

## THE SOLID WASTE MANAGEMENT OF MUNICIPAL CORPORATION IN MADURAI CITY

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### **ABSTRACT**

*With 1.416 billion people, India is the second-largest country in the world and home to about 18% of all people on the planet. Despite this, the country lacks the means to properly handle its solid wastes due to a lack of resources and a lack of effective systems.*

**KEYWORDS:** *Solid Waste Management.*

### **INTRODUCTION**

With 1.416 billion people, India is the second-largest country in the world and home to about 18% of all people on the planet. Despite this, the country lacks the means to properly handle its solid wastes due to a lack of resources and a lack of effective systems. More people live in its cities than in the whole United States, the third most populous nation in the world, which saw its urban population increase at a pace of 31.8 percent over the past ten years to 377 million. Between the country's growing urban population and the services and resources that are offered, there is a stark disparity in India. One area where India has to make significant improvements is solid waste management. This will assure the sustainability of the environment. There is a glaring lack of a proper solid waste disposal system to handle the growing volume of trash.

As long as there have been humans on earth, waste has been produced. From the pre-industrial age, when vast cities were the norm, trash has been recognized as a concern. Although recycling and recovery alternatives have been considered at least since 1960, there has been a notable rise in interest in the waste problem during the past ten years. Unhealthy and degraded environments are largely caused by rapid and widespread industrial expansion, unplanned urbanization, a frequent influx of people from rural to urban regions, and incorrect and insufficient action by the authorities tasked with pollution management and environmental protection. Many people's quality of life was impacted by this. The biggest issue facing contemporary towns and industry, aside from the concerns with air and water pollution, is the challenge.

The biggest difficulty facing Indian local authorities is managing solid garbage. The management of solid waste is a public function that safeguards both the environment and public health. Technologies that have been shown to be ecologically friendly, enable beneficial reusing, and provide customers with value. The state government is responsible for managing solid waste, including the management of construction and demolition waste. The ministry of urban development facilitates the creation of broad policies, programmes, and guidelines for sanitation, including municipal solid waste management, and it also supports state efforts through federal funding. Swachh Bharat Mission was introduced by

the ministry of urban development on October 2, 2014. There are 4041 statutory towns included in the mission. The implementation of solid waste management is the primary aspect of the Swachh Bharat goal with disposing of solid waste.

### **Solid Waste Management**

The term "solid waste management" refers to the collection, treatment, and disposal procedure for solid wastes. Wastes are gathered from various sources and are disposed of through the waste management process, which involves the collection, transportation, treatment, analysis, and disposal.

It is a serious worldwide problem as it causes both water and air pollution. It shows its direct effect on health, economic growth, and degradation of the environment. It can lead to pollution of the environment and outbreaks of vector-borne diseases (diseases spread by rodents and insects).

One of the fundamental services given by local administrations to maintain urban centres clean is solid waste management. Unfortunately, this system is antiquated and inefficient, has minimal population coverage, and marginalises the poor, making it one of the basket systems' worst-performed services. Garbage is everywhere, which results in unhygienic living conditions. Urban local government is governed by municipal laws that lack the necessary provisions to address the rising issue of solid waste management. Rapid urbanisation has made the situation in solid waste management severe.

Solid waste is the undesirable or pointless stuff that is produced in a specific region by a combination of commercial, industrial, and residential activity. It can be divided into categories based on its place of manufacture (home, industrial, commercial, building, or institutional), its contents (organic material, glass, metal, plastic paper, etc.), or its level of hazard (toxic, non-toxin, flammable, radioactive, infectious etc.). The proper management of solid waste promotes economic growth and a higher standard of living while minimising or eliminating negative effects on the environment and human health. For a municipality, managing garbage successfully involves a variety of procedures. They include keeping track of, gathering, moving, processing, recycling, and discarding.

Many byproducts of human activity are discarded as garbage because they are seen to be worthless. They are produced by both the home in the form of waste and by the industry in the form of waste products from production. The amount of garbage produced by contemporary civilization has dramatically increased due to population expansion, urbanization, and industrialization. For instance, urban living produces a lot of garbage, which puts pressure on landfill sites. Biodegradable and non-biodegradable garbage are two categories of trash. Food, agricultural waste, yard trash, paper, and other biodegradable waste may all decompose both anaerobically and aerobically. Composting trash that cannot be broken down by other living creatures, such as metallic garbage, plastic, and glass, can turn them into a variety of goods.

### **Characteristics of Solid Waste Management**

In order to identify the exact characteristics of municipal wastes, it is necessary that we analyse them using physical and chemical parameters. This study will emphasize about the various characteristics of solid wastes and their importance.

### **PHYSICAL CHARACTERISTICS**

Information and data on the physical characteristics of solid wastes are important for the selection and operation of equipment and for the analysis and design of disposal facilities. The following physical characteristics are to be studied in detail.

**(a) Density**

Density of waste, i.e., its mass per unit volume (kg/m<sup>3</sup>), is a critical factor in the design of a solid waste management system, e.g., the design of sanitary landfills, storage, types of collection and transport vehicles, etc. To explain, an efficient operation of a landfill demands compaction of wastes to optimum density. Any normal compaction equipment can achieve reduction in volume of wastes by 75%, which increases an initial density of 100 kg/m<sup>3</sup> to 400 kg/m<sup>3</sup>. In other words, a waste collection vehicle can haul four times the weight of waste in its compacted state than when it is uncompacted. Significant changes in density occur spontaneously as the waste moves from source to disposal, due to scavenging, handling, wetting and drying by the weather, vibration in the collection vehicle and decomposition

**(b) Moisture Content**

Moisture content is defined as the ratio of the weight of water (wet weight - dry weight) to the total wet weight of the waste. Moisture increases the weight of solid wastes, and thereby, the cost of collection and transport. In addition, moisture content is a critical determinant in the economic feasibility of waste treatment by incineration, because wet waste consumes energy for evaporation of water and in raising the temperature of water vapour. In the main, wastes should be insulated from rainfall or other extraneous water. We can calculate the moisture percentage, using the formula given below

$$\text{Moisture content(\%)} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \times 100$$

A typical range of moisture content is 20 to 40%, representing the extremes of wastes in an arid climate and in the wet season of a region of high precipitation. However, values greater than 40% are not uncommon. Climatic conditions apart, moisture content is generally higher in low income countries because of the higher proportion of food and yard waste.

**(c) Size of Waste Constituents**

The size distribution of waste constituents in the waste stream is important because of its significance in the design of mechanical separators and shredder and waste treatment process. This varies widely and while designing a system, proper analysis of the waste characteristics should be carried out.

**(d) Calorific Value**

Calorific value is the amount of heat generated from combustion of a unit weight of a substance, expressed as kcal/kg. The calorific value is determined experimentally using Bomb calorimeter in which the heat generated at a constant temperature of 25°C from the combustion of a dry sample is measured.

The physical properties that are essential to analyse of wastes disposed at landfills are:

**I. Field Capacity**

The field capacity of municipal solid waste is the total amount of moisture which can be retained in a waste sample subject to gravitational pull. It is a critical measure because water in excess of field capacity will form leachate, and leachate can be a major problem in landfills. Field capacity varies with the degree of applied pressure and the state of decomposition of the wastes.

## II. Permeability of Compacted Wastes

The hydraulic conductivity of compacted wastes is an important physical property because it governs the movement of liquids and gases in a landfill. Permeability depends on the other properties of the solid material include pore size distribution, surface area and porosity. Porosity represents the amount of voids per unit total volume of material. The porosity of municipal solid waste varies typically from 0.40 to 0.67 depending on the compaction and composition of the waste.

## III. Compressibility

It is the degree of physical changes of the suspended solids or filter cake when subjected to pressure.

## CHEMICAL CHARACTERISTICS

Knowledge of the classification of chemical compounds and their characteristics is essential for the proper understanding of the behaviour of waste, as it moves through the waste management system. The products of decomposition and heating values are two examples of chemical characteristics. If solid wastes are to be used as fuel, or are used for any other purpose, we must know their chemical characteristics, including the following

- **Chemical:** Chemical characteristics include pH, Nitrogen, Phosphorus and Potassium (N-P-K), total Carbon, C/N ratio, calorific value.
- **Bio-Chemical:** Bio-Chemical characteristics include carbohydrates, proteins, natural fibre, and biodegradable factor.
- **Toxic:** Toxicity characteristics include heavy metals, pesticides, insecticides, Toxicity test for Leachates (TCLP), etc.

### (a) Lipids

This class of compounds includes fats, oils and grease. Lipids have high calorific values, about 38000 kcal/kg, which makes waste with a high lipid content suitable for energy recovery processes. Since lipids in the solid state become liquid at temperatures slightly above ambient, they add to the liquid content during waste decomposition. They are biodegradable but because they have a low solubility in waste, the rate of biodegradation is relatively slow.

### (b) Carbohydrates

Carbohydrates are found primarily in food and yard waste. They include sugars and polymers of sugars such as starch and cellulose and have the general formula  $(CH_2O)_X$ . Carbohydrates are readily biodegraded to products such as carbon dioxide, water and methane. Decomposing carbohydrates are particularly attractive for flies and rats and for this reason should not be left exposed for periods longer than is necessary.

### (c) Proteins

Proteins are compounds containing carbon, hydrogen, oxygen and nitrogen and consist of an organic acid with a substituted amine group ( $NH_2$ ). They are found mainly in food and garden wastes and comprise 5-10% of the dry solids in solid waste. Proteins decompose to form amino acids but partial decomposition can result in the production of amines, which have intensely unpleasant odours.

**(d) Natural Fibres**

This class includes the natural compounds, cellulose and lignin, both of which are resistant to biodegradation. They are found in paper and paper products and in food and yard waste. Cellulose is a larger polymer of glucose while lignin is composed of a group of monomers of which benzene is the primary member. Paper, cotton and wood products are 100%, 95% and 40% cellulose respectively. Since they are highly combustible, solid waste having a high proportion of paper and wood products, are suitable for incineration. The calorific values of oven-dried paper products are in the range 12000 – 18000 kcal/kg and of wood about 20000 kcal/kg, which compare with 44200 kcal/kg for fuel oil.

**(e) Synthetic Organic Material (Plastics)**

They are highly resistant to biodegradation and, therefore, are objectionable and of special concern in solid waste management. Hence the increasing attention being paid to the recycling of plastics to reduce the proportion of this waste component at disposal sites. Plastics have a high heating value, about 32,000 kJ/kg, which make them very suitable for incineration. But, one should note that polyvinyl chloride (PVC), when burnt, produces dioxin and acid gas. The latter increases corrosion in the combustion system and is responsible for acid rain.

**NON-COMBUSTIBLES**

This class includes glass, ceramics, metals, dust and ashes, and accounts for 12 – 25% of dry solids.

**Heating Value**

An evaluation of the potential of waste material for use as fuel for incineration requires a determination of its heating value, expressed as kilojoules per kilogram (kJ/kg). The heating value is determined experimentally using the Bomb calorimeter test, in which the heat generated, at a constant temperature of 25°C from the combustion of a dry sample is measured. Since the test temperature is below the boiling point of water (100°C), the combustion water remains in the liquid state. However, during combustion, the temperature of the combustion gases reaches above 100°C, and the resultant water is in the vapour form. While evaluating incineration as a means of disposal or energy recovery, one has to consider the heating values of respective constituents.

**Ultimate Analysis**

This refers to an analysis of waste to determine the proportion of carbon, hydrogen, oxygen, nitrogen and sulphur, and it is done to perform mass balance calculation for a chemical or thermal process. Besides, it is necessary to determine ash fraction because of its potentially harmful environmental effects, brought about by the presence of toxic metals such as cadmium, chromium, mercury, nickel, lead, tin and zinc. One should note that other metals (e.g., iron, magnesium, etc.) may also be present but they are non-toxic.

The following table shows an ultimate analysis of a typical municipal solid waste

Table: 1.1

Element	Range (% dry weight)
Carbon	25-30
Hydrogen	2.5-6.0
Oxygen	15-30
Nitrogen	0.25-1.2
Sulphur	0.02-0.12
Ash	12-30

Source: Secondary data, Madurai

(<http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2595>)

### Proximate Analysis

This is important in evaluating the combustion properties of wastes or a waste or refuse derived fuel. The fractions of interest are:

- Moisture content, which adds weight to the waste without increasing its heating value, and the evaporation of water reduces the heat released from the fuel;
- Ash, which adds weight without generating any heat during combustion;
- Volatile matter, i.e., that portion of the waste that is converted to gases before and during combustion;
- Fixed carbon, which represents the carbon remaining on the surface grates as charcoal. A waste or fuel with a high proportion of fixed carbon requires a longer retention time on the furnace grates to achieve complete combustion than a waste or fuel with a low proportion of fixed carbon.

The following table shows an proximate analysis of a typical municipal solid waste

Table: 1.2

Components	Value (%)	
	Range	Typical
Moisture	15-40	20
Volatile matter	40-60	53
Fixed carbon	5-12	7
Glass, metal, ash	15-30	20

Sources: Secondary Data, Madurai (<http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2595>)

### Municipal Solid Waste

Every day goods such as product packaging, yard trimmings, furniture, clothing, bottles, cans, food, newspapers, appliances, electronics, and batteries make up the municipal solid waste.

With rising urbanisation and change in lifestyle, the amount of municipal waste is also rising.

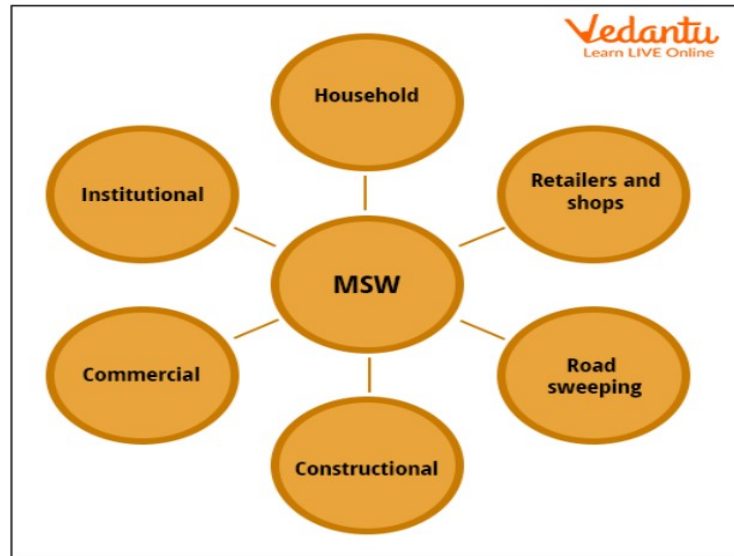


Figure 1

#### Different Sources of Municipal Solid Waste

- It is roughly classified into five categories:
  1. **Recyclable Material:** Glasses, bottles, cans, paper, metals, etc.
  2. **Composite Wastes:** Tetra packs, toys.
  3. **Biodegradable Wastes:** Kitchen waste, flowers, vegetables, fruits, and leaves.
  4. **Inert Waste:** Rocks, debris, construction material.
  5. **Domestic Hazardous and Toxic Waste:** E-waste, medication, light bulbs, etc.
- Municipal solid waste management is the need of the hour and is important for the safety of public health and better environmental quality.

#### Harmful Effects of Solid Waste

- Bad odour of waste
- Production of toxic gases
- Degradation of natural beauty
- Air pollution
- Water pollution
- Soil pollution
- Spread of diseases
- Effect on biodiversity

### **Sources of Financing for Solid Waste Management**

- JNURM Grants
- PPP as a source of funding
- Loans from Bilateral and Multilateral Agencies
- National/ State level Infrastructure Funds:
- Municipal Bonds and Debentures
- Loans from Financial Institutions
- Bank loans:
- Enhancing continuous revenue in solid waste management projects

### **Objectives**

- To identify the sources of solid waste generation of municipal corporation in study area.
- To study the physical and chemical composition of garbage in Madurai corporation.
- To disposal of solid waste management of municipal corporation in Madurai city.
- To different sources of solid waste generation in Madurai district.

### **NEED FOR THE STUDY**

With rapid urbanization, industrialization, and an explosion in population in India, solid waste management will be a key challenge for state governments and local municipal bodies in the 21st century. Solid waste management is vital to the health and well-being of city dwellers. The urban poor is particularly vulnerable, as they generally live in informal settlements with little or no access to solid waste collection and in locations near open landfills. The ‘**Swachh Bharat Abhiyan**’ was created to tackle these issues related to waste management, and it created awareness among the people about the proper treatment of solid waste. Since the launch of this campaign, the waste management concept has started to gain momentum.

### **STATEMENT OF THE PROBLEM**

Both the quantity and diversity of trash produced in most cities have increased as a result of the issues of population expansion, urbanisation, industrial development, and growing standards of living. Many cities struggle with not just high levels of garbage but also more hazardous waste products that result from almost all human activity. In recent years, solid waste has become a severe danger, and unless proper eco-friendly measures are done right away, the situation is expected to get worse in the years to come. This is because of the importance of the problem and its detrimental effects on the environment and economy of Madurai. Dumping the garbage has two unfavourable effects. On the one hand, it contaminates waste land, and on the other, it taints the air, causing an epidemic of illnesses.



In order to promote eco-awareness in the study field, there has been a glaring lack of connection between the range of sustainability issues, the triple bottom line, and sustainable development. As a result, the current study makes an effort to investigate the composition of solid waste in Madurai City.

## REVIEW OF LITERATURE

**P. U. Asnani (2020)** In his topic solid waste management he explains solid waste management is one among the basic essential services provided by municipal authorities in the country to keep urban centers clean. However, it is among the most poorly rendered services in the basket the systems applied are unscientific, outdated and inefficient; population coverage is low; and the poor are marginalized. Waste is littered all over leading to insanitary living conditions. Municipal laws governing the urban local bodies do not have adequate provisions to deal effectively with the ever-growing problem of solid waste management. With rapid urbanization, the situation is becoming critical.

## SOLID WASTE MANAGEMENT IN MADURAI CITY

The Collection, transportation and disposal of municipal solid waste is an obligatory function of the Madurai Corporation. The Municipal Solid Waste mainly comprises waste from households, market, commercial establishments, hotels, hospitals and industries in the town. The public health department of the corporation, headed by City Health Officer and Assistant Health Officer is responsible for the Solid Waste Management in the city. For the efficient administration and for day-to-day operational purposes, the town is divided into 4 Zones covering all the 100 Municipal Wards.

In Madurai City garbage is generated at the rate of 406 gram per day per head accumulating to a massive quantum of 548 Metric Ton per day. This is slightly higher when comparing similar level of cities where the per capita generation of waste is around 400 grams per day and the reason for the excess rate of creation of waste is due to the heavy influx of floating population which is estimated to be around 3 lakhs. Out the accumulated garbage released by the houses, shops, daily and weekly markets, commercial establishments, hotels, hospitals and industries, garbage generated from the house account of 64%. Household wastes contains mainly residual vegetables and food which could be easily disposed. But the scientific disposal of solid waste such as plastic, paper discharged by the commercial establishments, without affecting the environment remains to be a great challenge.

### Zone Wise Potential Sources of Base Line in Madurai Corporation

**Table 1: States That, There Were Five Zones and Three Base Line in Madurai Corporation**

Sl. No.	Zone No.	Ward Count	Population	%	Households	%	Commercial	%	Total	%
1	Zone 1	21	375,987	19.59%	94,004	20%	2,978	10%	472,969	19.44%
2	Zone 2	21	377,408	19.66%	93,360	19%	4,404	15%	475,172	19.53%
3	Zone 3	19	373,096	19.44%	93,280	19%	13,462	46%	479,838	19.72%
4	Zone 4	18	399,713	20.82%	99,934	21%	4,514	15%	504,161	20.72%
5	Zone 5	21	397,399	20.70%	99,357	21%	3,800	13%	500,556	20.58%
	Total	100	1,919,603	100%	479,935	100%	29,158	100%	2,432,696	100%

**Source:** Secondary data, Madurai Municipal Corporation Handbook 2022.

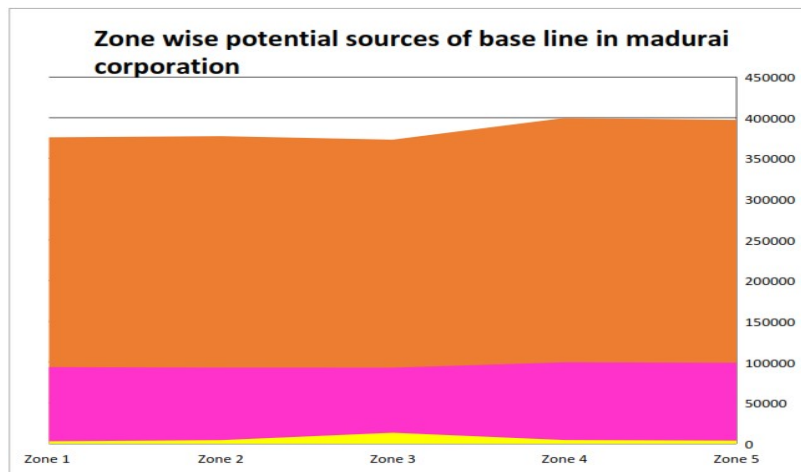
Zone – I have a 21 place in east side of Madurai city. they are shanthi nagar, kodal nagar, Anaiyur, sambancharalakulam, vilangudi, thathaneri, Aarappalayam, ponnaharam, krishanapalayam, azhagaradi, viswasपुरi, mela ponnaharam, railway colony, Ellis nagar, sscolony, ponmeni, aazhwarpuram, sellur, panthalkudi, goripalayam,

ahimsapuram. The population had 19.59%, household and commercial had 20% and 10%. commercial establishments like hotel, restaurants, shops, trading units , small times street traders, kalyana mandappam, etc., generate solid waste which mainly comprises of paper, plastic, food, etc., these are the percentages for potential sources of base line in Madurai corporation.

Zone – III have a 19 place in central side of Madurai city. They are swami sannidhi , ismailpuram, sourastra hr.sec.school, Mari Amman theppakulam, iraavadhanallur, sinnaanuppanadi, anuppanadi, chinthamani, meenakshi nagar, avaniyapuram, villapuram pudhu nagar, kathirvel nagar, manjana kara street, dhrowpathi amman kovil, St.mary's, kamarajpuram, madakkulam, pazhnagaanatham, sundarajapuram. The population had 19.44%, household and commercial had 19% and 46%. commercial establishments like hotel, restaurants, shops, trading units, small times street traders, kalyana mandappam, etc., generate solid waste which mainly comprises of paper, plastic, food, etc., these are the percentages for potential sources of base line in Madurai corporation .

Zone – IV have a 18 place in south side of Madurai city. They are masthanapatti, melamadi, narimedu, chokkikulam, thallakulam, kk nagar, k.pudur, lourdh nagar, reserve line, aathikulam, naahanakulam, pangajam colony, jadamuni kovil, kaajimar street, subramaniyapuram, solai azhagupuram, jaihindpuram, veerakali amman kovil .The population had 20.82%, household and commercial had 21% and 15%. commercial establishments like hotel,restaurants,shops,trading units, small times street traders, kalyana mandappam, etc., generate solid waste which mainly comprises of paper, plastic, food, etc., these are the percentages for potential sources of base line in Madurai corporation.

Zone – V have a 21 place in west side of Madurai city. They are bala ranganaatha puram, navarathina puram, lakshmiapuram, thirumalai naikar mahal, Madurai baskaradass nagar, perumal theppakulam, krishnarayar theppakulam, tamil sangam, sokkanadhar kovil, north Krishnan kovil, meenakshi kovil, thennaharam, kovalan nagar, T.V.S nagar, paamban swami nagar, mannar college, tirupparam kundram, haarvipatti, thiru nagar, balaji nagar, muthuramalingapuram . The population had 20.70%, household and commercial had 21% and 13%. commercial establishments like hotel, restaurants, shops, trading units , small times street traders, kalyana mandappam, etc., generate solid waste which mainly comprises of paper, plastic, food, etc., these are the percentages for potential sources of base line in Madurai corporation.



**Figure 2**

**Table 2: Zone Wise Manpower Workers of Solid Waste Management in Madurai Corporation**

SI.NO	Zone No.	Ward No.	Total Manpower				Total
			Permanent	Consolidate	Daily wages	Contract	
1	Zone 1	21	87	131	41	506	765
2	Zone 2	21	234	0	172	463	869
3	Zone 3	19	343	0	197	336	876
4	Zone 4	18	237	58	140	439	874
5	Zone 5	21	166	2	54	485	713
	TOTAL	100	1067	191	604	2229	4097

Source: Secondary data, Madurai Municipal Corporation, Handbook 2022.

Table 2 shows that the zone wise manpower workers of solid waste management in madurai corporation.

Zone- I, the permanant (87), consolidate (131), daily wages (41) and contract based man power workers were worked in different kinds of solid waste collected around the area, the nature of work had source reducing, recycling and disposal.

Zone – II, the permanant (234),consolidate (0) ,daily wages (172) and contract(463) based man power workers were worked in the different kinds of solid waste collected around the area, the nature of work had source reducing, recycling and disposal.

Zone – III, the permanant (343),consolidate (0) ,daily wages (197) and contract(336) based man power workers were worked in the different kinds of solid waste collected around the area, the nature of work had source reducing, recycling and disposal.

Zone – IV, the permanant (237),consolidate (58) ,daily wages (140) and contract(439) based man power workers were worked in the different kinds of solid waste collected around the area, the nature of work had source reducing, recycling and disposal.

Zone – V, the permanant (166),consolidate (2) ,daily wages (54) and contract(485) based man power workers were worked in the different kinds of solid waste collected around the area, the nature of work had source reducing, recycling and disposal.

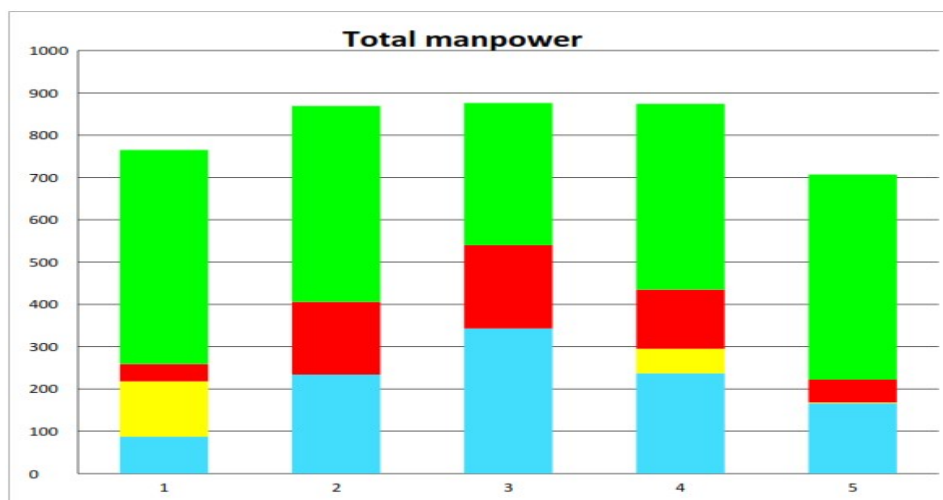


Figure 3

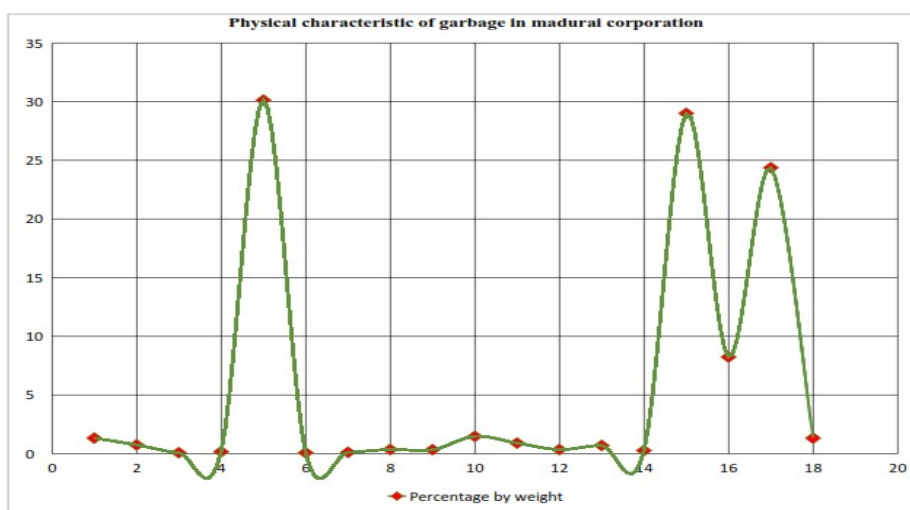
**Objective 1: To Study the Physical and Chemical Composition of Garbage in Madurai Corporation**

**Table 3: Physical Characteristic of Garbage in Madurai Corporation**

SI. NO.	Components	Percentage by Weight
1.	Paper	1.3325
2.	Plastic	0.7525
3.	Metals	0.085
4.	Glass	0.1675
5.	Silt	30.13
6.	Rubber / Rexin	0.0845
7.	Gunny bags	0.1175
8.	Cotton	0.36
9.	Wood	0.3425
10.	Paddy straw	1.477
11.	Cow dung	0.9046
12.	Banana stem	0.35325
13.	Coconut husk	0.70
14.	Baggage	0.26535
15.	Vegetables & Fruit waste	29.00
16.	Leaves waste	8.238
17.	Food waste	24.367
18.	Fish waste	1.3228

**Source:** Secondary Data, Madurai Municipal Corporation, Handbook 2022.

According to Table 3, a research of the waste characterization of solid waste undertaken by the madurai firm in 2004 found that around 65.40 % of garbage is biodegradable and the remaining portion is not (which mainly include paper, plastic, food waste, glass, metals, etc). The degradable waste are food, garden waste, paper and cardboard. The Non-degradable waste are plastic, glass, expired medicine, etc. Self help groups. (SHG) in 7 wards and bus stands, a privatisation in 2 wards, and the corporation in 63 wards are responsible for the majority of the waste collection in madurai town. In physical components of garbage weight are, paper had be 1.33%of weight, plastic had be 0.75% of weight, metals had be 0.08% of weight, cotton had be 0.36% of weight, paddy straw had be 1.47% of weight, food waste and fish waste had been 24.36% and 1.32% of weight. They made by madurai corporation.



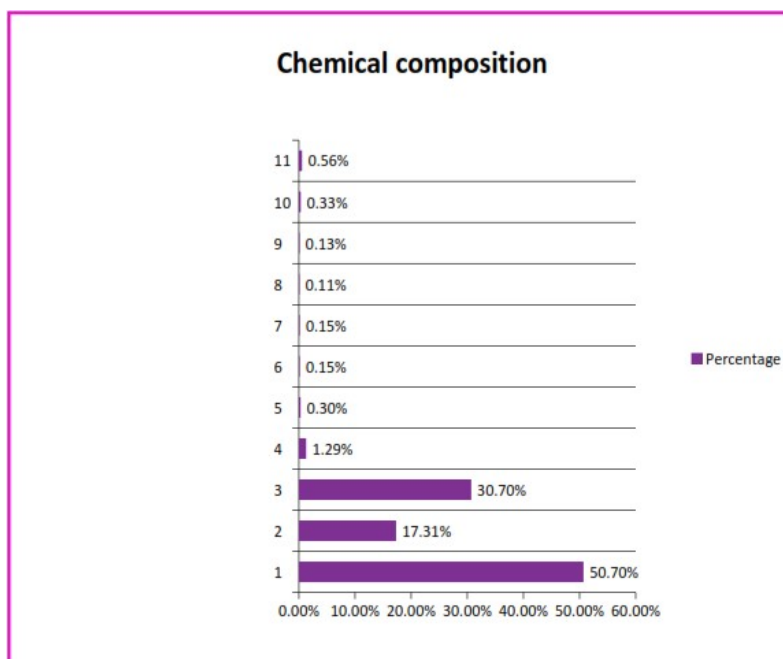
**Figure 4**

**Table 4: Chemical Composition of Soild Waste Management**

Sl.NO	Element	Mg/kg	Percentage
.	Moisture	507000 mg/kg	50.70%
.	Net VS	173100 mg/kg	17.31%
.	Ash	307000 mg/kg	30.70%
	Coal	12900 mg/kg	1.29%
	Sulphate	3000 mg/kg	0.3%
	Phosphate	1457 mg/kg	0.1457%
	Chloride	1499 mg/kg	0.1499%
	T.K.N	1105 mg/kg	0.1105%
	Sodium	1302 mg/kg	0.1302%
	Pottassium	3315 mg/kg	0.3315%
	Calcium	5600 mg/kg	0.56%

Source: Secondary Data, Madurai Municipal Corporation, Handbook 2022.

Table 4, shows that 65.40% of waste is biodegradable (or) chemical composition in 2004, according to a research of the characterization of solid waste undertaken by the Madurai corporation. (The chemical composition elements are moisture, ash, coal, chloride, etc.) Self-help groups (SHGs) in 7 wards and bus stands, a privatization in 2 wards, and the corporation in 63 wards are responsible for the majority of the waste (or) rubbish collection in Madurai town. Moisture had to be 50.80% and 507000 mg/kg, Net vs had to be 17.31 % and 173100 mg/kg, Ash had to be 30.80% and 307000 mg/kg , coal had to be 1.29% and 12900 mg/kg , sulphate had to be 0.3% and 3000 mg/kg, phosphate had to be 0.1457 % and 1457 mg/kg, chloride had to be 0.1499% and 1499 mg/kg, T.K.N had to be 1105 mg/kg and 0.1105 % , sodium had to be 0.1302% and 1302 mg/kg , potassium had to be 0.3315% and 33145 mg/kg , calcium had to be 0.56% and 5600 mg/kg , respectively of the chemical composition.

**Figure 5**

**Objective 3: To Disposal of Solid Waste Management of Municipal Corporation in Madurai City**

**Table 5: Zone Wise Waste Collection and Target of Madurai Corporation**

Madurai Corporation MCC Waste Collection and Target					
Zone No.	No of Ward	MCC: Wet Waste Collection (MT)	Garbage to Dumping Yard (MT)	Total Waste Collection (MT)	Total Waste Collection (%)
1.	21	14	107	121	16.18%
2.	21	16	141	157	20.99%
3.	18	12	165	177	23.66%
4.	19	12	146	158	21.12%
5.	21	14	121	135	18.05%
	Total			748	

**Source:** Secondary Data, Madurai Municipal Corporation, Handbook 2022.

Table 5 indicates that, zone wise waste collection and target of madurai corporation

Zone – I, They have a 21 wards of madurai corporation, the wet waste collection of madurai city corporation of Madurai city corporation had 14 MT ( Mega tone ) , garbage to dumping yard had be 107 MT and they percentage of total waste collection had be 16.18% of MCC waste collection & target.

Zone – II, They have a 21 wards of Madurai corporation, the wet waste collection of Madurai city corporation of Madurai city corporation had 16 MT (Mega tone), garbage to dumping yard had be 141 MT and they percentage of total waste collection had be 20.99% of MCC waste collection & target.

Zone – III, They have a 18 wards of madurai corporation, the wet waste collection of madurai city corporation of Madurai city corporation had 12 MT ( Mega tone), garbage to dumping yard had be 165 MT and they percentage of total waste collection had be 23.66% of MCC waste collection & target.

Zone – IV, They have a 19 wards of Madurai corporation, the wet waste collection of madurai city corporation of Madurai city corporation had 12 MT (Mega tone), garbage to dumping yard had be 146 MT and they percentage of total waste collection had be 21.12% of MCC waste collection & target.

Zone – V, They have a 21 wards of Madurai corporation, the wet waste collection of madurai city corporation of Madurai city corporation had 14 MT (Mega tone), garbage to dumping yard had be 121 MT and they percentage of total waste collection had be 18.05% of MCC waste collection & target.

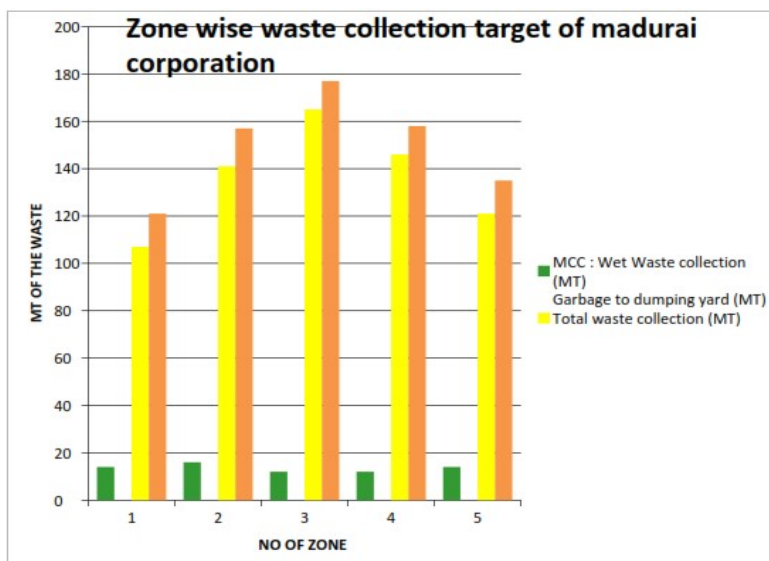


Figure 6

Table 6: MCC Zone Wise Wet Waste in Madurai Corporation

Zone No.	No of Wards	Wet Waste Generation (MT)	MCC: Wet Waste Collection (MT)	Total of Wet Waste	Total Percentage of Wet Waste (%)
	21	64	14	78	17.07%
	21	82	16	98	21.44%
	18	92	12	104	22.76%
	19	81	12	93	20.35%
	21	70	14	84	18.38%
Total	100	389	68	457	100.00%

Source: Secondary Data, Madurai Municipal Corporation, Handbook 2022.

Table 6, display that MCC zone wise wet waste in madurai corporation.

Zone 1, had a east side of madurai city. The wet waste generation had 64 MT, wet waste collection had 14 MT and the total percentage of wet waste had 17.07% of the MCC waste collection and target.

Zone 2, had a north side of madurai city. The wet waste generation had 82 MT, wet waste collection had 16 MT and the total percentage of wet waste had 21.44% of the MCC waste collection and target.

Zone 3, had a centre of madurai city. The wet waste generation had 92 MT, wet waste collection had 12 MT and the total percentage of wet waste had 22.76% of the MCC waste collection and target.

Zone 4, had a South side of madurai city. The wet waste generation had 81 MT, wet waste collection had 12 MT and the total percentage of wet waste had 20.35% of the MCC waste collection and target.

Zone 5, had a west side of madurai city. The wet waste generation had 70 MT, wet waste collection had 14 MT and the total percentage of wet waste had be 18.38% of the MCC waste collection and target.

## SHANNON – WEINER DIVERSITY INDEX

Table 7: Wet Waste Generation

No of wards	Wet Waste Generation (MT)	Pi	In (Pi)	Pi*In(Pi)	(- Pi* In (Pi))
21	64	0.164524422	-1.80469626	-0.296916608	0.296917
21	82	0.210796915	-1.556860096	-0.328181306	0.328181
18	92	0.236503856	-1.441790767	-0.340989076	0.340989
19	81	0.208226221	-1.569130189	-0.32673405	0.326734
21	70	0.179948586	-1.715084102	-0.308626959	0.308627
100	389			<b>Total</b>	<b>1.601448</b>

Table 7 shows that, The value of wet waste generation & wet waste collection are **1.601447999** they are related to  $1.5 < \times < 2.5$ , medium of diversity.

Table 8: Wet Waste Collection

No of Wards	MCC: Wet Waste Collection (MT)	Pi	In (Pi)	Pi*In(Pi)	(- Pi* In(Pi))
21	14	0.205882353	-1.580450376	-0.325386842	0.325386842
21	16	0.235294118	-1.446918983	-0.340451525	0.340451525
18	12	0.176470588	-1.734601055	-0.306106069	0.306106069
19	12	0.176470588	-1.734601055	-0.306106069	0.306106069
21	14	0.205882353	-1.580450376	-0.325386842	0.325386842
100	68			<b>TOTAL</b>	<b>1.603437347</b>

Table 8 states that, The value of wet waste generation & wet waste collection are **1.603437347** they are related to  $1.5 < \times < 2.5$ , medium of diversity .

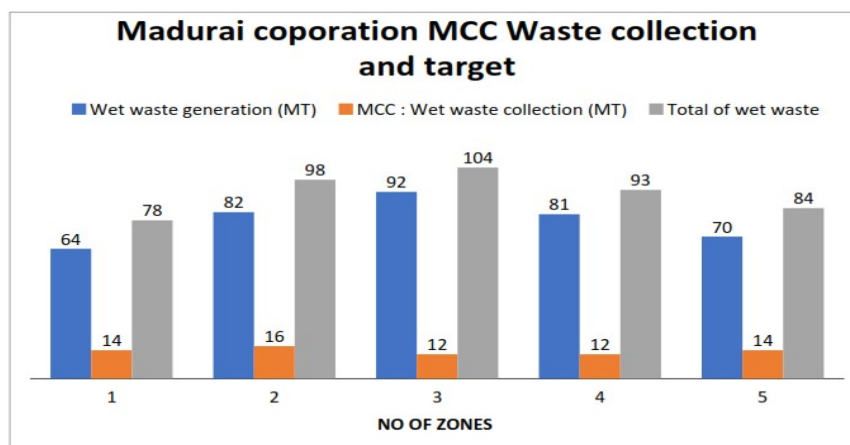


Figure 7

Table 9: Soild Waste Management in Madurai City

Solid Waste Management	
No. of Zones	4 zones
No. of Wards	72 wards
Population (2004)	1051434
Floating Population (20%)	2100000
Garbage Generated Per Day (Including Floating Population)	450 MT
Garbage Collected Per Day	360 MT
Collection Efficiency	80%

Source: Secondary Data, Madurai Municipal Corporation, Handbook 2022.



Table 9, shows that the outline of the solid waste management in 2004. They are number of zones ,in Madurai corporation had 4 zones, no. of wards under Madurai corporation had to be 72 wards. In the population of madurai corporation had 1051434 on 2004, the floating population (20%) had a 2100000, they garbage generated per day had to be 450 MT and garbage collected per day had be 360 MT. The collection efficiency of solid waste management had 80% of the Madurai corporation.

**Table 10: Total Vehicles of Solid Waste Management in Madurai Corporation**

Vehicles	Nos.
Corporation Tipper Lorries	8
Corporation Dumper Placer (4.5 Cum)	4
Corporation Dumper Placer (8 Cum)	2
Hard Carts	150
Tricycles	135
Dumber Bins	74
Hired Tractors	57
Hired Auto's	53
Hired Tipper Lorries	8

Source: Secondary data, Madurai Municipal Corporation, Handbook 2022.

Table 10, states that the total vehicles of solid waste management in Madurai corporation. Corporation tipper lorries are 8 number of lorries, corporation dumper placer (4.5 cum) had be 4 number , corporation dumper placer (8 cum) had be 2 number. The corporation manages primary collection through 135 tricycles (carrying capacity – 20 kg) and 150 hand carts (carrying capacity – 100 kg). Collection and transfer of waste to collection points is also managed by auto minder (57 hired tractors).There are 74 dumper bins with a total carrying capacity of approximately 100 tones placed at main collection locations around the city. The hired auto's are 54 and the hired tipper lorries are 8. In Madurai corporation waste transportation is being carried out using open vehicles. Transfer of garbage to collection points is done by corporation owned handcars, tricycles and rented vehicles like auto minders , which is further taken to dumping yard by means of corporation own vehicles and rented vehicles.

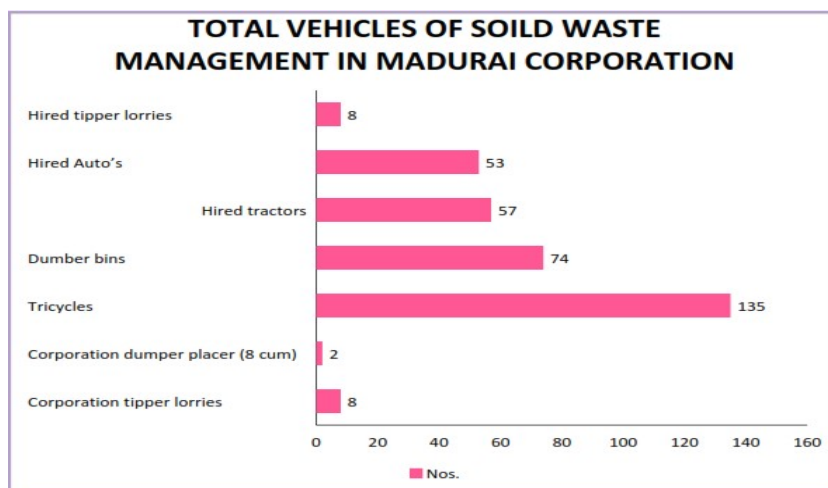


Figure 8

#### Objective 4: To Different Sources of Solid Waste Generated in Municipal Corporation

**Table 11: Solid Waste Generated From Different Sources**

SI. NO.	Source Generation	Garbage
	Residential	288.00 MT
	Street Sweeping	36.00 MT
	Commercial & Market	72.00 MT
	Institutional	36.00MT
	Hospital & Nursing	18.00 MT
	Total	450 MT

Source: Secondary Data, Madurai Municipal Corporation, Handbook 2022.

Table 11 states that solid waste generated from different sources. The residential waste had 288.00 MT garbage, street sweeping had 36.00 MT they night sweeping is done effectively around the temple areas., the core city areas, some markets and around bus stands. The commercial and market waste are 72.00MT garbage, the institution waste like school, college, coaching centre etc had be 36.00 MT and the hospital and nursing waste are 18.00MT garbage waste are generated this sources.

#### SIMPSON'S DIVERSITY INDEX

**Table 12: Source Generation of Solid Waste Management**

Source Generation	Garbage	n-1	n(n-1)
Residential	288	287	82656
Street Sweeping	36	35	1260
Commercial & Market	72	71	5112
Institutional	36	35	1260
Hospital & Nursing	18	17	306
Total	N= 450		$\Sigma n (n-1) = 90594$

$$= 1 - 0.448$$

$$SDI = 0.051$$

Table 12 shows that, The result of table is  $SDI = 0.448$ , the simpson's diversity index should be homogenous it is 0 or hetrogenous it is 1 this source generation of garbage has been not more than 0 it is 0 it is called homogenous simpson's diversity index .

**Table 13: Present Status - Man Power**

SI. NO.	Designation	Sanctioned Strength	Present Strength	Vacancy
	Sanitary Workers	2700	2516	184
	Circle Sanitary Officer	-	4	-
	Sanitary Inspector	84	37	47
	Conservancy Inspector	72	-	72
	Driver	91	65	26
	Sanitary Supervisor	110	63	47
	TOTAL	3057	2685	376

Source: Secondary data, Madurai Municipal Corporation, Handbook 2022.

Table 13 shows that, the madurai corporation is collecting solid waste by employing 2700. Sanitary workers in sanctioned strength they may divided to present strength had be 2516 and the vacancy had be 184. They are the sanitary workers in man power of madurai city. A clearing the garbage using hand carts and tricycles. Who collections waste form dustbins and dumper bins.

The madurai city sanitary officer are present strength 4 of the man power the sanitary inspector.

The madurai corporation is collecting solid waste by sanitary inspector 84. Sanitary inspector in sanctioned strength they may divided to present strength had be 37 and the vacancy had be 47. They are the sanitary inspector in man power of madurai city.

The madurai corporation is collecting solid waste by conservancy inspector 72. conservancy inspector in sanctioned strength they may divided to present strength had be nil and the vacancy had be 72 . They are the conservancy inspector in man power of madurai city.

The madurai corporation is collecting solid waste by driver 91. driver in sanctioned strength they may divided to present strength had be 65 and the vacancy had be 26. They are the driver in man power of madurai city.

The madurai corporation is collecting solid waste by sanitary supervisor 110. sanitary supervisor in sanctioned strength they may divided to present strength had be 63 and the vacancy had be 47. They are the sanitary supervisor in man power of madurai city.

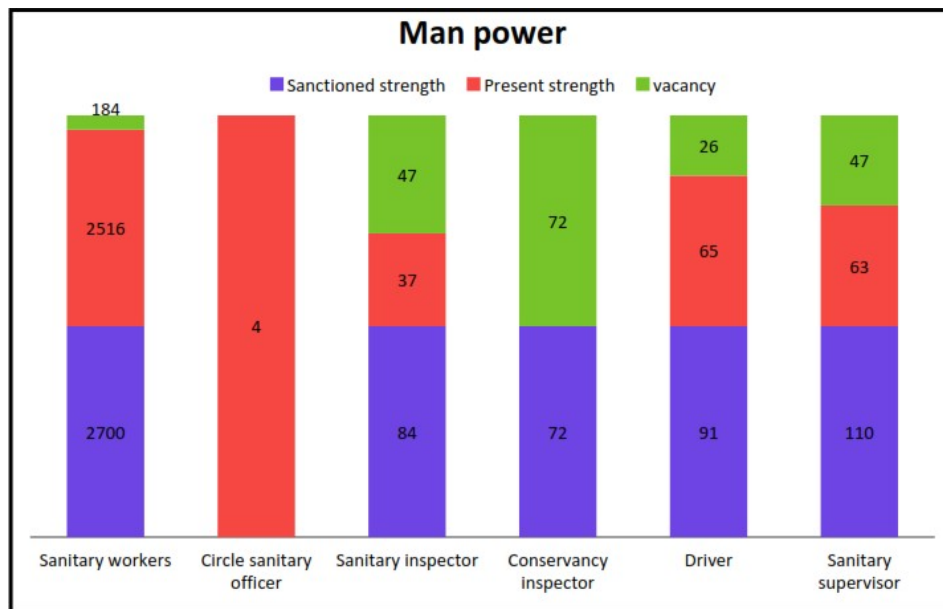


Figure 9

**OBSERVATION**

The per capita generation of waste in the city is 22 percent higher than the quantity prescribed in the CPHEEO Manual and is about 330 grams (Standards 270 grams for the cities with a population between 10 to 20 lakhs).

Wastes are consisting of food waste and other discarded waste materials such as paper, plastic, glass, metal, rags, packaging materials, etc. The household industries (brassware) are contributing wastes in the form of ash.

Households, shops and commercial establishments in Madurai City are yet to start the practice of segregation of recyclable waste at source. Such waste on the streets or in the municipal bins are found going to disposal sites un-segregated.

The habit of storage at the source of waste generation for the effective door-door collection is not practiced in all the area.

In the absence of the system of storage of waste at source, the waste is thrown on the streets, treating streets as receptacle of waste.

There is a need to educate people to change their habit so as to store waste at source, dispose of the wastes as per the directions of the Local Body and effectively participate in the activities of the Local Body to keep Madurai City clean.

In few areas, the bins in use are without lids and found unsuitable for storage of food wastes for 24 hours or more especially in households, restaurants, hotels and eateries as wastes start stinking due to putrefaction.

The people are found throwing the wastes on the streets and expecting the Sanitary Workers of the Local Body to clean leading to an ugly and unhygienic atmosphere prevailing in the city.

Since Madurai Corporation is having 615Km length of roads needs to be swept every day, major roads of width more than 7.5m requires mechanical sweeping machines in order to save time and manpower.

Inadequate supply of essential tools like wheelbarrows/baskets to the Sanitary Workers, often found forcing the Sanitary Workers to make a heap in undesignated open yards.

All roads and streets are not being swept on daily basis. Certain important roads and markets are swept daily, some are swept on alternate days or twice a week, some are swept occasionally or not at all.

Sweeping in commercial areas are found beginning in the morning around 7.30 am, but shops open after 9.00 am and found start throwing their sweepings on the streets soon thereafter, nullifying the work just done by the Sanitary Workers.

In many places, the MS containers without lid are found to be either damaged or toppled to horizontal positions and thereby not facilitating for the use.

Tractor-Trolleys are of 35 years old and have exhausted their economic life, requiring immediate replacements to economize the operations. The hydraulic Tractor-Trolley is procured about 6 years back, left with 2 years of economic life. Animal carts need to be discontinued as they are not complying to norms/standards.

Waste handling is partially mechanized and the waste is handled multiple times leading to potential health hazards for the workers as all types of wastes including hospital wastes are disposed off in the same storage points. The Sanitary Workers are not given proper protective clothing.

## **KEY ISSUES**

Some problems are faced by Madurai Corporation while disposing the solid waste. They are as follows:

- Segregation of the collected waste from households at source is not being practiced leading to mixing of waste and entrainment of recyclable waste being dumped without proper and full recovery.
- Door-to-Door collection is not practiced in a complete manner resulting in haphazard disposal of waste by households on streets and adjacent to waste bins rendering the general environment unaesthetic.

- It is felt that in absence of adequate manpower, regulated transportation, narrow streets and financial constraints are some of the reasons that are deterring door to door collection.
- As specified above, recyclable waste is not being removed from the general waste at the source of subsequent pre-disposal points. This is leading to rag pickers disturbing the waste dump and posing a significant public health risk.
- Separation of waste that is bio-medical in nature at the household level is also not performed which could entail some quantity of bio-medical waste reaching the disposal site although a common treatment and disposal facility has been reportedly made available at Madurai.
- Waste is not covered with earth to prevent ingress of vector, pigs, dogs etc. A large number of stray animals are found during site visits to the disposal site. Waste from slaughter houses are observed to be disposed along public areas resulting in public health and pollution problems.

## **SUGGESTION OF THE SOLID WASTE MANAGEMENT**

Solid waste generation is spontaneous process of households, corporate and hospitals. This needs to be regulated and monitored effectively in the study area through stricter laws. The problem of solid waste management in Madurai is a very serious agenda. The households must respect nature, consider the ecological environment as an asset, integrate environmental issues into planning and administration, and contribute towards the accelerated transitions to sustainable development.

### **1. Shop Eco-Friendly with Reusable Bags**

With cities like Montreal banning the distribution of plastic bags, Link opens in a new window. in stores, reusable grocery bags are already commonplace across Canada. Furthermore, they can significantly help reduce the number of plastic bags collecting in our landfills.

(Germany is the first in solid waste management)

### **2. Ditch Disposables in the Kitchen**

Sure, plastic wrap, tin foil, paper towels and plastic zip bags may be convenient – but they create a lot of waste. Try using a silicone baking sheet in place of tinfoil or parchment. When cleaning, swap out paper towels and single-use wipes for microfiber cloths you can wash and reuse. Reusable lunch containers and washable snack bags will keep your food just as fresh and will minimize the amount of trash coming from your household on a day-to-day basis.

### **3. Say so Long to Single Serve – Bulk Up Instead**

Items like snack packs, coffee pods and disposable cutlery save a little time and effort, but the packaging generates a lot of unnecessary waste. Try sticking to foods that have zero packaging or take your reusable containers to the bulk store and stock up – and save time and money on your shopping!

#### **4. Say No to Disposable Water Bottles and Coffee Cups**

Contrary to popular belief, disposable coffee cups are not recyclable, due to the inside coating they have. For coffee on the go, use a travel mug. It's just as convenient, and it can save you money too! And why not try a double-insulated bottle that can handle both your hot and cold beverages!

#### **5. Reduce Food Waste**

Did you know Canadians waste \$31 billion worth, Link opens in a new window of food every year – and 47% of it is produced in the home? Before putting food to the trash, ask yourself if it is so far gone that you really need to throw it out. Take the habit of noting the expiry dates of food in your fridge and planning your meals accordingly. If food goes bad, compost it! Composting transforms organic waste into nutrient-rich soil.

#### **6. Join buy-and-Sell Groups**

Did you know Canada's second-hand economy is alive and well? Keep your no-longer-needed items out of landfill and make some fast cash. There are dozens of online buy-and-sell web sites. Yes, someone could be interested in that blender that you never used, the skates too tight for your kid or the pine coffee table in the basement – they'll even pick it up and pay you in cash!

#### **7. Try a New Way to Buy (and Sell) Clothes**

Need some new clothes? Why not check out your nearest second-hand store? And while you're at it, the clothes you no longer use could be perfectly wearable for someone else. Try donating them to consignment or thrift shops, swapping clothes with friends, or even repurposing them as cloths and rags.

#### **8. Find a New Home for Old Furniture**

Why not give your old furniture a new home? Donate it to a local charity, put it on the curb with a "free" sign on it, or post an online ad to sell it or give it away. Some donation centres even offer pickup services for used furniture.

#### **9. Dispose of e-Waste Responsibly**

Old computers, TVs and other devices are placing an increasing burden, Link opens in a new window. on Canadian landfills. These devices have components that can contain potentially harmful chemicals, so before you put your e-waste at the curb, find out if the manufacturer has drop-off programs, or find recycling programs in your province, Link opens in a new window.

#### **10. Choose Paperless Billing**

Paying bills can be fast, easy and paper-free! Why not spend an hour switching all your paper statements to electronic delivery sometime this week? Enter your invoices' due date on your online calendar or set up automated payments so you don't have to worry about missing a payment.

**RECOMMEDATION TO EFFECTIVE MANAGEMENT OF SOLID WASTE MANAGEMENT**

- Public education on solid waste and numerous associated concerns is necessary. In general, preventative measures should be promoted widely, particularly on radios, TVs, in newspapers, and in schools to inform people about suitable methods for handling solid waste and maintaining a clean environment.
- The municipality must assume responsibility for educating the populace about the usage of conventional solid waste containers for residential and commercial use.
- The volume of solid trash and residues produced by dealers in the study area has to be started, evaluated, and described. Trying to find out trash inventory strategy would help in managing solid waste in the study region effectively and efficiently.
- Laws should be more strictly enforced, and administrative sanctions for small infractions should be quickly implemented.
- Including preventing marine and riverine litter as a goal in your efforts to enhance your solid waste management system.
- At strategic spots, build garbage traps or other methods of removing plastics.
- Residents of the neighborhood should work on the management of solid waste in Madurai. They would behave more responsibly as a result.
- Boost the frequency and quality of services.
- Through both formal and informal education, people should be given the right attitudes and perceptions regarding garbage disposal.
- Analyze plastic trash leaks into streams and the ocean on a regular basis, and keep an eye on marine debris.
- Support for the required institutional and legal structure will improve collection services, including waste segregation at source.
- Spread awareness among individuals and in the political realm.
- It is important to persuade the government, donor nations, non-governmental organizations, and other stakeholders to make it possible to acquire qualified personnel and equipment.
- Encourage the growth of institutional and personal capabilities.
- Environment Impact Assessment (EIA) must be set up in order to evaluate the environmental and social effects of solid waste on the local communities and eco- system.
- In order to ensure environmental purity, new duties for the top executives and other opinion leaders must be assigned. This can be accomplished by approving the extra task of guaranteeing Clean environmental practical, with the young playing a key part, to be undertaken by the relevant authorities in each region or community.
- Create long-term funding sources for garbage collecting.

- To remedy the issue, the community should use a self-help strategy. When the various communities band together and plan recurring cleanup events, much may be accomplished.
- Since that women handle and dispose of a larger portion of the community's solid waste, they should be given a significant role.
- Proper segregation would be vital for scientific disposal of waste.

It is intended that these recommendations, if followed by the government, local officials, and the people of Madurai, may help in resolving the city's concerns with solid waste management and associated matters.

## CONCLUSION

Research work on the economics of solid waste management at the many municipalities in the numerous emerging nations is lacking. The many economic components of solid waste management, such as economic instruments and policy concerns, have been covered in this chapter. The biggest issues, though, are with how economic instruments are implemented. Thus, it is necessary to improve local institutions and governance. Due to a lack of information on trash creation, disposal, and recycling, economists in many developing nations, such as India, have a difficult time assessing the economics of solid waste management. For local policy makers to develop a healthy urban planning strategy and create sustainable cities, a greater grasp of the economic estimation of solid waste is necessary. Most poor nations lack the resources and technology necessary for efficient solid waste management.

To draw the conclusion that the Health Department is now in charge of the MSW collection system, which is carried out by sanitary workers under the supervision of sanitary inspectors. The Engineering Department, however, is in charge of vehicle transportation and upkeep. It was highlighted that the dual (two-fold) accountability structure in place leads to ineffective collection, which generates complaints, and insufficient redress/correction mechanisms. To ensure efficient system administration, Madurai Corporation's institutional capability and strength need to be improved.

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