RESEARCH ARTICLE

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Small Scaled Home Composting Machine and Use of Trichoderma As A Bio-Fertilizer Agent

Prasanna S. Mahankar[1*], Yogesh Dandekar[2], Mahesh Shukla[3], Abhijit Getme[4] , Shruti Dhole[5]

[1.*] MKSSS's Cummins College of Engineering for Women Nagpur, India; e-mail : prasanna.mahankar@cumminscollege.edu.in

[2-5.] MKSSS's Cummins College of Engineering for Women Nagpur, India.

ABSTRACT

Organic waste composting is the leading way of recycling. By controling the microbial aerobic decomposition process of organic waste organic fertilizer can be otained. In the present paper a new design of home composter machine useful for a family of 4 to 6 people is discussed. A shredder with effective cutting angle and Trichoderma, a biofertilizer agent, are the main features af the machine. The motive behind using shedder is to cut solid waste into very small pieces and reduce the composting reaction time. Waste after cutting is decomposed by Trichoderma in the presence of required air circulation and temperature to form organic fertilizer. Trichoderma degrades organic matter and also produces nutrients and growth regulating compounds which is useful for plants. For efficient composting, other than better air circulation, frequent turning of waste, optimum level of moisture content use of some bulking agents like sawdust biochar were also taken in consideration. It resulted in the disposal of waste at the source and opening new economical avenues by producing fertilizer at home.

Keywords: Home Composting, Organic Waste, Trichoderma.

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INTRODUCTION

Composting is the natural process of decomposition of organic matter by microorganisms under controlled conditions. Composting process is necessary since the expelled biological materials contains complex chemicals which cannot be used as resource materials; hence they are converted into the simple inorganic available nutrient. If the waste is directly been put into the soil it will undergo conversion inside the soil which will take the nutrients from the crop and soil. Hence recycling plays an important role in maintaining soil quality, suppressing plant diseases and pests as well as reduces the need for chemical fertilizers. A typical composition of residential waste is given in figure 1 and it is estimated that average household waste is around 3.95 kgs per week. Hence there is a need for waste recycling [1-2].

In the present case, most of the composting machines that are available in the market are huge, expensive and require electricity, and are not suitable for recycling house waste. Hence this machine turns out to be a good option for a family of 4-6 people. The new design of the small composting machine has a shredder that cuts the kitchen waste into small pieces the shredder requires less torque to cut hence a handle is provided that rotates the shredder, where the shredder has an effective cutting angle. This designed home composting machine aims at reducing the municipal organic solid wastes generated at houses and it helps the users to make

Corresponding Author : Prasanna S. Mahankar, MKSSS's Cummins College of Engineering for Women Nagpur, India; e-mail : prasanna.mahankar@cumminscollege.edu.in

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their natural fertilizer. The home composter can be operable by everyone in the house and it can be placed in balconies or kitchens without causing any issues in the kitchen. We get biofertilizer in 19-21 days because of 2 reasons, first being cutting the waste into smaller pieces and 2nd using the chemical Trichoderma. Trichoderma is a biofertilizer agent which degrades the organic matter and produces nutrients and growth-regulating compounds for the plant and increases the speed of composting. Trichoderma spp. can kill plant pathogens and enhance plant growth stated that it works by degrading the cell wall of the food waste that decreases the rigidity of the cells inside the waste breaking the cellulose and hemi-cellulose. Through this proposed machine the food waste that was just discarded earlier now can be used as a biofertilizer in the house itself [3-5].

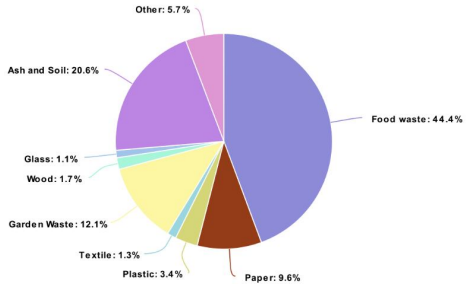

Figure 1: Typical composition of residential waste [2]

DESIGN, FABRICATION AND MATERIAL

CAD Design

CAD model of the compost machine as given in figure 2, shows different part of machine. It is designed to get a real idea of what the machine would look like in real life and to get the design of the machine for fabrication.

Figure 2: CAD Model

Fabrication and Mounting of Parts

Frame : The frame acts as a supporting structure for other components of the composting machine such as cutter, hopper, mesh plate, wheels, etc. Thus, frame needs to be strong enough. Considering all the factors (such as load-carrying capacity, strength, etc.), the frame of 500*400*400 mm made up of mild steel. It is shown in figure 3.12 iron angles of L shape are used to cut the exact squares of 50 mm sides. These angles were welded together carefully achieving a structure of equal size and proper alignment.

Hopper : Hopper is the primary part of the machine. It is trapezoidal in shape since it's used to maintain the laminar flow of the waste. The material of the hopper is a sheet of shaded tin because it is cheap, easily available in the market, and light weight. It is designed in such a way that one can feed kitchen waste continuously by hand into the hopper. Through the hopper the kitchen waste then falls on the cutter.

Mounting of Hopper: Hopper is mounted on the cutter and is made of shaded tin which is 0.8 mm in thickness in a trapezoidal shape.

Figure 3: Hopper

Cutter : The cutter is the main part of the machine. The purpose of the cutter is to cut the kitchen waste into smaller pieces. Cutter has 28 blades since the blades require less torque for cutting, 28 blades are sufficient to cut the kitchen waste. The material of the blades is Mild Steel. In between them, a Nylon rod of 5 mm thickness is used as a spacer. The blades and spacer are mounted on a shaft which is fitted by nut and bolts. The material of the rod is MS Bride bar. It is manually operated.

Mounting of Cutter : Cutter is mounted on a cage. The purpose of this cutter is to cut kitchen waste

into small pieces (onion, tomato, spinach, chilly, potato, cabbage, etc.). It is made up of mild steel blades. These blades are mounted on a shaft which is made up of a bride bar of diameter 19 mm. The distance between the two blades is 5mm which is maintained by adding a 5 mm nylon spacer. It is fitted on the cage with the help of pedestal bearings. For making the cutter, an MS sheet of thickness is 0.8 mm is used to cut the sheets into a circular shape. The outer diameter of the plate is 140 mm and the inner diameter is 20 mm. The plate undergoes shearing and the shearing angle is 65 degrees.

The less is the shearing angle the greater is the strain, machining forces, and power required. But to cut the kitchen waste we need less torque and less machining forces so a very small shearing angle is undesirable hence 65-degree angle is been chosen. Fabricated model of cutter is shown in figure 4.

Figure 4: Cutter

Body : Body contains four parts—

i) Compartments
ii) Mesh
iii) Door
iv) Wheel

Compartments :1st compartment The decomposition process is carried in the first compartment. Here the dead tissues break down and are converted into simpler organic forms. As soon as the breakdown of food waste starts to take place the waste starts to reduce gradually over a period of time and after 21 days, we get fully finished fertilizer. The size of the compartment is 300*400*400 mm.

2nd compartment: This compartment is used for the Collection of fertilizer. The size of the second compartment is 200*400*400 mm. The material of the compartments is acrylic sheets. The Compartments are separated by using a Mesh. The complete design of body is fabricated as shown in figure 5.

Mesh : Cut waste rests on the mesh plate for 21 days. After completion of the cycle, fertilizer comes out in the second compartment through a vibrating mesh plate. The size of the mesh plate is 400*400mm and the size of the hole is 5mm. The material of the mesh plate used is Mild Steel.

Door : A door is provided for collecting the fertilizers and to vibrate the mesh plate.

Wheel : Wheels can be added at the base so that it is easily transportable.

Figure 5: Body of composting Machine

Mounting of Acrylic Sheet and Cage : After ensuring proper alignment of the frame, a transparent acrylic sheet is fitted in the L-angle with the help of nuts and bolts to damp vibrations of the cutter and for proper alignment of wheels. Also, with the help of nut and bolt the mesh plate is fitted tightly.

The cage is mounted on the body and it supports the cutter to cut the waste. The cage is made up of a plate that is slotted first in rectangular shape and then an MS rod of diameter 3 mm and is welded on a rectangular plate. The distance between two rods in the cage is 3mm.

Moisture

As the volume of available water increases, the rate of decomposition also increases. Many decomposers secrete enzymes onto decaying matter and then absorb any dissolved molecules. Without water, this reaction cannot occur. To decide the exact amount of moisture to be maintained in the biomass series of experimentation is conducted and values of reduction of moisture with respect to days are observed. The complete decomposition process is carried out for 19 days and amount of biomass is measured on 1, 5, 10 and 15 th day as given in Table-1. This is expressed in terms of the amount of

water to be added for the required moisture level. Having too little moisture will slow or stop the composting process. Having too much moisture in the pile will fill the necessary air spaces and turn the process into an anaerobic digester which is undesirable.

Moisture content to be added is decided as follows:

Moisture Content (% wb): = (Initial Weight of Kitchen Waste - Final Weight of Kitchen Waste)

We try to maintain the moisture level as far as possible. If the compost it too wet we can add newspaper, brown (unbleached) cardboard or chopped straw. If the compost is too dry a simple solution would to be to add water but not too much to drench it completely.

Table-1: Experimental reading vs days needed

Sr.No	Day	Experimental Reading (gram)
1	1	390
2	5	245
3	10	144
4	15	95

Specifications

The following are the dimensions and the material of each component of the composting machine given in the table-2.

Table-2: Specification of every component of machine

Sr. No.	Component		Material
1	Hopper	H =250mm TL=240mm BL=140mm T=2mm Slope Angle=1050	Shaded tin
2	Cutter	L=180mm Dia. of shaft=19mm Cutting Angle=550 Dia. of blade=140mm Length of cutting blade=140mm	Mild steel
3	Compartment 1	300*400*400mm	Acrylic sheet
4	Compartment 2	200*400*400mm Total Dia.=500*400*400mm	Acrylic sheet
5	Mesh	400*400 Hole size= 5 mm	Mild Steel

A step-by-step block diagram of this home composting machine and finished model is given in figure 6 and figure7 respectively.

As shown in figure 6, the house waste is fed to the hopper and falls on the cutter where the cutter cuts the kitchen waste into smaller pieces, then the waste goes into the compartment where the composting process starts and then the compost stays for 19 days on the mesh plates and then it can be collected through the door for further purposes.

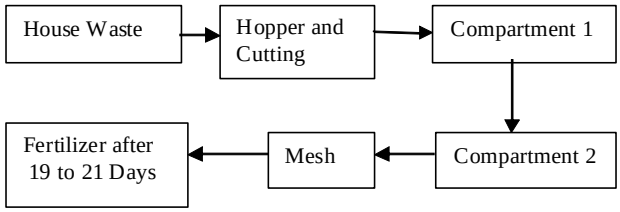

Figure 6: Block diagram of Working of home compost machine

Figure 7: Finished Model

RESULT AND DISCUSSION

Composting Process

1 kg of kitchen waste is added into the hopper and then the cutter cuts the waste into smaller pieces then this cut waste is stored in the first compartment where the process of decomposition will start. After the process starts to maintain the moisture by about 40%, we add Trichoderma and water to the required quantity. In half liter water, we add 2ml Trichoderma, and for the next 19-20 days we add 1kg waste and the same amount of water and Trichoderma and will observe the process for 21 days. Then the kitchen waste which was added first will convert into fertilizer and will be stored in the 2nd compartment and this process continues even after 21 days. The complete decomposition process is also shown in figure 6.

1 kg waste + 0.5 liters water + 2ml Trichoderma
(9,12,15-octadecatrienoate+ phytol)
($C_{20}H_{40+}$ $C_{19}H_{32}$)

↓ Repeat the same process for 19-20 days

On 21st day we get the Fertilizer

Trichoderma chemical is used in the composting process but Trichoderma is a genus of saprophytic fungi that feed on dead decaying plant matter and breaks down the complex organic matter into simpler substances that are taken up by the plants for various metabolic activities, because of which the reaction rate of the composting increases as the Trichoderma feds on the kitchen waste.

Trichoderma degrades the cell wall of the kitchen waste and decomposes it. The chemical releases after decomposing also turns out to be a nutrient to improve soil quality and plant yield. The plant cell wall being made up of cellulose and hemi-cellulose, the T. virens present in Trichoderma produces a cell wall degrading enzyme. This activity eventually accelerates the degradation of cellulose and hemicellulose that help to reduce the time of the decomposition process. It is reported that the degradation of the crop residues such as cane trash, paddy trash and wheat trash with mixture or urea, cattle dung mixed with Trichoderma spp. have increased N, P, K (Nitrogen, Phosphorous Potassium) content. Trichoderma infused-compost also increases the yield of plant to about 9-12%.

Besides this Trichoderma produces nutrients and growth regulating compounds for plant whereas, they also help plants to uptake nutrients, overcome stress episodes and can difficult the proliferation of pathogenic fungi and acts as a biocontrol agent of plant disease. Hence the generated compost turns out to be the best bio-fertilizer. Adding the chemical Trichoderma decreases the reaction/ composting time to nearly half from 40-19 days. [5-9].

Physical Properties of Composting Process

Aeration: Oxygen is essential for the respiration of aerobic microorganisms. Without sufficient oxygen, the process will become anaerobic and produce undesirable odour. Aeration is also useful in reducing the high initial moisture content in composting materials. Therefore, we need to maintain aerobic conditions. This is simple: mix and turn as frequently as necessary or at least once daily.

Moisture: The moisture content of 50 - 60% is generally considered optimum for composting.

(i) Too little moisture (say, less than 30%) inhibits bacterial activity; and

(ii) Too much moisture (more than 65%) results in slow decomposition, odour production, and nutrient leaching. If the compost crumbles, it is too dry. That means you need to sprinkle some water and enhance the moisture level. Frequencies of turning or total number of turns are governed primarily by moisture content and type of material.

- Moisture> 70%: it should be turned every day until the moisture content is reduced to less than 70%
- Moisture 60%-70%: turn at 2-day intervals; approximate number of turns, 4 to 5
- Moisture 40%-60%: turn at 3-day intervals; approximate number of turns, 3 to 4
- Moisture below 40%: add water.

Temperature: At certain temperatures, certain microorganisms are most active. Generally, in a range of 50 to 65 degrees Celsius, proper composting takes place. It is found that actively working microbes can raise the pile's temperature by as much as 60 to 65 degrees Celsius. The temperature in your compost determines how much and how often aeration is required.

Fertilizer and Source of Kitchen Waste: Avoidable food wastes include the food that was thrown away when it could have been sold or eaten. Unavoidable wastes were vegetables and fruit peels, eggshells, etc. Using trichoderma complete amount of biowastes converted into fertilizer in a period of 19-21 days. It is found that the addition of fungi(Trichoderma) to compost reduces the decomposition time of three lignocellulosic components, cellulose, hemicelluloses, and lignin.

CONCLUSION

The proposed machine cuts the vegetable waste into very small pieces and the rate of the decomposition process is increased with the addition of the Trichoderma chemical. Cycle time is reduced to 19-20 days. This small size home composting machine does not require electricity, portable and

can be operable by everyone in the house. 60 to 70 % of moisture level with a turning of mixture at day 2 to 3 and the temperature of 50 to 60 deg Celcius is optimum for decomposition of organic waste and effective production of organic fertilizer. Trichoderma can be effectively used as a bio fertilizer agent for converting organic waste into fertilizer. A home composting machine with other geometries of cutter, cutting angle and other bio fertilizer agents can be a taken as a future work.

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