Design of Composting Plant at College Campus

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Abstract - *Due to rapid growth of population, growing of waste quantity and its harmful influence on environments and world experiences has had so far impose the necessity for the analyses of economic possibilities of the processes for treating the organic fraction of solid waste stream in our college campus. In this paper, treatment of solid waste and composting process, which represents one of the most acceptable options for the processing of solid waste, are given. Composting involves the aerobic biological decomposition of organic materials to produce a humus like product. In this paper, based on composting process and various methods of composting, a windrow method of composting plant at different sections such as triangular, trapezoidal and semicircle is designed and use of compost , benefits of composting process and composting process realization with economic analysis for the construction of composting plant on our government college of Technology campus.*

Key Words**: Solid waste, waste management, aerobic treatment, compost, windrow composting.**

1. INTRODUCTION

One of the major environmental concerns in today is the issue of solid waste management. In India about 50 million tons of municipal solid waste was generated every year from cities [CPCB, 2000]. Uncontrolled dumping of wastes on outside of cities has created overflowing landfills, which are not only impossible to reclaim because of the haphazard manner of dumping, but also have serious environmental implications in terms of ground water pollution and contribution to global warming. Municipal solid waste (MSW) also known as domestic waste or household waste, is generated within a community from several sources, and not simply by the individual consumer or household. MSW arises from residential, commercial, institutional, industrial and municipal origins. Municipal solid waste (MSW) also known as domestic waste or household waste, is generated within a community from several sources, and not simply by the individual consumer or household. MSW arises from residential, commercial, institutional, industrial and municipal origins.

1.1 Poor Solid Waste Management

Uncontrolled dumping of waste materials at the land areas produces a foul smell and it becomes a breeding ground for different types of disease causing insects as well as infectious organisms. On top of that, it also spoils the aesthetic value of the area. Toxic materials and chemicals may seep into the soil and pollute the ground water. During the process of collecting solid waste, the hazardous wastes usually mix with ordinary garbage and other flammable wastes making the disposal process even harder and risky. When hazardous wastes like pesticides, batteries containing lead, mercury, zinc, cleaning solvents, radioactive materials, E-waste and plastics are mixed up with paper and other scraps are burned they produce dioxins and gases.

1.2 Methods of Solid waste Management (composting)

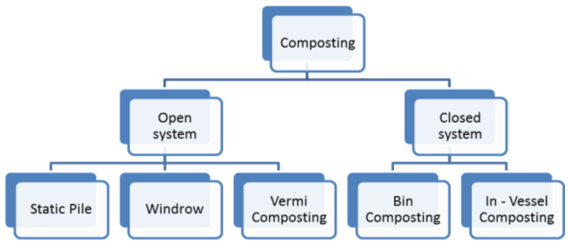

Fig -1: Composting Methods

2. COMPOSTING

Composting is an alternative solid waste management system; it can be used to recycling of organic material into useful products. In addition, it can also be used to control the increase in waste. Composting is defined as the controlled biological decomposition of organic matter into stable, humus like product called compost. Soil organic matter plays an important role in sustaining soil fertility and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico – chemical and biological properties of the soil.

Generally there are two types of composting techniques,

1. Anaerobic composting
2. Aerobic composting

3. AREA OF STUDY

Government College of Technology (11.0182°N, 76.9360°E) is located on the Thadagam road, Coimbatore District, Tamil Nadu. This educational institution campus has a population of around 5000 people inclusive of staff and students. The trees and other grass clippings, leaves are the sources of generation of yard trimming waste whose management is dealt with in this thesis.

From the study of literature, which type of composting method is suitable for the yard (leaves) waste management among the various methods is selected and the cost estimation is calculated for various sections to adopt which is economical.

3. 1 Objective of study

1. To control, collect process and disposal of solid waste in an economical way consistent with the public health protection.
2. To design a composting plant that would solve disposal issues of yard (leaves) wastes generated in GCT Campus.
3. To suggest an efficient, economic, practically and scientifically viable solid waste management system for the Government college of technology campus.

4. METHODOLOGY AND DESIGN

The flow of work undertaken for the purpose of the paper is shown in the following. The step in each category of work is shown in the chronological order.
1. Waste generation
2. Collection and Segregation
3. Estimation of waste generated in a campus
4. Planning and Design of composting plant
5. Comparison of composting methods
6. Estimation of the work

4.1 Collection of Data

Number of trees in a campus (M) : 450 (approx.)
Waste generation (ton)

$$\mathbf{G_r = G_R * M * 10^{-3} * 365}$$

Where,

G_r = Waste generation in ton
G_R = Waste generation coefficient (per capita)
M = Number of trees in campus

1. G_R is generally varies from 0.005 -0.05. (According to tchobaonglous for institutional buildings)

2. G_R is generally varies from 0.01 – 0.163 (According to MOI University, Kenya for institutional buildings)

For our GCT campus (approximately of population is 5000)

The generation rate co efficient = 0.015 (approx.)

This value can be calculated based on Number of times waste collected per day in a campus, survey conducted to the workers involved in the collection of wastes etc.

So, $\mathbf{G_r = G_R * M * 10^{-3} * 365}$

$G_r = 0.015 * 450 * 10^{-3} * 365$

$= 2.464$ ton

Waste generation $= 1.25 * 2.464$

$= 3.1$ ton. (25% extra for adding nitrogen rich material)

The Average uncompacted density of leaves and other plant materials $= 104\ kg/m^3$

Volume of waste generated

$$= \frac{mass}{density}\ m^3$$

$$= \frac{3100}{104}\ m^3 = 29.81\ m^3$$

The total pad area is the sum of the area required for the windrows plus needed for maneuvering the material (e.g., constructing windrows, turning the composting mass, water trucks, force aeration equipment etc.)

4.2 Design of Composting Plant

Composting can be of various types such as Windrows, Static piles, In-vessel type, Bin type and Vermi composting. Composting bins or window sections are the best methods for composting of leaves and yard trimming wastes. In this paper I have to use the design Windrow composting method of different section such as Triangular, Trapezoidal and Semicircular and compare this sections which is to be efficient and economical.

4.2.1 Design of Triangular Windrow Section

- Volume of material to be composted $=29.81\ m^3$
- Composting period (detention time) =60days (Tchobaonglous, 2002).
- Total volume of material on pad = 60 x 29.81 = 1788.6 m^3
- Assume dimensions of windrow:
  Length = 40 m (<91m or more)
  Height = 1.5 m (1.5 – 3 m)
  Width = 2.5m (2- 6 m)
- Volume of windrow: triangle section
  $V = 1/2 \times (2.5 \times 1.5) \times 40 = 75\ m^3$
- Number of windrows = total volume of material/volume of windrow = 1788.6 / 75 = 23.848 ≈ 24
- Distance between windrows = 2.5 m (2-4 m)

- Space around perimeter of composting area = 3.5 m
- Length of composting area = windrow length and perimeter space = 40 m + 2(3.5) = 47 m
- Width composting area:
  = Width of windrows + distances between windrows + perimeter Space
  = (24× 2.5) + (24 × 2.5) + (2 × 3.5)
  = 60 + 60 + 7 m
  = 127m
- Area required = length × width = 47 × 127
  = 5969 m^2 for triangle section of windrow

4.2.2 Design of Trapezoidal Windrow Section

- Volume of material to be composted =29.81 m^3
- Composting period (detention time) =60days (Tchobaonglous, 2002).
- Total volume of material on pad = 60 x 29.81 m^3
- Total volume of material on pad = 1788.6 m^3
- Assume dimensions of windrow:
  Length = 40 m (<91m or more)
  Height = 1.5 m (1.5 – 3 m)
  Top Width = 2.5m (2- 6 m)
  Bottom Width = 1.25m
- Volume of windrow: trapezoidal section
  V = 1.5/2 × (1.25 + 2.5) × 40 = 112.5 m^3
- Number of windrows = total volume of material/volume of windrow = 1788.6 / 112.5 = 15.89 ≈ 16
- Distance between windrows = 2.5 m (2-4 m)
- Space around perimeter of composting area = 3.5 m
- Length of composting area = windrow length and perimeter space = 40 m + 2(3.5) = 47 m
- Width of composting area: = Width of windrows + distances between windrows + perimeter Space
  = (16× 2.5) + (16 × 2.5) + (2 × 3.5)
  = 40 + 40 + 7 m = 87m
- Area required = length × width = 47 × 87
  = 4089 m^2 for trapezoidal section of windrow

4.2.3 Design of Semicircle Windrow Section

- Volume of material to be composted = 29.81 m^3
- Composting period (detention time) =60days (Tchobaonglous, 2002).
- Total volume of material on pad = 60x 29.81 m^3
  = 1788.6 m^3
- Assume dimensions of windrow:
  Length = 40 m
  Height = 1.25 m (assume)
  Width = 2.5 m (assume)
- Volume of windrow: semicircle section
  V = ∏/4 × 2.5 × 1.25 × 40 = 98.175 m^3
- Number of windrows = total volume of material/volume of windrow = 1788.6 / 98.17 = 18.22 ≈ 19
- Distance between windrows = 2.5 m (2-4 m)
- Space around perimeter of composting area = 3.5 m
- Length of composting area = windrow length and perimeter space = 40 m + 2(3.5) = 47 m
- Width of composting area: = Width of windrows + distances between windrows + perimeter Space
  = (19× 2.5) + (19 × 2.5) + (2 × 3.5)
  = 47.5 + 47.5 + 7 m
  = 102 m
- Area required = length × width = 47 × 102
  = 4794 m^2 for semicircle section of windrow

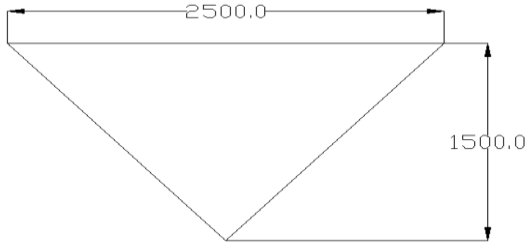

Fig -2: Cross section of Triangular windrow pile

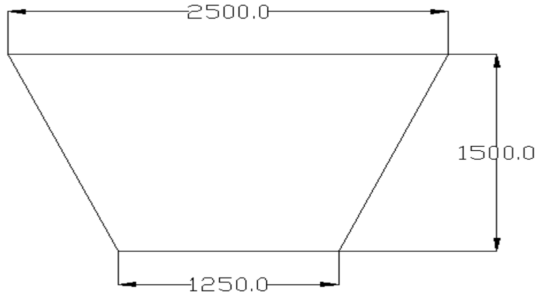

Fig 3: Cross section of Trapezoidal windrow pile

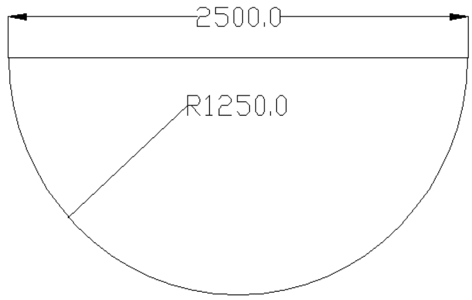

Fig 4: Cross section of semicircle windrow pile

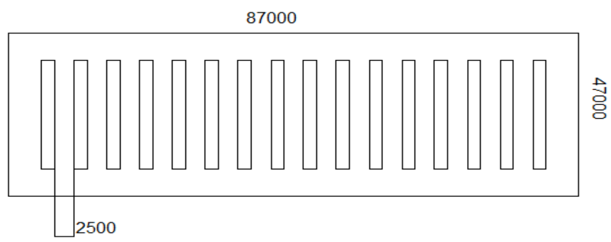

Fig 4: windrow area for Trapezoidal section

5. COST ESTIMATION

Rate of Excavation per cubic meter: Rs 200/-

Table -1: Cost Estimation

Particulars	Triangle Section	Trapezoidal section	Semicircle section
Total Volume (m^3)	1800	1792	1866
Rate/cum - 200 Rs	360000	358400	373200
*Miscellaneous 10%	36000	35840	37320
Total Cost (Rs)	396000	394240	410520

(*Miscellaneous charges include contingencies, equipment costs etc.)

6. RESULTS

Different sections of windrow were selected for the design of windrow of triangle, trapezoidal and semicircle. The dimensions and areas for the proposed areas for composting process are given in the table 2.

Table -2: Results of Different Composting Sections

Particulars	Triangle Section	Trapezoidal Section	Semicircular Section
Length (m)	40	40	40
Width (m)	2.5	2.5	2.5
Height (m)	1.5	1.5	1.25
Area (m^2)	5969	4089	4794
Cost Estimation (Rs)	396000	394240	410520

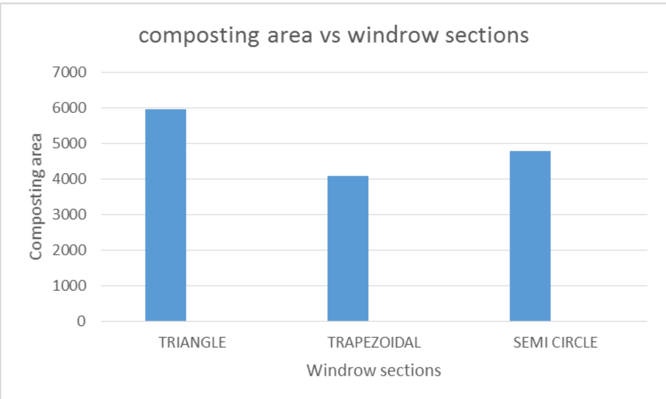

Chart -1: Composting area vs Windrow sections

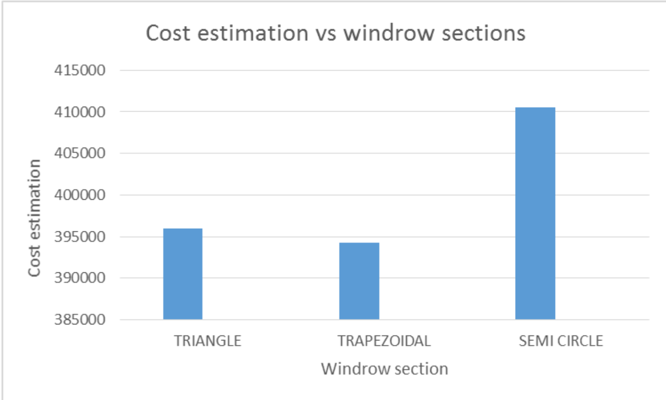

Chart -1: Cost Estimation vs Windrow sections

7. CONCLUSION

From the literature review, study the effectiveness of the various methods of composting process and the treatment of organic wastes by means of composting process were studied. For the design of windrow of different sections were studied such as triangular, trapezoidal and semicircular sections. The obtained area of triangular section is 5969 m^2 with the cost of 396000. The obtained area of trapezoidal section is 4089 m^2 with the cost of 394240. The obtained area of semicircular section is 4794 m^2 with the cost of 410520. So, the trapezoidal section was selected for the design of composting process site because it needs smaller area and economical than other sections, due to results of trapezoidal section is economical design for the project.

Economic analysis for design of composting area by using different procedures may be helpful for selecting the adequate method for the area of work, because the problems associated with land disposal of MSW were studied.

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