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The Organic Compost Machine and Factors Effecting Performance of Composting: A Review

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Abstract:
Every day Metropolitan cities generate more and more waste and this is overloading our municipal systems, systematic management of waste is big problem. Composting is known and easy process of organic waste management. It is a biological conversion self-heating, which generates desired end products such as substrates for cultivation of mushroom, bio-gas and fertilizers. The proper maintenance of temperature and humidity in pulverized organic waste will increase the process of bio-degradation. The study is done to evaluate the performance of compost machine. The proper management of temperature and humidity is important. The aim is to decrease unscientific land filling, segregation of waste and to increase quality of compost or manure.

Keyword: Manure, Municipal Solid Waste, Organic Waste, Shredding.

1. INTRODUCTION:

In India 101066.27 MT of Municipal Solid Waste (MSW) generated daily according to report of Government of India's Ministry of Urban Development (MoUD) [8]. As the cities are expanding fast with vast migration of public from rural to urban areas, the MSW is also increasing day by day [9]. Most part of the waste is used for unscientific landfilling or irregular dumping on outskirts of cities, which is the big reason for global warming because the green-house gases emits from that landfill [10] [11]. The available MSW management system containing collection, storage, transportation, segregation, and disposal and processing of waste is not up to the level [10] [16].

In relation with MSW management, one of the big problem being faced by towns or cities is that the quantity of solid waste is increasing and government bodies are not capable to modify he facilities require to manage such MSW [8]. A survey is conducted by Natural Environmental Engineering Research Institute (NEERI), Nagpur in 59 cities and predict about 57 000 Tons of MSW generated per day [8]. The efficient method to dispose the organic waste is by composting it to use in agriculture field. Composting is an aerobic process in which microorganisms degrades the organic waste to nitrogen rich manure. Currently only 9-10% of organic waste generated utilised for composting. Different type of methods are used to convert compost from organic waste by various enterprises and government bodies. The compost quality is depends upon the type of organic waste, procedure of composting, time period etc. [1]. In India, the potential of producing organic waste is about 4.4 million tons each year [9]. The main problem in generation of good quality compost is that there is inappropriate MSW management system. The proper sorting of biodegradable and non-biodegradable waste is important to obtain good quality of compost. There are two types of organic waste found in urban areas or cities.

Table.1. Types of city waste or MSW

Green Waste	Fruit peels, chopped vegetables remains, food, leaves etc.
Animal Waste	Bones, inedible fats, tissues etc.

The Composting is beneficial in soil fertility enhancement, stabilizing the environment, decreasing the global warming, improving the waste management system etc. The composting technique reduces the volume of organic waste and kills the pathogens [13] [14]. Also organic composting converts the ammonia waste to useful nitrogen rich product [14]. The manure when used in soil increases its fertility. For natural organic composting with the help of micro-organisms, near about 30-40 days required. The segregation is required for natural organic composting but the desirable conditions obtain for micro-organisms to degrade the waste then there will be less time requires for producing organic compost.

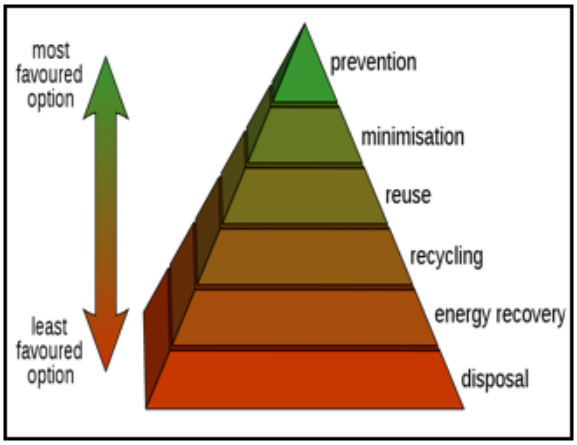

Figure. 1. Hierarchy of Waste Management.

The large amount of municipal, industrial, and agricultural wastes has led increasing environmental, social and economic problems. Stringent environmental regulations for waste disposal and landfills make finding new sites for waste disposal and management a growing challenge. Additionally, landfills use arable lands and soils which can be used for agriculture. The two primarily environmental concerns related to landfills are leachate generation and gas emission. The leachate produced from landfills may contain a variety of toxic and polluting components. If managed improperly, leachate can contaminate groundwater and surface water. Landfill gas emissions are a mixture of carbon dioxide and methane, small amounts of nitrogen and oxygen, and trace amounts of various other gases such as benzene, toluene, and vinyl chloride. Some components of landfill gas may be toxic or explosive, other components can include ammonia, hydrogen sulphide and other organ sulphur compounds, which produce the characteristic unpleasant odor. The generation of these landfills by-products depends on the constitution of the disposed material. The more organic wastes are present, the more gas is produced by bacterial decomposition; the moisture content is increased, and thus the more leachate is produced. Moreover, disposal sites produce noise, dust and odor which make the surrounding area undesirable for habitation. Solid waste management requires the application of effective strategies for proper wastes disposal and treatment. Successful waste policy requires a five-step waste management hierarchy. As demonstrated in Figure 1.1, the hierarchy consists of waste prevention, reuse, recycle, recovery, and disposal. Recycling involves conserving resources and preventing material from entering the waste stream. Biological treatment technologies (e.g., composting and anaerobic digestion) permanently remove the organic material from the waste stream [33].

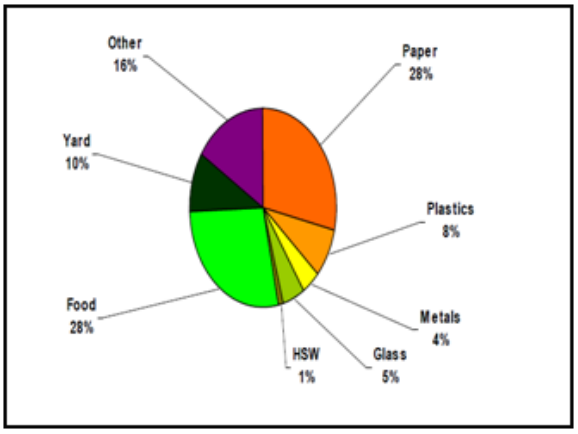

Figure.2. Typical composition of residential waste

Municipal Solid Waste (MSW) management has become one of the largest environmental concerns in recent decades. Due to the high moisture content (60-70%) and organic fraction (70-80%), MSW receives more attention than other solid wastes because it shows more negative environmental impacts if it is not treated properly. Luckily, the high organic fraction in MSW makes it easy to be converted to the energy sources through composting [28]. Therefore, composting has become an increasingly important strategy for the treatment of MSW. Centralized composting facilities have become more common since the early 1990s. These are used by municipal cities for households and commercial establishments alike. As well, some businesses and other organizations in the industrial, commercial and institutional sectors use on-site composting facilities.

2. ORGANIC COMPOST MACHINE:

The organic compost machine is 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. In this machine the organic waste volume is lowered with the

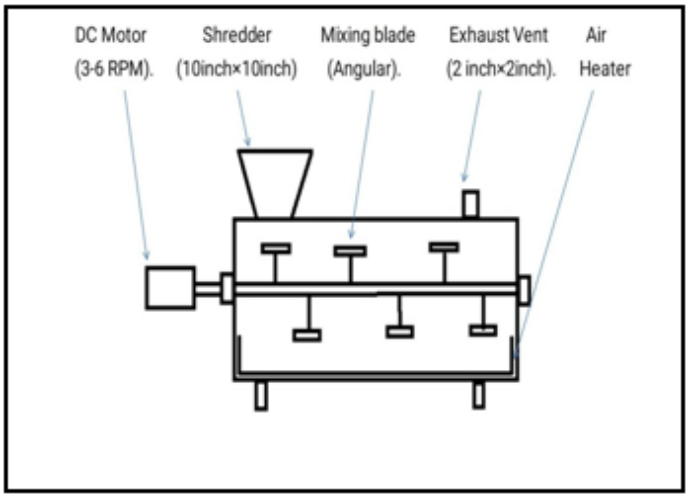

Figure.3. Organic Compost Machine

Help of shredder which pulverizes it. The proper management of temperature and moisture content decreases the time period required for composting. Due to which the segregation and improper landfilling is restricted.

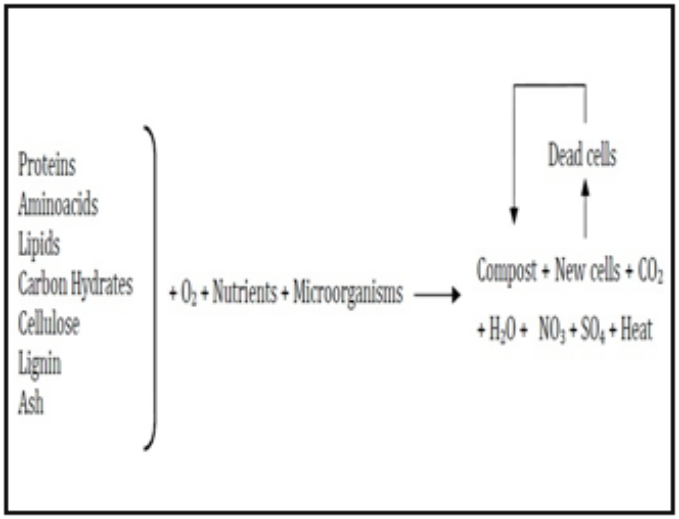

Figure.4. Diagram of the composting process

2.1 Design of Machine Elements

2.1.1 Composting Drum

The composting drum is a small sized cylindrical-shaped hollow solid made of galvanized steel pipe. It is the major container of the waste materials, and it houses the masher with its shaft.

The composting drum's total volume is given by:

$V = \pi r^2 l$

Where, *V*= volume of the drum
r= inner radius of the drum
l= total length of the drum

2.1.2 Masher or Shredder Assembly Design

B = Axial distance between mashers
T = Tolerance between drum and first mesh
W = Distance of flight perpendicular to flight $(B/Cos\emptyset) + T$…… (2.1)
Ø = helix angle
Masher Thickness = (length h $ofinnerdrum$ - w) / ($Noofmashers$)
Volume of masher =1/3 ($\pi r^2 T$)
For n mashing surfaces, volume = V x n
Mass of masher = density x volume
$forceperunit$ length = $force/total$ length

2.1.3 Shaft Diameter

The diameter of the shaft is given by the equation:
d3 = 16 /π (Ss √M*b* x K*b*) ² x (M*t* x K*t*) ²
Where, M*b* = maximum bending moment,
M*t* = maximum torsion moment,
K*b* = combine shock and fatigue applied to bending,
Kt = combine shock and fatigue applied to torsion,
Ss = allowable shear stress for shaft with keyways.

2.1.4 Maximum Volume of Food Waste

Maximum volume of food waste that can be composted at a time is given by:
VA = *VD* – *VM*
Where,
VA= Actual volume of inner cylindrical drum
VD = Volume of inner cylindrical drum
VM = Volume of mashers

2.1.5 Heat Generated by Heater

The amount of heat generated Q, is determined using,
Q = MC (ø2– ø1)
Where, M = Mass of heating coil
C = Specific heat capacity of air = 1.0035J/KgK = 1003.5J/gK
ø2 = Final Temperature of heating coil
ø1 = Initial temperature of heating coil

3. PARAMETERS EFFECTING PERFORMANCE OF COMPOSTING:

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.

3.1 Temperature

Temperature is an important factor for evacuating composting efficiency [29]. It can affect microbial metabolism, population dynamics (e.g., composition and density) of microbes and diversity of microorganisms [24] [34], and thus can be considered as a promising index of microbial activities and bio-oxidative stages [32]. Godden et al. suggested three distinct stages during composting, including the (a) mesophilic (below 40°C), (b) thermophilic (above 40°C), and (c) cooling (ambient temperature) stage.

3.2 pH

Another important environmental factor is the pH value of composting materials [31]. The presence of short chain organic acids in raw materials, mainly lactic and acetic acids, leads to low pH of MSW, with the value normally ranging between 4.5 and 6. The degradation of organic waste increases the concentrations of organic acids which are intermediate by-products of microbial breakdown of easily degraded substrates such as sugars, fats, starch, and greases during the initial phase of composting. Low pH as a result of organic acids most of the time inhibits progress of composting process [31] [35].

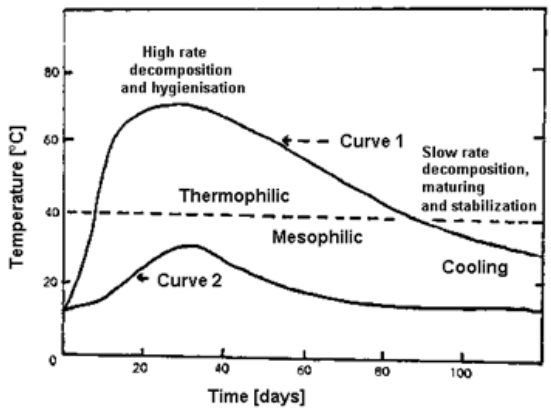

Figure.5. Phases in Composting

3.3 C/N ratio

The C/N ratio is one of the most important parameters to control the composting process and to determine the feedstock recipe and the degree of maturity of the end product of compost [26] [36]. Guo et al. found that the major factors in composting process are aeration rate and C/N ratio. The nutrient that has received the most attention in composting systems is nitrogen since it is the most needed element for plant nutrition. Moreover, it has often been recognized as a limiting factor for microbial growth and activity during the decomposition of plant residues especially in materials with a high C/N ratio.

3.4 Moisture content

Microbial activity and the physical structure in the composting process can be affected by moisture content; also it has a central influence on the biodegradation of organic materials [23] [26]. Moisture content is one of the critical design and operating parameters used in compost engineering systems [30]. It is important to transport dissolved nutrients required for the physiological and metabolic activities of microorganisms [26]. Moisture works as a medium to transfer dissolved gas and nutrients absorbed through the cell membrane of microorganisms [25]. The water during composting is produced as a by-product of microbial activities; also the generated heat through degradation will dry up part of the moisture. The moisture content can be adjusted by blending of components or by adding water.

3.5 Aeration rate

The aeration rate is the one of most important parameters for the composting process [24]. The main purposes of air supply to composting is to provide oxygen for biological degradation, dry up the wet materials and remove excess moisture, and to carry off exhaust gas and generated heat. Air flow influences spatial

distribution of gases, moisture, temperature, and the decomposition rate of the organic matter. The aeration provides oxygen to inhibit anaerobic condition and support the aerobic microbial activity. In addition, it removes the waste gaseous products [27]. Physical turning (mechanical and non-mechanical) of the mass, natural convection, and forced aeration (positive and negative modes) are well-known ways to control effective aerobic composting [28]. Lack of aeration can lead to anaerobic conditions and excess aeration will increase the cost the heat, as well as the loss of moisture and ammonia [26].

4. LITERATURE REVIEW:

J. C. Hargraves The recycling of Municipal Solid Waste by using composting is very efficient. The compost can be used for agriculture but it has to be nutrient rich and low metal content. For good quality compost the garbage has to be separated at early stage. The metal content can be increased if sewage sludge is added into the compost. [1]

K. R. Atalia The management of municipal solid waste can be increased by developing technology or method to convert waste into useful product. The organic waste which is biodegradable can be converted to environmental friendly organic compost. The organic compost increases soil productivity, decreases environmental pollution and reduces cost. The excess use of chemical fertilizers is hazardous to soil as well as to the environment as it causes water and air pollution. The composting is beneficial as it reduces landfilling, decreases water pollution due to contamination, minimizes the transportation cost etc. The composting is sustainable and wealth generating method. [2]

Tom. L. Richard The ideal way to produce compost is by separating the waste, reducing the size and proper mixing. The step by step process has to bedone to make good system of composting. While designing the system following factors has to be considered: cost such as operational, maintenance and capital, market for the compost, flexibility etc. [3]

SutriptaSarkar In many cities the proper management of waste is major problem. The organic composting is good way to handle the waste. The heating is self-generated by micro-organisms, which produces manure, biogas etc. The degradation process can be accelerated by the thermophilic phase. The moisture has to be about 60% and the temperature is in the range 65˚C-67˚C. [4]

MohdSahaidKalil The landfilling is considered to be used for waste management. But because of it the green-house gases liberates to the atmosphere. The organic waste should be composted to increase the quality of the soil. [5]

AjinkyaHande By using the shredder the organic waste can be chopped to small particles so that proper aeration is done. Due to which the manure is formed in less time and the farmer will get good quality manure at low cost. [6]

El-Sayed. G. Khater The chemical and physical properties of manure made from the organic waste is studied. The properties such as porosity, water holding capacity, pH, Carbon: Nitrogen ratio, etc. are studied. The manure quality is depends upon the proportion a physical existence. [7]

5. CONCLUSION:

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 quality of the compost is depends upon factors such as moisture content, pH, temperature, time etc.

6. REFERENCES:

[1]. J.C. Hargreaves, “A review of the use of composted municipal solid waste in agriculture”, Agriculture ecosystems and environment, 2016

[2]. Talia. K. R.,”A review on composting of municipal solid waste”, Journal of Environmental Science IOSR, Toxicology and Food Technology (IOSR-JESTFT), 2015

[3]. Tom L. Richard, Cornell Waste Management Institute, 2016

[4]. SutriptaSarkar, Subrata Pal, SunandaChanda. “Optimization of Vegetable waste composting process with a significant Thermophilic Phase”. Journal of Science direct Procedia Environmental Sciences 35 (2016) 435-440.

[5]. MohdSahaidKalil, Saleh Ali Tweib and RakmiAbdRahman, A literature reviews on composting. 2015 International Conference on Environment and Industrial Innovation

[6]. Hande Ajinkya, PadoleVivek, “Design and fabrication portable organic waste chopping machine to obtain compost”. IJIRST –International Journal for Innovative Research in Science & Technology| Volume 2 | Issue 03 | August 2015 ISSN (online): 2349-6010

[7]. El-Sayed. G. Khater, Some physical and chemical properties of compost. Int J WasteResources2015,5:1 http://dx.doi.org/10. 4172/2252-5211.1000172

[8]. CPCB 2016. Status of municipal solid waste generation, collection, treatment and disposal in main cities. Central Pollution Control Board. Ministry of Environment and Forest. Government of India, New Delhi.

[9]. Saha. J. K, Panwar N Singh. M. V., 2016, an assessment of municipal solid waste compost quality produced indifferent cities of India in the perspective of developing quality control indices. Waste management 30, 192-201.

[10]. Sharholy, M., Ahmad, K., Mahmood, G., Trivedi, R.C., 2014. Municipal solid waste management in Indian cities –a review. Waste Management 28, 459-467.

[11]. Narayana, T., 2015. Municipal solid waste management in India: from waste disposal to recovery of resources. Waste Management 29, 1163-1166.

[12]. Sarkar, S., Banerjee, R., Chanda, S., Das, P., Ganguly, S., Pal, S., 2015. “Effectiveness of Inoculation with isolated Geo-bacillus strains in the thermophilic stage of vegetable waste composting”. Bio-res. Technol. 101, 2892-2895.

[13]. Tiquia, S.M., Tam, N.Y.F., 2014. “Co-composting of Spent pig litter and sludge with forced-aeration”. Bio-res. Technol. 72, 1-7.

[14]. Zhu, N., 2016. “Composting of high moisture content swine manure with corncob in pilot scale aerated static bin system”. Bio-resource. Technol. 97, 1870-1875

[15]. Walkley, A., Black, L. A., 1934. “An examination of Degenerative method for determination of soil organic matter and proposed modification of chromic acid titration method”. Soil Science 37, 29-38.

[16]. Kumar, S., Bhattacharya, J.K., Vaidya, A.N., Chakrabarti, T., Devotta, S., Akolkar, A.B., 2015. Assessment of the status of municipal solid waste management in metro cities, state capitals, class 1 cities, class 2 towns in India.: an insight. Waste Management 29, 883-895.

[17]. Strom, P.F., 1985. Effect of temperature on bacterial species diversity in thermophilic solid waste composting. Appl. Environ. Microbiol. 50, 899-905.

[18]. Lee, J.-J., Park, R.-D., Kim, Y.-W., Shim, J.-H., Chae, D.-H., Rim, Y.-S., Sohn, B.-K., Kim, T.-H., Kim, K.-Y., 2014. “Effect of food waste compost on microbial population, soil enzyme activity and lettuce growth”. Bio-res. Technol. 93, 21-28.

[19]. Acevedo, M., Acevedo, L., Restropo- Sanchez, N., Pelaez, C., 2016. The inoculation of microorganisms in composting processes: need or commercial strategy? Livestock research for rural development. 17, 1-12.

[20]. Annepu, R.K. 2015. Sustainable Solid Waste Management in India (Master Thesis). Waste-to-Energy Research and Technology Council (WTERT), 2012.

[21]. Chattopadhyay, S., Dutta, A., Ray, S., 2014. “A Review-Municipal solid waste management in Kolkata, India. Waste Management 29, 1449-1458.

[22]. Glanville, T.D. (2016). Design a composter for your facility. Ames, Iowa: Department of Agricultural & Bio-system Engineering, Iowa State University.

[23]. Ahn, H. K., Richard, T. L., & Glanville, T. D. (2008). Optimum moisture levels for biodegradation of mortality composting envelope materials. *Waste Management*, *28*(8), 1411-1416.

[24]. Arslan, E. I., Ünlü, A., &Topal, M. (2015).Determination of the effect of aeration rate on composting of vegetable–fruit wastes. *CLEAN–Soil, Air, Water*, *39*(11), 1014-1021.

[25]. Christensen, T. H. (Ed.). (2015). *Solid waste technology & management* (Vol. 2). Chichester, West Sussex, UK: Wiley.

[26]. Guo, R., Li, G., Jiang, T., Schuchardt, F., Chen, T., Zhao, Y., &Shen, Y. (2012).Effect of aeration rate, C/N ratio and moisture content on the stability and maturity of compost. *Bio-resource Technology*, *112*, 171-178.

[27]. Leton, T. G., &Stentiford, E. I. (1990). Control of aeration in static pile composting. *Waste Management & Research*, *8*(4), 299-306.

[28]. Jolanun, B., &Towprayoon, S. (2015). Novel bulking agent from clay residue for food waste composting. *Bioresource technology*, *101*(12), 4484-4490.

[29]. Miyatake, F., &Iwabuchi, K. (2014). Effect of high compost temperature on enzymatic activity and species diversity of culturable bacteria in cattle manure compost. *Bioresource technology*, *96*(16), 1821-1825.

[30]. McCartney, D., &Tingley, J. (1998). Development of a rapid moisture content method for compost materials. *Compost science & utilization*, *6*(3), 14-25.

[31]. Nakasaki, K., Shoda, M., & Kubota, H. (1985). Effect of temperature on composting of sewage sludge. *Applied and environmental microbiology*, *50*(6), 1526-1530.

[32]. Godden, B., Penninckx, M., Piérard, A., &Lannoye, R. (1983). Evolution of enzyme activities and microbial populations during composting of cattle manure. *Applied Microbiology and Biotechnology*, *17*(5), 306-310.

[33]. Sakai, S., Sawell, S. E., Chandler, A. J., Eighmy, T. T., Kosson, D. S., Vehlow, J &Hjelmar, O. (2015). World terends in municipal solid waste management. *Waste management*, *16*(5), 341-350.

[34]. Suler, D. J., &Finstein, M. S. (1977). Effect of temperature, aeration, and moisture on CO2 formation in bench-scale, continuously thermophilic composting of solid waste. *Applied and Environmental Microbiology*, *33*(2), 345-350.

[35]. Sundberg, C., &Jönsson, H. (2016). Higher pH and faster decomposition in bio-waste composting by increased aeration. *Waste Management*, *28*(3), 518-526.

[36]. Iglesias Jiménez, E., & Pérez García, V. (2015). Relationships between organic carbon and total organic matter in municipal solid wastes and city refuse composts. *Bioresource technology*, *41*(3), 265-272.