062] In operation of the apparatus, the container 112 is loaded with worm-containing waste as described and the temperature, aerobicity and dampness of the material waste is adjusted if required for optimum conditions.

[0063] The high population of worms within the container (typically 3 to 6 Kg of worms per square metre of material) will continually refine the waste, breaking it down to a smaller particle size.

[0064] The worms will continually move upward to new layers of waste as the previous layers become exhausted. Discharge of processed waste through the floor of the container takes place at substantially similar intervals to those at which new waste is added to the top, maintaining a fixed amount of continually renewed waste for processing in the container.

[0065] Because worms move up to the fresh waste layers, the processed waste will be substantially worm-free and can be discharged through the floor as already discussed for recovery by scraper, conveyor, skip or other suitable means.

[0066] In running the apparatus, the aim is always to maintain a high population of worms and achieve maximum throughput of waste.

[0067] A typical weekly output of vermicompost when using separated solids waste derived from cattle slurry is about 0.08 cubic meters per square metre of floor space of the apparatus.

[0068] In cases where the retention time of waste in the container is only four or five days, the waste throughput is too fast to enable worm cocoons to hatch and grow in the container and they will be lost in the discharged waste. In this case some addition of small worms may be necessary to maintain the desired level of performance.

[0069] Conversely, if the waste is passing so slowly through the apparatus as to give a waste retention time of 30 to 40 days, for example, the same worms will need to be harvested from the top layer of the material to prevent a continually expanding worm population.

[0070] Where wastes are strongly self-heating due to microbial degradation, careful control of feed layer depth and retained depth should be practised with the aim of keeping temperature at the 20-25 C optimum. In particular, overheating to above 30 C should be avoided as above this temperature damage to the worms may result.

[0071] With the discharge system of Figure 11, movement of the bar 20 across the container floor causes localised breakdown of bridging of contained material and discharge results as the bar advances. However, Figure 12 shows an alternative design of discharge mechanism in which the container floor consists of finned metal square-section elements 124 spanning the base of the container and able to rotate clockwise and anti-clockwise (e.g. through 90^0) to obtain through-floor discharge of the contents of the container.

[0072] Typically, the elements 124 will be steel tubes or rolled hollow sections to which the fins have been welded. The optimum centre spacings of elements 124 will depend on the bridging properties of the material to be discharged but a centre spacing of around 150 mm would be typical. Although if the elements are of square or other non-circular cross-section, the fins may not be necessary for effective discharge to occur, the fins are nevertheless found to result in a more positive discharge and hence their presence is to be preferred. In the illustrated embodiment, the fins might project by about 25 mm, say, from the upper three corners of the square-section elements 124.

[0073] Rotation of the sections 124 in a to and fro motion is by an actuator device 126 in which a common linear actuator 130 is linked to the various sections by a,series of crank arms. With relatively small containers or in small portions of a large unit, it will often be feasible to operate the linear actuator by hand without mechanical assistance.

[0074] As well as its uses in vermicomposting systems, apparatus according to the present invention could also find application in the discharge of materials such as municipal sludge or materials presenting severe bridging or other flow problems.

[0075] One such apparatus is shown in Figure T3 and consists of a hopper 140 with vertical sides and a floor 142 constructed of a steel grid or mesh. The optimum dimensions of the hopper are determined by the type of material to be fed.

[0076] Above the hopper 140 and in contact with the floor 142 is a framework 144 supporting a number of members 146 which span the width of the hopper.

[0077] Members 146 comprise breaker bars of any of the designs illustrated in the previous Figures and they serve to cause localised breakdown of the bridging effect by which the material rests on the floor 142. To achieve this end, the members 146 are caused to reciprocate slowly (say, 100 mm/sec) by, for example, a variable-speed electric screw type linear actuator 148. This causes a controlled and even discharge over the whole hopper floor area and has the beneficial effect of breaking down lumps and structures within the material.

[0078] Below the floor 142 is mounted a simple light duty belt conveyor 150 to collect the discharge and transport it to a delivery point. This conveyor is lightly loaded and its speed is not critical as it does not serve as a metering device. Metering is done by the discharge floor 142 and flow rate is adjusted by the rate at which the linear actuator 148 reciprocates the breaker bar members 146.

[0079] In an alternative embodiment (not shown), the breaker bars form part of a motor-driven chain loop conveyor but this detracts from the simplicity and serviceability of a simple reciprocating breaker bar framework. In a further

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LEGAL EVENTS

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Jan 18, 1989	17Q	First examination report	**Effective date:** 19881130
Nov 15, 1989	18D	Deemed to be withdrawn	**Effective date:** 19890411
Aug 8, 2007	RIN1	Inventor (correction)	**Inventor name:** BILLINGTON, RICHARD STEPHEN **Inventor name:** FLETCHER, KEITH ERNEST **Inventor name:** PHILLIPS, VICTOR ROGER **Inventor name:** PRICE, JAMES STANLEY **Inventor name:** WILKIN, ARTHUR LEONARD

Method and apparatus for processing waste
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Inventors	John Ronald Scott Gilchrist, Lynne Totten, Albert Briggs Eggen, John Mccluskey
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ABSTRACT

Organic waste is mixed and shredded in a mixer shredder (16) and composted in a thermophilic composting system (32). A portion of the compost as used as feedstock for a vermiculture system (46) to produce worm castings. The compost and castings can be used separately or blended. Liquid wastes may be treated in a digester (26) by aerobic or anaerobic digestion, and the resulting sludge fed to the vermiculture system (46).

DESCRIPTION

Method and Apparatus for Processing Waste

This invention relates to a method and apparatus for processing waste. In particular, this invention relates to a method for converting the organic portion of the wastestream into a variety of useful products, including a quality growing medium; and to apparatus for putting this method into practice.

Every year, one thousand million tonnes of putrescent waste are dumped in landfill sites in Europe alone. This has a damaging impact on the environment. EU legislation implementing enforcement of recycling targets has recently been put in place. There is thus an urgent requirement for a feasible and cost effective system for achieving these targets. Since at least 40% of the municipal wastestream is organic this proportion of the wastestream has the potential for conversion into useful products such as compost and soil amendment. Currently, the best practical environmental option (BPEO) for waste treatment is incineration. However, incineration recovers only a fraction of the energy contained in organic material; it produces toxic ash; and the variable nature of the waste needing treatment causes serious operational problems in an incinerator.

Thermophilic composting is a more attractive option. However current thermophilic composting practice necessitates utilising large areas of land for heaping waste out of doors, in long windrows. Variations in weather conditions affect the waste making the process of composting slow, and its product inconsistent. There is a requirement to turn the heaps periodically, and this is achieved by using expensive diesel fuelled machinery. Windrow composting produces gaseous and leachate emissions, which cause adverse environmental impact. The products of such composting are of inconsistent and unpredictable quality which, whilst usable, are not very suitable for sale as compost, and therefore are of limited value.

An alternative thermophilic composting practice is to utilise in-vessel thermophilic systems. However, to date many of these are mechanically and electronically complex. They are mostly batch processes; are capital intensive; and require considerable energy input. The problem of converting organic waste economically into a usable product has led to the development of the use of worms to recycle organic material. In this method, worms in a worm bed, a support structure supporting a layer of biodegradable organic material, are fed biodegradable organic waste material (BOWM) to produce digested biodegradable organic material, known as castings. These castings are exceptionally good soil amendment. This process can take place in an organic digester.

CLAIMS (1)

1. 1. A method for processing organic waste, in which waste is treated by microbial decomposition, and at least a proportion of the resulting treated waste is further treated by vermiculture in worm bed.

2. The method of claim 1, in which at least some of the waste is treated by microbial decomposition by means of thermophilic composting.

3. The method of claim 2, in which the thermophilic composting subjects the material being composted to a temperature of at least 70 °C for a period of at least one hour.

4. The method of claim 3, in which the temperature of 70 °C is maintained for 24 hours,

5. The method of any preceding claim, in which the waste consists of or includes liquid waste which is treated by microbial decomposition by means of aerobic or anaerobic digestion to produce a clarified liquid and a sludge, some or all of the sludge then being treated by vermiculture.

6. The method of claim 5, in which the liquid waste undergoes a preliminary step of moisture modification to separate it into a liquid part which is then treated by digestion and a solid part which is treated by thermophilic composting.

7. The method of any preceding claim, in which material to be composted is first shredded.

8. The method of claim 7, in which the shredding step is also used to mix together a number of incoming waste streams .

9. The method of any of claims 2 to 4, in which the compost produced by thermophilic composting is separated into coarse and fine fractions, and a selected proportion of the fine fraction is passed to vermiculture

Referring to Fig 1, this method uses the steps of treating organic material using selected micro- organisms to produce compost and then treating the compost in a variety of ways, including introducing part of the compost to a worm bed to produce digested biodegradable organic material known as castings.

The apparatus and system of Fig. 1 treats a number of organic waste streams 10, 12, 14. These waste streams are separated at source and may comprise green matter, catering slops, sewage sludge, manure, abattoir waste, poultry waste fish waste, seaweed, household organic waste, brewery/distillery waste, paper, cardboard, supermarket waste, and other biosolids . Wastes which are substantially dry, such as waste streams 12 and 14, are passed directly to a shredding and mixing machine 16.

Wastes which have a significant liquid content, such as waste stream 10, are first shredded by a shredder 18 and then treated in a moisture modification apparatus 20 (which may be, for example, a filter, belt press or centrifuge) to produce a solid stream 22 and a liquid stream 24. The solid stream 22 passes to the mixer/shredder 16. The liquid stream 24 is passed to a digester 26 of known type for aerobic or anaerobic digestion to produce a clarified liquid 28 which is discharged to drain or watercourse, and sludge 30 which is used as described below.

Optionally, bioaugmentation as indicated at 50 may be applied to the digester 26 and/or to the shredder/mixer 16, bioaugmentation being the addition of micro-organisms which will be beneficial to the breakdown of the waste material. Treating organic material using selected micro-organisms (bioaugmentation) encourages immediate initiation of the degradation of the material. Encouraging degrading in this way ensures that the method proceeds optimally.

The mixer/shredder 16 reduces the organic waste to a small size and mixes the various waste streams together. An important factor in the rapid breakdown of waste by thermophilic material has been found to be the shredding of paper, cardboard and green material right down into its constituent individual fibres . The shredder blades should rotate at a speed sufficient to achieve this. This ensures that extensive surface areas of material are exposed to bacterial action, and by ensuring optimal conditions in an in-vessel system the composting process is both very rapid and consistent.

The resulting material passes to a thermophillic composting system 32. Optionally, nitrogen sources and/or bulking agents may be added at this point . Alternative forms of thermophillic composting system which may be used at 32 are discussed below The resulting compost passes through a screen 34 to be separated into a coarse fraction 36 and a fine fraction 38.

The coarse fraction 36 is passed to a first curing store 40. A selected proportion of the fine fraction 38 is passed to a second curing store 42. The compost is held in the relevant curing store for about four weeks to cure or fully stabilise before being packed or transported for use. An alternative is to pack immediately in porous sacks, which enable sufficient air to penetrate the product to allow for the final bacterial and fungal activity which will render the product stable.

The remaining portion of the fine fraction 38 of the compost is passed to a shredder 44 which reduces the compost further in size to a very fine fibrous form, which is fed to a vermiculture apparatus 46. The digested sludge 30 is also fed to the vermiculture apparatus 46. The vermiculture apparatus 46 is preferably a self-contained, compact, highly automated apparatus of the type describer in CA 2170294 (Eggen) ; however, other types of vermiculture apparatus may be used in the present invention.

Feeding the vermiculture apparatus with material which has undergone shredding and thermophilic composting has a number of advantages. The feedstock has already had pathogen kill and the destruction of all weed seeds. In addition, the rapid action of the thermophilic bacteria has increased the palatability of the fraction for the worms by breaking down the material, and in particular by starting to break down the tough fibrous material, which speeds up the vermidigestion phase and raises the production rate of castings.

The castings which are produced in the vermiculture apparatus 56 are passed to a screen 48 to be separated into coarse castings 52 and fine castings 54. Unlike the compost from the thermophilic digester, the vermiculture castings are chemically and microbially stable as soon as they emerge from the casting removal system.

The system of Fig 1 thus produces four distinct products: 1. Coarse compost 2. Fine compost 3. Coarse castings 4. Fine castings.

These may be used individually according to their suitability for particular crops or soil conditions, or may be blended to obtain properties desired for particular use. It has been found that a particularly valuable product is formed by about 90% fine compost (product 2) mixed with about 1 - 10% castings (products 3 and 4) , preferably about 10%, which has greatly enhanced plant growth characteristics; it is of course possible to choose the proportion of material passing to vermiculture to optimise the process for this mixture.

Turning to the thermophilic composting process, this can be operated as a batch process. For this method, a heap of waste is placed in a container to decompose, and is aerated until the decomposition process is almost complete. The container is then emptied and refilled with a fresh heap of waste. The initial composting process occurs thermophilically . Bulking agents are used if necessary to provide an aerobic structure for active composting. The heap is structured such that air can circulate through the heap to aerate the mix naturally,, and to facilitate aerobic composting. Preferably however, the composting is operated as a continuous flow process. That is, there is continuous addition of waste to one

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1	*	CHEMICAL ABSTRACTS, vol. 133, no. 14, 2 October 2000 (2000-10-02) Columbus, Ohio, US; abstract no. 192617r, G. MASCIANDARO ET AL.: ""In situ" vermicomposting of biological sludges and impacts on soil quality" page 640; XP001039485 & SOIL BIOL. BIOCHEM., vol. 32, no. 7, 2000, pages 1015-1024,

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Citing Patent	Filing date	Publication date	Applicant	Title
WO2004092079A1 *	Apr 16, 2004	Oct 28, 2004	Aqua Clarus Holdings Pty Ltd	Apparatus and method for the treatment of waste
US6991728	Nov 10, 2003	Jan 31, 2006	Aqua Clarus Holdings Pty Ltd	Apparatus and method for the treatment of waste
US7294272	Jul 24, 2006	Nov 13, 2007	Aqua Clarus Holdings Pty Ltd	Method for the treatment of waste
US7323107	Oct 14, 2005	Jan 29, 2008	Aqua Clarus Holdings Pty Ltd	Apparatus and method for the treatment of waste

* Cited by examiner

CLASSIFICATIONS

International Classification	C05F9/04, C05F17/00, C05F17/02
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European Classification	C05F17/02, C05F17/00, C05F9/04

LEGAL EVENTS

Date	Code	Event	Description
Jun 13, 2002	AL	Designated countries for regional patents	**Kind code of ref document:** A2 **Designated state(s):** GH GM KE LS MW MZ SD SL SZ TZ UG ZM ZW AM AZ BY KG KZ MD RU TJ TM AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG
Jun 13, 2002	AK	Designated states	**Kind code of ref document:** A2 **Designated state(s):** AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CO CR CU CZ DE DK DM DZ EC EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW
Jul 3, 2002	WWE	Wipo information: entry into national phase	**Ref document number:** 2001999544 **Country of ref document:** EP
Aug 7, 2002	121	Ep: the epo has been informed by wipo that ep was designated in this application	
Jul 8, 2003	WWW	Wipo information: withdrawn in national office	**Ref document number:** 2001999544 **Country of ref document:** EP
Oct 16, 2003	REG	Reference to national code	**Ref country code:** DE **Ref legal event code:** 8642
Jan 21, 2004	122	Ep: pct app. not ent. europ. phase	
Jan 18, 2006	WWW	Wipo information: withdrawn in national office	**Country of ref document:** JP
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High efficiency vermiculture process and apparatus
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Original Assignee	Harry N. Windle
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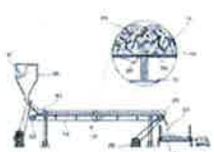
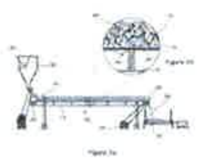
ABSTRACT

An apparatus and process for the efficient vermicomposting of organic containing wastes. A continuous thin layer of biomass is formed in which worms are established and encouraged to compost and migrate. The thinness of the biomass layer increases uniformity and allows for a higher rate of worm activity. By moving the biomass upon a conveying surface a continuous open system is created. New matter is introduced, digested and withdrawn while maintaining the active worms within a portion of the biomass. Spatial efficiency is provided by creating multiple beds in a stacked configuration.

IMAGES (5)





DESCRIPTION

BACKGROUND OF THE INVENTION

The present invention pertains to vermiculture and vermicomposting. In particular, the present invention provides a high efficiency process and apparatus for vermiculture and vermicomposting utilizing thin beds. Worm culture, or vermiculture, can provide worms as a raw material for an animal feed ingredient, live worms for sport fishing, or for other product uses. Vermicomposting is the use of worms to break down waste materials such as livestock manures and municipal waste. Generally, worms consume inorganic and organic matter, digest and absorb largely organic matter, and pass the remainder back to the soil. As a result of their feeding behavior, worms aid in the breaking down of organic material within the material they consume. The activity of worms also ventilates the soil and promotes bacterial and other microbial decomposition processes.

Large scale vermiculture typically uses thick beds in which large quantities of organic material are worked by worms in a relatively stationary mode. Thick beds typically become stratified with regions of active worms and regions of compacted material. These compacted regions often "sour" due to anaerobic decomposition resulting in unattractive conditions for worm activity. This requires turning or "freshening" of the beds such as by introduction of bedding materials. Thick bed operation is also typically a batch process requiring manual loading of fresh biomass. After the organic material is substantially broken down, the worms and digested material must be separated and harvested.

A need exists for a method of vermicomposting which provides: 1) uniform composting with lower labor demands; 2) better control of environmental conditions; 3) consistent and higher rates of worm activity with higher composting rates; 4) easier separation of worms from digested matter; and 5)

CLAIMS (20)

I claim:

1. A high efficiency vermiculture apparatus which reduces stratification of worms in the biomass being composted and increases worm density and efficacy, the apparatus comprising:

a thin layer biomass, said thin layer biomass having a thickness in the range of about 2 to 8 inches;

a worm mass within said thin layer biomass;

an input end and an output end;

a conveyor means for conveying the thin layer biomass from the input end to the output end: such that the thin layer biomass may be digested by the worm mass as the thin layer biomass is conveyed from the input end to the output end.

2. The vermiculture apparatus of claim 1 wherein:

said thin layer biomass has a thickness of about 4 inches.

3. The vermiculture apparatus of claim 1,

wherein the conveyor means comprises a movable first bed surface; and

said apparatus further comprising:

a control means for controlling the movement of said first bed surface, said control means being functionally connected to said first bed surface;

similar devices are used to maintain favorable temperatures and moisture content, and promote higher activity and digestion by the worms.

Higher efficiency may be obtained by providing incentives to keep the worms moving toward the new undigested material. Effective incentives are strong light and moving air at the unloading point at an end of the bed surface which encourages worms to move toward the loading point of the bed surface. The presence of new material at the loading point of the bed surface also encourages movement of the worms. Other incentives are electrical barriers and radiant heat devices.

In one configuration a continuous belt of a woven plastic sheet is used. It in turn is supported beneath by a bed pan of the same material. One advantage of such a construction is low cost which is particularly relevant in such locations as farms. These belts are slung between rollers of plastic or even wood, again allowing low cost. By inclining the beds, a single drive device connected to one roller of each worm bed in a stack can drive the entire assembly. Alternatively, independent drives may be employed.

These devices and processes may be used both with the objective of waste handling and as a means of producing worms as a product, or both simultaneously. Because of the uniform manner of composting, thin layer vermicomposting reduces the labor required as a means of waste processing. Because of the low space needs for such systems, environmental control allows for higher worm activity levels raising average composting rates. This is particularly advantageous in the northern climates where worms are otherwise dormant at ambient conditions much of the year.

The example embodiments provided are but a few illustrations of this novel vermicomposting invention. Other variations of the invention will be obvious to those skilled in the art of vermicomposting and vermiculture.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram of a vermicomposting process using a thin layer biomass.

FIGS. 2*a* and **2** *b* depict one embodiment of the invention using a single horizontal bed.

FIG. 3 is an embodiment of the invention having multiple beds in a vertical stacked configuration.

FIG. 4 is an alternative configuration in which two stacked bed assemblies are arranged back-to-back to facilitate loading.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is an apparatus and process for composting organic wastes in a highly efficient manner. In particular, the invention utilizes the great capacity of vermicomposting. The term "vermicomposting" as used here is understood to be the breakdown of organic matter by the ingestion and digestion of the matter by worms. As well, vermicomposting also includes the collateral biotransformation of such organic matter from the bacterial action inherent in such systems. The present invention has the capacity to cultivate a large number of worms—as excess over that needed for composting purpose. As such the present invention is also an apparatus and process for worm production. There is believed to be at least hundreds of species of what are commonly known as "red" worms in the vermicomposting technology. One example being the Lumbricus rubellus. Generally, species of red worm are regarded equally in vermicomposting and while the red worm is the type used to demonstrate the present invention, other types will work equally, depending somewhat upon the type of organic matter and environment.

The present vermicomposting invention utilizes a relatively thin bed, or layer, of organic matter in which the worm mass does its job. This process can be effectively used to transform or compost any number of waste materials such as restaurant food wastes; farmyard wastes such as chicken, pig, or bovine

a. a plurality of conveyors, each of said conveyors comprising:

1. a movable continuous loop belt, said belt being formed of a woven fabric, and each belt having a bed surface;

2. a pair of separated rollers, said belt being supported around said rollers;

3. a bed pan; said bed pan being formed of a woven fabric and being fixedly disposed beneath said belt; and

b. a support structure, said support structure being formed of wood members, each of said conveyors being supported in an inclined orientation by said structure in a vertically stacked configuration;

c. a drive motor connected to at least one of each pair of said rollers; and

d. a control device functionally connected to said drive mechanism;

e. a thin layer biomass formed on at least one of the bed surfaces; said thin layer biomass being capable of sustaining an infiltrated worm mass.

12. The vermiculture apparatus of claim **11**, further comprising:

a. a second support structure;

b. a second plurality of conveyors, each of said second plurality of conveyors being supported in an inclined orientation by said second support structure in a vertically stacked configuration;

c. both of said support structures being relatively located to form a space between the first and second plurality of conveyors; and

d. a loading trough formed around and at least partially enclosing said space; such that in operation additional biomass may be placed into the feeding trough and thereby be loaded onto said bed surfaces.

13. A high efficiency vermiculture process in which a worm mass is moved through a biomass layer such as to digest the biomass in complete and thorough manner to form a more uniform compost, the process comprising the steps of:

establishing a worm mass within a biomass;

introducing undigested biomass in a distributed, substantially continuous manner, creating a substantially continuous thin layer in communication with the worm mass;

retaining said thin layer in a substantially continuous manner such that the undigested biomass may be infiltrated by the worm mass and is thereby appreciably digested;

moving the thin layer to allow the effectively continuous introduction of new undigested biomass; and

withdrawing the digested biomass such as to create an exposed biomass surface while retaining the worm mass in communication with the undigested biomass;

such that a continuous open process is provided whereby a continuous flow of undigested biomass may be infiltrated and digested by worm mass moving through the stream.

14. The vermiculture process of claim **13** further comprising:

encouraging the worms to move toward the undigested biomass by providing an incentive.

15. The vermiculture process of claim **14**, further comprising:

enclosing the thin layer; and

motor with reduction or similar mechanisms well known in the arts may be used to obtain these low speeds. Some typical conveyor speeds are given in the example below. A bed pan **30** is provided secured rigidly to the support structure to form a foundation supporting the belt. In this configuration, the bed pan **30** is a fabric stretched between the individual members of the support structure **14**. The width of the entire assembly is arbitrary and is determined from the particulars of the site. In operation, a feed hopper or trough **35** is filled with undigested biomass **40** which is then introduced onto the belt **15**. The belt provides a bed surface **16** on which the biomass remains as it is composted. A leveler **45** is provided as necessary to provide an even distribution and thickness. Alternatively, a gate or weir may be provided the appropriate distance above the belt at the loading point. The biomass is then effectively extruded onto the belt by forcing the biomass between the belt and gate, the gate regulating the thickness of the layer. The belt **15** is driven at a speed which closely matches the worm mass progression through the thin layer biomass. The digested biomass **50** falls from the belt and is withdrawn from the site by a second conveyor **55**. In the expanded view, the thin layer biomass is shown infiltrated by worms **60**. While the various elements such as the feed hopper and conveyor may be structurally connected they may also be only functionally connected by being located in sufficient proximity and in proper orientation to function effectively together.

An example of a space and cost effective design for implementing the invention is shown in FIG. **3**. Multiple inclined conveyors **100** are supported in a vertically stacked configuration to form a conveyor assembly **101**. Each conveyor includes a loop conveyor belt **112** which is captured between rollers **114** as similarly described. A support structure **116** is provided to support the weight of the loaded belts. The top surface of each belt **112** forms bed surface which is loaded with undigested biomass by means of a single box feeder **105**. The feeder box is formed of a broad back **106** which spans the full width of the conveyor belts **100**. Sides **107** and a bottom **108** extend toward the conveyor belts and capture the biomass introduced. The near side of the feeder box **105** is cut away in the view to expose the conveyor loading ends. The fourth, open, side of the feeder box is effectively filled by the loading ends of the conveyors. The sides **107** are snug to the conveyor sides to reduce leakage. Biomass to be loaded is introduced into the feeder box mouth **109** and allowed to accumulate in the box. The weight of the biomass will force it to flow between the individual conveyors and onto the belts **112**. The gap between rollers at the loaded end of the conveyors determines the thickness of the biomass layer formed. This spacing is exaggerated in the figure for clarity. Other devices and methods for loading such a material stream onto a conveying surface are within the knowledge of those skilled in materials transportation. Each conveyor **100** is inclined at a downward angle from the loading end to the unloading end as shown. Because the weight of the biomass on the bed surfaces may be extreme, the frictional resistance to belt movement may be great. The incline allows the weight of the biomass drawing the belt down to counter the frictional forces and reduce the motor power required to drive the belts. The exact angle is dependent on the construction materials and the density of the biomass. The belt material and bed pan material greatly influence the friction forces as the contact surface area is great. A reduced speed drive **110** similar to that in the previous figure is provided, linked either directly or indirectly to each belt. A speed and timing control **115** is provided on the drive **110**. These components are but one way in which the belt motion may be controlled. Alternative methods such as independent drives for each belt are also available. While motion of the conveyor belts and bed surfaces has been discussed as continuous, noncontinuous motion will also be satisfactory. Short duration motions with long intervening stationary periods will effect the same result so long as the motions are short enough that large portions of the digested biomass are not withdrawn at a single time carrying along worms.

A screen tumbler **120** is shown, for convenience, placed at the unloading end of the conveyor assembly **101** such that digested biomass will fall into the open end of tumbler. The function of the screen tumbler is to separate the larger undigested lumps of biomass **125**, and incidental worms, from the more fine worm castings material **130** which has been digested. The screen size is again dependent upon the particular biomass. For cow manure vermicomposting, a ⅛ inch screen followed by a ¼ inch screen has been found to work well. Preferably, all but the material passing through the ⅛ inch screen is returned to the undigested biomass to be reloaded and form the thin layer. It has been found that in this manner a large quantity of worm egg casings will be returned to hatch within the worm mass thereby supporting the worm population. Alternatively, the egg casing containing portion may be removed to allow for incubation of the worm eggs and production of worms.

EXAMPLE

A vertically stacked vermicomposting assembly was built having 7 individual inclined thin layer biomass beds. The beds were each inclined at an included angle of 24 degrees from the horizontal—the output end being lower. The assembly sides were covered with a polyethylene sheet to help maintain an elevated temperature. A supply of cow manure was liquefied, pumped into a hopper, and then allowed to gravity drain for 24 hours after which it was hand loaded into a gravity feed trough loading simultaneously all of the beds. The trough enclosed the loading end of the beds and the weight of a height of biomass above the beds forced a portion of the biomass from the trough, through a slot, onto each bed surface. Between vertically adjacent beds, this slot was formed by the space between the respective bed rollers. The device was similar to that shown in FIG. 3. A supply of red worms was obtained, distributed onto the beds, and briefly allowed to become established. The beds were put into motion and additional biomass was loaded maintaining a continuous thin layer on the beds. Both a simple electrical fan and two 40 watt fluorescent light bulbs were directed at the unloading end of the assembly as incentives. The digested biomass was withdrawn by gravity drawing the overhanging portion of the thin layers to fall from the beds into trays. The digested biomass was then screened through an 118 inch wire mesh and the residual returned to the feed trough. The residual consisted primarily of small lumps of undigested

Citing Patent	Filing date	Publication date	Applicant	Title
			Rutgers, The State University	Apparatus and method for separation of nematodes from suspension
US6601243 *	Apr 1, 2002	Aug 5, 2003	Ecosphere Technologies	Toilet installation implementing composting with worms
US6838082	Feb 14, 2002	Jan 4, 2005	M-I Llc	Vermiculture compositions
US7004109 *	Jul 1, 2002	Feb 28, 2006	Seabait Limited	Aquaculture of marine worms
US7018831	Sep 26, 2001	Mar 28, 2006	Biosystem Solutions, Inc.	Composting apparatus and method
US7141169	Jun 18, 2004	Nov 28, 2006	Koehler Peter L	Method and apparatus for biosustaining waste activated vermicular environment
US7156048	Feb 2, 2006	Jan 2, 2007	Seabait Limited	Aquaculture of marine worms
US7867396	Jul 11, 2005	Jan 11, 2011	Black & Grey Holdings Pty Ltd	Water treatment apparatus, method and system
US7964385	Apr 10, 2007	Jun 21, 2011	Rt Solutions, Llc	Organic waste treatment system utilizing vermicomposting
US8304227	May 11, 2011	Nov 6, 2012	Rt Solutions, Llc	Organic waste treatment system utilizing vermicomposting
US8465567	Aug 10, 2007	Jun 18, 2013	Palaterra Gmbh & Co. Kg	Method for the production of humus- and nutrient-rich and water-storing soils or soil substrates for sustainable land use and development systems
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US20060124063 *	Feb 2, 2006	Jun 15, 2006	Seabait Limited	Aquaculture of marine worms
EP2144859A1 *	May 1, 2008	Jan 20, 2010	Ivan Milin	System for processing organic waste using insect larvae
EP2458136A1	Feb 14, 2002	May 30, 2012	M-I L.L.C.	Method of bio-remediating wellbore cuttings
WO2002087321A2 *	Apr 25, 2002	Nov 7, 2002	Gaugler Randy	Apparatus and method for mass production of insecticidal nematodes
WO2009021528A1 *	Aug 10, 2007	Feb 19, 2009	Joachim Boettcher	Method for the production of humus- and nutrient-rich and water-storing soils or soil substrates for sustainable land use and development systems

* Cited by examiner

CLASSIFICATIONS

U.S. Classification	119/6.7
International Classification	A01K67/033, C05F17/00
Cooperative Classification	C05F17/0009, A01K67/0332, Y02W30/43
European Classification	A01K67/033B, C05F17/00B

LEGAL EVENTS

Date	Code	Event	Description
Jul 13, 1998	AS	Assignment	**Owner name:** WORM WORLD, INC., FLORIDA **Free format text:** ASSIGNMENT OF ASSIGNORS INTEREST;ASSIGNOR:WINDLE, HARRY N.;REEL/FRAME:009316/0611 **Effective date:** 19980707
Jun 21, 2004	FPAY	Fee payment	**Year of fee payment:** 4
Oct 26, 2006	AS	Assignment	**Owner name:** WINDLE, HARRY, FLORIDA **Free format text:** ASSIGNMENT OF ASSIGNORS INTEREST;ASSIGNOR:WORM WORLD, INC.;REEL/FRAME:018433/0617 **Effective date:** 20061024
Sep 26, 2008	FPAY	Fee payment	**Year of fee payment:** 8
Dec 10, 2012	REMI	Maintenance fee reminder mailed	
May 1, 2013	LAPS	Lapse for failure to pay maintenance fees	
Jun 18, 2013	FP	Expired due to failure to pay maintenance fee	**Effective date:** 20130501

Method and apparatus for biosustaining waste activated vermicular environment
US 7141169 B2

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Also published as	US20050133442, WO2005063011A2, WO2005063011A3
Inventors	Peter L. Koehler
Original Assignee	Koehler Peter L
Export Citation	BiBTeX, EndNote, RefMan

Patent Citations (14), Referenced by (2), Classifications (17), Legal Events (3)

External Links: USPTO, USPTO Assignment, Espacenet

ABSTRACT

A system for processing sewage into vermicompost includes a holding tank for receiving and initially processing the sewage. A treatment tank, connected to the holding tank by a first pipe, is used for treating the initially processed sewage from the holding tank to ensure optimal pH, percent of solids, and electrical conductivity of the sewage. A distribution tank, connected to the treatment tank by a second pipe, is used for heating or cooling the sewage from the treatment tank as necessary. A distribution apparatus, connected to the distribution tank by a third pipe, distributes the sewage to a vermicular environment, wherein the vermicular environment contains a plurality of worms which digest the distributed treated sewage into vermicompost.

IMAGES (3)



DESCRIPTION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from U.S. Provisional Application Ser. No. 60/531,716 entitled BIOSUSTAINING WASTE ACTIVATED VERMICULAR ENVIRONMENT filed on Dec. 22, 2003, incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates generally to the field of waste treatment systems, and more particularly to a waste treatment system in which the waste is treated by being digested by worms.

BACKGROUND OF THE INVENTION

The ability of worms to compost organic matter has long been known. Various attempts have been made to apply this knowledge to treating human waste. For example, U.S. Pat. No. 4,262,633 (Taboga) discloses using worms for reclaiming and processing biodegradeable waste into poultry products and humus-like substances. U.S. Pat. No. 5,192,428 (Lindstrom) discloses using worms in a natural composting bed which includes human waste. U.S. Pat. No. 6,223,687 (Windle) discloses using worms for composting a thin layer of biomass, and especially cow manure. U.S. Pat. No. 6,601,243 (Colombot) discloses using worms to compost a composting medium formed in part by human waste.

Common limitations are the quantity of waste able to be processed and the smell involved when processing human waste. The known prior art which uses vermiculture to process wastes requires extensive processing of the waste

CLAIMS (49)

1. A system for processing sewage into vermicompost, comprising:

at least one holding tank, wherein said sewage is initially processed;

at least one treatment tank connected to said holding tank by a first pipe, wherein said initially processed sewage from said holding tank is treated to ensure optimal pH, percent of solids, and electrical conductivity of said sewage;

at least one distribution tank connected to said treatment tank by a second pipe, wherein said treated sewage from said treatment tank is heated or chilled as necessary to reach an optimal temperature; and

a distribution apparatus, connected to said distribution tank by a third pipe, which distributes said sewage to a vermicular environment, wherein said vermicular environment contains a plurality of worms, wherein said worms digest said distributed treated sewage into vermicompost.

2. A system according to claim 1, further comprising a first screen, a first agitator, and a first pump operatively associated with said holding tank.

3. A system according to claim 2, further comprising a second screen, a second agitator, and a second pump operatively associated with said treatment tank.

4. A system according to claim 2, further comprising a coarse screen operatively associated with said first holding tank and disposed such

step of measuring, the treated sewage to a vermicular environment containing a plurality of worms, wherein the worms digest the distributed treated sewage into vermicompost.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic diagram of an embodiment of the present invention.

FIG. 2 shows a schematic diagram of an embodiment of the present invention.

FIG. 3 shows a flow chart of an embodiment of a method of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1–2, a system **10** includes discrete components which are interrelated within specified tolerances resulting in an efficient, effective, and economically feasible method of treating and disposing of a substantial volume of human and animal sewage/waste. The entire system operates indoors, under one roof, thus presenting an exterior appearance that can be aesthetically pleasing, unassuming, and architecturally appropriate in a wide range of settings. The process involves the application of sewage/waste in liquid state ("effluent") to specifically prepared earthworm beds wherein virtually all environmentally harmful or undesirable solids are digested by the worms, resulting in the production of a high nutrient vermicompost suitable for direct application in a number of settings such as horticulture, landscaping, golf courses, municipal parks, etc. In one embodiment, system **10** includes an effluent input line **12** which passes effluent into a first tank **14** for initial processing, while in another embodiment, effluent is pumped from a truck or other container directly into first tank **14**. After processing in first tank **14**, the effluent is sent to a second tank **16** via a line **28**. After processing in second tank **16**, the effluent is sent to a third tank **18** via a line **30**. The effluent is ready for feeding to a worm bed **22** after being processed in third tank **18**. The effluent is shown being sent to worm bed **22** via a line **32**, which connects to either a plurality of drip lines **24** or a plurality of spray lines **26** as shown in FIG. 2. These components are housed in an enclosure **20**, which may be completely closed for northern climates or partially open for hotter climates. At least one drain line **34** collects leachate from worm bed **22** which is then available for use in the process. Drain line **34** is shown in FIG. 1 as running the length of worm bed **22**, but is shown in FIG. 2 as drain line **34'** running across the width of worm bed **22**.

Referring to FIG. 3, a flow chart for treating sewage according to an embodiment of the invention is shown. The sewage is received in step **40**, where it is screened in step **42** to remove a majority of the nondigestible solids from the sewage. The screened sewage is then ground in step **44** so that particulate matter in the sewage is no larger than about ¼ inch. The sewage is then tested in step **46** for pH, percentage of solids in the sewage, and electrical conductivity, and if the variable are determined to be within optimal ranges (step **48**), the temperature is measured in step **52**. If the variables are not within optimal ranges, fluid, preferably leachate from worm bed **22** or optionally fresh water, is added until the variables are within the optimal ranges, after which the temperature is measured in step **52**. If the temperature is not within the optimal range in step **54**, the temperature is adjusted in step **56** before the sewage is distributed in step **58**. If the temperature is within the optimal range in step **54**, the sewage is then distributed to the worm bed in step **58**, where the worms digest the distributed treated sewage into vermicompost.

The sewage/waste treatment system utilizes the natural eating/digestive process of earthworms to transform raw sewage into environmentally useful compost suitable for use in a number of applications in horticulture, landscaping, golf courses, etc. The component parts of the system include earthworms, a structure to house the waste system components, an earthworm living environment/waste treatment bed, a series of tanks for collecting and processing the effluent, several pumps, grinders, and filters/screens used to

includes a mixture of peat moss and nutrient rich, sand free topsoil from about 6 inches to about 15 inches deep.

19. A system according to claim 18, wherein:

said means for receiving said sewage includes at least one holding tank, wherein said sewage is initially processed;

said means for treating said received sewage includes at least one treatment tank connected to said holding tank by a first pipe, wherein said initially processed sewage from said holding tank is treated to ensure optimal pH, percent of solids, and electrical conductivity of said sewage; and

said means for distributing said treated sewage includes at least one distribution tank connected to said treatment tank by a second pipe, wherein said treated sewage from said treatment tank is heated or chilled as necessary to reach an optimal temperature, and a distribution apparatus, connected to said distribution tank by a third pipe, which distributes said sewage to a vermicular environment, wherein said vermicular environment contains a plurality of worms, wherein said worms digest said distributed treated sewage into vermicompost.

20. A system according to claim 19, wherein said means for receiving further includes a first screen, a first agitator, and a first pump operatively associated with said holding tank.

21. A system according to claim 20, wherein said means for treating further includes a second screen, a second agitator, and a second pump operatively associated with said treatment tank.

22. A system according to claim 20, wherein said means for receiving further includes a coarse screen operatively associated with said first holding tank and disposed such that sewage entering said holding tank passes through said coarse screen before entering said holding tank.

23. A system according to claim 22, wherein said means for receiving further includes a grinder effective for grinding solids in said sewage after said sewage has passed through said first screen in said holding tank.

24. A system according to claim 23, wherein said means for treating further includes a third screen operatively associated with said second screen, such that sewage entering said treatment tank from said holding tank passes through said second screen and then said third screen.

25. A system according to claim 24, wherein said second screen has about a inch mesh and said third screen has about a ⅛ inch mesh.

26. A system according to claim 19, wherein said optimal pH is a range between about 5 and about 8, said optimal percent of solids is in a range between about 1–5% by volume, and said optimal electrical conductivity is no more than 3 millisiemens.

27. A system according to claim 19, wherein said optimal temperature is effective to keep said worm bed at a temperature in a range from about 60 to 70 degrees F.

28. A system according to claim 18, wherein said means for distribution includes at least one gravity-feed drip pipe.

29. A system according to claim 18, wherein said means for distribution includes at least one pressure spray nozzle.

30. A system according to claim 18, wherein said worms are of a species *Eisenia foetida*.

footage/surface area) are constant regardless of the bed's surface dimensions. For example, the top layer of all beds should be 6" to 15" deep for the earthworm living environment depending on the climate. The depth of the top layer varies from 6" for moderate climates to 15" for very warm/hot climates. Appropriate bed depth is a critical aspect of maintaining bed temperature within the optimal range of 60 to 70 degrees Fahrenheit. Within this range, the eating habits and metabolic processes of the worms assure efficient and thorough waste digestion and processing. The worms themselves can and do tolerate temperatures within a much wider range of 45 to 95 degrees F., but their feeding/digestive performance drops off considerably as the outer limits of the broader temperature range is approached. It is preferable to build in simple liquid waste heating/cooling capabilities in the system process just prior to applying the effluent to the waste bed in order to be able to regulate or fine tune the bed temperature during brief periods of extreme outside temperature fluctuations lasting more than a day or two.

The top layer is preferably composed of 50% peat moss and 50% nutrient rich, sand free topsoil, and e.g. black dirt/muck land soil. This sits on top of the base layer, composed of a sand/gravel mix 12"–18" deep, with 18" being the preferred embodiment as this affords optimal drainage for the bed. A sheet of porous landscaping fabric is optionally used to separate the two layers. This fabric sheet is optionally used as an integral component of compost harvesting later in the process. The entire bed sits on grade and is preferably contained within a berm around the perimeter, with a poly-liner or asphalt liner which creates a water tight "basin" in which the bed is located. In the experimental embodiment, a series of 4" perforated pipes within the base layer run from the outer edges every 6' to the center where they join a 4" perforated pipe running the length of the bed to provide drainage for the leachate which seeps down through the earthworm living environment (above) into the base layer. These drain pipes are pitched (e.g. 1"/20 ft.) and lead into a sump pit where the leachate is collected to be pumped back into one of the processing tanks (recirculated) through the system as needed. The size by volume of the sump pit is related to the overall size, i.e., the surface area, of the treatment bed. In this example, with a bed size of 525 sq. ft treating 390 gal/day, a sump pit of 300 gal capacity is optimal.

Tanks. The three tanks in the system are constructed from steel, concrete, fiberglass, plastic, etc. The material used in the tank construction is not in and of itself critical to the system. Practical considerations such as cost and maintenance determine tank construction material. In the experimental embodiment, a tank size in gallons appropriate for processing 390 gal. of raw sewage per day is 1000 gal. capacity per tank. Within each tank, the filters, screens, agitators and pumps utilize some volume (1½ to 2½ cubic feet per tank). In addition, each tank may be holding some of the effluent as it is being ground up, filtered, screened, adjusted for pH, electrical conductivity, etc. The capacity of three 1000 gal. tanks for 390 gal/day raw sewage being treated affords a reasonable working margin of safety to accommodate constantly incoming effluent in the event of an interruption in the process from such things as power outages, external events, accidents, etc.

Sewage/waste is delivered to the system location, either from a sewer system or from special trucks which pump out septic tanks, and pumped into one or more collecting tanks such as first tank **14** through a coarse screen, such as a bar screen, preferably set at ½". This initial screen separates the large (greater than ½" size), heavy, consolidated objects and particles in the incoming raw sewage, such as sanitary napkins, condoms, hair masses, grease balls, and miscellaneous foreign objects which were collected as part of the raw sewage from local septic systems or municipal waste treatment facilities. The nondigestible solids which were part of the waste/sewage introduced at the beginning of the process now constitute merely approximately 0.05% of the total volume of effluent being processed. These solid wastes (0.05% of total volume) are set aside for deposit in the local landfill. The remaining 99.95% of the effluent volume is processed by the worms in the system.

Preferably while still in first tank **14**, the raw sewage passes through a ⅜" screen filter and then is drawn into a grinder pump, which preferably sits on the bottom of first tank **14**, where it is ground into ¼" or smaller particles to reduce the solid/particulate size so the solids remain in suspension during the next treatment phase. The sewage is then pumped from first tank **14** to second tank **16**. In the experimental embodiment, the pumping from first tank **14** to second tank **16** is accomplished though line **28**, which is a 2" diameter, schedule **80**, PVC pipe. The preferable type and size of pipes depends on the volume of effluent being processed, and such a determination is considered to be within the skill level of one skilled in the art.

From the collecting tank, the effluent is passed through one or more screens into one or more treatment tanks such as second tank **16**. In the experimental embodiment, the effluent is pumped through a ¼" mesh sidehill screen on the top of second tank **16** onto a second screen with ⅛" openings and then into tank **2**. The purpose for the two consecutive screens at the top of second tank **16** is to catch as much hair as possible for manual collection and removal prior to the effluent entering second tank **16**. In second tank **16**, the liquid sewage/waste and small particle mix are agitated, sampled and

44. A method according to claim 43, wherein said worm bed is contained in a shelter, wherein said shelter is an open-sided structure when said worm bed is disposed below about 36 degrees North latitude, and wherein said shelter is an enclosed building when said worm bed is disposed above about 36 degrees North latitude.

45. A method according to claim 43, further comprising the step of removing excess vermicompost from said worm bed when said vermicompost layer reaches about 6 to nine inches in depth.

46. A method according to claim 35, further comprising the step of illuminating said vermicular environment 24 hours per day.

47. A method according to claim 46, wherein a level of said illumination during hours of darkness is approximately 40%–50% of a level of said illumination during daylight hours.

48. A method according to claim 35, wherein said vermicular environment includes a leachate drain pipe.

49. A method according to claim 35, wherein said step of distributing includes distributing only an amount of treated sewage that can be fully digested by said worms within about 24 hours.

Cited Patent	Filing date	Publication date	Applicant	Title
US20040065610 *	Apr 28, 2003	Apr 8, 2004	Shankar Hariharan S.	Process for treatment of organic wastes
EP0999194A2	Nov 2, 1999	May 10, 2000	Glas Anois Reo	Waste treatment system
FR278508A				*Title not available*
JPS5667597A *				*Title not available*
JPS57135093A *				*Title not available*
JPS57147491A *				*Title not available*

* Cited by examiner

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Citing Patent	Filing date	Publication date	Applicant	Title
US7964385	Apr 10, 2007	Jun 21, 2011	Rt Solutions, Llc	Organic waste treatment system utilizing vermicomposting
US8304227	May 11, 2011	Nov 6, 2012	Rt Solutions, Llc	Organic waste treatment system utilizing vermicomposting

CLASSIFICATIONS

U.S. Classification	210/602, 210/173, 119/6.7, 210/259
International Classification	C02F3/32, C05F7/00, C05F17/00
Cooperative Classification	C05F17/0009, C02F3/32, C05F17/0018, C05F7/00, Y02W30/43, Y02W10/37
European Classification	C02F3/32, C05F7/00, C05F17/00D, C05F17/00B

LEGAL EVENTS

Date	Code	Event	Description
Feb 13, 2007	CC	Certificate of correction	
Apr 29, 2010	FPAY	Fee payment	**Year of fee payment:** 4
Apr 22, 2014	FPAY	Fee payment	**Year of fee payment:** 8

USPTO Patent Full-Text and Image Database

United States Patent 8,642,324
Bell February 4, 2014

Continuous flow worm farm

Abstract

An apparatus for the treatment of organic matter with worms, includes a receptacle with a side wall at least a portion of which is downwardly tapering to facilitate compression of organic matter as organic matter is processed, an upper entry aperture for loading the receptacle with the organic matter and worms, a lower discharge aperture for discharging compressed material including castings and organic matter, and a base lid adapted to releasably close the discharge aperture and to permit removal of the compressed material from the receptacle.

Inventors:	**Bell; Benjamin** (Auckland, **NZ**)
Applicant:	**Name** **City** **State Country Type** **Bell; Benjamin** Auckland N/A NZ
Assignee:	**LOW Impact Limited** (Onehunga, Auckland, **NZ**)
Family ID:	**42542550**
Appl. No.:	**13/146,441**
Filed:	**February 4, 2010**
PCT Filed:	**February 04, 2010**
PCT No.:	**PCT/NZ2010/000016**
371(c)(1),(2),(4) Date:	**July 27, 2011**
PCT Pub. No.:	**WO2010/090537**
PCT Pub. Date:	**August 12, 2010**

Prior Publication Data

Document Identifier	Publication Date

The invention claimed is:

1. A vermicomposter apparatus to treat organic matter with worms, comprising: a receptacle including: side walls including: an upper portion which is downwardly tapering and configured to facilitate compression of organic matter as said organic matter is processed, a lower portion connected at a connecting line with a lower edge of said upper portion and which extends vertically without any taper, an upper entry aperture defined by an upper periphery of the respective side walls and configured for loading said receptacle with organic matter and worms and a lower discharge aperture configured to discharge compressed material comprising castings and organic matter, wherein the lower discharge aperture is defined by a lower periphery of the lower portion; a base lid completely removably connected to the receptacle at the lower discharge aperture and adapted to releasably close said discharge aperture and configured to permit removal of said compressed material from said receptacle, the base lid including a bottom having: a liquid drain opening, and a filter positioned at a lower portion of said base lid immediately above said liquid drain opening, for restricting the passage of compressed material; and a securing arrangement for releasably securing said base lid to said receptacle at said lower discharge opening to completely remove said lid from said receptacle; a support for elevating said receptacle off a ground surface to a height such that the base lid is spaced from the ground surface so as to be completely removable from said receptacle, and the receptacle sits within the support such that the upper portion of the receptacle contacts the support; the support includes a frame and an element connected to the frame for elevating said frame above the ground surface; the lower portion having a length which serves to hold compressed material to be removed and which is discharged into said base lid above said filter, while permitting removal of the compressed material in the lower portion below the connecting line when said base lid is completely removed from the receptacle.

2. The vermicomposter apparatus according to claim 1 wherein the receptacle has a central axis and the downwardly tapering side walls are angled at between 5and 20 degrees with respect to the central axis.

3. The vermicomposter apparatus according to claim 2 wherein the downwardly tapering side walls are angled at between 10 and 15 degrees with respect to the central axis.

4. The vermicomposter apparatus according to claim 1 wherein the lower periphery of said side walls are non-tapered.

5. The vermicomposter apparatus according to claim 4 wherein the base lid comprises a sleeve adapted to fit said lower periphery and to retain said compressed material after disengagement of said base lid from said receptacle.

6. The vermicomposter apparatus according to claim 5 wherein a height of said lower periphery is equal to a height of said sleeve.

7. The vermicomposter apparatus according to claim 1 wherein the upper periphery of said side walls are non-tapered.

8. The vermicomposter apparatus according to claim 1 wherein an interior surface of the receptacle is smooth to enhance the rate at which said organic matter is compressed as said organic matter is

as required and have a perforated base to allow the passage of both worms and liquids. The trays may have slightly sloping sides with the result the floor of a tray rests directly upon the organic waste contained in the tray immediately below. The trays are periodically rotated in order to remove processed waste from the lowermost tray.

Continuous flow systems, such as Australian patent 712227, comprise a single container, either elevated from the ground, or resting directly upon it. Organic waste is introduced to the top of the container and digested by the worm population within. The processed organic matter passes through container to the floor where it generally exits via a wide aperture mesh and falls onto a tray. Excess liquid is then drained from the finished castings. In some systems, the walls of the container may also be formed of a wide aperture mesh, allowing castings, liquid and worms to pass through and fall to the collection tray below.

Both systems have significant disadvantages. Tiered systems result in separate populations of worms either becoming stranded in individual trays due to a gap arising between the top of the waste present in the tray and the bottom of the tray immediately above it, or the worms failing to migrate from the lower trays to the organic waste present in higher trays because sufficient nutrients are available in the tray they are inhabiting. Worms are also able to migrate downwards to the lowest tray and drown in any liquid present. Further, due to the fact that trays must be periodically rotated, the lifecycle of the worms is disturbed. Still further, the trays when full of organic waste are a considerable weight for a single individual to lift. To overcome this problem a shallow tray may be used to enable an operator to lift its weight. However the shallow tray prevents the finished castings within from becoming compressed, allowing worms to remain active in the castings and increasing the handling weight of finished castings. In addition, trays must be entirely emptied to access the older castings situated in the bottom of the tray, and the lower tray may have substantial numbers of adult worms present which must be separated from the castings prior to use.

As stated, continuous flow systems generally rely on a wide aperture mesh to prevent the organic waste present from falling through the farm. As castings pass through the mesh and fall to a collection tray they have high moisture content and are uncompressed. The mesh in a continuous flow design can become blocked by unprocessed vegetable fibre or with the inadvertent introduction of foreign material such as plastic coated paper. Large numbers of worms and worm eggs can be present in the castings, and are unable to re-enter the farm subsequent to falling into the collection tray, reducing the overall capacity of the farm to process waste. Continuous flow designs with doors in the lower part of the farm for removal of processed waste allow removal of waste only from the side of the container in which the door is located. This results in the uneven removal of castings from within the farm.

Unless the context clearly requires otherwise, through out the description and the claims, the words `comprise` and `comprising`, and the like are to be construed in an inclusive as opposed to an exclusive or exhaustive sense; that is to say in the sense of "including, but not limited to".

SUMMARY OF THE INVENTION

The present invention concerns an apparatus for the treatment of organic matter with worms. The apparatus comprises a receptacle with a side wall at least a portion of which is downwardly tapering to facilitate compression of organic matter as said organic matter is processed, an upper entry aperture for loading said receptacle with said organic matter and worms and a lower discharge aperture for discharging compressed material comprising castings and organic matter. The apparatus further comprises a base lid adapted to releasably close said discharge aperture and to permit removal of said from a non corroding metal or a lightweight non porous sheet material.

It is preferred that the passage of liquid is unrestricted from the receptacle. The drained liquid can be collected in a suitable receptacle placed immediately below the receptacle. This liquid collecting receptacle may be in direct or indirect communication with the base lid.

BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of the present invention will become apparent from the following description of an embodiment, by way of example only, with reference to the accompanying drawings, wherein like numerals refer to like parts throughout, and in which:

FIG. 1 is a perspective view of an apparatus for the treatment of organic matter with worms;

FIG. 2 is a top view of the apparatus as shown in FIG. 1;

FIG. 3 is a bottom view of the apparatus as shown in FIG. 1;

FIG. 4 is a front elevation of the apparatus as shown in FIG. 1;

FIG. 5 is a side elevation of the apparatus as shown in FIG. 1;

FIG. 6 is a perspective view of an entry lid of the apparatus as shown in FIG. 1;

FIG. 7 is a perspective view of an upper portion of the receptacle as shown in FIG. 1;

FIG. 8 is a perspective view of a lower portion of the receptacle as shown in FIG. 1;

FIG. 9 is a perspective view of a filter of the apparatus as shown in FIG. 1;

FIG. 10 is a perspective view of a base lid of the apparatus as shown in FIG. 1;

FIG. 11 is a cross sectional view through A-A of FIGS. 2 & 4;

FIG. 11.A illustrates a detailed view of the top of an upper periphery shown in FIG. 11;

FIG. 11.B illustrates a clip arrangement as shown in FIG. 11; and

FIG. 12 is a cross section of an embodiment of the apparatus when packed for sale or freight.

DETAILED DESCRIPTION OF THE DRAWINGS

FIGS. 1 to 12 illustrate an apparatus 50 for the treatment of organic matter with worms. The apparatus 50 comprises a receptacle 60 which is formed of two separate parts, an upper body 2 and a lower body 3. The receptacle also includes an upper periphery 30 and a lower periphery 40 which are integrally formed with the upper body 2 and a lower body respectively. The apparatus 50 further includes a base lid in the form of a detachable outlet cover 4.

The apparatus further includes an entry lid 1 which is adapted to engage the upper periphery 30 of the

Referring to FIGS. 9 and 10, a floor of the outlet cover 4 is modified to hold a filter 13 in place, with apertures of sufficient size 14 to allow liquids to pass there-through but substantially restricting the passage of compressed material. A drain hole 23 in the base of the outlet cover 4 allows any liquid passing through the filter to freely drain from the receptacle 60 to a suitable receptacle 5 placed below.

When the clips are released, the outlet cover 4 slides downwards away from the lower periphery 40 of the lower body 3, allowing the removal of material previously withheld from exiting the receptacle 60 by the outlet cover 4 and filter arrangement.

In operation, the receptacle 60 is filled or partially filled with soil and/or organic material with an initial population of worms.

Organic waste is placed on the surface of the organic material within the receptacle 60, and subsequently processed by the compost worm population therein. Compost worms are surface feeders. They are adapted to live in the humus layer on the forest floor and do not make burrows as do common earthworms. The worms are most active in the upper 300 mm of the container 60 where the organic material is fresh, aerated and un-compacted. The majority of the worm population within the receptacle will generally be found within the top 250 mm of the surface. The design has the additional advantage of maximising the available surface area in the upper periphery 30 of the receptacle in order to optimise the productivity of the worms within it, while simultaneously reducing the surface area of the lower periphery 40 to facilitate the easy removal of castings.

As a result of the compression the castings undergo as they move through the farm, caused by the weight of fresh castings accumulating, the compost worms are naturally forced toward the surface of the receptacle. If the receptacle 60 has sufficient depth for this process to take place, the castings in the lower part of the receptacle will be largely free of worms. Typically this will require a depth of castings greater than 350 mm.

It is preferable that the waste is introduced to the farm at a rate equal to the ability of the worms within to consume it. This prevents uneaten waste rotting within the farm causing undesirable anaerobic conditions.

Worms have a gizzard much like that found in birds, which in combination with their mouth parts reduce the organic matter they consume and subsequently excrete to a very fine and uniform consistency. The liquid draining from a properly functioning worm farm will have a high proportion of suspended solids, the majority of which will be matter finely divided by its passage through digestive system of the worms within the farm. This result reduces the frequency with which, and the volume of, organic matter removed from the receptacle 60.

In dry conditions, and dependent on the organic matter introduced to the receptacle 60, water may have to be periodically introduced to the receptacle 60 to maintain optimum growing conditions for the worms. In some instances additional organic material or lime may need to be introduced in order to balance the acidity of the organic material introduced to meet an ideal PH of between 6.5-7.5.

Over a period of time the worms increase in population, along with the amount of processed waste captured by the receptacle 60.

In normal operation the processed organic waste is allowed to mature for a holding period, typically of several weeks, prior to removal from the farm. The holding period also allows any adult worms time to migrate upward towards the top of the receptacle 60 in search of fresh food material.

The design of the lower body 3 results in finished castings in only the lower periphery 40 of the outlet falling away from the farm when the outlet cover 4 is removed. In proper operation compression caused by the sloped walls 12 prevents castings from breaking away any higher than the end of the taper 10. This feature enables harvesting a specific volume of castings, in a compressed state, each time the outlet cover is removed.

The compressed processed material can be accessed when required from the lower periphery 40 of the lower body 3 of the receptacle 60 by releasing the catches 9 holding the outlet cover 4 in place and sliding said outlet cover 4 downwards away from the receptacle 60. Moreover, the volume of the outlet cover 4 is comparable to that of the lower periphery 40 of the lower body 3, thus the compressed material takes up the space in the outlet cover 4.

In a typical situation this will be as often as once per month. As will be appreciated, the way in which the outer cover 4 is releasably attached to the lower portion 3 of the receptacle 60 ensures minimal disturbance to life cycle of the worms.

Complete removal of the outlet cover 4 has the advantage of allowing the processed waste to be removed evenly and completely from the lower part 3 of the receptacle 60 in a compressed state. In a compressed state the processed organic material contains less water than in an uncompressed state and accordingly takes up less volume than uncompressed material, a benefit in both processing and handling.

Normal operation of the worm farm results in very little if any worms present in the lower portion 3 of the receptacle 60, significantly reducing the handling required in order to separate worms from processed waste once removed from the receptacle 60.

Following the removal of processed waste, the outlet cover 4 is reinstated over bottom portion 40 of the lower body 3 by sliding upwards over the bottom portion and secured using the catches 9 on each side.

If worms are present in the compressed material, the upper lid 1 of the receptacle 60 can be inverted, and the collected organic material placed directly upon it. Any worms present will move away from the surface of the organic material to escape the light, allowing the surface layer to be collected. After a subsequent period of time additional material can be removed from the surface as the worms present move away from the light. Once any worms present have been separated in this manner they can be returned to the top of the active layer in the receptacle 60, and the lid 1 re-instated in its normal operating position.

While the above example has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention. For example, in the preferred embodiment, the passage of liquid is able to pass unrestricted from the receptacle. In optional embodiments the drain hole may be adapted with a tap or other suitable mechanism to enable liquid to be drained from the outlet cover 4 on demand. In such an alternative embodiment a ledge may be provided on the inner side walls of the outlet cover such that the filter 13

VERMICOMPOSTING

FLOW THROUGH VERMICOMPOSTING SYSTEM

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- Large Scale Worm Composting Bins
- Institutional Worm Composting Bins
- Vermicompost
- Compost Tea Brewers

Specifications

Model 5 x 48	$21,615.00
Model 5 x 96	$45,230.00
Finished Vermicompost	$0.85 p/lb - Quantity discounts available

Make Your Own Worm Castings

Dirt Maker is dedicated to vermicomposting, and to designing and building the machines to make it happen. Our manually operated flow-through worm bins currently come in two sizes. The model number refers to the vermicomposting area. These are the best worm composters you can find for medium scale vermicomposting. In addition to these medium size flow-through worm bins, we are now offering an industrial size flow-through worm bin for large scale vermicomposting.

The Dirt Maker DM14 flow-through worm bin with 14.1 sq ft of vermicomposting area.

The Dirt Maker DM38 flow-through worm bin with 38.4 sq ft of vermicomposting area.

The DM38 has been recently redesigned to greatly reduce the shipping cost. It is now a DM37 (37 sq ft) with the same functionality.

Click here for information on the design, construction, and operation of our worm bins.

Not yet reviewed
DM38 flow-through worm bin

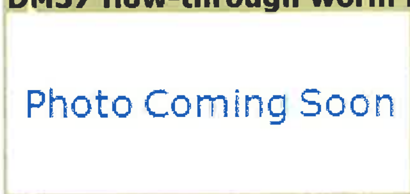
38.4 sq ft vermicomposting area.

See the owner's manual for photos and detailed information about the setup and operation of this machine.

$4175 + shipping.

This model is no longer available. It has been replaced by the DM37 below, which uses modules from our new large industrial flow-through worm bin.

Not yet reviewed
DM37 flow-through worm bin



37.2 sq ft vermicomposting area.

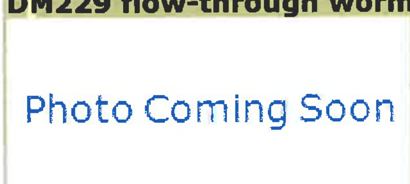
This redesigned machine replaces the DM38. It is priced lower, shipping is much cheaper, and assembly is quicker.

A photo will be available soon after the first machine comes back from the powder coating shop.

$3995 + shipping.

Request a shipping quote

Not yet reviewed
DM229 flow-through worm bin



229.1 sq ft vermicomposting area.

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Open Access Research Article

Production of Vermicompost from Temple Waste (Nirmalya): A Case Study

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Abstract
Vermicomposting is the phenomenon of compost formation by earthworms. Earthworms play an important role in the cycling of plant nutrients, turnover the organic matter and maintain the soil structure. The temple wastes consist of vegetable material (mainly flowers, leaves, fruits, sugar, jaggery etc.), milk and milk products, grains and water most of which are biodegradable and contain elements required for growth of microorganisms and the temple wastes are released in the water bodies or dumped at the available places of land which creates severe environmental pollution and health hazards ,hence it was thought to attempt use temple waste for ecofriendly treatment methods like Biomethanation and vermicomposting. The effluent of biomethanation upon mixing with biodegradable organic solids serves as good raw material for vermicomposting. In the present studies vermicomposting, the effluent from biogas digester (biomethanation) run on Ganesh temple waste (Sangli, Maharashtra) was admixed with temple waste solids and cattle dung and after partial the decomposition for 30 days at 30^{O}c, it was used to fill up 2 kg capacity plastic tubs and subjected for optimization of parameters like moisture content, particle size, p^{H} of material and temperature of vermicomposting using *Eudrilus eugeniae* earth worm species. It was found that 25^{o}C temperature, pH 8.0, 1-2mm particle size and 80% moisture content were optimum parameters of vermicomposting. It was further found that vermicompost obtained by above method was rich in percent carbon, Nitrogen, Phosphorus and Potassium content i.e. 28, 1.58, 0.33 and 0.28, respectively. The pot culture studies using five flowering plants (Gulab, Jaswand and Mogra varieties) of the test set (using prepared vermicompost as fertilizer) used in the studies showed good enhancement of growth in terms of height, flowering time as well as number of flowers produced as compared to control sets(without use of vermicompost as fertilizer). Thus, vermicomposting of temple waste is an excellent and ecofriendly method of temple waste management.

Keywords: Nirmalya, Pot culture, Temple waste, Vermicompost

1.0 Introduction:
Vermicomposting is the method which, recycles the crop residues and significantly increases the amount of N, P and K concentration in compost (Jambhekar, 1992). The important role of earthworms in ecosystem is in nutrient recycling, particularly nitrogen. Thus, they affect the physico-chemical properties of soil. By using variety of earthworms number of wastes can be converted into compost like, vegetable waste, domestic waste, paper, food refuses, agro - industrial waste, biogas digester effluent, sewage sludge and other industrial waste. Also vermicomposting can be also employed for plant based residues those containing high quantity of cellulose, hemi cellulose, lignin, starch etc. (Table-1).

In the vermicomposting the soil microflora are also playing very important role directly or indirectly like bacteria, yeasts, molds and actinomycetes. The earthworms feed on plant refuses or any organic matter and digest in their gut with the help of their own enzymes and enzymes secreted by gut micro flora which are having mutualistic relation with earthworms. One Kg earthworm can consume one Kg organic materials in a day. They secrete castings (vermicompost) which are rich in Ca, Mg, K, N, useful microorganisms, (bacteria, fungi, actinomycetes and protozoa) hormones, enzymes and vitamins and certain micronutrients needed for plant growth. (Lee, 1985; Bansal and Kapoor, 2000). The casts of earthworms promote growth of many important microorganisms like nitrogen fixers and phosphate solublisers. In general in the presence of casts and earthworms these microorganisms multiply faster (Parle, 1963; and Satchell, 1967). Earthworms secrete mucus and some fluids and in this way maintain pH of surrounding between 6.5 to 7.5 which is favorable for soil microflora. Vermicompost has sweet and earthy pleasant smell like the smell of first rain (Kadam, 2004).

2.4 General Vermicomposting Process

The 2 kg material was filled in the set of six plastic tubs (in triplicate) and kept in dark for five weeks by adding two earthworms / pot. Every week the weight of earthworm biomass / pot and count of cocoons / pot was taken after thorough washing and blotting of earthworms and cocoons and then they were reinnoculated in the respective pots. This procedure was followed for every week

Eudrilus eugeniae

2.5 Optimization of Parameters of Vermicomposting (Kadam, 2004):

2.5.1 Effect of Temperature on Vermicomposting:

The temperature range selected for experiment was 15, 20, 25, 30, 35 and 40^{O}c taking into account average minimum and maximum temperatures found in the Sangli area and in the seasonal variations in the year. For every temperature selected, the three plastic tubs / pots were used and were incubated for five weeks in BOD incubators and biomass weight of earthworm pots and cocoons count was taken as above.

2.5.2 Effect of pH of Material on the Vermicomposting:

The P^{H} of vermicomposting material was adjusted with 1 N HCL / 1 N NaOH to 2,3,4,5,6,7,8,9 and 10. The pH values adjusted materials were filled in 2kg amount in three pots (in triplicate) and inoculated with two earthworms per pot and incubated in dark at 25^{O}c for five weeks. The average biomass of worms and cocoon count / pot was taken per week as above.

2.5.3 Effect of Particle size of Material on the Vermicomposting:

(P^{H} of material was adjusted to P^{H} 7.0)

The particle size range of material selected for experiment was 0.5 - 1mm, 1 - 2 mm, 2-4 mm, 5-10 mm, 10-20 mm and material of each particle size was filled in three pots in 2 kg amounts (in triplicate) and inoculated with two earthworms / pot and incubated at 25^{O}C for five weeks in dark. The average biomass of worms and cocoon count / pot was taken per week as above.

2.5.4 Effect of Moisture Content of Material on the Vermicomposting:

(pH of material was adjusted to 7.0 and 1 -2 mm size). The moisture contents of vermicomposting material was adjusted to 50,60,70,80 and 90 % with water and filled in 2 kg amounts in three pots (in triplicate) and inoculated with two earthworms / pot and incubated at 25^{O}c in dark for five weeks. The average biomass of worms and cocoon count / pot was taken per week as above.

2.6 Optimized Parameters of Vermicomposting:

Using Optimized parameter of vermicomposting i.e. temperature of incubation (25^{O}c) , P^{H} (7.0), particle size (1 - 2mm) and moisture content (80%) of organic material vermicomposting was done in 2 kg pots (in triplicate) and after five weeks of incubation the vermicomposting was separated by straining out off juveniles (earthworms) and their cocoons and then it was analyzed for the percentage of N, P and K and used for pot culture studies.

2.7 Pot Culture Studies with Vermicompost Prepared from Temple Waste:

Plastic pots with 5 kg of garden soil were used for pot culture trial studies. Different common flowering plants were selected (Table-3) and used to study the effect of vermicompost on enhancement of plant growth. The experiment was performed for period of three months. In the studies two sets of flowering plants in the pots were prepared - a control set with only soil and test set with 10% vermicompost added with soil in the pots. Daily 0.5 L of tap water was added in each pot. The extent of plant growth (height of plant in cm and no. of flowers), flowering time and number of flowers were studied every week for three months. Extent of enhancement in plant growth and flowering by using vermicompost was studied.

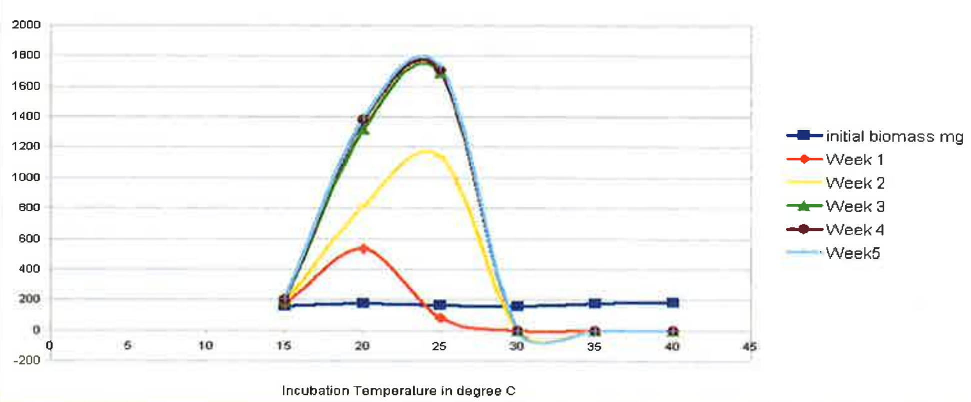
3.0 Results and Discussion:

Table 4: Growth of *Eudrilus eugeniae* at different incubation temperatures in vermicomposting (pH-7, particle size 1-2mm)

Sr. No.	Incubation temperature (°C)	Initial average biomass (mg) cocoon count/pot	Week 1 Biomass (BM) (mg) & cocoon count (CC)	Week 1 % gain	Week 2 BM (mg) and CC	Week 2 % gain	Week 3 BM (mg) CC	Week 3 % gain	Week 4 BM (mg) and CC	Week 4 % gain	Week 5 BM (mg) and CC	Week 5 % gain
1)	15	155 (-)	167 (-)	107	179 (3)	115	193 (5)	125 (167)	201 (5)	130 (167)	208 (5)	134 (167)
2)	20	174 (-)	533 (2)	306	817 (4)	470 (200)	1320 (9)	759 (450)	1383 (10)	795 (500)	1395 (11)	802 (550)
3)	25	166 (-)	880 (4)	530	1140 (7)	687 (175)	1688 (12)	1017 (300)	1705 (14)	1027 (350)	1730 (14)	1042 (350)
4)	30	158 (-)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5)	35	179 (-)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6)	40	183 (-)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Average results in different weeks / pot

Fig.2 Growth of Eudrilus eugeniae at different incubation temperature in vermicomposting



3.1 Incubation Temperature Optimization Studies:

The table 4 and figure 2 shows that out of 15,20,25,30, 35 and 40^{O}c temperatures used for incubation there was gradual increased in biomass of earthworms and cocoon production from 15 - 25^{O}C temperatures at all the five weeks incubation and maximum average biomass of 1730 mg and average of 14 cocoons were produced at 25^{O}C. At the incubation temperatures beyond 25^{O}C i.e. 30, 35, 40^{O}C the earthworms could not survive indicating 25^{O}C being optimal when the 7.0 p^{H} and 1-2 mm particle size of material used. It was reported by Kadam, 2004, Viljoen and Reinecke, 1992 and by Loehr et al 1985 that above 30^{o}c high mortality of *Eudrilus eugeniae* was observed. The better biomass and cocoon production was reported by them at 25-30^{o}c temperatures. It was observed that the results of present studies regarding vermicomposting temperature using *Eudrilus eugeniae* are constant.

3.3 Particle Size Optimization Studies:

The particle size ranged selected was 0.5 - 1.0, 1- 2, 2 -4, 5-10 and 10-20 mm. It is evident from table -6 and figure4 that the average biomass increase and cocoon production was gradual from 0.5 - 1 to 1 -2 mm size i.e. 2 - 4, 5 - 10 and 10 - 20 mm the average biomass and cocoon production was decreased. The maximum average biomass of 1835 mg and maximum average cocoon production of 8 was obtained at the end of 5th week at 1- 2 mm particle size indicating 1-2 mm particle size of material is optimal for vermicomposting using *E. eugeniae* at p^{H} 7.0, 25^{O}c temperatures and 80% moisture level. It was reported by Kadam, 2003 that maximum biomass of *E. eugeniae* was attained at 1 mm particle size using Tendu leaves *(Diospyros melanoxylon Roxb)* as raw material and findings in present investigations showed 1- 2 mm particle size as optimal. These findings are also supported by the reports of Lowe and Butt, 2003, who reported increased biomass and cocoon production by small sized particles using *Allolobophora chlorotica* and *Lumbricus terristris* earthworm species. These findings supported present results indicating large size particles are not amenable to earthworms.

Table 6: Growth of *Eudrilus eugeniae* at different Particle Sizes of Vermicomposting Material (pH 7, Temperature of Incubation -25^{O}C)

Sr. No.	Particle sizes (mm)	Initial average biomass (mg) cocoon count / pot	Average results in different weeks / pot									
			Week 1		Week 2		Week 3		Week 4		Week 5	
			Biomass (BM) (mg) and cocoon count (CC)	% gain	BM(mg) and CC	% gain	BM(mg) and CC	% gain	BM(mg) and CC	% gain	BM(mg) CC	% gain
1)	0.5 - 1	183 (-)	315 (1)	172	765 (2)	418 (200)	920 (4)	503 (400)	1060 (6)	579 (600)	1095 (6)	598 (600)
2)	1-2	159 (-)	870 (2)	547	1240 (3)	780 (150)	1765 (5)	1110 (250)	1820 (7)	1145 (350)	1835 (8)	1154 (400)
3)	2 - 4	176 (-)	515 (4)	290	940 (6)	534 (150)	1315 (8)	735 (200)	1440 (9)	804 (225)	1475 (9)	824 (225)
4)	5 -10	164 (-)	290 (6)	177	370 (5)	226 (150)	635 (11)	387 (183)	680 (12)	415 (200)	715 (12)	436 (200)
5)	10 - 20	151 (-)	190 (5)	126	275 (7)	182 (140)	405 (9)	268 (180)	460 (10)	305 (200)	525 (10)	348 (200)

Fig.4 Growth of Eudrilus eugeniae at different particle size

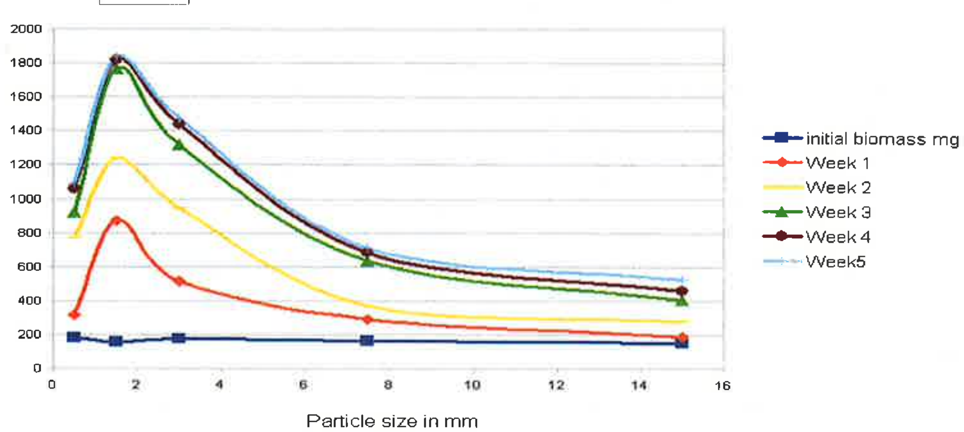


Table 8: Extent of Enhancement of Plant Growth and Flowering Using Temple Waste Vermicompost

Sr. No.	Week no.	Type	Height (cm) and average number of flowers / plant							Remark
			1	2	3	4	5	6	7	
1)	0	C	10	11.5	12.0	11.3	14.0	13.3	12.6	No flowering
		T	10	11.5	12.0	11.3	14.1	13.2	12.5	
2)	1	C	03.3	14.2	13.3	13.5	15.3	15.6	14.1	No flowering
		T	14.5	14.8	15.5	12.9	16.3	15.9	14.9	
3)	2	C	15.8	15.9	15.8	15.4	17.6	17.9	16.4	No flowering
		T	17.6	16.8	18.3	15.5	19.5	19.5	17.8	
4)	3	C	17.9	17.1	16.9	18.6	19.4	20.2	18.6	No flowering
		T	20.5	19.5	21.6	18.6	23.6	22.8	20.3	
5)	4	C	19.5	19.5(1)	18.1 (-)	20.4 (-)	23.6(-)	22.8 (-)	21.2 (-)	No flowering
		T	23.3	22.8(2)	24.5 (3)	21.8 (2)	28.5(3)	24.6 (3)	23.5 (5)	Flowering
6)	5	C	22.5 (-)	21.3(-)	20.8 (-)	23.6 (-)	25.4 (-)	24.9 (-)	23.5 (-)	No flowering
		T	25.8 (1)	24.5(5)	27.3 (4)	25.5 (5)	32.1 (3)	26.5 (3)	27.6 (7)	Flowering
7)	6	C	24.1 (1)	22.8(-)	21.9 (2)	25.9 (-)	27.8 (1)	26.5 (-)	25.4 (-)	No flowering
		T	29.3 (3)	27.3(7)	29.8 (4)	28.3 (5)	36.5 (5)	28.3 (3)	30.5 (8)	Flowering
8)	7	C	25.6 (2)	24.3(1)	23.2 (2)	27.3 (3)	29.5 (1)	27.5 (2)	27.7 (2)	Flowering
		T	31.3 (6)	29.5(8)	31.5 (6)	31.5 (6)	38.7 (6)	31.5 (6)	32.5 (9)	
9)	8	C	26.5 (3)	26.1(3)	25.3(3)	29.5 (3)	31.6 (3)	28.8 (2)	29.3 (4)	Flowering
		T	33.5 (10)	31.8(11)	33.5(7)	34.5 (6)	40.2 (4)	33.7 (6)	34.9 (10)	
10)	9	C	27.8 (4)	27.3(5)	27.2(3)	31.3 (4)	32.9 (3)	29.5 (2)	30.6 (4)	Reduced Flowering
		T	35.5 (12)	34.4(11)	35.1(7)	36.5 (7)	42.3 (4)	35.2 (5)	36.1 (7)	Flowering
11)	10	C	28.2 (4)	27.9 (5)	29.0(3)	32.6 (4)	33.5 (2)	34.4 (3)	31.8 (3)	Reduced Flowering
		T	36.8 (13)	35.9 (12)	36.8(7)	38.1 (6)	43.2 (3)	36.8 (5)	37.3 (6)	Flowering
12)	11	C	29.0 (3)	28.2 (4)	29.7(1)	33.1 (2)	33.9 (1)	30.7 (1)	32.3 (2)	No flowering
		T	37.5 (6)	36.3 (5)	37.5(2)	39.3 (3)	44.6 (3)	37.6 (3)	37.6 (3)	Reduced flowering
13)	12	C	29.2 (-)	28.3 (1)	30.0(-)	33.4 (-)	34.3 (-)	30.8 (-)	32.5 (-)	No flowering
		T	38.1 (4)	37.1 (3)	37.8(2)	40.1 (1)	45.1 (2)	37.9 (2)	37.9 (3)	Reduced flowering
Total flowers		C	17	19	14	16	10	10	15	
		T	56	64	40	41	33	36	58	
Plant length (total) after 12 weeks		C	289.4	256.5	283.2	315.9	318.9	318.9	318.2	
		T	353.7	342.2	361.2	353.9	424.7	363.5	363.4	

It is evident from table 9 that vermicompost is rich in percent carbon, Nitrogen, Phosphorus and Potassium content i.e. 28, 1.58, 0.33 and 0.28 respectively. It was reported by Kadam, 2004 that vermicompost prepared from Tendu leaves using *E. eugeniae* earthworm contained percent carbon, nitrogen, phosphorus of 29, 1.43, 0.29 and 0.23 respectively. Thus vermicompost prepared from temple waste is composition consistent with that reported by other workers previously.

It is evident from the table-8 that all the five flowering plants of the test set used in the studies showed good enhancement of growth in terms of height, flowering time as well as number of flowers produced as compared to control sets. In case of test set flowering appeared from fourth week, while in the control set it appeared from sixth week of experiment. The total number of flowers in the test set produced in twelve weeks of experiment for seven flowering plants ranged from 33 - 64, while in the control set it ranged from 10 - 19 flowers i.e.

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Vermicomposting - Composting with Worms (vermicompost107)

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Vermicomposting - Composting with Worms

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Vermicomposting: Composting with Worms

by Soni Cochran, Extension Associate

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NOTE: The following information is for the home vermicomposting enthusiast. This resource is not intended to be a reference for commercial bins or bins located in businesses, schools, and/or government agencies.

Many gardeners compost both yard waste and kitchen waste with compost piles, sheet composting or some other method during the growing season. Fortunately, very little yard waste is generated during winter months when cold temperatures make scavengers and rain. Like us, worms need air to live, so be sure to have your bin sufficiently ventilated.

1-2-3 Portable Worm Bin

Mary Appelhof's 1-2-3 Portable Worm Bin (1' deep, 2- wide and 3 long). This bin has a bottom so it can be moved and used in a heated garage or basement during cold weather. When a worm box is used outside, it does not need to have a bottom. You may want to line the bottom with rocks or boards to keep rodents and other worm-loving creatures from tunneling in. Wooden boxes will typically last for 2 or 3 years.

Bedding:

The bedding for vermicomposting systems must be able to retain both moisture and air while providing a place for the worms to live. Bedding does not have to be purchased and most of us have plenty of bedding resources in our home, office or school. Here are some suitable sources of bedding.

Shredded corrugated cardboard is an excellent bedding, but is difficult to find.

Shredded paper like newspaper and computer paper is easy to find, but may dry out quicker than corrugated cardboard. There is not a problem with the ink from the paper.

Peat moss has a low pH level that may cause a problem for the worms and it is more expensive.

Commercial worm bedding is available in sporting goods stores, but it is also more expensive.

The amount of bedding depends on the size of the box. A 2-by-2 foot box will need between 4 and 6 pounds of dry bedding, a 2-by-3 foot box will take 9 to 14 pounds. No matter what the size, the bin should be 2/3 filled with "fluffed" prepared bedding (see below). For smaller bins, experiment--if you prepare excess bedding, it can be dried, stored and used another time.

Prepare the Bedding:

Water is needed to moisten the bedding. Place the dry, shredded bedding in a large container and add water until it covers the bedding. Allow the bedding to absorb as much water as possible before putting it in the worm bin. This could take from two to 24 hours, depending on the bedding used.

Before putting the bedding in your bin, squeeze the water out from the bedding as much as possible. The bedding should feel like a well-wrung washcloth. Place the bedding in the bin and fluff.

Your bedding needs to remain moist. If it is drying out, mist the paper with water from a spray bottle and dampen the bedding again.

The easiest method is to spread the scraps in a thin layer on top of the bedding. If the bin is kept in a dark place or covered, the worms will come to the surface to eat. You can also pull back a small amount of bedding in the bin and dump in the scraps. Cover the scraps with an inch of bedding. Start at one corner of the bin and bury garbage in a pattern to fill in all the spaces. By the time you get back to the first burying spot, the worms will have composted most of the waste.

If you notice odors, cut back on the amount of food or try chopping the food up into smaller pieces. Note: citrus does have a strong odor and the peelings seem to last a long time in the bin. Bins seem to be more manageable when there is less fruit and citrus and more of the leafy vegetables.

Harvesting the Compost:

Given the right environment, the worms will go to work to digest the kitchen scraps and bedding faster than any other compost method. The material will pass through the worms' bodies and become "castings." In about 3-4 months, the worms will have digested nearly all the garbage and bedding and the bin will be filled with a rich, black natural fertilizer and soil amendment. Compared to ordinary soil, the worm castings contain five times more nitrogen, seven times more phosphorus and 11 times more potassium. They are rich in humic acids and improve the structure of the soil.

To keep your bin going, you will need to remove the castings from time to time and there are several ways to go about it. One way to do this is to shine a bright light into the bin. The worms are sensitive to light and will move to the lower layers of the bin. Remove the top layer of casting by using your hands or a sieve. Each time you remove some bedding, the worms will be exposed to the light and they will keep migrating down to the bottom of the bin. Pick out any wigglers or worm eggs (small, opaque cocoons) and return them to the bin. Refill the bin with fresh layers of moist bedding and food.

Another method of harvesting composts is to push the black, decomposed material to one side of the bin, and fill the other side with new, moist bedding and kitchen scraps. Then wait several days. The worms will migrate to the freshly filled side of the bin and you can just scoop out the finished compost. Make sure you pick out any wigglers or worm eggs and return them to the bin.

NEW Try the "onion bag" method to harvest your worms. Visit the City Farmer Web site (http://www.cityfarmer.org/wormharv80.html).

Using the Compost:

For potted plants, add a thin layer to the top of the potting soil. You can also add the compost directly into your soil mix when repotting. In the garden, simply work it into the ground around the base of each plant. The compost is very mild and you won't have to worry about accidental burning or overfertilizing.

Some Don'ts:

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INFINITE VERMICAST SOLUTIONS

Established 2015

Fall Project Report - December 3rd, 2015

Taylor Conley

Magen Kegley

Guy Barker

Matthew Gallagher

Introduction to the Problem

Problem Statement

This project includes the design and implementation of an innovative continuous vermiculture system. To achieve this, our team will study the habitat and physiology of various worms to develop the proper feeding and nutrient system. A digested waste delivery and casting harvesting system will be developed based off of our research.

Statement of Work

Background

More and more precious land space is taken up every year by the spreading of landfills, caused by increased consumer wastes. However, a large amount of the trash that is carelessly thrown away can be transformed into nutrient-rich silage via composting. Although composting is beneficial, it lacks the efficiency since all of the decomposition must be performed by microorganisms. An alternative and faster method to accomplish the degradation of organic materials is by adopting a vermicomposting system, which introduces worms to the compost area.

The customer, Dale Robinson, proposed that a continuous, flow-through worm bin be designed so that even the busiest person would be able to utilize benefits that results from vermicomposting. The customer requires that the team design and develop the technology for a continuous flow-through vermiculture system that will treat organic wastes and harvest digested Red Wiggler worm castings. This system will aid in reducing landfill wastes from kitchen and industrial settings, while providing a nutrient-rich topsoil that can be used to grow high quality produce.

This project is similar to a continuous conveyor vermiculture system[i] because it utilizes a continuous automatic worm castings collection system. However, the system that will be designed includes a digester that will implement a higher efficiency for the total process. Although there are no specific regulations for vermicomposting, a permit is required for composting if the process reaches commercial scale[ii].

Objectives

The objective of this project is to design a fully integrated flow-through vermicomposting system that includes a digester that will increase the efficiency of the process as a whole, as well as research and collect data on the best breed of worm to exploit in the flow-through bins. By utilizing a continuous system, it will be easier for consumers of the product to reduce waste in landfills, and introduce a way for the consumer to be self-sustaining by providing fertile soil for produce growth. Goals that lie within this objective are to make the design take up as little space as possible, as well as using materials that are inexpensive and easy to find. Preferably, the total system will cost $1,000 or less, but the client has noted that this is not a firm limit.

Scope

Mr. Robinson of The Big Squeegee© expects a flow-through vermiculture bin design that includes a process that digests the food before it is delivered to the worm beds. The design is also expected to have separate areas for the worms to lay eggs and eat the food. Therefore, by employing a system that includes a sprayer that delivers the food to the worms in a pre-digested form, the worms will constantly be at the top to consume the food. To determine the most suited breed of worm for the bin, data on the

Table 1. Task List.

* Completion Dates are tentative and subject to change

4.1 Task 1 – Review Customer Order

This concludes preliminary reviews of the presented project. These reviews include literature reviews, patent searches, biological specifications of Red Wigglers, engineering specifications of materials within the system, analysis of customer requirements, and detailed problem statement formation. This also concludes design of company name, mission statement, and logo.

4.2 Task 2 – Preliminary Design Modeling

This concludes the modeling of the preliminary design utilizing SolidWorks. This includes a conference call with applications and extension engineers, engineers within the department of Biosystems & Agricultural Engineering, the client, and the contractors in order to present initial ideas and gain valuable guidance and feedback.

4.3 Task 3 – Preliminary Design Report Draft

A preliminary design report draft is submitted to Dr. Paul Weckler on the progress of the project.

4.4 Task 4 – Preliminary Design Final Report

A corrected version of the preliminary design report draft is submitted to Dr. Paul Weckler on the progress of the project.

4.5 Task 5 – Preliminary Design Presentation with Client

The contractors will present the progress of the project and the prototype to the client and associated engineers. Throughout the presentation, those in attendance will offer critiques and suggestions on the feasibility of the current design and possible changes that could be made to benefit the system.

4.6 Task 6 – Manufactured Prototype

The manufactured prototype is assembled in order to begin testing the system.

4.7 Task 7 – Prototype Testing

This concludes the testing period of the manufactured prototype at the Bioenergy Laboratory and data is taken to determine effectiveness of the system.

4.8 Task 8 – Final Design Presentation with Client

The contractors will present the findings of the project and the final prototype to the client and associated engineers.

Security Considerations

There are multiple security considerations to accommodate on this project. The first concern is who has access to the vermiculture bins. The team will be designing and testing a new system of continuous vermiculture processing. The design setup should be kept out of public eye as to avoid premature or unlawful replications.

The second concern for housing the bins in a securely monitored location is the safety and wellbeing of the worms. The team will be altering and testing different parameters on the bins to ensure the most efficient setup. The monitoring process will be based upon the success rate of the worms and their produced castings. If unauthorized persons enter the work space and purposely or accidentally change any conditions in the worm's environment, the testing outcomes will be flawed. The team may be unaware of the intruder's actions and deem the setup flawed when in reality it was due to the outsiders alterations.

A variety of parts will be assembled during the construction of the continuous vermiculture setup. Some of these parts will either be small in size, valuable, or dangerously sharp. The setup location shall be limited from the public to ensure no parts are lost, stolen, or damaged. The isolation will also ensure no public entities are injured on exposed unfinished pieces.

Permission to access the facility responsible for housing the project will be granted to all team members. This will be approved by Dr. Doug Hamilton of the Oklahoma State University Biosystems and Agricultural Engineering Department. His contact information is 226 Agriculture Hall, Stillwater, OK, (405) 744-7089, dhamilton@okstate.edu.

Travel

The contractors have decided that there is no applicable reason to visit Mr. Dale Robinson's facility. After speaking with him and viewing the pictures of his operation, they do not see any benefit in viewing the facility or current process. The contractors will travel to the Bioenergy Annex laboratory facilities west of campus in order to conduct their experiments and tests. Upon completion of the design process, it would be of assistance to travel with Dr. Hamilton to meet with Mr. Cunningham and Dr. Lake to discuss possible ideas and the feasibility of the process design.

Special Material Requirements

- Provided space in the Bioenergy Annex
- Worms (Red Wigglers)
- For the purposes of our project and its exposure to potential corrosive materials we will need to powder coated the materials in the drum and potentially use stainless steel for the bearings.

Place of Performance

The project will be housed in the Bioenergy Annex belonging to the Biosystems and Agricultural Engineering (BAE) Department of Oklahoma State University. The location of the annex, thus deemed as a laboratory, is Marvista St, Stillwater, OK, 74074. All construction and setup testing, either on the worms or the design features, will be made in this location.

Technical Analysis and Market Research

A system that provides a solution to a continuous vermiculture system is a patented slow-moving conveyor system that automatically applies thin layers of organic wastes to a bed of worms. The conveyor moves the digested biomass into separate bins while keeping the worms on the conveyor system. This allows for worms to work both at a high activity level and for the system to be continuous. Durability issues that come along with the system are the eventual corrosion of the conveyor system and the replacement of items related to it. Chains and belts would have to be replaced often due to the introduction of a wet environment to the metal parts. The system is quite reliable because of the relative simplicity of the design, as long as the mechanical aspects remain functioning. The dangers that exist within this system are finger pinching in the gears and belt mechanism. Also, the wet "worm tea" might form a slippery area around the system. As far as maintenance requirements, the bin that collects the castings must be manually emptied and taken away. The parts, as mentioned earlier, must be replaced when necessary to prevent rusting and corrosion in the wet environment. The conveyor belt system overview can be viewed in Figure 1.

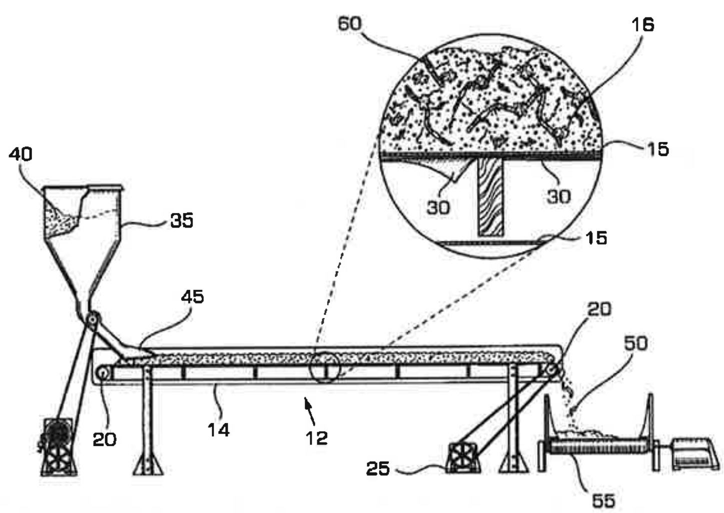

Figure 3. Conveyor vermiculture system. Patent ID US 6223687 B1.

Another process that holds similar solutions to components needed within a continuous vermiculture system digests sewage material, then distributes it among a bed of worms. The system treats sewage waste to optimize it for worm digestion, and heats or cools it before feeding it to worms. The system poses a few hazards since it contains grinding pumps, heating and cooling coils, and raw sewage. Therefore, those maintaining it should be properly trained to replace the necessary parts. Corrosion over a few years could also become an issue in durability, because the pipes and holding tanks most likely have steel or metal components. It is reliable for properly digesting and distributing the sewage material onto the vermiculture beds, as long as the heating and cooling coils do not exceed the required temperatures, which could cause a lack of efficiency or even death among the worms. The pipes and temperature coils must be maintained, as well as the correctional fluid that adjusts pH, electrical conductivity, and percent solids. The logical flow of the sewage treatment and distribution can be viewed in Figure 2.

http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&u=%2Fnetahtml%2FPTO%2Fsearch-adv.htm&r=12&f=G&l=50&d=PTXT&p=1&S1=%28%28vermiculture+AND+continuous%29+AND+compost%29&OS=vermiculture+AND+continuous+AND+compost&RS=%28%28vermiculture+AND+continuous%29+AND+compost%29

This is a patent for a rectangular container fabricated specifically for the composting of animal and household waste using vermiculture. The bins are painted specifically to absorb sunlight on the front end and cover (black) and to reflect sunlight on the opposite end (white). Compost is extracted via an opening adjacent to the base of the container. This is a very simplified and small vermiculture composting unit that uses the temperature gradient to draw in new oxygen and cool the increasing temperatures within the bin due to respiration. The manipulation of sunlight in order to maintain an ideal temperature within the containers could greatly assist our project.

Patent ID EP 0196887 A2: Published on October 8, 1986

https://www.google.com/patents/EP0196887A2?cl=en&dq=continuous+vermiculture&hl=en&sa=X&ved=0CCoQ6AEwAmoVChMIwpykx5ikyAIVhZENCh2WjA3R

This is a patent for the use of a breaker bar unit to extract the base layer of the finished compost within a unit with a perforated floor. As it separates the completed compost at the bottom of the container, it does not disrupt the worms that are near the top of the bin. This can also serve to harvest worms for the marketable venture of protein-rich feed for pig, poultry, and fish farming. Ultimately, this provides an idea for the mechanized extraction of compost after the waste products are broken down and excreted by the worms.

Patent ID WO 2002046127 A2: Published on June 13, 2002

https://www.google.com/patents/WO2002046127A2?cl=en&dq=continuous+vermiculture&hl=en&sa=X&ved=0CEYQ6AEwBmoVChMIwpykx5ikyAIVhZENCh2WjA3R

This is a patent for composting organic waste using a thermophilic vermiculture system in order to produce worm castings. This is a very similar system to what we are trying to implement in this project, but does not give many specifics on the technology used. This is still helpful because it describes the process and necessity of this type of system.

Patent ID US 6223687 B1: Published on May 1, 2001

http://www.google.com/patents/US6223687

This is a patent for a conveying system in which a thin layer of biomass is moved along a layer of worms in order to increase their activity. This creates a continuous open system and maintains efficiency due to increased spatial awareness from the worms. The beds can then be stacked in order maximize this efficiency. This is likely a system that would greatly exceed our budget, but it is helpful because it provides insight into spatial efficiency and the continuous process we are seeking to develop.

Patent ID US 7141169 B1: Published on November 28, 2006

http://www.google.com/patents/US7141169

This is a patent for the digestion and distribution of raw sewage among the bed of worms. The system controls the temperature of the waste before its dispersal among the worms through simple heating and cooling coils. While this may be slightly too intensive for our project, it provides insight about the

Customer Requirements

Our customer is requiring that we design and develop the technology for a continuous flow-through vermiculture system in order to treat organic wastes and to harvest digested Red Wiggler worm castings. The castings can then be transported to a growth bin that would provide nutrients to a certain crop. A filtration system will be developed in order to separate the worms from the castings. After the flow-through system is flooded by the digester, the residual fluid or "worm tea" will be separately harvested.

An important requirement is to research and verify the biological specifications of the worms, and more specifically, the doubling time of the species. We must find an ideal depth for proper growth and activity for the Red Wigglers, and their dietary habits must also be researched in order to determine the waste delivery system. Our vermiculture unit should be able to maintain a certain ideal volume for each individual worm in order to maximize the composting process. Ultimately, we are required to design and manufacture a prototype for a continuous waste management and composting unit utilizing vermiculture.

Quantitative Engineering Specifications

The continuous flow-through system will be made utilizing a 55-gallon drum (the bin diagram mockup, rendered through SolidWorks, is shown in Figure 5) as the compost bed where the worms will be located. A three-quarter horsepower garbage disposal will be used as the digester for the provided organic waste, which will then be used to flood the bin using a sprayer. A hydroseeder (specifications for Finn and Reinco hydroseeders listed in Table 2) will be used in order to flood the bins with the waste material and water solution. A relay switch will be used to activate and deactivate the hydroseeder. The air pump and porous air stone can be used to oxygenate the organic waste solution prior to flooding the container. A thermistor will be used during the testing process to record the optimal temperature of the worm bin as it fluctuates due to aerobic digestion.

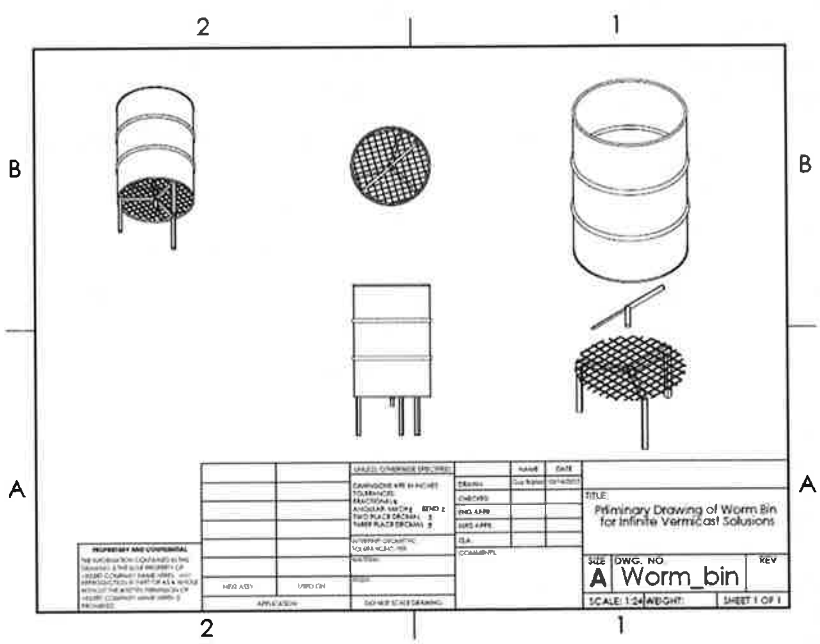

Figure 5. SolidWorks rendering of bin diagram.

Environmental/Global Impact of System

The Infinite Vermicast Solutions group is seeking to create a sustainable, continuous flow-through vermiculture system that could have an immense impact on society as a whole. This system would allow for clean organic waste treatment by utilizing effective species of worms to create a compost that could be used as fertilizer in gardens and agricultural pastures. This design could be implemented in globalized communities that have poorly or underdeveloped waste treatment systems in order to increase the production of farmland or provide feed and bait to different species of animals and fish. Due to its relatively small budget, this design by IVS can be implemented to reduce landfill waste and produce fertilizer by utilizing efficient and reliable organisms in a wide array of global societies.

Generation of Design Concepts

The first design that was considered was a flatbed "box" system for the vermicompost system. In this system, the worms and compost would be distributed in a semi-shallow (6-10") bin with the worms evenly distributed throughout. A blade would run lengthwise along the screen underneath the boxes to collect the compost as it moves to the bottom and is pushed out. Compost would have to be added manually to the top of the bins, as would water for moisture. This type of system is widely utilized for commercial aspects of vermicompost system. However, based off of the client's requirements, this design would not work for a flow-through system. The rectangular set-up of this design makes it difficult for even distribution of compost and nutrients, as well as water and the worms themselves. A shallow, rectangular bin is also less convenient for the domestic use of a vermicompost system, since it is bulky and more time-demanding than the average person would be able to manage. A rectangular bin is more useful for vermiculture systems where the worms are harvested for bait and feed.

Another design concept that was considered is similar to the one that was decided on. A deep, circular bin would be utilized, with a flow-through system where compost would be added to the top of the bin and worms would be introduced to the system. As castings are formed they travel to the bottom of the bin, food is manually loaded to the top of the system, while water is loaded via water hose. Castings are then separate from the worm bedding and compost by sinking to the bottom of the cylindrical system, and can then be harvested out of the bottom. However, although this system is a flow-through design, it is not as continuous as it could be. To improve the design of the cylindrical system, a better casting harvesting system can be considered, as well as a new food delivery design.

The final design that was designed was based off of this one, with a 55-gallon drum serving as the bin, and instead of the compost being manually added into the bin separately from the water, the compost will be digested with the needed amount of water and concocted into a slurry, then sprayed onto the top of the bin. With a sprayer, the distribution of the compost and nutrients are more controlled. Also, a rotating blade is added to the bottom of the barrel to scrape off the castings as they are produced by the worms. A collection bin will be place below the vermicomposting bin to hold the castings as they are produced.

Proposed Budget

Worm Bin Parts List & Prices			
Part	**Quantity**	**Price**	**Details**
Drum	1	$ 100.00	
Square steel tubing	13'	$ 26.00	1 X 1 X 11 GA (.120 wall) A513 Square Steel Tube
22" Mower blade	1	$ 15.00	
Taper bearing	1	$ 16.33	Taper Roller Bearing Cone, 0.750 Bore In
3/4" shaft	1	$ 11.00	
Worms (Red Wigglers)	n/a	n/a	
Expanded metal	1	$ 11.00	
Hydroseeder pump	1	n/a	
Digester drum	1	$ 50.00	
Timer for motor & blade rotation	1	$ 20.00	
Motor	1	n/a	
Paint/powder coating	1	$ 30.00	
System Fabrication Labor	$15/hr (? Hrs)	$ -	
Tentative Budget		$1,500.00	

United States Patent **6,576,462**
Thompson **June 10, 2003**

Vermiculture composting device

Abstract

The present invention relates to a composting device for composting organic waste, specifically animal and vegetable household waste. The device consists of a container having four rectangular sides, a base and a removable, reversible cover. The container is provided with a sealable ***compost*** extraction opening disposed on a front side of the container near the base. Ventilation openings are provided in the sides. One surface of the cover and front side of the container is painted dark to absorb sunlight and heat the interior chamber defined by the container. The opposing side of the cover is painted white to substantially reflect sunlight. The cover is removed and waste is added to the container through the top. Worms and microorganisms provide a way for degrading the waste into ***compost,*** which is removed through the extraction opening adjacent to the base for recycling. The temperature in the ***compost*** may be adjusted by increasing or decreasing absorption of sunlight. The temperature gradient thus formed in the container draws air through the ventilation openings and into the container to provide ventilation for the composting waste. In one embodiment, the composting device is provided in the form of a kit for home assembly.

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Family ID: **25130628**
Appl. No.: **09/783,861**
Filed: **February 16, 2001**

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Current International Class:	A01K 67/033 (20060101); A01K 67/00 (20060101); C05F 17/00 (20060101); C05F 17/02 (20060101); C05F 009/02 ()
Field of Search:	;435/290.1,290.4,810 ;71/8-10

4. The kit of claim 3 further comprising a third rectangular sheet of building material adapted to form a base for said container.

5. The kit of claim 4 further including handles for said door.

6. The kit of claim 5 further including a locking bar adapted for rotatable attachment to said container.

7. The kit of claim 3 further comprising worms of a species adapted for survival when exposed to climatic conditions corresponding to a particular geographic area.

8. The kit of claim 7 further comprising an inoculum of microorganisms operable for biodegrading organic waste material.

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

A composting device for the biodegradation and recycling of household waste and, more particularly, organic kitchen waste.

2. Prior Art

Organic waste recycling methods in which organic waste such as kitchen waste and newspaper are deposited into a composting container are well known in the art. Composting devices normally provide interim storage for such waste and provide and maintain environmental factors, including moisture, air, warmth and certain bacteria and worms (such as Eisenia foetida, Eisenia hortensis or Eudrilus eugeniae) and other wormlike organisms. The organic material is composted or digested to produce a pleasant smelling, uniform, well granulated ***compost*** that can be recycled as a plant food. Such devices are, in essence, bioreactors, wherein waste feed stock is converted into a desired product (***compost***) which may be inexpensively removed from the bioreactor for distribution, most preferably in a ***continuous*** process.

Numerous composting devices have been patented and are disclosed, for example, in U.S. Pat. No. 5,185,261 to Warrington, U.S. Pat. No. 5,413,934 to Fischer, U.S. Pat. No. 5,285,534 to Criss, U.S. Pat. No. 5,741,344 to Warkentin and U.S. Pat. No. 6,103,124 to Inoue. However only a few claim the ability to process ALL kitchen wastes. Unfortunately, these earlier art devices possess inherent deficiencies which have prevented them from becoming popular with consumers. There is a continuing need for a composting device that is inexpensive, easy to operate and adapted for home use.

SUMMARY

It is a first object of the invention to provide a device operable for converting organic kitchen waste into ***compost***.

FIG. 2 is a side elevational view of a ***vermiculture*** composting device in accordance with the present invention.

FIG. 3 is a rear perspective view of a ***vermiculture*** composting device in accordance with the present invention.

FIG. 4 is a side elevational view of a ***vermiculture*** composting device in accordance with the present invention with the side panel removed to show the flow pattern of the contents of the device.

FIG. 5 is a plan view showing the unassembled components of the device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A composting device 10 in accordance with the present invention is shown in top, front perspective view in FIG. 1. The composting device 10 includes a rectangular container 11 having a a removable cover 12, a front panel 13, with a removable extraction door 20, a right side panel 14, a left side panel 15, a rear panel 16, and an optional base 17. The panels comprising the device are preferably 0.5 inch thick five ply AB Exterior grade plywood or equivalently robust composite. The removable cover 12 measures approximately thirty three inches by twenty three inches. This cover 12 is epoxy resin sealed and is painted with a dark colored paint on one surface and a light or white paint on the other.

The front panel 13 measures approximately thirty inches high by thirty two inches wide and is epoxy resin sealed and painted a dark color on its exterior surface. This front panel 13 includes a galvanized steel angle iron 13a attached to its superior, uppermost edge with galvanized steel bolts 21. The front panel 13 inscorporates an extraction opening 19, which is sealed by a removable door 20. The door 20 has two reinforcing stringers 20a and 20b which also act as handles for removing the door 20, as well as stops for the pivoting locking bars 13e, 13f, 13g, and 13h. The front panel 13 also includes a two inch by two inch reinforcing stringer 13b secured to its inside surface above the extraction opening 19. In addition, two spacers 13c and 13d provide anchorage for the locking bars 13e, 13f, 13g, and 13h, and also provide said locking bars sufficient clearance from the front panel 13 in order that they may pivot about their anchor points. The door 20 may be independent or hinge-attached to the front panel 13. A number of ventilation orifices 22 are spaced over this panel's surface. The front panel 13 is assembled with the side panels 14 and 15 and held in place with hot dipped galvanized steel bolts 24, washers 25, and nuts 26.

The right side panel 14 measures approximately thirty inches high on its front edge, thirty three inches high on its rear edge, and twenty two inches wide. It is epoxy resin-sealed and painted a variable color on its exterior surface. Five two inch by two inch wood stringers 14a, 14b, 14c, 14d, and 14e are glued and nailed to its periphery and to a point approximately ten inches superiorly from its inferior (lowest) edge. There are a number of variably dimensioned apertures 22 and 23 disposed in the side panels of the bin 10 for ventilation. The left side panel 15 measures approximately thirty three inches high on its rear edge, thirty inches on its front edge, and twenty two inches wide. The panel 15 is sealed with epoxy resin and painted a variable color on its exterior surface. Five two inch by two inch wood stringers 15a, 15b, 15c, 15d, and 15e are glued and nailed to its periphery and to a point approximately ten inches superiorly from its inferior edge. A number of variably dimensioned apertures 22 and 23 perforate its surface.

The rear panel 16 measures approximately thirty three inches high by twenty two inches wide. It is family of four), the five-gallon pail is emptied into the top of the ***compost*** bin. Approximately two and one-half gallons, or a half-bucket, of garden soil is then spread over the top of the waste in the bin. An equivalent amount of shredded newspaper bedding, or ***compost*** taken from the extraction opening of the bin may be used in place of garden soil to cover the waste. Covering the wastes allows the microbes and worms access from all sides and prevents flies from entering or odors from developing.

Clean-up consists of putting the one gallon kitchen-based container in the dishwasher nightly and garden-hose-spraying the five gallon bucket weekly. This entire process takes less time than is required for adding compostable material to prior art devices. I believe this process/device to be more time-efficient than putting kitchen wastes down the sink macerator (and certainly more conservative of precious potable water inasmuch as each pound of kitchen waste macerated requires co-disposal of seven gallons of fresh water.) The device and process of the present invention is cost-effective when compared to the financial burdens of expanding and operating wastewater treatment plants or land fills. Finished ***compost*** can easily be periodically shoveled from the large extraction opening and used to replenish/enhance soil fertility in the local landscape.

This device allows ***continuous*** composting of kitchen wastes as the result of a unique modified vertical flow of the chamber contents: the reinforcing stringer attached to the inside of the front panel acts as a baffle. This baffle diverts the flow of composting waste and bedding from a straight vertical flow to a `J` curve flow. This unique flow allows more complete waste composting while maintaining a compact vertical dimension for the device. Thus the present ***compost*** bin operates with a ***continuous*** flow pattern to produce a nutrient-rich soil product in a short period and without odors or fuss. Because of the novel proportions of my device, the worms may migrate within the chamber to microclimate regions where conditions are optimum for their physiology. For example, if waste such as a liquid vegetable oil marinade is added in significant volume (one or two quarts) this oil would normally smother earth worms. In devices with smaller volumes, the worms would have no place to escape. The worms prefer an oil substrate. With my device, the worms can move vertically a sufficient distance to safety, then feed upon the oil from the periphery.

My device demonstrates `thermal advantages` over prior art devices. During hot periods of the day, the bedding/***compost***/wastes may overheat in other devices exposed to direct sunlight. This overheating may occur despite ventilation openings (which I believe my invention utilizes more efficiently due to its unique ability to develop a `stack effect` updraft). With my device, should overheating occur, the worms can migrate vertically and/or horizontally to cooler microclimate regions within the bin chamber. The ***vermiculture*** composting bin has been designed with attention to small details that ensure convenience and durability. The galvanized steel angle iron at the top of the front panel serves the dual role as panel reinforcement and shield. When the user is shoveling soil and/or ***compost,*** some soil or ***compost*** frequently adheres to the shovel blade. The angle iron provides a convenient device upon which to tap the shovel in order to remove adherent materials.

The present ***compost*** bin has been engineered to be `bullet resistant`. It may operate efficiently for generations. My prototype device has functioned well for more than two decades. My vermicomposting bin has successfully recycled all of the kitchen waste produced by my family of four, as well as the periodic "shock loads" associated with holiday parties and fishing adventures. I believe that this device and its process have achieved a mastery of the science of kitchen waste recycling.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made

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(1 of 1)

United States Patent **8,919,282**
Jardine **December 30, 2014**

System and method for continuous vermiculture cycle

Abstract

A method for continuous vermiculture is provided. The method includes providing a continuous vermiculture culture system. The continuous vermiculture culture system includes at least one culture member that is fluidly connected to an irrigation system. After preparing a feeding solution, a volume of the feeding solution is then infused into the at least one culture member via the irrigation system. The steps of providing a feeding solution and infusing a volume of the feeding solution into the at least one culture member via the irrigation system are optionally repeated to promote formation of culture-grade soil and plant growth within the at least one culture member.

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Applicant:

Name	City	State	Country	Type
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Assignee: **The Local Soil Company, LLC** (Phoenix, AZ)
Family ID: **46314966**
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Prior Publication Data

Document Identifier	Publication Date
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Related U.S. Patent Documents

Application Number	Filing Date	Patent Number	Issue Date

RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/426,682, filed Dec. 23, 2010, which is hereby incorporated by reference in its entirety for all purposes.

Claims

Having described the invention, the following is claimed:

1. A method for continuous vermiculture comprising: (a) providing a continuous vermiculture culture system, the continuous vermiculture culture system comprising at least one culture member, comprising at least one earthworm, that is fluidly connected to an irrigation system; (b) preparing a feeding solution, wherein the feeding solution comprises organic food waste; (c) infusing a volume of the feeding solution into the at least one culture member via the irrigation system; and (d) optionally repeating steps (b) and (c) to promote formation of culture-grade soil and plant growth within the at least one culture member; wherein said step of preparing a feeding solution further comprises the step of placing an amount of organic food waste into a device for decomposing the organic food waste into a liquid effluent.

2. The method of claim 1, wherein said step of providing a continuous vermiculture culture system further comprises providing the irrigation system including: at least one source of the feeding solution; at least one primary fluid line connected to the at least one source; at least one junction member connected to the at least one primary fluid line; at least one secondary fluid line connected to the at least one junction member; and at least one tertiary fluid line that extends between, and is fluidly connected to, the at least one culture member and the at least one secondary fluid line.

3. The method of claim 1, wherein the at least one culture member comprises a mesh enclosure that surrounds a filler material and the at least one earthworm.

4. The method of claim 3, wherein the filler material further comprises soil, seeds, and at least one of coconut shavings and probiotic.

5. A method for forming culture-grade soil that facilitates plant growth, comprising the steps of: decomposing an organic waste material into a liquid feeding solution; infusing a portion of the liquid feeding solution into a medium, wherein the medium comprises an earthworm; and forming the culture-grade soil based on the earthworm consuming at least a portion of the liquid feeding solution; wherein decomposing organic waste material into a feeding solution comprises placing an amount of organic food waste into a device for decomposing the organic good waste into a liquid effluent.

Description

TECHNICAL FIELD

vermiculture system in FIG. 2;

FIG. 3B is a cross-sectional view taken along Line 3B-3B in FIG. 3A;

FIG. 4 is an image showing the continuous vermiculture system in FIG. 2 before initial seeding;

FIG. 5 is an image showing organic crops about 6 weeks after seeding in the continuous vermiculture system of FIG. 4; and

FIG. 6 is an image showing the organic crops in FIG. 5 about 10 weeks after seeding in the continuous vermiculture system of FIG. 4.

DETAILED DESCRIPTION

The present invention relates generally to a system and method for processing organic waste into a liquid solution to grow organic crops, and more particularly to a continuous vermiculture system and related cycle for producing culture-grade soil and growing plants. As representative of one aspect of the present invention, FIG. 1 illustrates a method 10 for a continuous vermiculture cycle for producing culture-grade soil and/or growing organic crops. The present invention harvests the regenerative power of nature by converting consumable organic waste (e.g., food waste) by-products into lush organic growth. Unlike conventional vermiculture systems and methods, which are eventually depleted of the minerals and nutrients needed to sustain the earthworm inhabitants, the present invention supplies earthworms with a liquid effluent of organic waste by-products so that the earthworms continuously create the needed nutrients to grow lush organic crops in any environment.

In one aspect of the method 10, a continuous vermiculture system 30 (FIG. 2) is provided at Step 12. The continuous vermiculture system 30 comprises at least one culture member 32 that is fluidly connected to an irrigation system 34. The irrigation system 34 generally comprises the following components: at least one source 36 of a feeding solution; at least one primary fluid line 38 that is fluidly connected to the source of the feeding solution; at least one junction member 40 that fluidly joins the primary fluid line and at least one secondary fluid line 42; and at least one tertiary fluid line 44 that is fluidly connected between the culture member and the secondary fluid line. Additional or optional components of the irrigation system 34 can include one or more pumps 46, one or more pressure gauges (not shown), one or more fluid flow control switches (not shown) (e.g., timed valves), one or more fluid flow sensors (not shown), one or more fluid quality sensors (not shown), and one or more central fluid flow controllers (not shown) for automated and/or centralized control of the continuous vermiculture system 30.

The source 36 of the feeding solution can include any device or structure (e.g., a vat or tank) capable of holding a volume of feeding solution (described in more detail below). The feeding solution is supplied to the source 36 via a conduit 37 that is fluidly connected to a device or system 39 capable of generating the feeding solution. Alternatively, the feeding solution can be manually supplied to the source 36 (e.g., by loading a pre-determined volume into the source as needed). In one example of the present invention, the device or system 39 can comprise a commercially-available food waste decomposer, such as the ORCA GREEN bioreactor (Orca Green, LLC, Marietta, Ga.). Other examples of devices and systems for decomposing organic food waste into a liquid effluent are known in the art. The device or system 39 is capable of decomposing organic waste (e.g., food waste, organic crop waste, lawn clippings, bark, leaves, branches, etc.) into a liquid effluent, which can then be fortified with one or more additives to form the feeding solution. Prior to supplying the source 36, for lines can be connected to one or more of the culture members. The tertiary fluid lines 44 can have any length and diameter desired. In one example of the present invention, the tertiary fluid lines 44 can have a diameter that is less than the diameter of the secondary fluid line 42 to provide increased fluid pressure within each of the tertiary fluid lines.

As shown in FIG. 2, the first end 48 of each of the tertiary fluid lines 44 partially extends into each of the culture members 32. Positioning the first end 48 of each of the tertiary fluid lines 44 in each of the culture members 32 helps facilitate widespread delivery of the feeding solution within the culture members. It will be appreciated, however, that the first end 48 of each of the tertiary fluid lines 44 may be flush-mounted to each of the culture members 32. Additionally, it will be appreciated that the tertiary fluid lines 44 can be fluidly connected to each of the culture members 32 in any desired pattern or configuration (e.g., symmetrically or asymmetrically spaced apart).

Referring to FIGS. 3A-B, each of the culture members 32 generally comprises an elongate mesh enclosure 52 that is formed from a mesh or netting-like material and includes a filler material 54 surrounded by the mesh enclosure. Each of the culture members 32 has a tube-like configuration defining a longitudinal axis LA and a longitudinal cross-section LC. The longitudinal cross-section LC can resemble any closed shape, such as a circle, a non-circle (e.g., an oval), and/or a polygon (e.g., a triangle, rectangle, square, hexagon, the shape of the letter "D", etc.). The particular dimensions of the culture members 32, such as length, width, cross-sectional area, etc., can be varied as needed. That is, the dimensions of one or more of the culture members 32 can be scaled up or down depending upon the particular application of the continuous vermiculture system 30.

The material used to form the mesh enclosure 52 can be fabricated from a flexible netting material, which can be woven, sewn, knitted, welded, molded, and/or extruded, etc. One example of a mesh enclosure 52 that may be used to form the culture members 32 is disclosed in U.S. Pat. No. 7,226,240 to Tyler, the entirety of which is hereby incorporated by reference. Briefly, the material used to form the mesh enclosure 52 can be biodegradable, such as cotton, a natural fiber, UV-sensitive plastic, and/or biodegradable polymer (e.g., starch) that can biodegrade at a predetermined rate. Alternatively, all and/or any portion of the material used to form the mesh enclosure 52 can resist biodegradation. For example, the material can be fabricated from plastic, UV-inhibited plastic, polyester, polypropylene, multi-filament polypropylene, polyethylene, LDPE, HDPE, rayon, and/or nylon. The material used to form the mesh enclosure 52 can be of any diameter and/or thickness. The material can have any mesh opening pattern, such as diamond, hexagonal, oval, round, and/or square, etc. Any number of mesh enclosures 52 can be coupled together in a process called "sleeving" to form a continuous mesh tube (and/or mesh sheet, not shown) of any size.

The filler material 54 can partially or completely fill each of the culture members 32. The filler material 54 can include one or a combination of materials, such as compost, composted products, mulch, sawdust, soil, gravel and/or various other organic and/or inorganic substances. As shown in FIG. 3B and described in more detail below, the filler material 54 includes one or more earthworms 56. Advantageously, the earthworms 56 can continuously create and replenish the nutrients needed for sustainable plant growth.

The filler material 54 can comprise any of a number of materials including, but not limited to, compost, composted organic materials, organic feedstocks, composted products, mulch, wood shavings, lime, clay, pea gravel, gravel, sand, soil, wood chips, bark, pine bark, peat, soil blends, straw, hay, leaves, sawdust, paper mill residuals, wood wastes, wood pellets, hemp, bamboo, biosolids, coconut fibers, coir, wheat straw, rice straw, rice hulls, corn husks, corn, grain, corn stalks, carbon dioxide are produced. The liquid effluent (or feeding solution) is then collected and prepared for further use.

At Step 18, the feeding solution is fed into the irrigation system 34. As indicated by the arrows in FIG. 2, the feeding solution is flowed through the source 36 via the primary fluid line 38 into the junction member 40, through the secondary fluid line 42, and then into each of the culture members 32 via the tertiary fluid lines 44. The rate and amount of the feeding solution delivered to the culture members 32 can depend on a number of factors including, but not limited to, the size and number of culture members, the type of organic crop(s) being cultured, the dimensions of the primary, secondary and tertiary fluid lines 38, 42 and 44, and the climate or environment in which the continuous vermiculture system 30 is located. For example, an arid environment may require a greater flow rate to prevent the filler material 54 from drying out.

The feeding solution can be flowed through the irrigation system 34 continuously and/or intermittently. The continuous vermiculture system 30 can be configured as a closed-loop system so, for example, the feeding solution is continuously flowed therethrough. Alternatively, the continuous vermiculture system 30 can be configured so that a desired amount of the feeding solution is delivered to one or more of the culture members 32 at specific time intervals. The feeding solution can be flowed through the irrigation system 34 via one or more pumps 46 or via a gravity-based mechanism (not shown). The feeding solution can be delivered to the culture members 32 one at a time, all at once, or a combination thereof (e.g., in a select pattern).

If it has not been done so already, one or more seeds of a desired plant (or plants) can be planted within each of the culture members 32 (FIG. 4). At Step 20, the culture members 32 are cultured by exposing the culture members to an appropriate amount of light and then infusing the appropriate amount of feeding solution into the culture members. Depending upon the type of plant(s) being cultured, all or only a portion of one or more of the culture members 32 can be exposed to partial or complete sunlight, for example. As shown in FIGS. 5-6, the culture members 32 are then cultured for an appropriate period of time until lush organic crop has been successfully cultured. At Step 22, the cultured organic crop can be harvested and consumed and/or converted into other non-food products, such as soaps, oils, medicines, etc.

After the organic crop is harvested and consumed, any organic waste (e.g., food waste and/or organic crops) can be disposed of at Step 24. To complete the virtuous cycle of the present invention, the organic waste can be recycled (Step 26) by depositing the organic waste into any device or system capable of decomposing the organic waste into a liquid effluent (feeding solution). Beginning at Step 14, the method 10 can then be repeated to once again culture organic crop that is ready for consumption. Not only are lush, healthy plants generated by the method 10, but so too is culture-grade soil that can be reused with the present invention or exported for other uses. Moreover, by generating a feeding solution from organic waste (e.g., organic food waste) to sustain the population of earthworms 56 in each of the culture members 32, the nutrients in the filling material are continuously regenerated to promote sustained and continuous plant growth.

From the above description of the invention, those skilled in the art will perceive improvements, changes and modifications. For example, other additives that can be included within the filler material 54 include fertilizers, pre-emergents, herbicides, nutrients, minerals, insecticides, pesticides, admixtures, aggregates, flocculants, polymers, chemical binders, and/or water absorbers, etc., chosen to enhance plant life. Additionally, it will be appreciated that the term "organic" as used herein is not restricted to "organically-certified" products or produce (as defined by the USDA, for example);

Vermicomposting system
EP 0196887 A2

ABSTRACT

A composting plant e.g. for use in vermiculture, comprises a cruciform-type breaker bar unit 16 (Figure 4) for moving the bottom layer of compost through the perforated floor of the plant. Alternative designs of breaker bar unit are also described.

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Inventors	James Stanley Price, 4 More »
Applicant	National Research Development Corporation
Export Citation	BiBTeX, EndNote, RefMan

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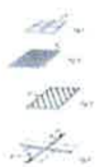
External Links: Espacenet, EP Register

IMAGES (6)






DESCRIPTION

[0001] The present invention relates to a solids discharge device and in particular, but not exclusively, to one for discharging friable and/or particulate material from a container e.g. as part of a vermicomposting system for commercial scale vermiculture.

[0002] Whilst the aim of vermicomposting is the improvement of wastes into a useful or marketable product, the production of worms is another result of the process as these have a high protein content and when separated from the processed waste, can be used as a feed additive, e.g. for fish farming, or for pigs or poultry.

[0003] To date, two production systems have been in use. The simplest is a batch system where a quantity of waste is inoculated with worms and left until the waste has been broken down. The more successful system, however, is a cumulative-batch layer-fed system. Here a smaller quantity of waste is inoculated with worms and as it becomes broken down another and successive layers are added. In both systems, waste and worms are 'harvested' in one operation when the whole is removed and another batch is then started.

[0004] Machines are already known which use one or more augers for discharging compost from a compost bin but such arrangements are expensive for large-area bins and also less than satisfactory in a vermicomposting system, for example, where, ideally, worked material should be extracted from the lowermost layers of the charge with only negligible disturbance of the upper worm-containing layers of material.

[0005] On-farm (non-worm) composting is also being considered, and here the possibilities contemplated at present are the use of expensive screw-auger discharge vessels or simple in-pile composting. The latter option tends to give an inconsistent product but the expense involved in the former makes it inappropriate.

[0006] In addition, problems are often experienced in obtaining slow, even feed of other difficult solids which display severe bridging, e.g. moist soils in soil processing lines, etc. Commonly used equipment

CLAIMS (10)

1. A discharge device comprising a container having an apertured floor, one or more material-displacing members engaging with or lying adjacent to the upper surface of the floor, and drive means for moving the one or more members bodily across the floor thereby to urge material in the container downwardly through the apertures in the floor.

2. A device as claimed in Claim 1 in which the container is square or rectangular when viewed in plan, and the one or more material-displacing members comprises an elongate member lying parallel to the length or width dimension of the container, the drive means being operative to move the elongate member in directions parallel to the other of these two dimensions.

3. A device as claimed in Claim 1 or Claim 2 in which the material-displacing member includes one or more vertical tines, each tine is apertured and the device includes aerating means for supplying air to these apertures.

4. A device as claimed in any preceding claim in which said elongate member comprises a first such member and the one or more material-displacing members includes a second elongate member arranged at right angles to the first member.

5. A device as claimed in any preceding claim in which the drive means comprises a winch or chain and sprocket system or one or more rams or other linear activators.

6. A vermicomposting system incorporating a discharge device according to any preceding claim.

7. A continuous vermicomposting apparatus as claimed in Claim 6 comprising a container for a charge of worm-containing waste material, feed means for adding further amounts of said material to the top of

[0032] Conveniently, the apparatus includes feed means operative to break up lumps in a supply of unprocessed material before loading it onto the upper surface of the charge.

[0033] Conveniently, the apparatus includes means for watering the upper layers of the charge.

[0034] Conveniently, the apparatus includes enclosure means operative to prevent overwetting of the charge by rain when the apparatus is installed in the open air and to discourage the excessive evaporation of water from the charge in dry conditions.

[0035] It is to be noted that the term 'apertured' as used above and in the claims is to be broadly interpreted as describing any non-continuous floor for the container, i.e. any floor not wholly closing off the bottom end of the container.

[0036] The invention further includes a bedding system for animals, or a feed hopper, when incorporating a discharge device according to the present invention.

[0037] According to another aspect of the present invention, a continuous vermicomposting apparatus comprises a container for a charge of worm-containing waste material, feed means for adding further amounts of said material to the top of the charge and discharge means according to the present invention for removing from the bottom of the charge quantities of the material processed by the worms in the container.

[0038] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which:-

Figures 1, 2 and 3 are perspective views of different designs of apertured floor for use in a vermicomposting system;

Figure 4 is a perspective view of a cruciform unit for displacing material through the apertured floors of Figures 1 to 3;

Figures 5 and 5a show alternative drives for moving the unit of Figure 4 from end to end of a container;

Figure 6 is a vertical section of one or other of the material-displacing members used in the unit of Figure 4, and Figure 6a shows a similar section of an alternative design;

Figure 7 shows an alternative design of soil-displacing unit to that shown in Figure 4;

Figure 8 shows a modification of the design of Figure 7;

Figure 9 illustrates how the invention may be applied to a bedding system for animals;

Figure 10 shows a schematic vertical section through a first embodiment of the apparatus in accordance with the present invention;

Figure 11 shows a schematic perspective view of a first discharge device for use in the apparatus of Figure 10;

Figure 12 is a vertical section of part of an alternative discharge device to that shown in'Figure 11;

Figure 13 is a schematic side view of a feed hopper for use with materials that display severe bridging;

Figures 14 and 15 are respectively side and end views of an underfloor collection scaper for use with the apparatus of the earlier Figures, and

Figure 16 is a schematic perspective view of a drive system for use in some embodiments of the invention.

[0039] Thus referring first to Figures 1 to 3, these show three alternative designs of apertured floor for the container of a continuous vermicomposting system, namely a grid 10 (Figure 1) a mesh 12 (Figure 2), and a slanting bar construction 14 (Figure 3). In all these designs, the spacing between adjacent floor members (measured perpendicularly to these members) would typically be of a value of from 75 mm up to 200 mm, say.

[0040] Figure 4 shows a simple form of breaker bar unit 16 comprising two elongate members 18, 19 arranged in a simple unbraced cruciform construction.

[0041] Lugs 21, 22 extending upwardly from member 18 allow the construction to be pulled in a direction parallel to this member across the floor of the container.

[0042] The cross-member 19 is dimensioned so as to span or substantially span the container and the length of member 18 is preferably not less than about two thirds of the length of member 19.

[0043] In the illustrated embodiment, in fact, the separation l of each lug 21, 22 from the adjacent edge of cross-member 19 was designed to be not more than one third the length w of the member 18.

[0044] As illustrated in the drawing, both members 18, 19 incline upwardly at either end e.g. at about 30° to the horizontal.

[0045] Turning now to Figures 5 and 5a, these show alternative designs of drive system for use in a layer composting system of, say, 50 to 75 square metres (corresponding respectively to containers of 20 metres to 30 metres length, say). In significantly smaller systems e.g. containers of 4 to 9 square metres area, a simple hydraulic ram or similar linear activator may be employed e.g. as shown in the arrangement of Figure 3 to be described hereinafter. A modified ram or linear activator system may be used to drive intermediate size soil-displacement units, such as shown, for example, in Figures 8 to 10 still to be described in detail below. One example of thiks latter type of drive system will be hereinafter described with reference to Figure 16.

[0046] Returning now to Figure 5, the drive system 24 comprises, in essence, a winch 26 and idler pulley 27, one at either end of the container 29. A steel cable 31 attached to lug 21 passes around the winch 26 and then underneath the container floor 33 and back around the idler pulley 27 for attachment to the second lug 22. In the drive system 35 of Figure 5a the steel cable 31 is replaced by a chain 37 and the winch 26 and idler pulley 27 are replaced by a sprocket drive 39, 40. In alternative drive systems (not shown), both rotary supports can be driven.

preferably provided as a safeguard to water the upper layers of waste 114 should conditions require. In the event of excess water being provided, this can freely drain through the floor mesh of the container.

[0062] In operation of the apparatus, the container 112 is loaded with worm-containing waste as described and the temperature, aerobicity and dampness of the material waste is adjusted if required for optimum conditions.

[0063] The high population of worms within the container (typically 3 to 6 Kg of worms per square metre of material) will continually refine the waste, breaking it down to a smaller particle size.

[0064] The worms will continually move upward to new layers of waste as the previous layers become exhausted. Discharge of processed waste through the floor of the container takes place at substantially similar intervals to those at which new waste is added to the top, maintaining a fixed amount of continually renewed waste for processing in the container.

[0065] Because worms move up to the fresh waste layers, the processed waste will be substantially worm-free and can be discharged through the floor as already discussed for recovery by scraper, conveyor, skip or other suitable means.

[0066] In running the apparatus, the aim is always to maintain a high population of worms and achieve maximum throughput of waste.

[0067] A typical weekly output of vermicompost when using separated solids waste derived from cattle slurry is about 0.08 cubic meters per square metre of floor space of the apparatus.

[0068] In cases where the retention time of waste in the container is only four or five days, the waste throughput is too fast to enable worm cocoons to hatch and grow in the container and they will be lost in the discharged waste. In this case some addition of small worms may be necessary to maintain the desired level of performance.

[0069] Conversely, if the waste is passing so slowly through the apparatus as to give a waste retention time of 30 to 40 days, for example, the same worms will need to be harvested from the top layer of the material to prevent a continually expanding worm population.

[0070] Where wastes are strongly self-heating due to microbial degradation, careful control of feed layer depth and retained depth should be practised with the aim of keeping temperature at the 20-25 C optimum. In particular, overheating to above 30 C should be avoided as above this temperature damage to the worms may result.

[0071] With the discharge system of Figure 11, movement of the bar 20 across the container floor causes localised breakdown of bridging of contained material and discharge results as the bar advances. However, Figure 12 shows an alternative design of discharge mechanism in which the container floor consists of finned metal square-section elements 124 spanning the base of the container and able to rotate clockwise and anti-clockwise (e.g. through 90^0) to obtain through-floor discharge of the contents of the container.

[0072] Typically, the elements 124 will be steel tubes or rolled hollow sections to which the fins have been welded. The optimum centre spacings of elements 124 will depend on the bridging properties of the material to be discharged but a centre spacing of around 150 mm would be typical. Although if the elements are of square or other non-circular cross-section, the fins may not be necessary for effective discharge to occur, the fins are nevertheless found to result in a more positive discharge and hence their presence is to be preferred. In the illustrated embodiment, the fins might project by about 25 mm, say, from the upper three corners of the square-section elements 124.

[0073] Rotation of the sections 124 in a to and fro motion is by an actuator device 126 in which a common linear actuator 130 is linked to the various sections by a,series of crank arms. With relatively small containers or in small portions of a large unit, it will often be feasible to operate the linear actuator by hand without mechanical assistance.

[0074] As well as its uses in vermicomposting systems, apparatus according to the present invention could also find application in the discharge of materials such as municipal sludge or materials presenting severe bridging or other flow problems.

[0075] One such apparatus is shown in Figure T3 and consists of a hopper 140 with vertical sides and a floor 142 constructed of a steel grid or mesh. The optimum dimensions of the hopper are determined by the type of material to be fed.

[0076] Above the hopper 140 and in contact with the floor 142 is a framework 144 supporting a number of members 146 which span the width of the hopper.

[0077] Members 146 comprise breaker bars of any of the designs illustrated in the previous Figures and they serve to cause localised breakdown of the bridging effect by which the material rests on the floor 142. To achieve this end, the members 146 are caused to reciprocate slowly (say, 100 mm/sec) by, for example, a variable-speed electric screw type linear actuator 148. This causes a controlled and even discharge over the whole hopper floor area and has the beneficial effect of breaking down lumps and structures within the material.

[0078] Below the floor 142 is mounted a simple light duty belt conveyor 150 to collect the discharge and transport it to a delivery point. This conveyor is lightly loaded and its speed is not critical as it does not serve as a metering device. Metering is done by the discharge floor 142 and flow rate is adjusted by the rate at which the linear actuator 148 reciprocates the breaker bar members 146.

[0079] In an alternative embodiment (not shown), the breaker bars form part of a motor-driven chain loop conveyor but this detracts from the simplicity and serviceability of a simple reciprocating breaker bar framework. In a further

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LEGAL EVENTS

Date	Code	Event	Description
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Jan 18, 1989	17Q	First examination report	**Effective date:** 19881130
Nov 15, 1989	18D	Deemed to be withdrawn	**Effective date:** 19890411
Aug 8, 2007	RIN1	Inventor (correction)	**Inventor name:** BILLINGTON, RICHARD STEPHEN **Inventor name:** FLETCHER, KEITH ERNEST **Inventor name:** PHILLIPS, VICTOR ROGER **Inventor name:** PRICE, JAMES STANLEY **Inventor name:** WILKIN, ARTHUR LEONARD

Method and apparatus for processing waste

WO 2002046127 A2

ABSTRACT

Organic waste is mixed and shredded in a mixer shredder (16) and composted in a thermophilic composting system (32). A portion of the compost as used as feedstock for a vermiculture system (46) to produce worm castings. The compost and castings can be used separately or blended. Liquid wastes may be treated in a digester (26) by aerobic or anaerobic digestion, and the resulting sludge fed to the vermiculture system (46).

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DESCRIPTION

Method and Apparatus for Processing Waste

This invention relates to a method and apparatus for processing waste. In particular, this invention relates to a method for converting the organic portion of the wastestream into a variety of useful products, including a quality growing medium; and to apparatus for putting this method into practice.

Every year, one thousand million tonnes of putrescent waste are dumped in landfill sites in Europe alone. This has a damaging impact on the environment. EU legislation implementing enforcement of recycling targets has recently been put in place. There is thus an urgent requirement for a feasible and cost effective system for achieving these targets. Since at least 40% of the municipal wastestream is organic this proportion of the wastestream has the potential for conversion into useful products such as compost and soil amendment. Currently, the best practical environmental option (BPEO) for waste treatment is incineration. However, incineration recovers only a fraction of the energy contained in organic material; it produces toxic ash; and the variable nature of the waste needing treatment causes serious operational problems in an incinerator.

Thermophilic composting is a more attractive option. However current thermophilic composting practice necessitates utilising large areas of land for heaping waste out of doors, in long windrows. Variations in weather conditions affect the waste making the process of composting slow, and its product inconsistent. There is a requirement to turn the heaps periodically, and this is achieved by using expensive diesel fuelled machinery. Windrow composting produces gaseous and leachate emissions, which cause adverse environmental impact. The products of such composting are of inconsistent and unpredictable quality which, whilst usable, are not very suitable for sale as compost, and therefore are of limited value.

An alternative thermophilic composting practice is to utilise in-vessel thermophilic systems. However, to date many of these are mechanically and electronically complex. They are mostly batch processes; are capital intensive; and require considerable energy input. The problem of converting organic waste economically into a usable product has led to the development of the use of worms to recycle organic material. In this method, worms in a worm bed, a support structure supporting a layer of biodegradable organic material, are fed biodegradable organic waste material (BOWM) to produce digested biodegradable organic material, known as castings. These castings are exceptionally good soil amendment. This process can take place in an organic digester.

CLAIMS (1)

1\. 1. A method for processing organic waste, in which waste is treated by microbial decomposition, and at least a proportion of the resulting treated waste is further treated by vermiculture in worm bed.

2\. The method of claim 1, in which at least some of the waste is treated by microbial decomposition by means of thermophilic composting.

3\. The method of claim 2, in which the thermophilic composting subjects the material being composted to a temperature of at least 70 °C for a period of at least one hour.

4\. The method of claim 3, in which the temperature of 70 °C is maintained for 24 hours,

5\. The method of any preceding claim, in which the waste consists of or includes liquid waste which is treated by microbial decomposition by means of aerobic or anaerobic digestion to produce a clarified liquid and a sludge, some or all of the sludge then being treated by vermiculture.

6\. The method of claim 5, in which the liquid waste undergoes a preliminary step of moisture modification to separate it into a liquid part which is then treated by digestion and a solid part which is treated by thermophilic composting.

7\. The method of any preceding claim, in which material to be composted is first shredded.

8\. The method of claim 7, in which the shredding step is also used to mix together a number of incoming waste streams .

9\. The method of any of claims 2 to 4, in which the compost produced by thermophilic composting is separated into coarse and fine fractions, and a selected proportion of the fine fraction is passed to vermiculture

Referring to Fig 1, this method uses the steps of treating organic material using selected micro- organisms to produce compost and then treating the compost in a variety of ways, including introducing part of the compost to a worm bed to produce digested biodegradable organic material known as castings.

The apparatus and system of Fig. 1 treats a number of organic waste streams 10, 12, 14. These waste streams are separated at source and may comprise green matter, catering slops, sewage sludge, manure, abattoir waste, poultry waste fish waste, seaweed, household organic waste, brewery/distillery waste, paper, cardboard, supermarket waste, and other biosolids . Wastes which are substantially dry, such as waste streams 12 and 14, are passed directly to a shredding and mixing machine 16.

Wastes which have a significant liquid content, such as waste stream 10, are first shredded by a shredder 18 and then treated in a moisture modification apparatus 20 (which may be, for example, a filter, belt press or centrifuge) to produce a solid stream 22 and a liquid stream 24. The solid stream 22 passes to the mixer/shredder 16. The liquid stream 24 is passed to a digester 26 of known type for aerobic or anaerobic digestion to produce a clarified liquid 28 which is discharged to drain or watercourse, and sludge 30 which is used as described below.

Optionally, bioaugmentation as indicated at 50 may be applied to the digester 26 and/or to the shredder/mixer 16, bioaugmentation being the addition of micro-organisms which will be beneficial to the breakdown of the waste material. Treating organic material using selected micro-organisms (bioaugmentation) encourages immediate initiation of the degradation of the material. Encouraging degrading in this way ensures that the method proceeds optimally.

The mixer/shredder 16 reduces the organic waste to a small size and mixes the various waste streams together. An important factor in the rapid breakdown of waste by thermophilic material has been found to be the shredding of paper, cardboard and green material right down into its constituent individual fibres . The shredder blades should rotate at a speed sufficient to achieve this. This ensures that extensive surface areas of material are exposed to bacterial action, and by ensuring optimal conditions in an in-vessel system the composting process is both very rapid and consistent.

The resulting material passes to a thermophillic composting system 32. Optionally, nitrogen sources and/or bulking agents may be added at this point . Alternative forms of thermophillic composting system which may be used at 32 are discussed below The resulting compost passes through a screen 34 to be separated into a coarse fraction 36 and a fine fraction 38.

The coarse fraction 36 is passed to a first curing store 40. A selected proportion of the fine fraction 38 is passed to a second curing store 42. The compost is held in the relevant curing store for about four weeks to cure or fully stabilise before being packed or transported for use. An alternative is to pack immediately in porous sacks, which enable sufficient air to penetrate the product to allow for the final bacterial and fungal activity which will render the product stable.

The remaining portion of the fine fraction 38 of the compost is passed to a shredder 44 which reduces the compost further in size to a very fine fibrous form, which is fed to a vermiculture apparatus 46. The digested sludge 30 is also fed to the vermiculture apparatus 46. The vermiculture apparatus 46 is preferably a self-contained, compact, highly automated apparatus of the type describer in CA 2170294 (Eggen) ; however, other types of vermiculture apparatus may be used in the present invention.

Feeding the vermiculture apparatus with material which has undergone shredding and thermophilic composting has a number of advantages. The feedstock has already had pathogen kill and the destruction of all weed seeds. In addition, the rapid action of the thermophilic bacteria has increased the palatability of the fraction for the worms by breaking down the material, and in particular by starting to break down the tough fibrous material, which speeds up the vermidigestion phase and raises the production rate of castings.

The castings which are produced in the vermiculture apparatus 56 are passed to a screen 48 to be separated into coarse castings 52 and fine castings 54. Unlike the compost from the thermophilic digester, the vermiculture castings are chemically and microbially stable as soon as they emerge from the casting removal system.

The system of Fig 1 thus produces four distinct products: 1. Coarse compost 2. Fine compost 3. Coarse castings 4. Fine castings.

These may be used individually according to their suitability for particular crops or soil conditions, or may be blended to obtain properties desired for particular use. It has been found that a particularly valuable product is formed by about 90% fine compost (product 2) mixed with about 1 - 10% castings (products 3 and 4) , preferably about 10%, which has greatly enhanced plant growth characteristics; it is of course possible to choose the proportion of material passing to vermiculture to optimise the process for this mixture.

Turning to the thermophilic composting process, this can be operated as a batch process. For this method, a heap of waste is placed in a container to decompose, and is aerated until the decomposition process is almost complete. The container is then emptied and refilled with a fresh heap of waste. The initial composting process occurs thermophilically . Bulking agents are used if necessary to provide an aerobic structure for active composting. The heap is structured such that air can circulate through the heap to aerate the mix naturally,, and to facilitate aerobic composting. Preferably however, the composting is operated as a continuous flow process. That is, there is continuous addition of waste to one

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Citing Patent	Filing date	Publication date	Applicant	Title
WO2004092079A1 *	Apr 16, 2004	Oct 28, 2004	Aqua Clarus Holdings Pty Ltd	Apparatus and method for the treatment of waste
US6991728	Nov 10, 2003	Jan 31, 2006	Aqua Clarus Holdings Pty Ltd	Apparatus and method for the treatment of waste
US7294272	Jul 24, 2006	Nov 13, 2007	Aqua Clarus Holdings Pty Ltd	Method for the treatment of waste
US7323107	Oct 14, 2005	Jan 29, 2008	Aqua Clarus Holdings Pty Ltd	Apparatus and method for the treatment of waste

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CLASSIFICATIONS

International Classification	C05F9/04, C05F17/00, C05F17/02
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European Classification	C05F17/02, C05F17/00, C05F9/04

LEGAL EVENTS

Date	Code	Event	Description
Jun 13, 2002	AL	Designated countries for regional patents	**Kind code of ref document:** A2 **Designated state(s):** GH GM KE LS MW MZ SD SL SZ TZ UG ZM ZW AM AZ BY KG KZ MD RU TJ TM AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG
Jun 13, 2002	AK	Designated states	**Kind code of ref document:** A2 **Designated state(s):** AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CO CR CU CZ DE DK DM DZ EC EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW
Jul 3, 2002	WWE	Wipo information: entry into national phase	**Ref document number:** 2001999544 **Country of ref document:** EP
Aug 7, 2002	121	Ep: the epo has been informed by wipo that ep was designated in this application	
Jul 8, 2003	WWW	Wipo information: withdrawn in national office	**Ref document number:** 2001999544 **Country of ref document:** EP
Oct 16, 2003	REG	Reference to national code	**Ref country code:** DE **Ref legal event code:** 8642
Jan 21, 2004	122	Ep: pct app. not ent. europ. phase	
Jan 18, 2006	WWW	Wipo information: withdrawn in national office	**Country of ref document:** JP
Jan 18, 2006	NENP	Non-entry into the national phase in:	**Ref country code:** JP

High efficiency vermiculture process and apparatus
US 6223687 B1

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Inventors	Harry N. Windle
Original Assignee	Harry N. Windle
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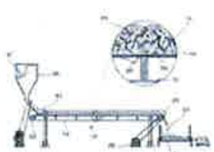
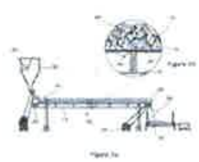
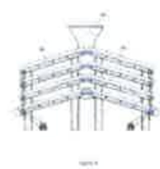
ABSTRACT

An apparatus and process for the efficient vermicomposting of organic containing wastes. A continuous thin layer of biomass is formed in which worms are established and encouraged to compost and migrate. The thinness of the biomass layer increases uniformity and allows for a higher rate of worm activity. By moving the biomass upon a conveying surface a continuous open system is created. New matter is introduced, digested and withdrawn while maintaining the active worms within a portion of the biomass. Spatial efficiency is provided by creating multiple beds in a stacked configuration.

IMAGES (5)







DESCRIPTION

BACKGROUND OF THE INVENTION

The present invention pertains to vermiculture and vermicomposting. In particular, the present invention provides a high efficiency process and apparatus for vermiculture and vermicomposting utilizing thin beds. Worm culture, or vermiculture, can provide worms as a raw material for an animal feed ingredient, live worms for sport fishing, or for other product uses. Vermicomposting is the use of worms to break down waste materials such as livestock manures and municipal waste. Generally, worms consume inorganic and organic matter, digest and absorb largely organic matter, and pass the remainder back to the soil. As a result of their feeding behavior, worms aid in the breaking down of organic material within the material they consume. The activity of worms also ventilates the soil and promotes bacterial and other microbial decomposition processes.

Large scale vermiculture typically uses thick beds in which large quantities of organic material are worked by worms in a relatively stationary mode. Thick beds typically become stratified with regions of active worms and regions of compacted material. These compacted regions often "sour" due to anaerobic decomposition resulting in unattractive conditions for worm activity. This requires turning or "freshening" of the beds such as by introduction of bedding materials. Thick bed operation is also typically a batch process requiring manual loading of fresh biomass. After the organic material is substantially broken down, the worms and digested material must be separated and harvested.

A need exists for a method of vermicomposting which provides: 1) uniform composting with lower labor demands; 2) better control of environmental conditions; 3) consistent and higher rates of worm activity with higher composting rates; 4) easier separation of worms from digested matter; and 5)

CLAIMS (20)

I claim:

1. A high efficiency vermiculture apparatus which reduces stratification of worms in the biomass being composted and increases worm density and efficacy, the apparatus comprising:

a thin layer biomass, said thin layer biomass having a thickness in the range of about 2 to 8 inches;

a worm mass within said thin layer biomass;

an input end and an output end;

a conveyor means for conveying the thin layer biomass from the input end to the output end: such that the thin layer biomass may be digested by the worm mass as the thin layer biomass is conveyed from the input end to the output end.

2. The vermiculture apparatus of claim 1 wherein:

said thin layer biomass has a thickness of about 4 inches.

3. The vermiculture apparatus of claim 1:

wherein the conveyor means comprises a movable first bed surface; and

said apparatus further comprising:

a control means for controlling the movement of said first bed surface, said control means being functionally connected to said first bed surface;

similar devices are used to maintain favorable temperatures and moisture content, and promote higher activity and digestion by the worms.

Higher efficiency may be obtained by providing incentives to keep the worms moving toward the new undigested material. Effective incentives are strong light and moving air at the unloading point at an end of the bed surface which encourages worms to move toward the loading point of the bed surface. The presence of new material at the loading point of the bed surface also encourages movement of the worms. Other incentives are electrical barriers and radiant heat devices.

In one configuration a continuous belt of a woven plastic sheet is used. It in turn is supported beneath by a bed pan of the same material. One advantage of such a construction is low cost which is particularly relevant in such locations as farms. These belts are slung between rollers of plastic or even wood, again allowing low cost. By inclining the beds, a single drive device connected to one roller of each worm bed in a stack can drive the entire assembly. Alternatively, independent drives may be employed.

These devices and processes may be used both with the objective of waste handling and as a means of producing worms as a product, or both simultaneously. Because of the uniform manner of composting, thin layer vermicomposting reduces the labor required as a means of waste processing. Because of the low space needs for such systems, environmental control allows for higher worm activity levels raising average composting rates. This is particularly advantageous in the northern climates where worms are otherwise dormant at ambient conditions much of the year.

The example embodiments provided are but a few illustrations of this novel vermicomposting invention. Other variations of the invention will be obvious to those skilled in the art of vermicomposting and vermiculture.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram of a vermicomposting process using a thin layer biomass.

FIGS. 2*a* and **2** *b* depict one embodiment of the invention using a single horizontal bed.

FIG. 3 is an embodiment of the invention having multiple beds in a vertical stacked configuration.

FIG. 4 is an alternative configuration in which two stacked bed assemblies are arranged back-to-back to facilitate loading.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is an apparatus and process for composting organic wastes in a highly efficient manner. In particular, the invention utilizes the great capacity of vermicomposting. The term "vermicomposting" as used here is understood to be the breakdown of organic matter by the ingestion and digestion of the matter by worms. As well, vermicomposting also includes the collateral biotransformation of such organic matter from the bacterial action inherent in such systems. The present invention has the capacity to cultivate a large number of worms—as excess over that needed for composting purpose. As such the present invention is also an apparatus and process for worm production. There is believed to be at least hundreds of species of what are commonly known as "red" worms in the vermicomposting technology. One example being the Lumbricus rubellus. Generally, species of red worm are regarded equally in vermicomposting and while the red worm is the type used to demonstrate the present invention, other types will work equally, depending somewhat upon the type of organic matter and environment.

The present vermicomposting invention utilizes a relatively thin bed, or layer, of organic matter in which the worm mass does its job. This process can be effectively used to transform or compost any number of waste materials such as restaurant food wastes; farmyard wastes such as chicken, pig, or bovine

a. a plurality of conveyors, each of said conveyors comprising:

1. a movable continuous loop belt, said belt being formed of a woven fabric, and each belt having a bed surface;

2. a pair of separated rollers, said belt being supported around said rollers;

3. a bed pan; said bed pan being formed of a woven fabric and being fixedly disposed beneath said belt; and

b. a support structure, said support structure being formed of wood members, each of said conveyors being supported in an inclined orientation by said structure in a vertically stacked configuration;

c. a drive motor connected to at least one of each pair of said rollers; and

d. a control device functionally connected to said drive mechanism;

e. a thin layer biomass formed on at least one of the bed surfaces; said thin layer biomass being capable of sustaining an infiltrated worm mass.

12. The vermiculture apparatus of claim **11**, further comprising:

a. a second support structure;

b. a second plurality of conveyors, each of said second plurality of conveyors being supported in an inclined orientation by said second support structure in a vertically stacked configuration;

c. both of said support structures being relatively located to form a space between the first and second plurality of conveyors; and

d. a loading trough formed around and at least partially enclosing said space; such that in operation additional biomass may be placed into the feeding trough and thereby be loaded onto said bed surfaces.

13. A high efficiency vermiculture process in which a worm mass is moved through a biomass layer such as to digest the biomass in complete and thorough manner to form a more uniform compost, the process comprising the steps of:

establishing a worm mass within a biomass;

introducing undigested biomass in a distributed, substantially continuous manner, creating a substantially continuous thin layer in communication with the worm mass;

retaining said thin layer in a substantially continuous manner such that the undigested biomass may be infiltrated by the worm mass and is thereby appreciably digested;

moving the thin layer to allow the effectively continuous introduction of new undigested biomass; and

withdrawing the digested biomass such as to create an exposed biomass surface while retaining the worm mass in communication with the undigested biomass;

such that a continuous open process is provided whereby a continuous flow of undigested biomass may be infiltrated and digested by worm mass moving through the stream.

14. The vermiculture process of claim **13** further comprising:

encouraging the worms to move toward the undigested biomass by providing an incentive.

15. The vermiculture process of claim **14**, further comprising:

enclosing the thin layer; and

motor with reduction or similar mechanisms well known in the arts may be used to obtain these low speeds. Some typical conveyor speeds are given in the example below. A bed pan **30** is provided secured rigidly to the support structure to form a foundation supporting the belt. In this configuration, the bed pan **30** is a fabric stretched between the individual members of the support structure **14**. The width of the entire assembly is arbitrary and is determined from the particulars of the site. In operation, a feed hopper or trough **35** is filled with undigested biomass **40** which is then introduced onto the belt **15**. The belt provides a bed surface **16** on which the biomass remains as it is composted. A leveler **45** is provided as necessary to provide an even distribution and thickness. Alternatively, a gate or weir may be provided the appropriate distance above the belt at the loading point. The biomass is then effectively extruded onto the belt by forcing the biomass between the belt and gate, the gate regulating the thickness of the layer. The belt **15** is driven at a speed which closely matches the worm mass progression through the thin layer biomass. The digested biomass **50** falls from the belt and is withdrawn from the site by a second conveyor **55**. In the expanded view, the thin layer biomass is shown infiltrated by worms **60**. While the various elements such as the feed hopper and conveyor may be structurally connected they may also be only functionally connected by being located in sufficient proximity and in proper orientation to function effectively together.

An example of a space and cost effective design for implementing the invention is shown in FIG. **3**. Multiple inclined conveyors **100** are supported in a vertically stacked configuration to form a conveyor assembly **101**. Each conveyor includes a loop conveyor belt **112** which is captured between rollers **114** as similarly described. A support structure **116** is provided to support the weight of the loaded belts. The top surface of each belt **112** forms bed surface which is loaded with undigested biomass by means of a single box feeder **105**. The feeder box is formed of a broad back **106** which spans the full width of the conveyor belts **100**. Sides **107** and a bottom **108** extend toward the conveyor belts and capture the biomass introduced. The near side of the feeder box **105** is cut away in the view to expose the conveyor loading ends. The fourth, open, side of the feeder box is effectively filled by the loading ends of the conveyors. The sides **107** are snug to the conveyor sides to reduce leakage. Biomass to be loaded is introduced into the feeder box mouth **109** and allowed to accumulate in the box. The weight of the biomass will force it to flow between the individual conveyors and onto the belts **112**. The gap between rollers at the loaded end of the conveyors determines the thickness of the biomass layer formed. This spacing is exaggerated in the figure for clarity. Other devices and methods for loading such a material stream onto a conveying surface are within the knowledge of those skilled in materials transportation. Each conveyor **100** is inclined at a downward angle from the loading end to the unloading end as shown. Because the weight of the biomass on the bed surfaces may be extreme, the frictional resistance to belt movement may be great. The incline allows the weight of the biomass drawing the belt down to counter the frictional forces and reduce the motor power required to drive the belts. The exact angle is dependent on the construction materials and the density of the biomass. The belt material and bed pan material greatly influence the friction forces as the contact surface area is great. A reduced speed drive **110** similar to that in the previous figure is provided, linked either directly or indirectly to each belt. A speed and timing control **115** is provided on the drive **110**. These components are but one way in which the belt motion may be controlled. Alternative methods such as independent drives for each belt are also available. While motion of the conveyor belts and bed surfaces has been discussed as continuous, noncontinuous motion will also be satisfactory. Short duration motions with long intervening stationary periods will effect the same result so long as the motions are short enough that large portions of the digested biomass are not withdrawn at a single time carrying along worms.

A screen tumbler **120** is shown, for convenience, placed at the unloading end of the conveyor assembly **101** such that digested biomass will fall into the open end of tumbler. The function of the screen tumbler is to separate the larger undigested lumps of biomass **125**, and incidental worms, from the more fine worm castings material **130** which has been digested. The screen size is again dependent upon the particular biomass. For cow manure vermicomposting, a ⅛ inch screen followed by a ¼ inch screen has been found to work well. Preferably, all but the material passing through the ⅛ inch screen is returned to the undigested biomass to be reloaded and form the thin layer. It has been found that in this manner a large quantity of worm egg casings will be returned to hatch within the worm mass thereby supporting the worm population. Alternatively, the egg casing containing portion may be removed to allow for incubation of the worm eggs and production of worms.

EXAMPLE

A vertically stacked vermicomposting assembly was built having 7 individual inclined thin layer biomass beds. The beds were each inclined at an included angle of 24 degrees from the horizontal—the output end being lower. The assembly sides were covered with a polyethylene sheet to help maintain an elevated temperature. A supply of cow manure was liquefied, pumped into a hopper, and then allowed to gravity drain for 24 hours after which it was hand loaded into a gravity feed trough loading simultaneously all of the beds. The trough enclosed the loading end of the beds and the weight of a height of biomass above the beds forced a portion of the biomass from the trough, through a slot, onto each bed surface. Between vertically adjacent beds, this slot was formed by the space between the respective bed rollers. The device was similar to that shown in FIG. 3. A supply of red worms was obtained, distributed onto the beds, and briefly allowed to become established. The beds were put into motion and additional biomass was loaded maintaining a continuous thin layer on the beds. Both a simple electrical fan and two 40 watt fluorescent light bulbs were directed at the unloading end of the assembly as incentives. The digested biomass was withdrawn by gravity drawing the overhanging portion of the thin layers to fall from the beds into trays. The digested biomass was then screened through an 118 inch wire mesh and the residual returned to the feed trough. The residual consisted primarily of small lumps of undigested

Citing Patent	Filing date	Publication date	Applicant	Title
			Rutgers, The State University	Apparatus and method for separation of nematodes from suspension
US6601243 *	Apr 1, 2002	Aug 5, 2003	Ecosphere Technologies	Toilet installation implementing composting with worms
US6838082	Feb 14, 2002	Jan 4, 2005	M-I Llc	Vermiculture compositions
US7004109 *	Jul 1, 2002	Feb 28, 2006	Seabait Limited	Aquaculture of marine worms
US7018831	Sep 26, 2001	Mar 28, 2006	Biosystem Solutions, Inc.	Composting apparatus and method
US7141169	Jun 18, 2004	Nov 28, 2006	Koehler Peter L	Method and apparatus for biosustaining waste activated vermicular environment
US7156048	Feb 2, 2006	Jan 2, 2007	Seabait Limited	Aquaculture of marine worms
US7867396	Jul 11, 2005	Jan 11, 2011	Black & Grey Holdings Pty Ltd	Water treatment apparatus, method and system
US7964385	Apr 10, 2007	Jun 21, 2011	Rt Solutions, Llc	Organic waste treatment system utilizing vermicomposting
US8304227	May 11, 2011	Nov 6, 2012	Rt Solutions, Llc	Organic waste treatment system utilizing vermicomposting
US8465567	Aug 10, 2007	Jun 18, 2013	Palaterra Gmbh & Co. Kg	Method for the production of humus- and nutrient-rich and water-storing soils or soil substrates for sustainable land use and development systems
US8735141	Nov 15, 2004	May 27, 2014	M-I L.L.C.	Vermiculture compositions
US20040159288 *	Jul 1, 2002	Aug 19, 2004	Olive Peter James William	Aquaculture of marine worms
US20050090405 *	Nov 15, 2004	Apr 28, 2005	Frederick Growcock	Vermiculture compositions
US20050133442 *	Jun 18, 2004	Jun 23, 2005	Koehler Peter L.	Method and apparatus for biosustaining waste activated vermicular environment
US20060124063 *	Feb 2, 2006	Jun 15, 2006	Seabait Limited	Aquaculture of marine worms
EP2144859A1 *	May 1, 2008	Jan 20, 2010	Ivan Milin	System for processing organic waste using insect larvae
EP2458136A1	Feb 14, 2002	May 30, 2012	M-I L.L.C.	Method of bio-remediating wellbore cuttings
WO2002087321A2 *	Apr 25, 2002	Nov 7, 2002	Gaugler Randy	Apparatus and method for mass production of insecticidal nematodes
WO2009021528A1 *	Aug 10, 2007	Feb 19, 2009	Joachim Boettcher	Method for the production of humus- and nutrient-rich and water-storing soils or soil substrates for sustainable land use and development systems

* Cited by examiner

CLASSIFICATIONS

U.S. Classification	119/6.7
International Classification	A01K67/033, C05F17/00
Cooperative Classification	C05F17/0009, A01K67/0332, Y02W30/43
European Classification	A01K67/033B, C05F17/00B

LEGAL EVENTS

Date	Code	Event	Description
Jul 13, 1998	AS	Assignment	**Owner name:** WORM WORLD, INC., FLORIDA **Free format text:** ASSIGNMENT OF ASSIGNORS INTEREST;ASSIGNOR:WINDLE, HARRY N.;REEL/FRAME:009316/0611 **Effective date:** 19980707
Jun 21, 2004	FPAY	Fee payment	**Year of fee payment:** 4
Oct 26, 2006	AS	Assignment	**Owner name:** WINDLE, HARRY, FLORIDA **Free format text:** ASSIGNMENT OF ASSIGNORS INTEREST;ASSIGNOR:WORM WORLD, INC.;REEL/FRAME:018433/0617 **Effective date:** 20061024
Sep 26, 2008	FPAY	Fee payment	**Year of fee payment:** 8
Dec 10, 2012	REMI	Maintenance fee reminder mailed	
May 1, 2013	LAPS	Lapse for failure to pay maintenance fees	
Jun 18, 2013	FP	Expired due to failure to pay maintenance fee	**Effective date:** 20130501

Method and apparatus for biosustaining waste activated vermicular environment

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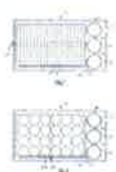
External Links: USPTO, USPTO Assignment, Espacenet

ABSTRACT

A system for processing sewage into vermicompost includes a holding tank for receiving and initially processing the sewage. A treatment tank, connected to the holding tank by a first pipe, is used for treating the initially processed sewage from the holding tank to ensure optimal pH, percent of solids, and electrical conductivity of the sewage. A distribution tank, connected to the treatment tank by a second pipe, is used for heating or cooling the sewage from the treatment tank as necessary. A distribution apparatus, connected to the distribution tank by a third pipe, distributes the sewage to a vermicular environment, wherein the vermicular environment contains a plurality of worms which digest the distributed treated sewage into vermicompost.

IMAGES (3)



DESCRIPTION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from U.S. Provisional Application Ser. No. 60/531,716 entitled BIOSUSTAINING WASTE ACTIVATED VERMICULAR ENVIRONMENT filed on Dec. 22, 2003, incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates generally to the field of waste treatment systems, and more particularly to a waste treatment system in which the waste is treated by being digested by worms.

BACKGROUND OF THE INVENTION

The ability of worms to compost organic matter has long been known. Various attempts have been made to apply this knowledge to treating human waste. For example, U.S. Pat. No. 4,262,633 (Taboga) discloses using worms for reclaiming and processing biodegradeable waste into poultry products and humus-like substances. U.S. Pat. No. 5,192,428 (Lindstrom) discloses using worms in a natural composting bed which includes human waste. U.S. Pat. No. 6,223,687 (Windle) discloses using worms for composting a thin layer of biomass, and especially cow manure. U.S. Pat. No. 6,601,243 (Colombot) discloses using worms to compost a composting medium formed in part by human waste.

Common limitations are the quantity of waste able to be processed and the smell involved when processing human waste. The known prior art which uses vermiculture to process wastes requires extensive processing of the waste

CLAIMS (49)

1. A system for processing sewage into vermicompost, comprising:

at least one holding tank, wherein said sewage is initially processed;

at least one treatment tank connected to said holding tank by a first pipe, wherein said initially processed sewage from said holding tank is treated to ensure optimal pH, percent of solids, and electrical conductivity of said sewage;

at least one distribution tank connected to said treatment tank by a second pipe, wherein said treated sewage from said treatment tank is heated or chilled as necessary to reach an optimal temperature; and

a distribution apparatus, connected to said distribution tank by a third pipe, which distributes said sewage to a vermicular environment, wherein said vermicular environment contains a plurality of worms, wherein said worms digest said distributed treated sewage into vermicompost.

2. A system according to claim 1, further comprising a first screen, a first agitator, and a first pump operatively associated with said holding tank.

3. A system according to claim 2, further comprising a second screen, a second agitator, and a second pump operatively associated with said treatment tank.

4. A system according to claim 2, further comprising a coarse screen operatively associated with said first holding tank and disposed such