International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 06 | June - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Fabrication of a Portable Solar Operated Garbage Composter Machine for Sustainable Waste Management

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ABSTRACT:
Garbage collection is an important task of ensuring that our communities have a pleasant environment in which to live. But the main problem we face today can be reduced by reducing or minimizing the amount of waste transportation, specific waste. A compactor can be used to reduce the amount of waste streams. The waste burden remains the same so there are no savings from the total waste generated. However, the amount of waste can be reduced by up to 80%, eliminating the need to empty the dumpster many times, resulting in lower pick-up charges. These paper focus on, to identify and analyze concepts and strategies for waste recycling. Its aim is to reduce their negative impact on the environment and human health and natural resources. Right now, garbage is an existential problem in India, so you must find financial solutions. In developing countries, reducing the amount of waste is one of the major challenges that need to be addressed to improve living conditions. By using management in waste recycling, one can contribute to urban development, but we must remember that there is a significant cost involved in waste management. In conclusion, we noted that the necessary discussions and discussions are taking place nationally and internationally to adopt management strategies in the area of waste recycling.

Keywords: Solar energy, Waste Management, Organic Composting, Composting process etc.

1. Introduction

Recently, the world has increased human interest in everything organic. According to Forbes, despite the high price tag, a large number of people prefer natural, organic or locally available food. Therefore, many people have started their own organic gardens. To ensure that their plants are getting enough nutrients, the soil should be properly conditioned without any chemical treatments. This farming method is called organic farming. Organic farming began in the 20thcentury. This alternative farming approach is mainly based on the following organic fertilizers [1]

Manure: Used as organic manure and a mixture of animal feces and grass. This organic matter was previously the main fertilizer.
Green manure: This popular practice has many benefits for the soil in the agricultural industry and in home gardening. It involves the transplantation of a variety of plants into the soil over a long period of time.
Bone Manure: Also known as bone meal, it is a mixture of animal bones found in kitchen waste. It is a slow-release organic fertilizer that contains the right amount of phosphorus and protein.
Composting: This is an inexpensive and environmentally friendly way to create nutrient-rich humus to promote plant growth and restore vitality to depleted soil. It is an organic fertilizer that occurs in nature, because it is basically an acceleration of the natural process, knowing that everything decomposes.

Therefore, the theme of this Capstone project will be composting. The goal of this Capstone project is to implement a pilot study with the realization of an experimental composting system [2].

2. Problem Identification

Waste of food is a serious problem these days. Our way, rubbish containers, landfills have enough evidence to demonstrate this. In recent years, food waste has become a complex phenomenon that attracts attention from researchers, buyers and activists [3]. It has been recognized around the world as a paradoxical approach to improving food security and emphasizing agriculture as ending up as distributed food waste. This is indicated by the FAO (Food and Agriculture Organization of the United Nations) report in 2013, which shows that 1.6 billion tons of whole food intended for human consumption per year accounts for about 33% of subsistence. It is becoming a matter of grave concern because of the economic, social and natural costs associated with it [4].

3.Objectives of Study

1. To Design and manufacture Garbage Composer which will make blocks of garbage for easy handling.
2. To analyze various forces this will be imparted on the parts of Composer while handling the garbage
3. To find solution to overcome and increase life of Composer parts.
4. To developed this model on portable size and powered with solar energy.
5. To developed all function like, garbage crusher, garbage mixer, water spraying and heating in compact model.

4. Literature Review

• Gaurav Chiplunkar and Prof. (Dr.) Avinash More,[1] In INDIA, approximately 50% Biodegradable Waste is generated in total MSW composition and now the numbers is increasing. So we have come up with idea SMART Composting Machine. Design of machine is such that every day we can process 10 to 15 kg of organic waste The paper is about processing daily Food Waste in such a way that we will get Fertilizer as our product. In this process Organic waste is going to get crushed in semi-powder form and then it will go under continuous mixing and heating process.

• Waruse Amir Hamza et al. [2] , Composition involves the method of aerobic decomposition adding bacterial action on bio degradable organic waste with heating 50-60 degree Celsius, results in good quality control. This paper works on fabricating a semi automatic composting machine using solar technology which uses home waste material and converts it useful fertilizer used for the development of plants. It uses 30 days for the whole process which consists of heating, mixing, ventilation, and addition of culture.

• Ahammad Vazim K. A et al [3], this paper was to design and fabricate a low cost food waste composting system which ultimately accelerate the composting process. Experimentally it was found that the composting of normal vegetable residues take about 60 days with the help of a bacterial composter, like any biochemical reaction time duration required for the completion of composting was contributed by many factors which includes particle size, water content, temperature, air circulation. The device fabricated was fully functional in controlling the major factors among the above stated and can accelerate the overall process by 50%.

• Mansi Pare and Mohd. Aman [4], The designed machine is a fully automatic and highly compact composting machine, which uses special microorganisms to break down and decompose all kinds of organic waste into compost within 24 hrs with a volume reduction of 85-90%. The entire process is natural and biological. The microorganisms we use thrive in high temperature and are effective even in high acidic or salty conditions. The machine has a U-shaped composting tank, with a humidity sensor, heater, mixing blades and an exhaust system. When organic waste is added to it, moisture is sensed by the humidity sensor, heater, mixing blades and an exhaust system.

• B Naveen kumar et al [5], The organic compost machine is used to make composting and the quality of the compost is depends upon factors such as temperature, time, aeration, moisture content, brown and green waste. This machine decreases the cost required for degradation, segregation, etc. of the waste. The total volume of organic waste is minimized. All materials required for composting are easily available so, it can be practiced at homes in the kitchen with very little cost.

4.1 Modern Composting

Sir Albert Howard introduced the indoor method in 1905. After 30 years of research Howard discovered the best modern compost. It consists of alternating layers of green, compost and soil until it reaches the desired height. The pile should be moist and rotated regularly according to the desired aerobic conditions, then the compost will be ready within a period of three months.

4.2 The Advantages of Composting:

Nowadays, composting is known for its many benefits [7]:
Reduces yard and food waste by 30% of waste flow and thereby removes those wastes from landfills.
• Well prepared compost makes the plants look better, produces better and is more resistant to disease.
• Addition of organic matter to the soil improves moisture retention.
• Addition of dissolved organic matter in the soil provides nutrients to the soil organisms.
• Compost provides a balanced source of nutrients, which helps the soil retain nutrients longer so that plants can utilize them.
Composting saves money.
• Manure improves our diet and plants contain the right amount of nutrients.

4.3 The Biology of composting:
Composting is a natural process. It involves all the natural decomposing activities in nature such as leaf breakage or animal manure aging. However, this process takes a lot of time, and here comes the importance of composting. In addition, fresh organic matter must be composed before being added to the soil, otherwise it can lead to ecosystem changes.
Well-prepared compost is dark brown in color and has a wild odor. It is made up of carbon, nitrogen, oxygen and water. These four factors are essential for the effective functioning of the composting organism.
Carbon: Brown material, which provides energy and produces micro-oxidized heat of carbon.
Nitrogen: Most organisms use fruits and vegetables that oxidize carbon to grow and reproduce.
Oxygen: For the oxidation of carbon, the decomposition process.
Water: In the right amount to maintain activity without creating anaerobic conditions.
The biology of compost is easy to understand. It starts with the carbon cycle. Carbon compounds are the source or high metabolic reaction that raises the temperature during composting. However, the loss of CO2 and H2O during the process reduces the nitrogen balance, i.e. the carbon-nitrogen (C / N) ratio decreases. Bacteria that stabilize nitrogen to compensate for this loss. This reaction is high at the end of decomposition and is affected by the presence of ammonia and high temperatures. Oxygen availability is also important because our process is bio-oxidation. Therefore, the compost should be rotated daily to supply O2 and allow for aerobic respiration. It is important to ensure that the percentage of oxygen in the compost does not fall below 18%.
Another important composting factor is temperature. Contrary to popular belief, high temperatures are required for good composting, as high temperatures slow down the decomposition process of organic matter. In fact, only bacteria below 70 C can work. The best conditions are different temperatures between 45 and 50 C. It is also important to maintain an adequate moisture level. This reduces the structural strength of the organic lotion and consequently accelerates the decomposition process.
With a high degree of accuracy, the C / N ratio should be between 25 and 35. If the ratio is less than 20, nitrogen is lost and ammonia is released, causing the compost to stink. However, if the C / N ratio is greater than 40, the decomposition

process will slow down. The size of the material is also an important factor. For rapid and efficient decomposition, the size of the compost material should be between 1.3 and 5 cm. If the materials are very large, it is important to reduce their size. The size should not be too small or cause a gas lake [9].
The following chemical reaction captures the composting process:
Organic waste + O2 → Compost + CO2 + H2O + Heat.

4.4 Composting Steps:

- It is imperative to be aware of the above factors and follow the next steps to make healthy compost:
- 1- Build a compost bin. Its size depends on the amount of compostable material
- We want to produce.
- 2- Select the compost location. The area should be flat and sunny.
- 3- Replace layers. The first layer should have branches to let air in.
- The second layer is the leaf covering, then we alternate the carbon and nitrogen layers until the bin is full.
- 4- Compost bin maintenance: Make sure the material is sufficiently moist and mix the compost once a week to help with the breaking process.
- This process can be done easily without mandatory farming experience. Indoor composting can be yard compost, for this type we need yard, fallen leaves or grass and grass clippings and food scraps. Or worm composting: A small yard or apartment will work well with enough food scraps.

5. Proposed System

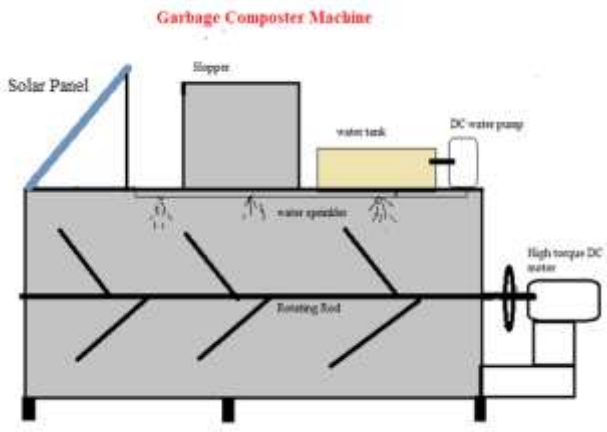

Fig.1 Proposed system of composter machine

Working Principal

- Composter is a simple mechanism involving use of solar energy to control the working of whole composter system. A compactor consists of cylindrical block in which the garbage is collected from the people in the society comes and through the garbage in the cylindrical block which is placed inside the society.
- Composter mechanism is performed through the action of belt-pulley mechanism and high torque dc motor. The dc water pump with water tank is place on the top of machine. Whenever we need to wet the mixer inside drums, the pump system is sprayed the water on it.
- Whole machine is heated by solar energy coming from sun. the whole machine is covered with aluminum frame. So that, it is easily heated. Also this energy is utilized by solar panel and convert into electrical energy. This electrical energy is stored into 12v battery. Further it is used to operate all functions.

- There is window at bottom of drums, to collect the composter after few days of degradation process.
- The composter is to be designed and analyzed such that the whole system sustains the crushing ,mixing force and maintain structural stability.

6.Components and Its Specification

Table 1. Components Specification

Sr. No.	Components	Rating	Specification
1	Solar Panel	12v25w	Provide power to system
2	Battery	12v14ah	Power storage
3	Adapter	12v 5ah	External power source
4	High torque DC motor	12V 50kg	For rotating mixing mechanism
5	DC water Pump	12v 1ah	For water sprinkler
6	Aluminum sheet	-	For hot temperature spread

7.Calculation

- **Solar Panel Calculation:**

$I_{pv} = E_i / (V \times H)$

Ipv, photovoltaic current = total current required to charge the battery from the solar panel
Ei= input energy to the battery
V = system voltage = 12V
H = peak sunshine hour, the average number of hours the solar energy can be captured. H = 5hrs.
Thus
Ipv=4395.06/ (12 x 5)
= 73.25Amperes.
In order to compensate for the losses due to the inefficiency of the solar panel,20% of Ipvis added so that
Ipv= 73.25 + (0.2 x 73.25) = 87.9A.
With a solar panel of the above rating, the peak or open circuit voltage, VP = 12V , 25w.

- **Motor Calculation:**

Cutting area made by edge of the blade:

A= W × T
A= 2mm× 2mm
A= 4 mm 2. 7 mm
Where, A = cutting area made by edge of the blade.
W = width of cutting edge.
T = thickness of cutting edge.

Force acting on edge of the blade:

Shear strength = 51.71 MPa.
Shear strength = Force /Area
51.71= force ÷ 4
Force = 206.78 N.

Torque exerting on the blade as well as shaft for cutting:

Torque (T) = Force × perpendicular distance
Torque = 206.78 × 50×e-3
Torque (T) = 10339 Nm.

Power required to mix the material

Required speed, N = 60 rpm
P = (2×Π×N×T) ÷ 60000
P = (2×3.143×60×10339) ÷ 60000
P = 64.92 w.
=>P = 1 HP (Aprox. DC power motor required).
We use 50 kg high torque dc motor to mix the materials. As per box capacity aprox. 30 kg of waste materials.
Blade material: mild steel [ultimate shear strength = 580 Mpa]
Assume factor of safety [FOS] = 3
FOS = ultimate tensile shear strength ÷ working shear strength
3 = 580 ÷ working shear strength.
Hence design is safe.
i.e; working shear strength = 193.33 Mpa > 51.71 Mpa.

- **Design of hopper**

Volume of the hopper = 1/3 [A1 + A2 +√(1 + 2)] × h
Where, A1= Area of top base
A2= Area of bottom base
h= Height of hopper

Volume of the hopper = 0.035625 m^3

- **Determination of shaft diameter**

$$d^3=\frac{1}{\pi}\sqrt{(K \times M)^2 + (K \times M)^2}$$

Where,
d = diameter of the mixing shaft = 10 mm
Allowable shear stress of metal with key way = 40 × 106 N/m2
Mb = maximum bending moment = 25.61 Nm
Mt = torsion moment = 22.3 N
Kb = combined shock and fatigue factor applied to bending moment = 2.0 (sudden loading)
Kt = combined shock and fatigue factor applied to torsional moment = 2.0 (sudden loading)

- **Pulley and speed of shaft**

By studying various research papers on design of plastic waste shredding machine we select the a speed of final output shaft, and the diameter of pulley. We assume that the input speed as per the motor specification which is mentioned as below.
We select the motor of ½ HP (dc high torque). and assume the motor speed is 300 rpm. The calculation for determination of pulley diameter and the speed of output shaft is given as below

Motor power = 1 HP (DC high torque)
= 0.372849 kW
Speed of the Motor = 300 rpm
Diameter of Pulley 1 = 50 mm (d)
Speed = 300 rpm (N1)
Diameter of Pulley 2 = 101 mm (D)
Speed (N2) =?

$$\frac{D}{d} = \frac{N1}{N2} \text{ rpm}$$

N2 = 149 rpm

8.Advantages of Composting

Now a days, composting is known for its numerous advantages which involve:

• Reducing yard and food waste make up 30% of the waste stream and therefore diverting that waste away from the landfills.

• The plants from a well-done compost will look better, will produce better and will have a much greater ability to fight diseases.

• Adding organic matter to the soil improves moisture retention.

• Adding decomposed organic material to the soil feeds the soil's organisms.

• Compost provides a balanced source of nutrients that helps the soil hold nutrients long enough so that the plants can use them.

• Composting saves money.

• Composting improves our diet, the plants will have fair amount of nutrients.

9. Results & Discussion

The composting process:

As mentioned in the literature review section, compost can be aerobic or anaerobic. The aerobic composting method was chosen for this project for various reasons. First, aerobic composting is faster because microorganisms eat and decompose organic matter faster and more efficiently than anaerobic ones. Considering the duration of the project, the airless method seems to be the best. Second, anaerobic bi-composting should be done underground to prevent it! By moving into compost, it further complicates the task. However, aerobic-composting works in the terrestrial environment and does not require digging into the soil. The selected process is a fast composting process that takes 14 to 21 days. This method requires changing the manure daily so that the microbes can get enough O2 to speed up their activity. In addition, a daily turn prevents the compost from overheating, which kills microorganisms and restarts the composting process. To track compost progress and measure its quality, I measured the temperature, pH and humidity of the compost at specific times.

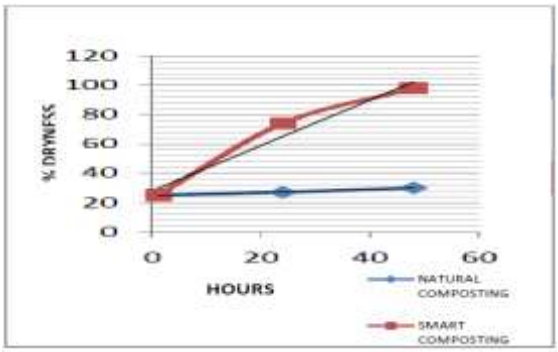

Fig. 6: Natural Composting –vs- SMART Composting

10. Conclusions and Future Work

To conclude, the project converted the organic waste into compost using a solar-powered composting machine. A pilot study was conducted to test the composting process using real waste. There are successful results, which mean the heavy can works effectively. Steps and recommendations are given in the report; however, for the project to continue, future work must be done at the top level. People need to maintain a compost machine because they have already taken the initiative to compost. In addition, kitchen waste or other organic waste must be sorted for inclusion in the composting material. Finally, the whole community should be aware of the importance of compost and participate in its continuation.

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