Design Of Solid Waste Management System For Angamaly Muncipality

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***Abstract*— A tremendous increase in the Muncipal Solid Waste (MSW) has been observed with increase in the population and rapid socio- economic development. In India it has become a serious issue because there are a few proper disposal systems for the MSW in many of the cities in India.. In the present Indian Scenario, suitable disposal of these MSW is a big concern. In this paper the treatment and disposal of the MSW of Angamaly muncipality in Kerala is planned. The details of Angamaly Muncipality including population and waste generation were collected from various sources. From the data collected, waste management facilities like incinerator and, a compost plant is designed for treatment of the city MSW and a landfill is also designed to dump the remaining waste after composting. For Angamaly muncipality, the total quantity of MSW is calculated as 12.59 tons/day, and the average generation rate of MS\W has been caleulated as 0.4 kg/capita/day For composting, required numbers of aerobic windrows are found as 60 and for landfill, which is designed with cover and liner, plan dimensions found as 12 m x 10 m with extra 25 m land around the landfill to set one of the components, The incinerator was designed with primary chamber dimensions 2.16 m× 1.23 m × 3m.**

Keywords*— *Muncipal Solid Waste; Landfill; Incinerator; Composting plant

I. INTRODUCTION

Solid Waste Management is one of the essential obligatory functions of the institutional and urban local bodies in India. This service is falling too short of the desired level of efficiency and satisfaction resulting in problems of health, sanitation and environmental degradation. Most institutional areas in the country are plagued by acute problems related to solid waste. Due to lack of serious efforts by authorities,garbage and its management has become a tenacious problem. Barring a few progressive municipal corporations and institutions in the country, most local bodies and institutes suffer due to non-availability of adequate expertise and experience, thereby the solid waste is not properly handled resulting into creation of environmental pollution and health hazards. It is reiterated that the local bodies lack technical, managerial, administrative, financial and adequate institutional arrangements. As such, it is very necessary to provide proper guidance to such Urban Local Bodies and institutes so as to make them efficient in managing the solid waste generated in their respective cities and towns. In the present scenario of waste management system in Indian cities, there is acute scarcity ofa suitable solid waste treatment and disposal system. Although the Angamaly municipal corporation is trying its best for the appropriate solid waste disposal of the city still there are many spaces for the improvement of the system with the help of proper technology and expertise. A well designed solid waste management system can help not only in treating and discarding the waste but also in maintaining a better environment. Landfilling is the final discarding practice for Municipal Solid Wastes (MSW) management (CPCB, 2008). Due to pretreatment there is a transform in the composition and properties of the waste which will influence the degradation and settlement characteristics of wastes (Siddiqui et al, (2012). If the MSW is first composted and the residual waste after composting is discarded in a sound designed sanitary landfill then the trouble of appalling environmental risk due to MSW can be treated with an excellent mode. Proper disposal of MSW is a necessity to minimize environmental health impacts and degradation of land resources. In developing countries like India, MSW is commonly disposed of by transporting and discharging in open dumps, which are environmentally unsafe. Systematic disposal methods are composting, landfilling and incineration. Studies indicate open dumping to be the management method for 90% of MSW in India [7]. However, the so-called landfill practiced in the country is mostly covering refuse in the dumpsite by soil neither with proper technical input nor with treatment of the emerging emissions to water, air and soil.

II. OBJECTIVES

For the pretreatment and disposal of municipal solid waste, a incinerator, compost plant and sanitary landfill is designed for Angamaly muncipality, so that a healthier and sustainable environment continues. This study aims to fulfill the following objectives

- To perform ultimate analysis of the solid waste generated in Angamaly muncipality.
- Design an incinerator
- Design of a compost plan
- Design of a sanitary landfill.

III. STUDY AREA

Angamaly is a municipality and the northernmost tip of the city of Kochi in Kerala, India. Situated about 30 km (19 mi) north of the city centre, the area is the northern gateway to the commercial capital of Kerala and is an integral part of the Kochi metropolitan area. The town lies at the intersection of Main Central Road (MC Road) and National Highway

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544. MC Road, which starts from Thiruvananthapuram ends at Angamaly at its intersection with NH 544.It is located 10.196°N 76.386°E. It covers a total area of 28.24 sq.km. Angamaly has an elevation of about 30 m.

IV. SOLID WASTE MANAGEMENT PROBLEMS IN ANGAMALY

Angamaly like any other urban metro cities of India has several environmental issues. Increasing population has resulted in overcrowding and congestion. Higher population and lack of space have resulted in the development of slums. This also have been identified as one of the solid waste problem because of lack of basic infrastructure like drainage facilities, solid waste clearance etc. The urban landuse in the city includes activities like residential, industrial, commercial, recreational, educational institutions etc. All these factors which constitute an urban environment are also the principal factors contributing to the solid waste management problems experienced by the city.

Some of the important environmental issues seen in Angamaly are air pollution, water pollution, high noise level and solid waste pollution. The air, the supplier of the essential oxygen is also the recipient of efluents from the industries, transportation, households, commercial sectors etc. These effluents include gases like sulphur di-oxide, nitrogen di-oxide, carbon di- Oxide, carbon monoxide, lead, suspended particulate matter and several others. In Ernakulam the surface water includes the major Periyar river. There are some lakes and small drainage running across the Ermakulam district. The water ways are the recipient of waste produced by domestic, industries and commercial activities. The dumping of waste has rendered it to an unusable state. Thus solid waste pollution is the main problem faced by the city. The management of huge quantity of waste generated by the city is an area of concern. The lack of adequate infrastructure to remove the waste produced by various activities has become a matter of concern. Uncleared solid waste on the road sides and overflowing dustbins are a common site in the city, generating several health and environmental issue.

V. CHARACTERISSTICS OF MSW

The composition of solid waste varies from zone to zone due to difference in activities at each zone. The quantity and composition of wastes from various zones is given in table I and the percentage of individual components in the waste is pictorically represented in fig. The total amount of waste generated is 12580 kg/ day.

TABLE 1 COMPOSITION OF MSW

Components	Quantity (kg/ day)	Percentage
Food wastes	10044.32	79.78
Paper	613.13	4.87
Plastic	608.09	4.83
Metal	44.065	.35
Glass	133.454	1.06
Rubber and leather	188.85	1.50
Inert	219.06	1.74
Ashes	211.512	1.68
Wood	492.26	3.91
Domestic hazards	35.25	.28

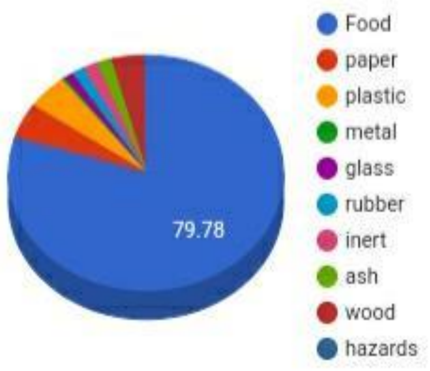

Fig 1 : Comopsition of MSW

VI. ULTIMATE ANALYSIS

The ultimate analysis of a waste component typically involves the determination of the percent C (carbon), HI (hydrogen), O (oxygen), N (nitrogen), S (sulphur), and ash. The ultimate analysis of the waste generated at different zones of the campus was performed based on the relative composition of various components at the source or waste generation points. The average moisture content (Mc) of the food waste, paper, plastic, metal, glass, rubber and leather and wood is assumed as 75%, 7%, 2%, 4%,2%, 10% and 30% respectively.

TABLE 2 ULTIMATE ANALYSIS PER DRY UNIT WEIGHT

Waste	C	H	O	N	S	Ash
Food	48	6.4	37.6	2.6	0.4	5.0
Plastic	60	7.2	22.8	-	-	10
Paper	43.5	6	44.0	0.3	0.2	6.0
Glass	0.5	0.1	0.4	0.1	-	98.9
Rubber	60	8	11.6	10	0.4	10.0
Metal	4.5	0.6	4.3	0.1	-	90.5
Wood	4.5	6.0	42.7	0.2	0.1	1.5
Ash	26.3	3.0	2.0	O.5	0.2	68.0

Based on assumed moisture content(MC) and weight of individual component of solid waste generated, the dry weight of each component is calculated using equation 1. Thereafter, the chemical composition of solid waste (kg of C, H, O ,N, S) is calculated based on ultimate analaysis data.

TABLE 3 ULTIMATE COMPOSITION OF MSW

Component	Percentage
Carbon	21.284
Hydrogen	1.75
Oxygen	15.35
Nitrogen	.862
Sulphur	.126
Ash	5.57

VII. DESIGN OF COMPOST PLANT

A **composting plant** for size reduction and the stabilization of mixed organic waste should be located as close to the disposal site as possible.

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Air Required for Aerobic Composting

From ultimate analysis the formula for the Guwahati waste is $C\ C_{454}H_{1945}\ 0_{992.5}\ N_{16.5}$

Theoretical air required for aerobic composting is calculated by the formula (1) and (2)

$C_aH_bO_cN_d + [(4a+b-2c-3d)/4]\ 0 = aCO2 + [(b-3d)/2]\ H,O + dNH3$ (1)

Oxidation of NH3:

$NH3+20_2=H20+HNO3$ (2)

Theoretical total air required = 587.64 kg/ton of organic matter

Actual air to be supplied =2 x Theoretical air

= 1175.2 kg/ton of organic matter

For 2021 total waste generate is = 12590 tons/day

Total air required for the solid waste = 14796.820 ton of air /day

Revenue from the Compost

Total compostable waste = 11.33 tons/day

Assuming total compost = 50% of original volume

Total compost = 5.67 tons/day

Price of compost in Kerala = Rs. 20 per kg

So, total revenue from compost = Rs. 113.3 per day.

Dimension of the Windrow Composting

Volume required for composting = (total solid waste in kg/ Density) = 40.45 m³

Considering air circulation arrangement and taking windrow height =2.7 m, Width = 3 m Upper and 6 m Lower

Length required for composting = (volume/ (height/2) x (upper width + lower width)) = 12.15 m

As composting takes minimum 2 months, at least 60 numbers of windrows are needed for the whole city.

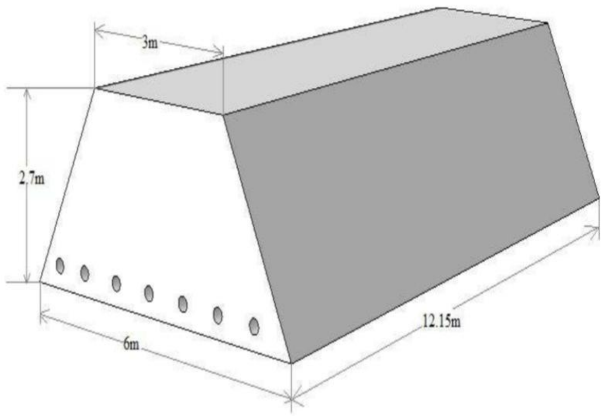

Fig 2 : Composting windrow

VIII. DESIGN OF LANDFILL

Landfill is a unit operation for final disposal of MSW on land, designed and constructed with the objective of minimum impact to the environment. The essential components of landfill include (i) A liner system at the base and sides of the landfill which prevents migration of leachate or gas to the surrounding soil, (ii) A leachate collection and control facility which collects and extracts leachate from within and from the base of the landfill and then treats the leachate, (iii) A gas collection and control facility (optional for small landfills) which collects and extracts gas from within and from the top of the landfill and then treats it or uses it for energy recovery, (iv) A final cover system at the top of the landfill which enhances surface drainage, prevents infiltrating water and supports surface vegetation, (v) A surface water drainage system which collects and removes all surface runoff from the landfill site, (vi) An environmental monitoring system which periodically collects and analyses air, surface water, soil-gas and ground water samples around the landfill site and (viii) A closure and post-closure plan which lists the steps that must be taken to close and secure a landfill site once the filling operation has been completed and the activities for long-term monitoring, operation and maintenance of the completed landfill.

The primary objective of landfill site design is to provide effective control measures to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, as well as the resulting risks to human health arising from landfilling of waste. Therefore, the design should consider all environmental media that may be significantly impacted through the life of the landfill. The chosen design will have a major influence on the operation, restoration and aftercare of the facility.

1 Basic Data

- Location- Angamaly
- Waste (non biodegradable) – 1221.2 kg per day
- Design life- 5 years
- Topography- flat ground
- Water table- 10 m below ground surface.

2 Landfill capacity, height and area

- Current waste generation W= 445738 kg
- Estimated rate of increase of waste generation per year, X=1%
- Estimated waste generation after 5 years= W(1+x) ^n = 445738(1+0.01) ^5 = 46475.12 kg.
- Total waste generation in 5 years= 0.5(W(1+x^n)^n = 2285.5 T
- Total waste volume Vw= T/.85 = 2285.5/ .85= 2688.8 m³.
- Volume of daily cover= 0.1 ×Vw= 268.8 m³
- Volume of liner and cover system Vc=.25×Vw= 672.2 m³
- First estimate of landfill volume Ci= Vw+Vc= 2688.8+672.2= 3361m³
- Likely shape of landfill- Rectangular
- Possible maximum height of landfill = 10m
- Area required= 3361/10= 336m²
- Approximate plan dimensions= 28m × 12m

3 Landfill section and plan

Landfill Section and Plan is evaluated by providing a side slope of 4:1 and 2:1 respectively, for the portion above-ground surface and the portion below the ground surface. The material excavated from the site is used as the material for daily cover, liner and final cover. Extra space was provided around the waste filling area for infrastructural facilities.

4. Landfill Phases

- Active life of landfill = 5 years
- Duration of one phase = one year
- Number of phases = 5. (Each phase extends from base to

final cover.)

- Volume of one phase = landfill capacity/5= 3361/5= 672.2 m
- Plan area of phase = (Volume of one phase)/landfill height= 672.2/10=67.2 m2
- Number of daily cells = 365
- Plan area of one cell (on the basis of Im lift of each cel)= (Volume of one phase)/365= (67.2×10)/365

= 1.84m²

- Temporary holing area: Excavated portion half to be used.
- Surface water drain: Adjacent to arterial road along periphery.

5 Liner and Leachate Collection System

Liner system: As per CPHEEO (9) the liner system will compromise of the following layers below the waste:

- 0.30m thick drainage layer compromising of Badarpur sand 55 course sand or gravels.
- 0.2m thick protective layer of sandy silt.
- . 1.50mm thick HDPE geomembrane
- 1.0m thick clay layer

Leachate Collection Pipe

- Diameter of HDPE pipe (perforated) = 10cm
- Spacing of one pipe required =2m

. Leachate holding tank

- Size of holding 3 days leachate = 7m*4m*3m

Leachate treatment facility: 40m*20m (in plan) (tentative)

6 Cover System Design

(a). Cover System: As per CPHEEO (9) the cover system were designed in three layers above the waste,i.e.

- 0.45m thick gas collection layer comprising of Gravels
- .0.6m thick barrier layer (sandy silt+5% bentonite)
- . 0.3m thick surface layer of local top soil for
- Vegetation growth.

(b). Passive Gas Vents: Passive gas vent of Im height side (above the ground level) will be provided at a Spacing of 10 m.

IX. DESIGN OF INCINERATOR

Incineration may be defined as the thermal destruction of the waste at elevated temperature say 1200 oC to 1600oC under controlled operational condition. The products of combustion are carbon-dioxide, water, and ash as a residue. The unit in which the process takes place is termed as Incinerator.

Properly controlled incineration is an effective means of reducing waste volume. It ensures cleaner and more complete combustion of waste and lends itself well to waste disposal in areas where population density is relatively high and availability of sites for landfill is low.

TABLE 3 QUANITITY OF BIOMEDICAL WASTES

Sl No	Name of health establishment	Quantity of waste generated per day	Quantity of waste generated pwr month
1	Private hospitals	184.8 kg	5544 kg
2	Health centres	4.305	129.15
	Total	189.52	5673

The following steps were used to design the incinerator. Each step of the design procedure has been discussed in great details including the assumptions involved in the design process.

1) Design of Primary Chamber

For designing of Primary chamber of Multiple Chamber Incinerator under controlled air conditions initially volume of primary chamber is to be determined so as 200 kg/ day is dumped and the volume of heap is considered

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Volume of heap (for 200 kg of waste) = 8m^3

Assuming suitable depth of 3m,

Volume= 8/3

= 2.66 m^2

Assume ratio of length and beadth as 1.75:1

Therefore L/ B= 1.75/1= 1.75

L= 1.75B

Dimensions of Primary Chamber =L*B*H

Area= LxB

2.66 =1.75 B*B

2.66 =1.75 B² , B = 1.23 m, L = 2.16 m, H= 3m

Hence, the dimensions of the primary chamber are 2.16 m x 1.23 m x 3 m

X. CONCLUSIONS

The characteristics of solid waste generated in Angamaly muncipality was analysed for their quantity and chemical characteristics. Ultimate analysis indicated a carbon content of 454 kg/ tonn of solid waste. It indicated the lowest occurrence of sulphur in the muncipal solid waste. Comopsting should be adopted for the management of biodegredable portion of solid waste. Non biodegradable portion of was can be properly disposed into a landfill. Design of incinerator, comopsting plant and landfill will be an excellent idea for muncipal solid waste treatment and disposal in Angamaly muncipality.It will surely create a healthy environment and also less land will be required for waste dumping which will be beneficial for future. As the landfill is nearer, transportation cost will be less and economical.

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