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Development of Zone wise solid waste management Processing unit for Coimbatore City, Tamil Nadu

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ABSTRACT

The effective solid waste management is one of the challenging tasks for the urban development in the metropolitan cities all over the world. The current scenario in waste management system is not satisfactory since most of the wastes are ideally dumped in the landfill site. This study focuses on the benefits and scope of decentralized solid waste processing units in Coimbatore municipal corporation, TN, India using the census data 2011 and geographic information system. In this study decentralized processing unit is designed for each zone of Coimbatore city considering all the parameters with respect to population of each zone and the costing has been done in accordance to solid waste management rules and amendments 2016.In this research a layout of processing unit has been done to arrive the land required to install a processing unit zone wise. The success stories of other states in region wise approach are initiative to carry out this paper various advantages and limitations of decentralized system is discussed in this paper.

Key words*: Population, Biodegradable waste, Composting yard, Decentralization, Waste management, Coimbatore.*

Introduction

The Decentralized Solid Waste Management (DSWM) is a system which can effectively reduce the amount of waste at the source and develop small waste management sectors within the locality. Census 2011 shows that urban sprawl can attract shifting of agricultural based nation to industrial and service oriented country. Exploring 2011 census in India 31.2% population is now living in urban areas which directly increase the load of solid waste management (Census, 2011).

Dumping of waste is the major contribution for failure of waste management system. The landfill dumping process should be least preferred process to reduce dumping of waste which will be an effective solid waste management (Jin *et al.*, 2006).

In spite of scarcity of land in country like India, the land filling is the most accepted practices acquiring of land for land filling in major cities like Delhi, Mumbai, Kolkata and Chennai is still challenging task for urban planner.

Urban population is the major portion to be considered for the waste management decentralized system effectiveness depends right from the generation of waste. India generates about 42 million tones of municipal solid waste per annum increase in urban population by 50% in 2050 will increase the demand for more effective waste management system, Gwalior city is analyzed for decentralized waste management.

The population study of each zone and waste generation of each zone in a Coimbatore city can help the sanitary inspectors and planners to take corrective action to increase the infrastructure and helps to implement decentralized waste manage-

ment units and plants for each zone.

The present study aims to access the decentralized processing unit especially composting yard in Coimbatore City. The Coimbatore city is also facing the inefficient waste management. The industrial growth, well equipped educational system and innovative smart development in infrastructure attracts more immigration and urban sprawl which in turn becomes a challenge for solid waste management problem hence by encouraging the decentralized system can help the city to sort out the issues and solve effectively through sector wise solid waste management.

Study Area

Coimbatore is an industrial city of Tamil Nadu. It lies in the geographic latitude and longitude of 11°01′06′′N and 76°58′21′′E respectively. This is one of the cities mentioned under the national smart city plan.

Methodology

For conducting this present study on decentralized processing unit the waste generation and present scenario of waste management was collected from the Coimbatore City Municipal Corporation, Coimbatore city. Data on population has been collected from census report 2011. For administrative purposes Coimbatore has been divided into hundred wards. Various data with respect to solid waste management have been derived from various government document and concerned officials to carry out the study on decentralized processing unit. The recommendation of Advisory on onsite and decentralized composting of municipal organic waste - June 2018 is referred for details and requirements of composting yard. Zone map and population map is done using ARC GIS in order to classify the population into categories so that the appropriate design can be carried out accordingly. This study will serve as an initial step to develop a decentralized treatment unit for Coimbatore city.

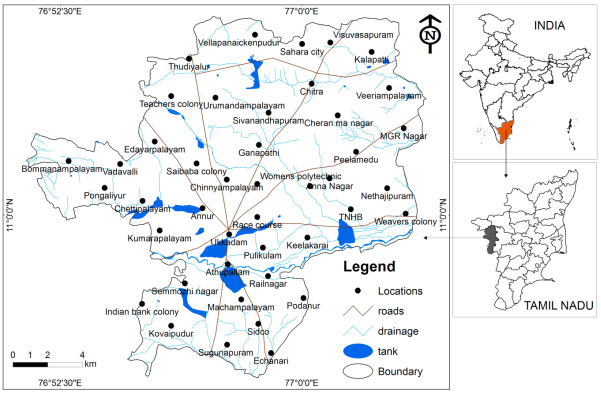

Fig. 1. Location of the study are Coimbatore Municipal Corporation highlights
(*Source:* Coimbatore City Sanitation Plan Report)

Table 1. Shows the information about Coimbatore city

S. No	Description Head	Information
1	Name of Urban Local Body	Coimbatore City Municipal Corporation (CCMC)
2	Name of Urban Agglomeration under which City is a part	Coimbatore
3	Population of ULB	16,01,438
4	Slum population	1,28,201
5	Daily floating population	1.5 – 2 Lakhs
6	Number of Households Area of the city	3,54,715, 257 Km^2
7	No of Administrative Wards	100 (05 Official Zones)
8	Topography and Geographic Location	Altitude - 432 meters above MSL; location - Western part of T.N State, surrounded by Western Ghats in the West, Nilgiri Biosphere Reserve (reserve forest) in the North and Noyyal River in its South. The Eastern side of the city is predominantly dry.
9	Climate	Salubrious climate. Average maximum and minimum temperatures are 35.8°C and 22.4°C respectively. The annual average rainfall is 71 cms.
10	Accessibility	The city is accessible through road, rail and air ways.
11	Other Cities to its vicinity	Tirrupur, Erode, Madurai, Ooty, and Mysore (Karnataka).

Present scenario of solid waste management in Coimbatore

Solid waste generation

Waste generation data has been obtained from CMCC officials on an average the Coimbatore corporation collects 1020 tons per day in which 60% wetwaste and 40% dry waste ,the waste collected from all the categories includes households, commercial establishments, restaurants, hospitals including medi waste and E-waste may summed up to 1453 tonnes/day. The decadal solid waste generation is shown in Table 2 and the organic waste percentage is shown in Table 4.

Waste characterization

The major portion of city waste in India is wet and also organic in nature. Characterization of city waste is shown in Table 3.

Existing MSW management practices

The elements of solid waste management are collection, transfer, storage, treatment and disposal. Failure or inefficient handling of any one of this element may lead to overall failure of waste management system, hence a quantified and validated focus on each element will lead to a successful system. The existing system in Coimbatore city is shown in the Table 5.

Need of this study

The current smart city project activities demonstrate the problem of Municipal Solid Waste can be handled by introducing latest technology and avoiding multiple manual handling of waste. The civic body is planning a monitoring system using information and communication technology to enhance the swach survekshan 2019 and to higher in garbage free city. Currently in the system the apartments are classified into bulk waste generators and civic body will stop collecting waste that is not segregated.

Table 4. Physical composition

Organic waste	Dry weight	Wet weight
	53%	48%

Source: Coimbatore city Municipal Corporation

According to the guidelines of Swachh Survekshan 2019, to score higher in the 'garbage-free city' ranking minimum 5% of households should have a composting system at home to turn organic waste into manure.

This implies that development of decentralized system will improve the source segregation and development of more composting plants and recovery plants in the city.

The major portion of waste is organic in nature so the decentralized composting units will minimize the waste generation, reduces the accumulation of waste and the waste can be turn up to wealth of the country.

The increasing population and waste generation becomes a great challenge for administration of waste so it become necessary to implement more conserved and economic method like decentralized management system.

Decentralized processing plant

There are 100 wards in Coimbatore which are divided into five administrative zones namely North, south, east, west and central.

Figure 2 shows the zone map of Coimbatore city.

The idea of decentralized model is to handle the waste near the source itself i.e., in each ward, a waste treatment plant In Coimbatore city currently the centralized waste management system is followed where in all the waste are been transported to Treatment plant located at Vellalore.

Due to urbanization the land allocation in different regions of city for waste treatment was found to

Table 2. Solid waste generation

Solid waste generation in tones	1981	1991	2001	2011	2021
	27.49	30.67	33.87	37.048	40.2

Table 3. Waste Characterization

Organic	Recyclable	Inert	Calorific value	Moisture content.
51%	17.5%	31%	7.3MJ/kg	47%

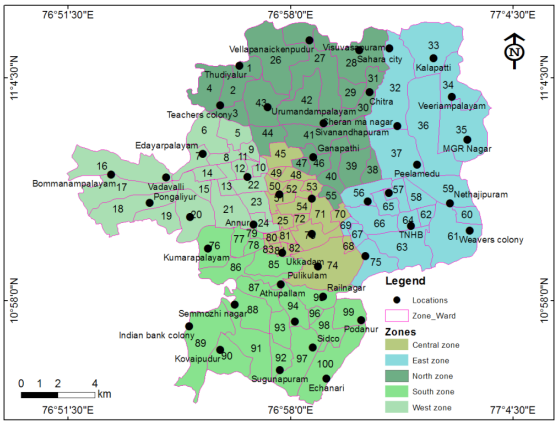

Fig. 2. Zone map of Coimbatore showing five zones.

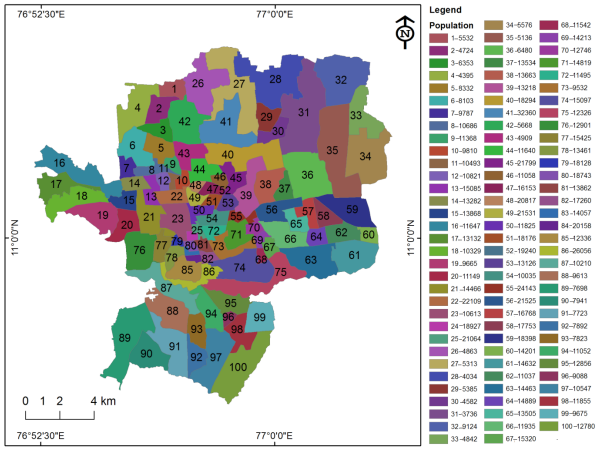

Fig 3. Ward wise populations Map showing 100 wards.

be a tough task so a centralized system was followed mandatory but due to population growth and high waste generation simultaneously lead to big chaos in segregation and treatment of waste. The centralized model involves transporting of waste to a common treatment plant Vellalore in Coimbatore, resulting in higher fuel consumption.

The decentralized treatment units will be an effective and absolute method due to decrease in cost of transportation and concise approach. In this decentralized system the urban space can be divided into various categories in terms of population and distribution of population to locate a treatment plant region wise thereby reducing the transportation cost and huge landfill is avoided.

Grouping of wards

Based on the population of the city and the zone map the total population of city can be categorized zone wise and each Zone can be analyzed for processing unit location and requirements.Population of each ward is shown in Figure 3. and the Grouping of wards is illustrated in Table 7.

Recommendation for composting units

Turning of waste into compost is an most integrated technique to minimize the waste hence the government under swach bharath mission along with CPHEEO and ministry of housing and urban have released an Advisory on onsite and decentralized composting of municipal organic waste in June 2018. In this an exhaustive focus is done especially on decentralized composting process. In this regulation the various composting techniques are recommended for different community of people.

Coimbatore is operated by urban local body the recommended techniques are Windrow Composting Rotary Drum Composter (Large), Vermi Composter, Tallboy. In which the Windrow Composting Vermi Composter are under practice so in this paper the windrow composting unit is designed for each zone to carry out the decentralized treatment units as shown in Table 8.

Table 5. Existing system in Coimbatore city

Collection	Source segregation in few regions
Vehicle for transfer	Pushcarts hydraulically operated
Processing methods	Windrow composting, Vermicomposting and biomethanation process.

Table 6. Capacity of processing units:

S.No.	Processing methods	Capacity/land area	Location
1	Windrow composting	600TPD	Vellalore
2	Vermicomposting	100TPD	Vellalore
3	Sanitary Landfill	25Acres	Vellalore
4	Incineration plant	Not Available	-

A. Design and layout of decentralised processing unit

The processing unit is designed for following sectors:

Processing unit is mainly used to reduce the volume, recover usable materials and alter the physical form of the solid wastes. Residential wastes mainly require food waste grinding, component separation, compaction and composting. Hence in this study the area required for the following process is calculated.

1. Composting yard
2. Screening unit
3. Baling unit
4. Shredder unit
5. Vehicle zone/Buffer zone

1. Composting Yard

The compost yard includes the windrow composting operation area plus the area required for storage of unprocessed waste materials and area required for storage of cured compost. Thus in this design the area is allotted for curing and storage..About 2.5 acres of land is required for 50 ton/day waste generation in which about 1.5 acres can be devoted to buildings, roads, fencing and plant equipment.

The space between the heaps is kept as 4m and the outer buffer length is kept as 5m in the design of composting area.

Table 7. Grouping of wards.

Zone	Ward numbers	No. of Wards	Average population
North Zone	1, 2, 3, 4, 26, 27, 28, 29, 30, 31, 38, 39, 40, 41, 42, 43, 44, 46, 47 and 55.	20	10001
South Zone	76, 77, 78, 79, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99 and 100.	20	11753
West Zone	5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 and 24	20	12184
East Zone	32, 33, 34, 35, 36, 37, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 69 and 75.	20	12783
Central Zone	25, 45, 48, 49, 50, 51, 52, 53, 54, 68, 70, 71, 72, 73, 74, 80, 81, 82, 83 and 84.	20	14877

Table 8. Recommendation for composting units:

Category	Composting techniques
Individual Households, Small Communities, Apartments etc. up to10 Households	Pit Composting, Pot Composting Tri Pot Composting, Bio-Composter Ring Composting, Kitchen Bin Composting Mose Pit Composting, Blue HDPE Digester Eco Pots, Drum Composting Rotary Drum Composting (Small), Composting Basket/Bin
Medium sized communities, apartments, RWAs - for 11 – 300 Households; medium sized offices, medium hotels, resorts, medium schools, canteens, marriage halls	Vermi Composting, Portable Household Bio Bin Aerobic Bin Composting, Centralised Masonry Biotank Composting, Organic Waste Composting Machine Byobin, Orbin Solar Composter, Aaga Bokashi, Plastic crates Steel Mesh Composter, FRP Aerobic Digester Drum Composting, Wet Waste Composter
Large Communities, Apartments, RWAs, high rise buildings for 301 –1000 Households; Large Offices, Large Hotels, Large Schools	Organic Waste Composting Machine, Marigold Soil and Health SWM consultant Aerobic and Anaerobic ComposterLarge Scale Composting Pits
Above 1000 Households operated by ULBs / Institutions / Outsourced Agencies	Windrow Composting Rotary Drum Composter (Large) Vermi Composter Tallboy

Source: Advisory on onsite and decentralized composting of municipal organic waste - June 2018.

2. Screening Unit

The main operation of this screening are separation of materials by different types of screening operation according to the requirement like size separation, metal separation and combustible material separation.

3. Baling Unit

The baling unit is meant for densification of paper, cardboards, plastics and aluminum into balers. Area is allotted for baling operation in processing plant.

4. Shredder Units

The unit operation is size reduction many types of shredder is available according to the waste material like wood, glass and so on.

5. Vehicle Zone

The vehicle zone varies with type of vehicle used and number of vehicles used for operation.

Layout of processing unit

In this paper the layout of processing unit is arrived according to the population served in each zone and the organic waste produced. The number of heaps, and dimension of processing unit varies for each zone as per the capacity required in that particular zone. Design result of processing unit is tabulated in Table 9. The layout plan of north zone are shown in Figures 4(a), 4(b) and 4(c) and the dimension of layout plan of other zones is tabulated as shown in Table 11 to get a clear idea for readers.

The Table 10 shows the cost calculation for executing the designed layout in which the machine cost, labour cost, maintenance cost and land cost is incurred to arrive the estimation of processing unit.

Design and cost calculation of processing unit:

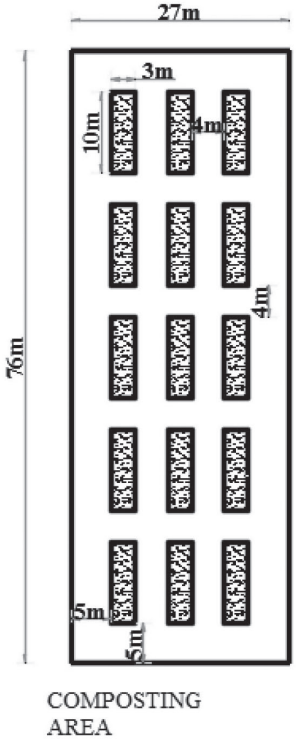

Fig. 4(a). Composting Area

Table 9. Design results of processing unit for each zone

Design parameter	North Zone	South Zone	West Zone	East Zone	Central Zone
Average waste generated (kg/day)	6400.54	7521.92	7797.76	8181.12	9521.28
Organic waste + Garden waste (%)	55%	55%	55%	55%	55%
Shredded waste density (kg/cum)	400	400	400	400	400
Quantity of waste in feed in composting (Kg)	3520	4137.056	4288.768	4499.62	5236.704
Volume of waste(cum)	8.8	10.34	10.72	11.25	13.091
No. of days	60	60	60	60	60
Total volume of material on pad (cum)	528	620.40	643.31	674.94	785.50
Assume windrow composting dimension,	Length =10m, a= 3m, b= 1.5m, Height = 1.5m	Length =15m, a= 3m, b= 1.5m, Height = 1.5m	Length =16m, a= 3m, b= 1.5m, Height = 1.5m	Length =17m, a= 3m, b= 1.5m, Height = 1.5m	Length =15m, a= 3m, b= 1.5m, Height = 1.5m
Volume of windrow (cum)	33.75	50.625	54	57.375	50.625
Number of composting units	15	12	12	12	16
Distance between windrow (m)	4	4	4	4	4
Space around perimeter of composting area (m)	5	5	5	5	5
Composting Area required (sqm)	2052	2142	2244	2346	2788
Composting yard area required (sqm)	7567	7680	8320	8960	8896
Total processing unit Land required (Acres)	5	5.5	5.7	6.5	5.5

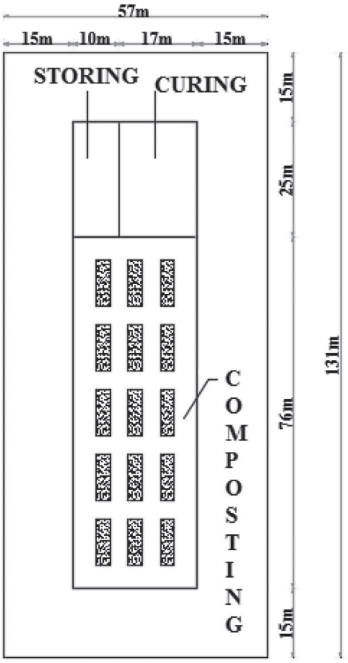

Fig. 4(c). Layout of processing plant

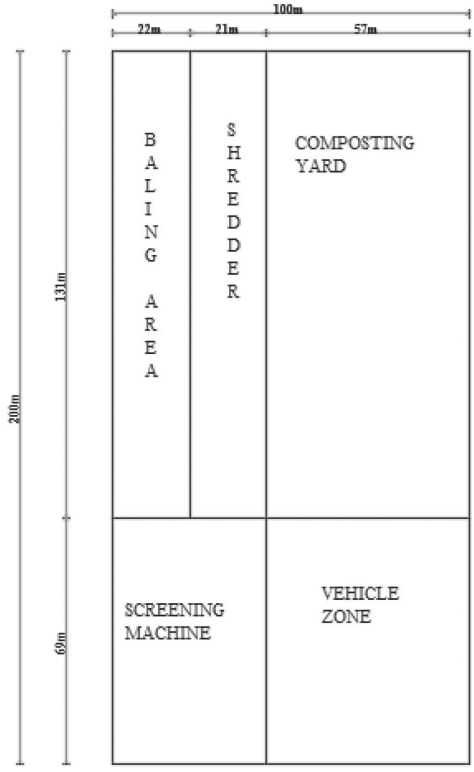

Fig. 4(b). Composting yard

Advantages of decentralized solid waste management

Decentralized systems enormously reduce the cost incurred for the collection, transportation, and disposal of waste by the corporation of city. It allows more precise mode of operation than the centralized system local sector people get more job opportunities and development of entrepreneurs at local sector and it is more advantageous with respect to Climate, social, and economic conditions.

Table 10. Cost estimation of processing unit for each zone

Description	North zone	South zone	West zone	East zone	Central zone
Food shredder cost (in lakhs)	1.5	1.5	1.5	1.5	1.5
Food shredder Installation cost (in lakhs)	0.5	0.5	0.5	0.5	0.5
Screening Machine cost (in lakhs)	20	20	20	20	20
Screening Machine Installation Cost (in lakhs)	2	2	2	2	2
Baling equipment (in lakhs)	1. 2	2	1. 2	2	1.2
Baling equipment Installation cost (in lakhs)	0.25	0.5	0.25	0.5	0.25
Composting yard, Fencing road cost (in lakhs)	10	12	12	12	10
land cost (in crores)	5	5.5	5.7	6.5	6.5
Windrow turner machine (in lakhs)	40	40	40	40	40
Side discharge trailer (in lakhs)	40	40	40	40	40
Truss construction (in lakhs)	40	50	55	60	40
Road cost (in lakhs)	20	20	22	25	20
Sanitary Inspector (Skilled labour) (in lakhs)	2.5	2.5	2.5	2.5	2.5
Unskilled labour (1.5 lakhs/capita) (in lakhs)	9	9	9	9	6
Maintenance and repair cost (in lakhs)	1	1	1.5	2.5	1
Additional cost (in lakhs)	2	2	2	2	2
Total cost (in crores)	6.9	7.5	7.8	8.7	8.4

Table 11. Design result of layout plan of processing plant

S. No.	Title	North zone		South zone		West zone		East zone		Central zone	
		Dimension (m)	Area (sqm)	Dimension (m)	Area (sqm)	Dimension (m)	Area (sqm)	Dimension (m)	Area (sqm)	Dimension (m)	Area (sqm)
1	Composting yard	131 x 57	7467	120 x 64	7680	120 x 64	7680	140 x 64	8960	139 x 64	8896
2	Vehicle zone	57 x 69	3933	64 x 80	5120	64 x 80	5120	64 x 80	5120	64 x 69	4416
3	Screening unit	43 x 69	2967	46 x 120	5520	46 x 120	5520	56 x 80	4480	43 x 69	2967
4	Baling unit	131 x 22	2882	80 x 23	1840	80 x 23	1840	140 x 28	3920	139 x 20	2780
5	Shredder unit	131 x 21	2751	80 x 23	1840	80 x 23	1840	140 x 28	3920	139x 23	3197

NORTH ZONE PROCESSING UNIT LAYOUT:

Limitations of decentralized waste management

Though the implementation of decentralized waste management brings up more benefits but the difficulty in practice is land scarcity in many urban areas especially to satisfy hygienic condition in and around the land and the expected outcome of resource is possible only with efficient workers which directly influence the economic viability to install a decentralized system.

Conclusion

The single stream system can be revised to a multiple stream decentralized system for the improvement in the solid waste management by the effective collection, reuse and recovery from the waste. Decentralized approach can enormously reduce chaos in transporting and managing the waste. The each zone of Coimbatore city is studied and the individual preliminary layout design of processing unit are done for future implementation. Also cost estimation is carried out for each zone.

Decentralized approach is a proven mode to follow in future. This mode will vastly improve the productivity, accountability and community participation. Responsible citizens are meant to make a clean city not for creating huge mountain of garbage. We may see better cities in days to come by adopting decentralized system for solid waste management.

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