Design and Development of Small Capacity Composting Machine for Domestic Wet Waste: A Review

Shoaib Kazi, Rohan Kulkarni, Chinmay Mulay, Satyajeet Bhosale, Omkar Siras

Department of Mechanical Engineering, Smt. Kashibai Navale College of Engineering Pune

Abstract

The current techniques of composting are Time consuming, Harmful for the environment due to release of gases like Methane and Carbon Dioxide, creates health hazards for residents, 100% of wet waste is not treated. Incomplete aeration of wet waste leads to generation of harmful acetic acid, Transportation of wet waste require heavy duty vehicles which consume greater amount of fossil fuels. It is clear that as we accelerate into the future, new methods for proper wet waste disposal are needed. These methods should be environment friendly, at root levels and should be designed considering the future needs.The objectives are to overcome the previous existing composting problems and to design a composting machine with certain parameters such as process time,easy to use,compact,odourless,use of automation,rapid composting and power saving.

I. Introduction

In ancient Athens each household was responsible for collecting and transporting its wastes. They used to place their wastes, covered periodically with layers of soil, in large pits. These practices basically are fundamentals of waste management nowadays. Most waste still ends up in landfill. However, before the industrial revolution the human population was about 1 billion people, now it is 7.5 billion. Before the demographic explosion humans could afford to simply take the trash somewhere out of the abode, today it is impossible. Mankind needs new solutions immediately. Waste management systems based on the collection of waste and transportation to disposal sites are outdated. It has been estimated that collection costs range between 40 and 60 % of a community's solid waste management costs. Moreover, garbage trucks are involved in more than 5 fatal accidents per 100 million miles travelled. Elimination of waste collection could also prevent CO_2 emissions of 4.2 to 12 kg CO_2 per tonne of waste, depending on the types of vehicles employed in the various stages of waste transportation and the estimates of payload and average journey distances. Disposing food waste into the landfill can cause the organic matter to react with other materials and create toxic mixtures Unfortunately, the use of some of these solutions such as dumping and waste burning in the home is disastrous.For a considerable time a large variety of waste management practises have been studied and developed. Some of them were adopted as key solutions in waste management, namely: source reduction, collection, recycling, composting, incineration (burning), landfilling and simply dumping. The higher the income per capita, the more effective and safe for environment and population are the solutions used in a particular region .

Food waste is becoming a critical global problem due to the continuous increase in the world population. It is stated that one-third of the food produced in the world for human consumption every year — approximately 1.3 billion tons — gets lost or wasted. The environmental implications of food waste to climate change is catastrophic. Thus, there is an urgent need to take appropriate actions to reduce food waste burden by adopting new combating practices. Thus, recycling food waste to compost is preferred more. Moreover, composting food waste will reduce the volume of the disposed waste and the disposal cost. In addition, it has a big environmental benefit, which is the absence of synthetic chemical fertilizers in compost. Thus, with all the benefits that the compost we get when recycling food waste holds makes it healthier for human usage than the man-made compost sold in the market.

This paper aim is to show the importance of recycling food waste and helping the environment by building a machine that converts food waste into compost. This food waste recycler machine is to be built and used at home safely. Since the world is seeking sustainability, our machine aims to lessen the food waste that is thrown into the landfills, which pollute the environment by recycling the food waste and turning it, in less than 30 hours, to compost that can be used in fertilizing the soil to plant healthy and organic food, and contributing in creating a safe and sustainable world.

II. Methodology

Juan Pablo Arrigoni, et.al authors have explained the thermal performance and stratification effect on process of small scale composting of kitchen and garden waste in vertical compost bins. In cold climates, decentralized small-scale composting performance to reach thermophilic temperatures (required for the product sanitization) could be poor, due to a lack of critical mass to retain heat. In addition, in these systems the composting process is usually disturbed when new portions of fresh organic waste are combined with previous batches. The objective of this work was to improve the understanding of these technical aspects through a real-scale decentralized composting experience carried out under cold climate conditions, in order to assess sanitization performance and to study the effects of fresh feedstock additions in the process evolution. Temperature profile, stability indicators (microbial activity, carbon and nitrogen contents and ratio) and other variables (pH and electrical conductivity), were monitored throughout the experiment.

M. Margaritis et.al, In this research paper, the objective was to perform and analyse a comparative research of the effect of four different additives viz. woodchips, perlite, vermiculite and zeolite in the composting process. The parameters that were monitored were temperature, moisture and pH. Four prototype bioreactors were used simultaneously to conduct the experiments. An additional bioreactor, containing no additives was used as 'blank' for the initial evaluation of the performance of the prototype bioreactor. Additives were added in a proportion of 10% w/w of the initial biowaste feed mass. The initial properties of the raw substrates were the following: moisture content = 69.8 ± 5.03% w/w, bulk density = 0.48 ± 0.08 g cm^3 w/w and pH = 6 ± 0.3. The temperature, moisture and pH variations that were observed for different.

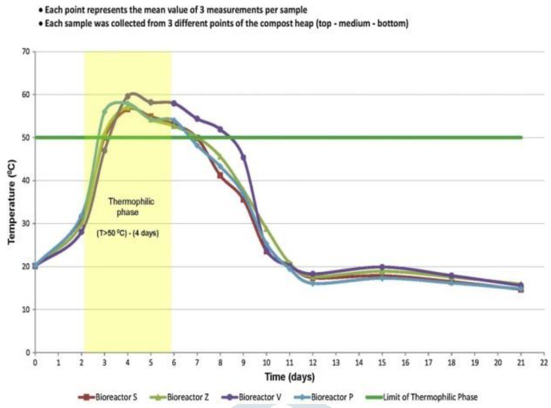

Fig.1 Variation of temp w.r.t time[2]

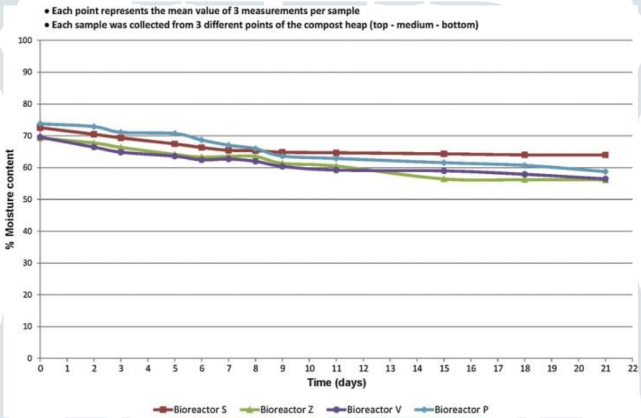

Fig.2 Variation of percent moisture content w.r.t time[2]

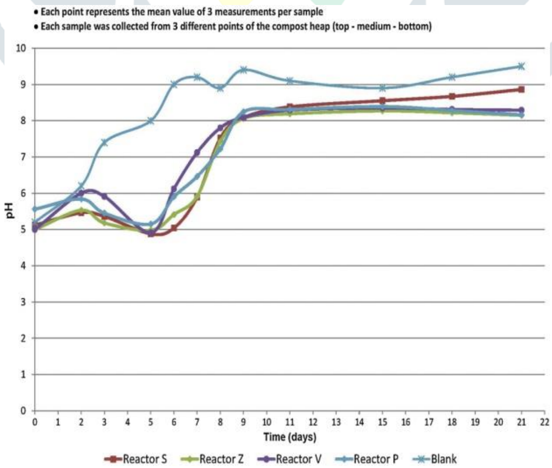

Fig.3 Variation of ph w.r.t. time [2]

The graph of moisture vs days shows that the initial moisture of the substrate, for reactor S is 74.82% w/w, for reactor Z it's 72.55% w/ w, for reactor V it's 69.28% w/w while for reactor P it's 69.56% w/w. These values are quite high due to the nature of the substrate. At the beginning the pH is slightly acidic due to the degradation of easily degradable compounds and the formation of organic acids. The action of proteolytic bacteria and the subsequent ammonization part of the organic nitrogen has resulted to an increase of the pH reaching the maximum value on day 15. At the end of the experiments it was observed and concluded that the moisture content of the finished product ranges between 55 and 65% and the pH in the final product is very basic, presenting values from 8 to 9.

Jayant Nikaju,VivekBorkar et.al This paper has all the parameters and calculations for the composting machine which is designed by authors. Composting is an aerobic process in which microorganisms degrades the organic waste to nitrogen rich manure. Currently only 9-10% of organic waste generated utilized for composting. The organic compost machine is designes and used to degrade the organic waste such as food and garden waste to nitrogen rich organic manure or compost quickly. The temperature and moisture required for degradation of waste with the help of microbial is about 66˚C and 60% respectively.The quality of the compost is depending upon factors such as moisture content, pH, temperature, time etc.

IjagbemiChristiana.O, et. Al ,Design factors such as availability of component parts, ease of machinability, affordability, efficiency and ease of operation were considered in the design of the kitchen waste composting machine.Various components of the composting machine were designed on the basis of formulas given below.

The composting drum's total volume is given by: $V = \pi r2\, l$ where, V= volume of the drum r= inner radius of the drum, l= total length of the drum.

The diameter of the shaft is given by the equation: $d3 = 16 /\pi\, (Ss\, \sqrt{Mb\, x\, Kb})2\, x\, (Mt\, x\, Kt)2$

Where Mt = maximum torsion moment, Kb = combine shock and fatigue applied to bending(1.5) ,Kt = combine shock and fatigue applied to torsion(1.0)Ss = allowable shear stress for shaft with keyways, factor of safety of 0.9

The shaft key is maximum allowable shear stress. Width of key, $w = d / 4$ Thickness of key, $t = 2w /3$ Where, d = inner diameter of the shaft to be selected.

Maximum volume of food waste that can be composted at a time is given by $Va = Vd - Vm$ Where, V_a= Actual volume of inner cylindrical drum,V_d = Volume of inner cylindrical drum = 0.035m^3,V_m = Volume of mashers

Fan Speed Calculation The speed of fan V is determined using: $V = \pi DN/60$ Where, D = diameter of fan = 0.1 m,N = speed of motor in the fan.

Heating Chamber Design $Volume\ of\ heater\ and\ fan\ chamber = L\, x\, B\, x\, h$

The volume of hopper is calculated using: $Volume\ of\ hopper, Vh = Vb - Vsm \quad Where\ Vb = volume\ of\ inlet = LxBxh\ , Vsm = volume\ of\ outlet = l\, x\, b\, x\, h$

Swapnesh H. Bhaisare et. Al ,There are a wide range of parameters which can be used to monitor physical, chemical, biological, and biochemical variations during composting, such as the aeration rate, temperature, pH, moisture content, carbon/nitrogen (C/N) ratio, respiration, enzyme activity, microbial colony, and bioassay The organic compost machine helps to improve composting and decreases the cost required for degradation, segregation, and transportation etc. of the waste. The flexibility is increased and the total volume of organic waste is minimized. Also the different phases of composting can be studied.

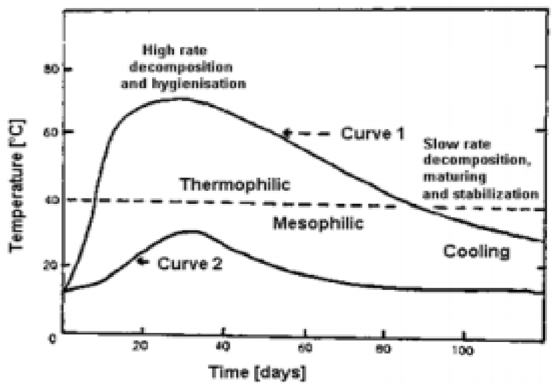

Fig.4 Phases of composting process [5]

III. Conclusion:

This research work have designed and developed "A Small capacity composting machine for household domestic food waste." Various parameters like temperature, moisture, carbon-nitrogen ratio, pH value, material selection criteria and its properties were studied. This study aims to maintain optimal values of all the factors mentioned above, achieving rapid composting of food waste within 30hours time span. Furthermore, compactness, portability, aesthetic design, affordability is taken into consideration.

IV. Future scope:

- Solar powered machine.
- Using IOT more Automation can be brought into picture.
- Using computer science and programming, App can be developed for assistance.
- Driving mechanism can be more optimized
- Fully Automated process can be achieved using mechatronics and robotics.
- Ceramic Heating pads can be replaced by Air fryers,which will be more effective.

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References:

1. Juan Pablo Arrigoni , Gabriela Paladino , Lucas Garibaldi , Francisca Laos. Inside the small-scale composting of kitchen and garden wastes: Thermal performance and stratification effect in vertical compost bins. Instituto de InvestigacionesenRecursos Naturales, Agroecología y Desarrollo Rural (IRNAD) – Universidad Nacional de Río Negro, Sede Andina, Av. Bustillo N 1500, Bariloche (8400), Rio Negro, Argentina Consejo Nacional de InvestigacionesCientíficas y Técnicas (CONICET), Argentina.
2. M. Margaritis, K. Psarras, V. Panaretou, A.G. Thanos, D. Malamis, A. Sotiropoulos. Improvement of home composting process of food waste using different minerals. Improvement of home composting process of food waste using different minerals Accepted 9 December 2017
3. IjagbemiChristiana.OAdepo S. Olusegun. Design, Development and Evaluation of a Small-Scale Kitchen Waste Composting Machine.OSR Journal of Engineering (IOSRJEN) ISSN (e):2250-3021, ISSN (p): 2278-8719 Vol. 04, Issue 04 (April. 2014), ||V6|| PP 29-33.
4. Jayant Nikaju,VivekBorkar,AtishPise, Prof.S.SPawar. Smt. RadhikataiPandav College Of Engineering, Umrer Road, Nagpur – 440009, India
5. Swapnesh H. Bhaisare ,Dr.PramodWalke , Dr. D. S. S. Ganguly , V.M. Wankar Department of Mechanical Engineering G.H.Raisoni College of Engineering, Nagpur, Maharashtra, India