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Quantification and Characterization of the Municipal Solid Waste from Dharapuram Municipality, Tamilnadu, India – A Case Study

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Abstract - Municipal Solid waste management (MSWM) is one of the most challenging issues in India than elsewhere at the global level. The present investigation is a case study of Dharapuram Municipality, Tirupur District Tamilnadu, the main fast growing town in Tirupur District, which succumbs to a major problem of municipal solid waste and its management. This paper presents an overview of the base line studies of Dharapuram Municipality, solid waste collection and landfill disposal. Population growth, industrialization, urbanization and modern development leads to more generation of municipal solid waste in all cities. In this work, the population growth and its greater impact on solid waste generation and management are also studied through various literatures. The case study was conducted for two seasons like summer (May) and winter season (December) to collect the uniform data. This paper also summarizes the proposed policies and suggestions to improve the existing MSW management system in Dharapuram Municipality.
Keywords: Municipal Solid waste, Ground water contamination, leachate, landfill, biodegradable

I. INTRODUCTION

"Municipal Solid Waste" includes the commercial and residential waste generated in municipal or notified areas in either solid or semi-solid form excluding industrial hazardous waste; e-waste and including treated bio-medical waste. Solid waste generation is a natural phenomenon and amount of waste produced is directly proportional to the population growth. India, the world's second highest populated country after China with population of 1.21 billion already containing 17.5% of the world's population, is a land of physical, climatic, geographic, ecological, social, cultural and linguistic diversity. The annual rate of growth of urban population in India is 3.35% [1]. Increasing population levels, booming economy, rapid urbanization and the rise in community living standards have greatly accelerated the municipal solid waste generation rate in developing countries and also these factors are further exacerbated by inadequate financial resources, and inadequate management and technical skills within municipalities and government authorities. Urban India generates 188,500 tonnes per day (68.8 million tonnes per year) of municipal solid waste (MSW) at a per capita waste generation rate of 500 grams/person/day. Table-1 Source: [2] suggests the per capita quantity of municipal solid waste in Indian cities. It also suggests that average municipal solid waste production from 0.21 to 0.50 Kg per capita per day in India.

TABLE I
PER CAPITA QUANTITY OF MUNICIPAL SOLID WASTE IN INDIAN CITIES

S.No.	Population	Waste Generation Rate Kg/Capita/day
1	Cities with a population <0.1 million(8 cities)	0.17-0.54
2	Cities with a population 0.1 - 0.5 million(11 cities)	0.22-0.59
3	Cities with a population 1-2 million(16 cities)	0.19-0.53
4	Cities with a population >2 million(13 cities)	0.22-0.62

India has 16.8% of the world's population and only 2.2% of the world's total land area. It is also estimated that the total MSW generated by 217 million people living in urban areas was 23.86 million t/yr in 1991, and more than 39 million tonne in 2001. In India, as in other developing countries, solid waste management and sanitation are the least prioritized public services. Generally, MSW is disposed of in low-lying areas without taking any precautions or operational controls. Therefore, MSWM is one of the major environmental problems of Indian megacities. It involves activities associated with generation, storage, collection, transfer and transport, processing and disposal of solid wastes. But, in most cities, the MSWM system comprises only four activities, i.e., waste generation, collection, transportation, and disposal [3].

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A. Waste Composition, Collection, Storage And Disposal

By and large lifestyles, cultural traditions, economic status, literacy rates, dietary habits, climatic and geographical conditions significantly contribute to the varied MSW characteristics [4]. The municipal solid waste is classified in to biodegradable and non-biodegradable. Waste composition is influenced by many factors, such as level of economic development, cultural norms, geographical location, energy sources, and climate. The composition of MSW at generation sources and collection points were determined on a wet weight basis and it consists mainly of a large organic fraction (40–60%), ash and fine earth (30–40%), paper (3–6%) and plastic, glass and metals (each less than 1%). The C/N ratio ranges between 20 and 30, and the lower calorific value ranges between 800 and 1000 kcal/kg.[3] In India most of the urban areas are lacking in MSW storage at the source, significantly. For both decomposable and non-decomposable waste common bins are used to collect the waste without any segregation, and disposed off at a community disposal centre. In India, very a few cities only practiced the sanitary landfilling, compositing, bio methanisation process, and majorly solid waste are disposed in open areas.

II. CASE STUDY

Dharapuram also known as Rajarajapuram by the Tanjore Cholas is a town and a municipality in the Tirupur district of the South Indian state of Tamil Nadu. Dharapuram is one of the oldest towns in Tirupur District. Dharapuram is located at 10.73°N and 77.52°E. It has an average elevation of 245 metres (803 feet). It is strategically located in the line of Palakkad pass which provides the wind that activates the town's numerous windmills. The area has a significant water shortage. The town features a hot semi-arid climate. The temperature here averages 27.7 °C. The rainfall here averages 538 mm. Dharapuram and Coimbatore gained the status of Municipality on the same day. The town has attained the status of a Municipality in the year 1916 and it was promoted to first grade municipality on May 9, 1983. Dharapuram Town is situated along 9.62 km2 of the bank of River Amaravathi. According to 2011 census, Dharapuram had a population of 56,163 with a sex-ratio of 1,045 females for every 1,000 males, much above the national average of 929. A total of 5,048 were under the age of six, constituting 2,566 males and 2,482 females. Scheduled Castes and Scheduled Tribes accounted for 21.48% and 0.1% of the population respectively. The average literacy of the town was 80.4%, compared to the national average of 72.99%. The selection of Dharapuram town for the purpose of this study was based on basic criteria: it is a fast developing town in Tirupur district, Tamilnadu and both, the city as well as the state have not been covered by existing literature on MSW. Yet another critical reason for the selection of this city for case study is the fact that the city through its private service provider is keen on developing a robust waste management plan in the near future. Therefore findings from this research will feed into the process and facilitate taking informed decisions. The study is associated with the control of generation, storage, collection, transfer and disposal of solid wastes in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations and that is also responsive to public attitudes.

III. MATERIALS AND METHODS

As a methodology, in the absence of any existing information on MSW in Dharapuram municipality, a citywide profiling was taken up to understand the solid waste characteristics, collection system, treatment processes, disposal methods and other management issues. The profiling was based on the primary information collected during interviews with stakeholders namely Dharapuram Municipal Corporation, Private Service provider, NGOs, Service Users, Informal Recycling sector, District Administration, and Regulatory Agency. Information about policy, legislation and general information on waste management was collected from various government reports and Dharapuram Municipal Corporation.

A. Quantification Of Solid Waste

To quantify the solid waste generation in Dharapuram area, two seasons were selected in a year like summer season at May month and winter season at December month. The entire month was surveyed to collect the data on solid waste generation from the Dharapuram municipality to get the average value. The per day generation rate was calculated from the daily quantity of waste arriving at the landfill facility which was obtained from the concerned municipal authority. Based on the total weight of waste disposed in the landfill in a day and the total population of the community from where the waste is generated, the per capita generation of MSW was determined.

$$PCG = \frac{Waste\ Generated\ per\ day}{Population} \quad \text{(Kg/ day/ person)} \qquad (1)$$

Where, PCG is the per capita waste generation [5].

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B. Characterization Of Solid Waste

Municipal solid waste characterization study helps to identify the nature of the waste and it gives an idea to handle the waste. The solid waste samples majorly classified into three types, such as Commercial Waste, Residential Waste and Dump Yard Waste. Fresh commercial and residential waste samples were collected alternative days at the time of disposal from Lorries on the dump site. Ten representative dump yard samples weighing around 10 kg were collected from 10 different locations of dumping yard in Dharapuram. The physical components and chemical analysis of the solid waste samples were performed following the procedures given by [6]. The physical components like biodegradable, plastic, paper, rubber, glass, silt, metal and cloth are segregated and quantified from the collected combined samples. The samples were divided into biodegradable and non-biodegradable components. The obtained non-biodegradable fractions were discarded and only biodegradable components were further studied for their physico-chemical characteristics such as Bulk density, Moisture, pH, Loss on ignition, Ash content, Total organic carbon (TOC), Ca, Na, K, SO4, PO4 and Total Nitrogen based on the procedure followed in [7].

IV. RESULTS AND DISCUSSION

A. Base Line Data Of Dharapuram Municipality

The base line data of the Dharapuram Municipality was given in the Table 2, which provides the wide information of the demographics and in and around the Dharapuram Municipality.

TABLE III
BASE LINE DATA OF DHARAPURAM MUNICIPALITY

S.No	Content	Details
1	Total Population	56163
2	Male Population	27648
3	Female Population	28515
4	No. of Wards	30
5	No. of Houses	15864
6	No. of Lodges	8
7	No. of Industries	nil
8	No. of Markets	1
9	No. of Ulavar sandhai	1
10	No. of Hospitals	17
11	No. of Vegetables stores	44
12	No. of TASMACS	7
13	No. of Grocery Shops	64
14	Private Schools	13
15	Govt. Schools	8
16	No. of Colleges	1
17	No. of Theatres	3
18	Temples	12
19	Churches	1
20	Mosques	5

Source: Dharapuram Municipal Corporation

The total population of the Dharapuram Municipality is 56163. Even though it is one of the oldest municipalities in Tamilnadu, the growth of the population is very marginal and most of the people belongs to the town are migrated to nearby areas for their occupation. From the above data it clearly shows that the houses, markets, schools, temples, Vegetable stores, groceries etc are the major contributor of the municipal solid waste.

B. Solid Waste Generation

MSW generation rates are influenced by economic development, the degree of industrialization, public habits, Cultural development and local climate. The total quantity of the solid waste generation in Dharapuram Municipality is shown in Table II. Total generation of the municipal solid waste quantity in town area is 30 MT per day. According to this study, the rate of

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waste generation in this region is 0.53 kg/day/person. In this biodegradable waste generation quantity is 24.5 MT and non-biodegradable waste includes bottles, polythene bags, cloth, rubber quantity is 5.5 MT per day.

TABLE III
SOLID WASTE GENERATION IN DHARAPURAM MUNICIPALITY

Waste generation Details		
S.No.	Nature of Waste	Quantity in MT
1	Market Waste per day	3
2	Ulavar Sandhai waste per day	0.5
3	Total Waste Per day	30
4	Other Waste	3
5	Biodegradable waste per day	24.5
6	Non-biodegradable waste per day	5.5

The solid waste generation rate was studied by collecting the municipal solid waste for 30 days regularly and the average quantity waste per day was estimated for two seasons. The MSW generation for the summer and winter season is shown in fig. 1. Both seasons shows the average generation of solid waste of around 30 MT / day. During the period of summer the generation of solid waste was bit high when compared with the winter season.

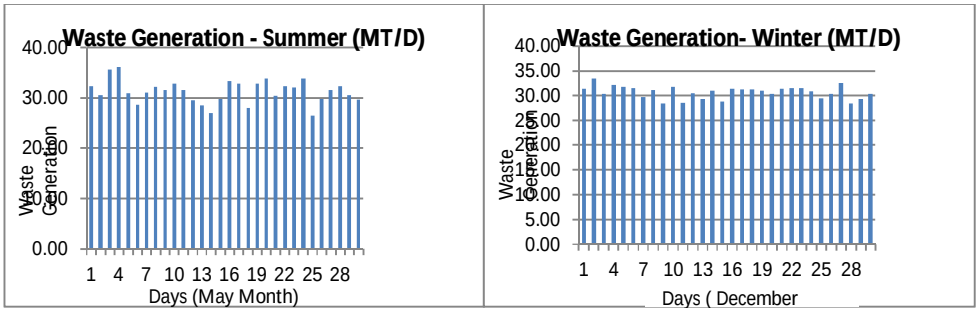


Fig. 1 Solid waste generation charts for summer and winter season

C. Composition And Characterization Of Solid Waste

The recyclable and non-recyclable wastes are segregated manually by from residential, commercial and dump yard waste. And then the wastes are quantified and organic waste samples were utilised for the physico-chemical analysis. However, these recyclables are not segregated to the maximum extent, thereby allowing them to be a part of the landfill waste. The composition of waste determines possibilities for waste treatment and a change in waste composition can therefore have a severe impact on the waste management practices. The composition of waste also determines the effects of improperly managed waste [8]. Table III and IV shows the MSW composition in winter and summer season.

TABLE IV
AVERAGE COMPOSITION OF COMMERCIAL, RESIDENTIAL AND DUMP YARD WASTE IN SUMMER SEASON

Types of Waste	Commercial Area(%)	Residential Area(%)	Dump Yard(%)
Biodegradable	60.30	52.64	76.95
Plastic	12.30	17.56	5.50
Paper	10.50	3.36	0.60
Rubber	1.50	3.32	0.55
Glass	1.80	2.60	0.95
Silt	12.10	13.32	14.35
Metal	0.90	1.10	0.65
Cloth	0.60	7.20	0.45

TABLE V

AVERAGE COMPOSITION OF COMMERCIAL, RESIDENTIAL AND DUMP YARD WASTE IN WINTER SEASON

Types of Waste	Commercial Area(%)	Residential Area(%)	Dump Yard(%)
Biodegradable	59.07	51.09	75.95
Plastic	12.30	19.67	5.46
Paper	12.23	3.52	0.72
Rubber	1.30	2.67	0.46
Glass	1.20	1.87	0.99
Silt	11.00	12.14	15.08
Metal	0.80	2.34	0.78
Cloth	2.10	6.70	0.56

In this study, different fractions of waste have been segregated in the collected sample. The major one is organic waste which accounts for 60.30%, 52.64%, and 76.95% of commercial, residential and dump yard waste respectively summer season. Also in winter season the results shows that 59.07%, 51.09% and 75.95% of commercial, residential and dump yard waste respectively. On the other side, the inorganic fraction occupies the remaining portion of the MSW. The study shows that the generation of organic waste is higher in summer season than in winter season. These results are supported by preview studies [9].

The huge quantity of organic waste present in the MSW stream has the potential to cause environmental problems and at the same time has a great potential for resource recovery. More the organic fraction, the higher will be the biochemical oxygen demand (BOD) of leachate. The amount of landfill gas produced in a sanitary landfill also depends on the quantity of organic fraction present in the MSW. However, a waste stream with a high organic content can be processed to produce high quality compost and thus is advantageous [10]. But in this case study, Dharapuram Municipal Corporation didn't take any steps for the resource recovery from the major portion of the organic waste.

In the remaining portion of the waste composition, plastics play a major role in both summer and winter season. It was observed in the study that plastic containers of soft drinks, cheese, juices and beverages which are frequently consumed essential foods come in plastic containers itself contribute to larger composition in the waste stream. Plastic containers tend to occupy more space in landfill due to its rigidity against compaction in the landfill. It follows the paper waste, which is made up of paper packages (cardboard and combined packages) and prints (newspapers, magazines and books).

The physico-chemical characteristics of the segregated bio-degradable organic waste for the summer and winter seasons were studied. The characterization results were shown in table V and VI for summer and winter seasons respectively. The moisture content was found to be between 18 and 25 percent for both summer and winter season. The organic carbon ranged from 9 to 20 percent for the both seasons. The nitrogen content ranged from 0.61 to 0.89. Nitrogen content might be due to huge quantity of food wastes. The phosphate content in solid waste ranged from 0.78 to 1.73 percent. The potassium content ranged from 1.02 to 2.34 percent, and sodium from 1.54 to 2.10 percent. The presence of phosphate and potassium in organic portion might be due to the addition of fertilizers to the crops growth. The C/N ratio values were shown that the MSW may be suitable for biomethanation or composting. The same kinds of results were supported by the other studies [9].

TABLE VI

PHYSICO CHEMICAL CHARACTERISTICS OF ORGANIC WASTE IN SUMMER SEASON

Types of Waste	Commercial Area (%)	Residential Area (%)	Dump Yard (%)
Bulk Density	184(kg/m3)	186(kg/m3)	196(kg/m3)
Moisture	21.18	22.90	18.93
pH	7.52	7.98	8.01
Loss on Ignition	20.12	16.98	9.61
Ash Content	9.25	8.20	7.18
Total Organic Carbon(TOC)	17.81	18.54	15.79
Calcium(Ca)	0.98	0.92	0.73
Sodium(Na)	2.10	1.65	1.55
Potassium(K)	1.17	1.32	1.02

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Sulphate(SO4)	2.04	1.92	1.84
Phosphate(PO4)	1.08	0.85	1.73
Total Nitrogen (TN)	0.87	0.69	0.61

TABLE VII
PHYSICO CHEMICAL CHARACTERISTICS OF ORGANIC WASTE IN WINTER SEASON

Types of Waste	Commercial Area (%)	Residential Area (%)	Dump Yard (%)
Bulk Density	185(kg/m3)	187(kg/m3)	194(kg/m3)
Moisture	23.00	24.90	23.25
pH	7.34	7.12	7.87
Loss on Ignition	19.12	15.89	9.54
Ash Content	8.56	8.20	7.12
Total Organic Carbon(TOC)	17.67	19.34	14.98
Calcium(Ca)	0.87	1.02	0.86
Sodium(Na)	1.98	1.56	1.54
Potassium(K)	2.34	1.89	1.23
Sulphate(SO4)	1.98	1.67	1.75
Phosphate(PO4)	1.23	0.78	1.45
Total Nitrogen (TN)	0.89	0.78	0.87

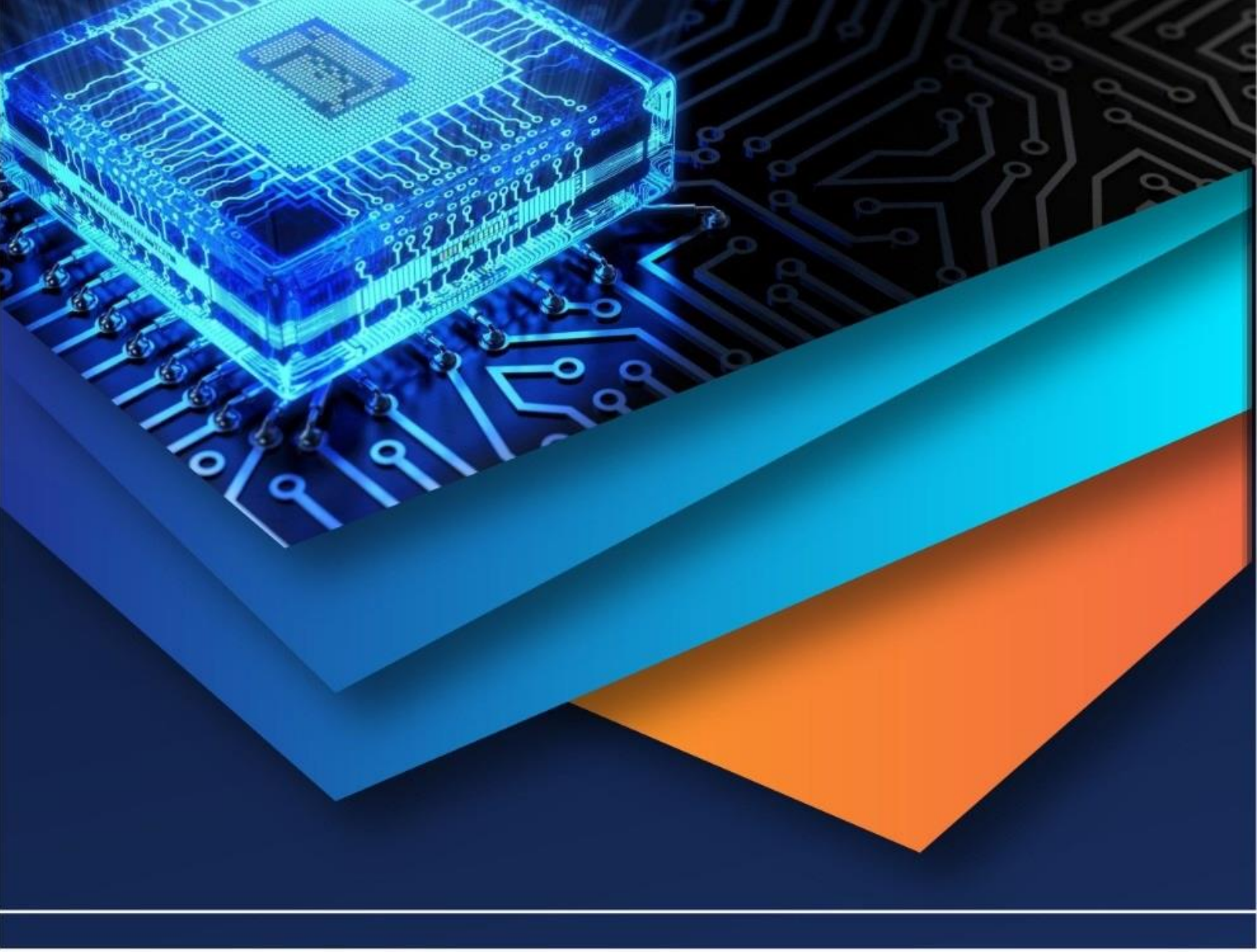
V. CONCLUSION

The case study of Dharapuram Municipality gives field data about the quantity and characteristics of solid waste, and projects future implications of treatment techniques to enhance the MSW management. The increase in generation of municipal solid waste is due to the increased population density, consumption pattern, life style behaviour and economic development etc. The waste composition has higher percentage of organic waste than inorganic. The high amount of organic waste can be effectively used as organic manure through composting, biogas production, biofuels etc., whereas recycling and energy recovery would be an appropriate option for the inorganic fraction of the MSW. Public education, involvement, participation, awareness, cooperation among the businessmen, people, and service providers of municipality and application of suitable methods, sustainable solutions and low cost technologies will facilitate the sustainable integrated solid waste management in Dharapuram Municipality. It not only brings the remedial measures to the present environmental scenario but also revenue to the municipality.

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