International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
doi : https://doi.org/10.32628/IJSRST

Solid Waste Management in Madurai City : An Assessment

Dr. I. K. Manonmani*
Assistant Professor, Department of Geography, Madurai Kamaraj University, Madurai, India
*Corresponding author's email: ikmm141@rediffmail.com

Article Info
Volume 4, Issue 11
Page Number : 744-749

Publication Issue
November-December-2018

Article History
Accepted : 05 Nov 2018
Published : 20 Dec 2018

ABSTRACT

The haphazard urbanization and large floating population created acute problem of solid waste management in Madurai city.Solid waste management includes all activities that seek to minimize the health, environmental and aesthetic impacts of solid wastes. The solid waste management in Madurai has multiple processes from collection of waste to disposal. However, the waste management has been rather unsatisfactory in certain parts of the city. The study shows that's 450 MT of solid waste in generated out of which only 360 MT is collected and processed. City core and north have high accumulation of waste disposal due to a multitude of reasons. Madurai city is one of the metropolitan cities and now it upgraded to smart city, hence it is recognized as an important aspect to study the solid waste disposal and management in Madurai metropolitan city.

Keywords : Urbanization , Floating Population, Solid Waste, Health And Environmental Problems, Madurai City.

Introduction

'Solid Waste' is the term used internationally to describe the non-liquid waste arising from domestic, trade, commercial, industrial, agriculture, mining activities and from the public services (e-Krishi Shiksha, 2013). Solid wastes comprise countless different materials like dust, food wastes, packaging in the form of paper, metals plastics or glass, discarded clothing and furnishings, garden wastes, hazardous and radioactive wastes (Jamal, 2016). Proper solid waste management has been a major challenge across the globe due to the changing lifestyles, increased production of goods, rapid urbanization, increasing waste diversity and lack of effective implementation of consistent waste policies (Ndhlovu, 2018). Solid waste management includes all activities that seek to minimize the negative impacts of solid wastes on health, environmental and aesthetics. A solid waste management (SWM) system includes collection, segregation, transportation, processing and disposal of waste (CPR Environmental Education Centre, 2020). Solid waste management is a worldwide phenomenon.

Growth of population, industrialization, urbanization and economic growth, a trend of significant increase in Municipal Solid Waste generation has been recorded worldwide. As urbanization and sub- urbanization increased, the burden of urban waste, along with social cost that was imposed upon the metropolitan environment increased. With the result of urbanization, the management of solid waste is becoming a major health and environmental concern in urban people of many developing countries (Guerrero, Maas, & Hogland, 2013).The concern is serious, particularly in the capital cities, which are often gateways to the countries for businessmen and tourists (Ogawa, undated). It is a big challenge all over the world for human beings. With modern life style, there has been a substantial increase in the generation of solid waste resulting into contamination of air, water and land resources (Abdel-Shafy & Mansour, 2018). Human activities create waste, and it is the way these wastes are handled, stored, collected and disposed of that pose risks to the environment and to public health. World Health Organization, since its inception has studied the environmental health through the different measures such as water supplies, wastewater treatment, solid waste management, vector control etc. The waste has been categorized as municipal solid waste, health care waste and e-waste and annually over two billion tons of municipal solid waste are generated (WHO, 2023). Guerrero et al. in 2013 argued that solid waste management has increasingly become a challenge for urban areas due to increasing population, waste generation and rising cost of disposal and treatment. Researchers argue the municipal solid waste management has been unsatisfactory for countries around the world. Ikiara et al. (2004) in Kenya; Dehghanifarda & Dehghani (2018) in Iran and Fadhullah et al. (2022) in Malaysia highlighted the unsatisfactory services of the city in solid waste management process is a necessity to sustain the development process. Hence, it is recognized as important aspect to study and to the problems related to urban centers since it is growing very fast than the rural areas.

Environmental crisis, stress, protection, management, monitoring and like have become catchwords or rather watchwords in the scientific literature. As the world is developing hour to hour, the number of problems added to the environment also increases. Most of the environmental problems affect the population directly or indirectly. Among the various environment of the city the disposal of solid waste in an important one as it highly related to day to day life of the city people. It is almost a common practice in all cities of developing countries to dump the city refuse in the low lying areas (Central Pollution Control Board Central Zonal Office, 2010-11) or near open spaces and on roads which create apparently disorder in a way by creating an ugly site and infusing into ground water (Vasanthi, Kaliappan, & Srinivasaraghavan, 2008). It also gives rise to foul air and increase the breeding of mosquitoes and other insects (World Bank, 2022). The magnitude of the sewage and solid waste problem is different in world cities as they vary with the nature and degree of development (World Bank, 2023). The attention paid to on environmental sanitation and waste disposal aspects is very little.

The per capita generation of Municipal Solid Waste has also increased tremendously with improved lifestyle and social status of the populations in urban centers. Per capita waste generation varies between 0.2 kg-0.6 kg per day in cities with population ranging between 1.0 lakhs-50 lakhs in India as per the Ministry of Housing and Urban Affairs (undated). Because of the increasing per capita waste generation of about 1.3% per year, and growth of urban population between 3% - 3.5% per annum; the yearly increase in

the overall quantity of solid waste in the cities is about 5% (Ministry of Housing and Urban Affairs, undated). As more land is required for the ultimate disposal of these solid wastes, issues related to disposal have become highly challenging. Generally, in India, Municipal Solid Waste is disposed in low lying areas without taking proper precautions or operational controls. Therefore, Municipal Solid Waste Management is one of the major environmental problems of Indian cities (Sharholy et al., 2008). In most Indian cities, the Municipal Solid Waste Management System comprises only four activities, namely waste generation, collection, transportation, and disposal (Ikiara, Karanja, Davies, 2004). Poor collection and inadequate transportation causes the accumulation of Municipal Solid Waste at every nook and corner.

Madurai city is also one of the metropolitan cities and now it upgraded to smart city, hence it is recognized as an important aspect to study the solid waste disposal and management in Madurai metropolitan city. The main aim is to study the solid waste disposal in Madurai City and the main objectives are to understand the infrastructural facilities in the city and to analyze the solid waste disposal in the city.

Study Area

Madurai is an ancient city in the state of Tamil Nadu situated on the banks of the River Vaigai in Madurai district. Madurai Corporation is the second largest Municipal Corporation in the state of Tamil Nadu. Madurai was the capital city with an ancient southern civilization in the past. The world famous Sri Meenakshi Sundareshwara temple is located in Madurai city. It is situated in south central part of Tamil Nadu from $9^0$48'17" to $9^0$59'26" N latitude and from 78^0 02'58" to 78^0 11'34" E longitude at a distance of nearly 500 km from Chennai. The city has grown on both sides of River Vaigai and lies at low altitude being only about 100m above the mean sea level. The fast increase in the area of the city has also facilitated the growth of the number of wards, now Madurai city has 100 wards.

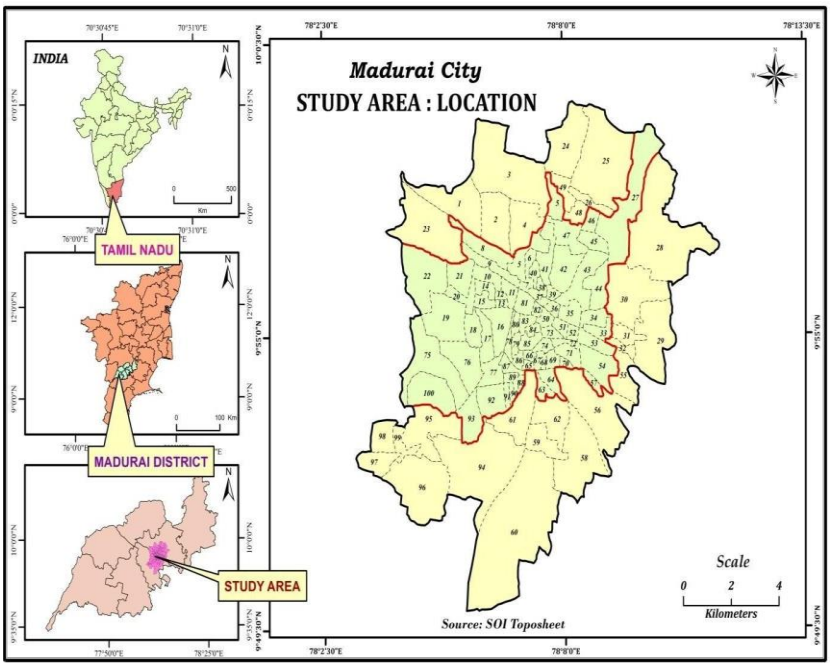


Fig. 1 Location of study area

Materials and Methods

The Geographic Information System (GIS) has been applied along with Survey of India maps like 1:25000 scale (58 K/1 NE , 58K/5 NW, 58 K/1SW, 58K/1SE, 58 K/ 5 SW), 1:50000 scale map 58 K/1, 58 K/2, 58 K/5 ; Army Services Maps like NC 44- 9, NC 43-12) and taluk map from Madurai Municipal Corporation. Arc GIS 9.3 was used for geographical analysis and presentation of maps. The Survey of India Toposheets and the Madurai city maps, which were obtained from the Madurai Municipal Corporation Office, were geo-referenced using ArcGIS 9.3 software and various thematic layers were prepared from it.

Solid Waste Generation, Transport and Disposal with Increase of Madurai's Boundaries

Growth of Waste Generation with Madurai's Growth

The civic and sanitation requirement of Madurai were managed by a city council during the up graded period 1866-1970 (Corporation of Madurai, 2021). Madurai city is administered by the Municipal Corporation which is responsible for the day-to-day running of the municipal school board, the city bus services the municipal hospitals, and the city library. The city services as the head quarters of Madurai district. In 1974, 13 town Panchayats on the out-skirts of Madurai city were included in Madurai Corporation and number of wards was increased to 65 in 1990, a delineation committee was formed to identify new wards and the total number of wards was increased from 65 to 72 and it was again increased 100 wards in 2011 (Corporation of Madurai, 2021)(Table 1). Madurai is also divided into 4 zones (Table 2).

Table 1. Growth of Madurai Municipal Corporation

Sl.No.	Year	Area in sq. km.	No. of Wards
1	1951	18.52	35
2	1965	22.17	35
3	1967	22.46	35
4	1968	22.90	35
5	1971	23.07	45
6	1981	46.99	65
7	1991	51.04	72
8	2001	51082	72
9	2011	147.99	100

Source: Office Records of Madurai Corporation

Table 2. Madurai City- Zone, Ward and its Area

Details	Zone I	Zone II	Zone III	Zone IV	Total
Ward No	23	26	25	26	100
Ward List	1-23	24-49	50-74	75-100	100
Area sq.k.m	37.35	46.94	27.01	36.7	148

Source: Office Records of Madurai Corporation

With the ever-growing city size, garbage is generated at the rate of 406 gram per day per head accumulating to a massive quantum of 548 metric ton per day (Corporation of Madurai , 2021). 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 (Corporation of Madurai , 2021). 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% (Corporation of Madurai , 2021). Household wastes contain 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. Garbage is divided into residential waste, commercial and market waste, street waste, hospital waste etc. (Table 3).

Table No. 3

Sources of Solid Waste Generation

Sources generation	Garbage in Tons	Composition (percentage)
Residential Waste	288	64
Commercial & Market Waste	108	24
Street Waste	36	8
Hospital Waste	18	4
Total	450	100

Source: Office Records of Madurai Corporation

The Madurai Corporation generated 450 tons of solid waste per day, which is at per compared to the norms of approximate, 400 g per capita for cities of similar size. High influx of floating population (approximate, 2.10 lakhs persons annually) is also cited as person for high generation of solid wastes, especially commercial wastes. Over 50 percent of solid has been a nagging problem for civic authorities.

Collection and Transfer of Waste

The functional element of collection includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be materials processing facility, a transfer station, or a processing site. The functional element of transfer and transport involves the transfer of wastes from the smaller collection vehicle to the larger transport equipment. Set-out container is one of the major factors that most collection system depends on. This is usually a paper or plastic bag, or metal or plastic garbage or craft paper bags in a metal or wooden frame. Set-out containers of rural areas include bags, pots, plastic etc. Madurai generates 450 MT of solid waste out of which 360 MT (Table 4) is collected with the help of workers (Table 5) and vehicles (Table 6).

Table No. 4. Existing solid wastes management

No. of Zones	4 Zones.
No. of Wards	100 Wards
Floating Population (20%)	2100000
Garbage Generated per day (including Floating population)	450 MT.
Garbage Collected per day	360 MT.
Collection efficiency	80%

Source: Office Records of Madurai Corporation

Table 5

Present Status of Man Power

Designation	Sanctioned Strength	Present Strength	Vacancy
Sanitary workers	2700	2516	184
Circle sanitary officer	-	4	-
Sanitary inspector	84	37	47
Conservancy inspector	100	-	72
Drivers	91	65	26
Sanitary supervisor	110	63	47
Total	3057	2685	376

Source: Office Records of Madurai Corporation

Table No. 3

Vehicles used in the Transportation of Wastes

Vehicles	No. of Vehicles
Corporation tipper lorries	8
Corporation dumper placer (4.5cm)	4
Corporation dumber placer(8cm)	2
Hand carts	150
Tricycles	135
Dumper bins	74
Hired vehicles	
Hired tractors	57
Hired Autos	53
Hired Tipper lorries	8

Source: Office Records of Madurai Corporation

Sorting, Processing and Transformation of Solid Waste

Sorting of commingled (mixed) wastes usually occurs at a materials recovery facility, transfer stations, combustion facilities, and disposal sites. Sorting often includes the separation of bulky items, separation of

waste components by size using screens, manual separation of waste components, and separation of ferrous and non-ferrous metals. Processing is required to alter the physical and chemical characteristics of wastes for energy and resource recovery and recycling. The important processing techniques include compaction, thermal volume reduction, and manual separation of waste components, incineration and composting. Depending on the nature of the source material, there are plethora of sorting and processing activities utilized that range from labor intensive hand picking operations through mechanized or technically complex processes.

Disposal

The final functional element in the solid waste management system is disposal. Disposal is the ultimate fate of all solid wastes, be they residential wastes, semi-solid wastes from municipal and industrial treatment. On the general concept, disposal means to put waste in to fill for the purpose of final burial. Today the disposal of wastes by land filling or uncontrolled dumping is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities, residue from the combustion of solid waste, rejects of composting, or other substances from various solid waste-processing facilities. A municipal solid waste landfill plant is an engineered facility used for disposing of solid wastes. As the terminal action for pollution control of solid waste, the final target of disposal is isolating solid waste and its environmental impact from the infection biosphere and to human kind and environment from any unacceptable hazard from the infection of hazardous components in wastes. Thus, land use planning becomes a primary determinant in the selection, design and operation of landfill operations (Corporation of Madurai , undated). The city's main dump yard at Vellakkal near Avaniyapuram can process 450 tons of waste a day. Site is located at about 10 km from the city and the total area of the site is 82 Acres.

The Madurai Corporation plans to set up 41 micor-composting centers at a cost of 33.2 crore to decentralize solid waste disposal. The micro-composting centers can process can process up to 240 tons. In accordance with solid waste management rule 2016, it has identified locations across the four zones to set up the 41 composting units and as many on-site composting yards at Thathaneri, Kochadai, Anuppanadi, Vilangudi, Madakulam and Avaniyapuram and other places which were annexed to the city a few years back. While micro-composting centre, a vital component in the waste management chain, can process up to five tones of wet waste a day, an on- site composting yard, usually set up at parks, can process up to one tone of organic waste. At the composting centers, the waste is segregated as inorganic and organic, and the latter is shredded and dumped into cubical cement tanks for decomposition. While it decomposes, in 30-40 days, a micro-organism solution will be added to control odour and also to hasten the process.

1) **Analysis of Solid Waste Management in Madurai City**

Zone I: In the first one, out of 23 wards, 22 have low level of concentration (less than 1%) of solid waste generation. These wards are Visalakshi Nagar, Ellis Nagar, B.B.Kulam, S.S.Colony, Santhi Nagar, Koodal Nagar, Viswasapuri, Railway Colony, Anaiyur, Vilangudi, Ponnaharam, Melapponnaharam, Meenambalpuram, Thathaneri, Azhagaradi, Kailaasapuram, Aarappalayam, Krishnaapalayam, Arasaradi,

Bethaniyapuram, Kochadai and Sambandhar Alankulam. These areas mostly found in peripheral area of the city. Only one ward namely Ponmeni registered with high level of solid waste with more than 2% found in found in the periphery of the city (Table 6, Fig. 2).

Table 6. Solid Waste Disposal in Zone – I, Madurai City – 2018

Ward No	Ward Name	Solid Waste Disposal %	Ward No	Ward Name	Solid Waste Disposal %
1	Santhi Nagar	0.59517	13	Azhagaradi	0.7285
2	Koodal Nagar	0.67061	14	Viswasapuri	0.67037
3	Anaiyur	0.70327	15	Melapponnaharam	0.71563
4	Sambandhar Alankulam	0.92812	16	Railway Colony	0.69584
5	B.B.Kulam	0.37649	17	Ellis Nagar	0.00495
6	Meenambalpuram	0.71118	18	S.S.Colony	0.38169
7	Kailaasapuram	0.76461	19	Ponmeni	2.7257
8	Vilangudi	0.7186	20	Arasaradi	0.78242
9	Thathaneri	0.72899	21	Bethaniyapuram	0.82126
10	Aarappalayam	0.76338	22	Kochadai	0.87519
11	Ponnaharam	0.71514	23	Vishalakshi Nagar	0.37142
12	Krishnaapalayam	0.76362			

Source: Corporation of Madurai

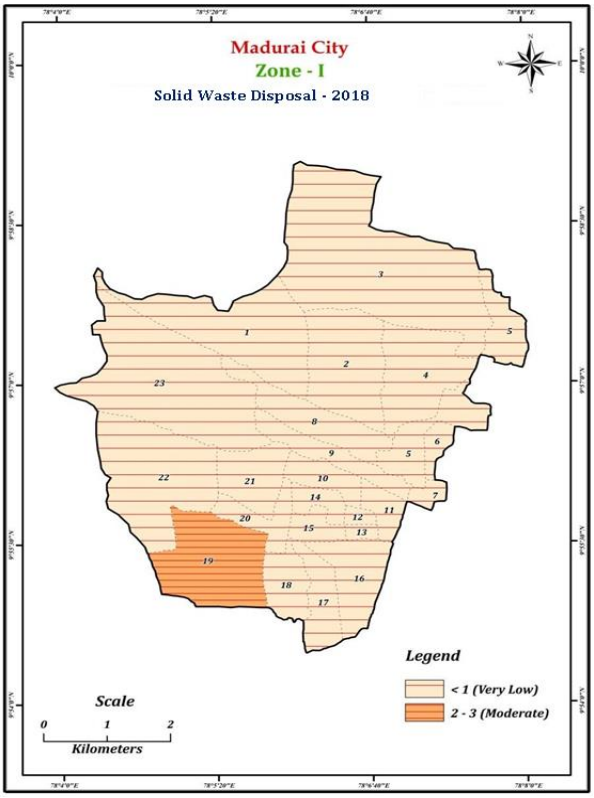
Zone II : The very low concentration of less than 1% of solid waste have been notable in 21 wards in the second zone. The wards are Tallakulam, K.K.Nagar, Pudur, Madhichiyam, Melamadai, Naahanakulam, Thiruppaalai, Kannanenthal, Vandiyur, Ahimsapuram, Saathamangalam, Goripalayam, Karpaga Nagar, Sellur, Panthalkudi, Tahsiltharpuram, Chokkikulam, Masthaanpatti, Aathikulam, Aazhwarpuram and Arignar Anna Nagar. These areas are mostly found in the northern part of the River Vaigai and these wards are mainly residential area. The low level of concentration (1-2%) occurs in Parasuraaman patti and Reserve Line. The high level (3 -4%) of solid waste seen in Uthangudi and very high concentration of solid waste seen in Lourdhu Nagar and Narimedu found in outer area of the city limit (Table 7, Fig.3).

Table 7. Solid Waste Disposal in Zone – II, Madurai City – 2018

Ward No	Ward Name	Solid Waste Disposal %	Ward No	Ward Name	Solid Waste Disposal %
24	Thiruppaalai	0.79009	37	Sellur	0.73394
25	Kannanenthal	0.68323	38	Panthal kudi	0.7426
26	Parasuraamanpatti	1.00332	39	Goripalayam	0.72033
27	Karpaga Nagar	0.72033	40	Ahimsapuram	0.7144
28	Uthangudi	3.52721	41	Narimedu	4.83554
29	Masthaanpatti	0.77203	42	Chokkikulam	0.76362
30	Melamadai	0.5217	43	Tallakulam	0.34805
31	Tahsiltharpuram	0.74754	44	K.K.Nagar	0.40519
32	Vandiyur	0.69362	45	Pudur	0.45862
33	Saathamangalam	0.71365	46	Lourdhu Nagar	4.34476
34	Arignar Anna Nagar	0.90017	47	Reserve Line	1.37338
35	Madhichiyam	0.46307	48	Aathikulam	0.80295
36	Aazhwar puram	0.82522	49	Naahanakulam	0.63277

Source: Corporation of Madurai

Zone III : The low level of (less than 1%) solid waste generation have been noticed in 22 wards namely Sourashtra Hr. Sec. School, Iravadhanallur, Pangajam Colony, Ismailpuram, Mariamman Theppakulam, Kaamarajapuram, Chinna Anuppanadi, Balaranganathapuram, Lakshmipuram, Keeraithurai, Chinthamani, Avaniyaapuram, Sappani Kovil, South Krishnan Kovil, Kathirvel Nagar, Anuppanadi, Villapuram Pudu Nagar, Dhrowpathi Amman Kovil, St.Marys, Meenakshi Nagar, Manjanakara Street, Thirumalai Naicker Mahal. These wards are located either residential areas or nearest to the water bodies like River Vaigai have the lowest concentration of solid waste. The medium solid waste noticed over east and southern part of temple area, around the city core. The wards in the river banks bordering the southern part of the city is one of the commercial activities in the study area. The medium solid waste (1-2%) seen the wards like Navarathinapuram and Villapuram. The high level of concentration more than 2% of solid waste noticed in only one ward namely Swami Sannidhi has found in around River Vaigai and nearby city core (Table 8).



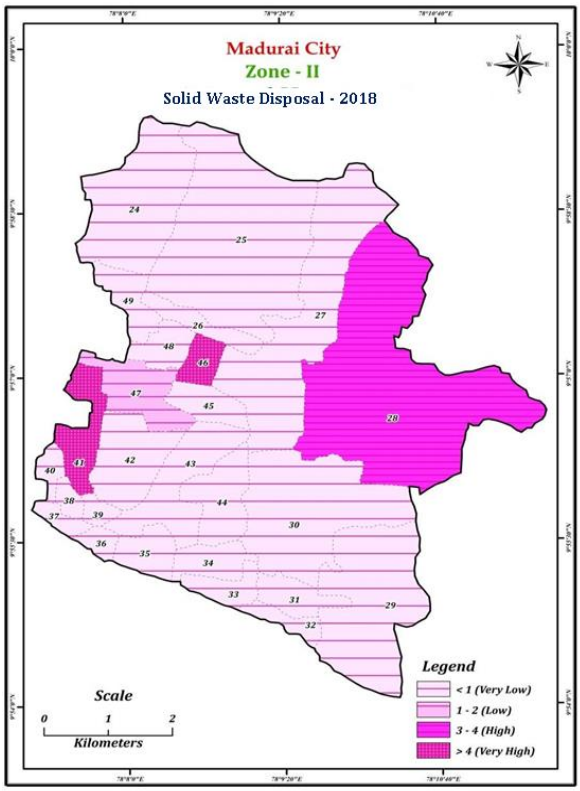
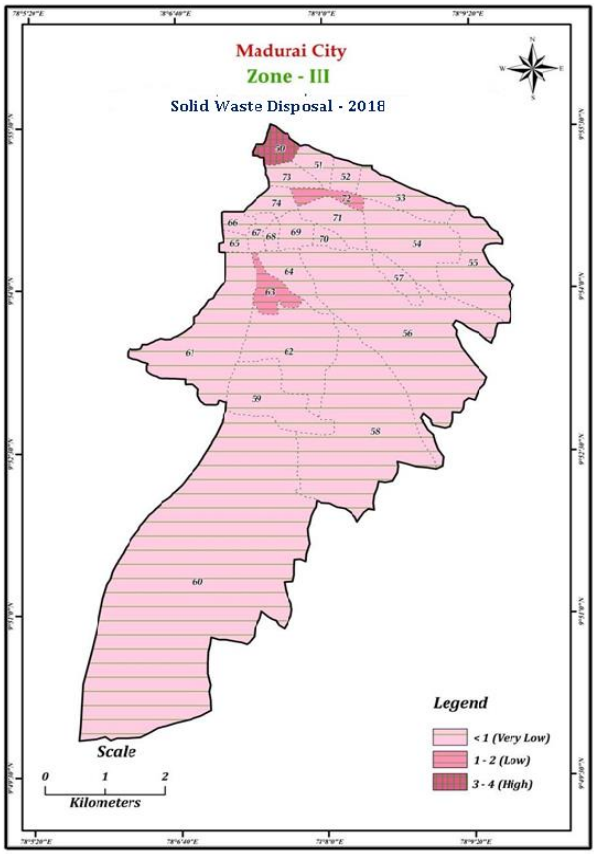


Fig. 2 Solid Waste Disposal in Zone – I.

Fig. 3: Solid Waste Disposal in Zone – II



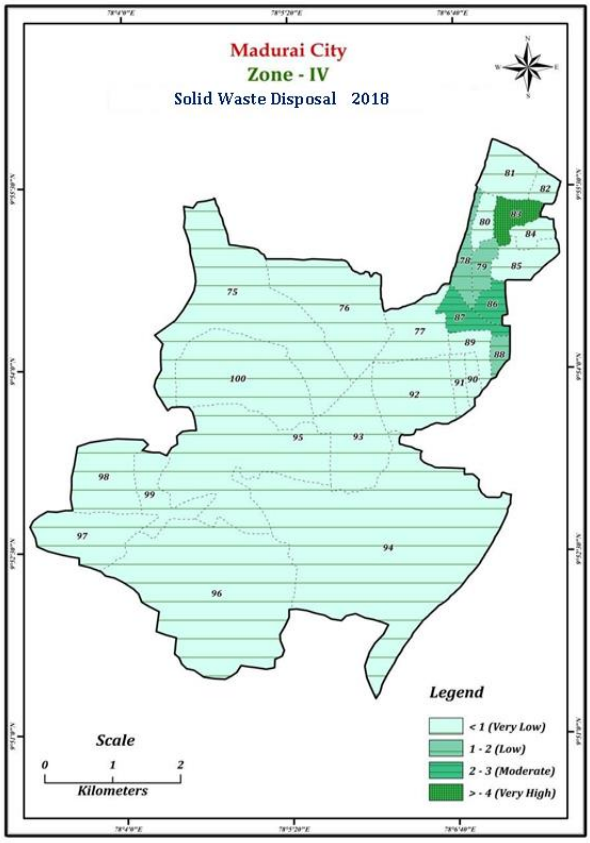


Fig. 4 Solid Waste Disposal in Zone – III

Fig. 5 Solid Waste Disposal in Zone – IV

Table 8

Solid Waste Disposal in Zone – III , Madurai City – 2018

Ward No	Ward Name	Solid Waste Disposal %	Ward No	Ward Name	Solid Waste Disposal %
50	Swami Sannidhi	3.81564	63	Villapuram	1.55817
51	Ismail puram	0.37847	64	Keeraithurai	0.74829
52	Sourashtra Hr. Sec. School	0.00046	65	Sappani Kovil	0.75076
53	Pangajam colony	0.3755	66	South Krishnan Kovil	0.7656
54	Mariamman Theppakulam	0.3755	67	Manjanakara Street	0.90932
55	Iraavadhanallu	0.3713	68	Dhrowpathi Amman Kovil	0.76362
56	Sinna Anuppanadi	0.587	69	St.Marys	0.7896
57	Anuppanadi	0.7656	70	Kaamarajapuram	0.39702
58	Chinthamani	0.7473	71	Balaranganathapuram	0.73344
59	Meenakshi Nagar	0.78094	72	Navarathinapuram	1.23981
60	Avaniyaapuram	0.7567	73	Lakshmipuram	0.74754
61	Villapuram pudu Nagar	0.76412	74	Thirumalai Naicker Mahal	0.90932
62	Kathirvel Nagar	0.76412			

Source: Corporation of Madurai

Zone IV: The very low level of (concentration less than 1%) solid waste generation is seen in around 20 wards in the fourth zone. T.V.S.Nagar, Thennaharam, Paamban Swami Nagar, Muthuramalingapuram, Tamilsangam, Mannar College, Meenakshi Kovil, Jadamuni Kovil, Krishnarayar Theppakulam, Kovalan Nagar, Balaji Nagar, Thiru Nagar, Sokkanadhar Kovil, Pazhanganatham, Haarvipatti, Jaihindpuram, Sundarajapuram, Veerakali Amman Kovil, Thirupparamkundram and Maadakkulam are found in the periphery of the city core and have low levels of waste generation. 2 wards are namely Madurai Baskaradass Nagar, Perumal Theppakulam have low (1-2%) concentration of solid waste disposal. These areas were found in railway junction and near Meenakshi Amman Temple area in Madurai city. 2 wards registered moderate level of concentration (2 - 3%) namely Kaajimar Street and Subramaniapuram. North Krishnan Kovil has been noted for very high concentration of solid waste disposal and it is located at core area of the city around Meenakshi Amman Temple with the agglomeration of commercial activities especially the wholesale and retail shops (Table 9, Fig. 5).

Table 9. Solid Waste Disposal in Zone – IV, Madurai City – 2018

Ward No	Ward Name	Solid Waste Disposal %	Ward No	Ward Name	Solid Waste Disposal %
75	Maadakkulam	0.9093	88	Solai Azhagupuram	1.943
76	Pazhanganatham	0.7712	89	Jaihindpuram	0.805
77	Sundarajapuram	0.8153	90	Veerakali Amman Kovil	0.842
78	Madurai Baskaradass Nagar	1.0960	91	Thennaharam	0.547
79	Perumal Theppakulam	1.0960	92	Kovalan Nagar	0.738
80	Krishnarayar Theppakulam	0.7344	93	T.V.S.Nagar	0.023
81	Tamilsangam	0.6993	94	Paamban Swami Nagar	0.583
82	Sokkanadhar Kovil	0.7571	95	Mannar College	0.707
83	North Krishnan Kovil	4.8053	96	Thirupparamkundram	0.840
84	Meenakshi Kovil	0.7307	97	Haarvipatti	0.781
85	Jadamuni Kovil	0.7346	98	Thirunahar	0.750
86	Kaajimar Street	2.846	99	Balaji Nagar	0.730
87	Subramaniapuram	2.8711	100	Muthuramalingapuram	0.679

Source: Corporation of Madurai

Zone I shows that higher solid waste disposal percentage is seen in the southwest border (Fig. 6) of the zone which is fully covered by residential and industrial land use category. This area also has moderately high population, population density and households. Here the solid waste could be of domestic and industrial in nature. Zone II shows high waste disposal around areas, which have residential, industrial, waster bodies, fallow land, scrub land and agricultural land use categories. These are present at both the core and the city periphery. We can infer that solid waste disposal is also found in water bodies in some parts of the city. Zone III shows that waste disposal is taking place at areas of industrial land use and agricultural land use. They are located mostly at the core of the city. Zone IV shows high disposal of waste in industrial land use area, residential area and water body all of which are located at the core of the city. It is found from Chapter II that a high percentage of industrial workers are located in these areas. It can be inferred from the study that the core areas generate higher solid waste overall as compared to the periphery. However, the core also has better solid waste disposal system as compared to the periphery. In all the zones, except in Zone I, the wards with most solid waste disposal are located in near or at the core of the city around industrial, residential and water body areas. Only in Zone II, since there is huge fallow and scrubland available there is rampant solid waste disposal. The number of streets present in each zone and the number of street length in each zone is positively correlated to the amount of garbage generated per day. The number of streets and the street length showed a positive correlation of 0.20

with the garbage generation. Meaning to say that increase in the number of streets and length of streets leads to increase in garbage generation (Table 10).

2) **Table 10**

Relationship between Waste Generation between Number of Street and Street Length in each Zone

Zone	Population	No. of Streets	Street Length (M)	Garbage Generated (Metric Ton)
N	333579	989	201	11358
E	262566	577	88	8734
W	297233	1110	151	9524
S	282573	886	132	15386

Source: Corporation of Madurai

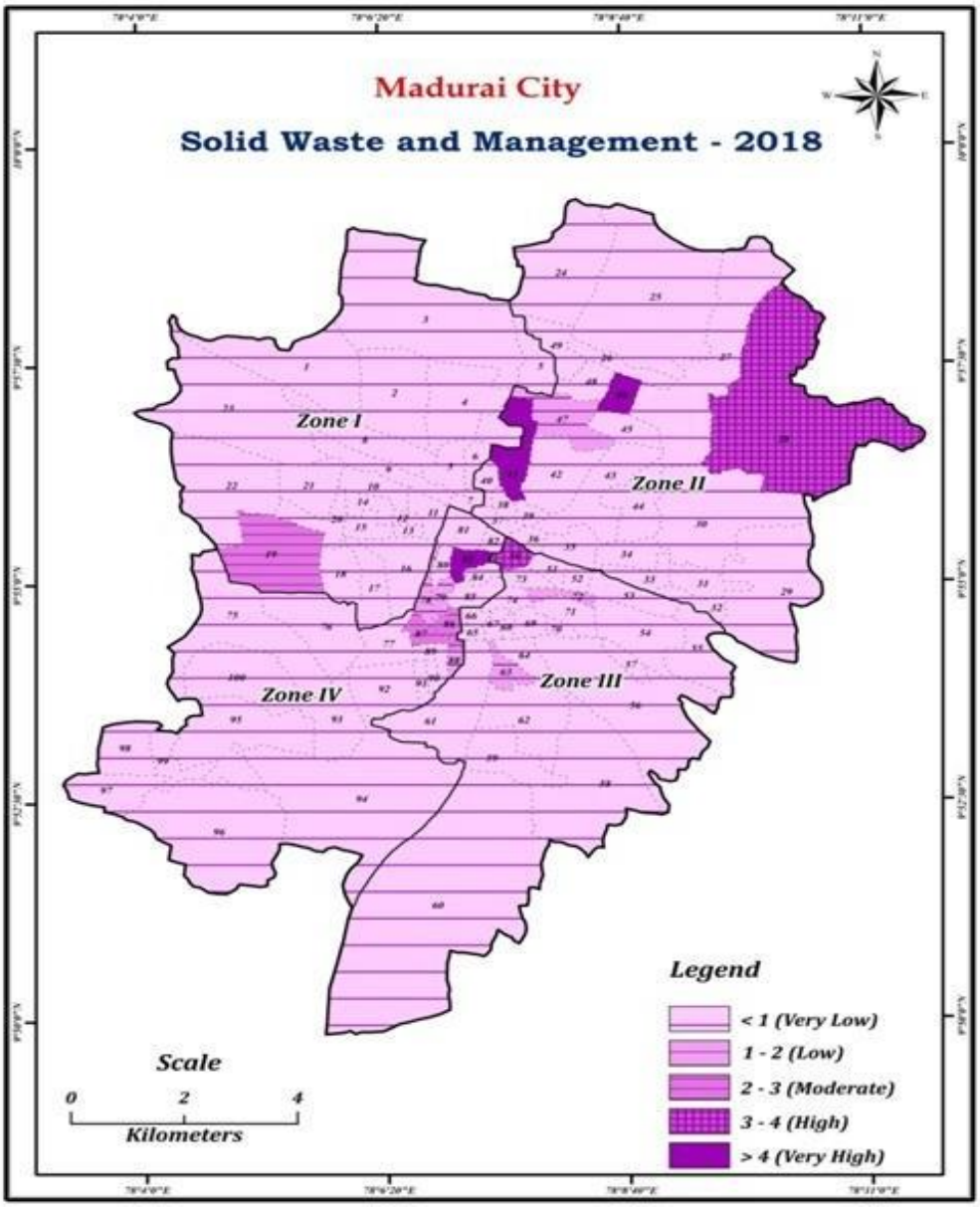


Fig. 6 Solid Waste Management in Madurai City, 2018

Conclusion

Based on the analysis of solid waste management in Madurai city, segregation of the collected waste house hold of sources is not being practiced leading to mixed of wastage and entertainment recyclable waste being dumped without proper and full recovery. Recyclable waste is not being transportation system is not fully developed logistic management in transportation component is required by proper routing of vehicles. The area available for solid waste processing/ disposal is presently being used only as a massive dumping ground. Waste is not covered with earth to prevent increases of vector, pig, dog etc. There is inadequate manpower and infrastructure like lack of workshop facility. People are unaware about the waste segregation. Lack of door-to-door collection, lack of proper vehicles for secondary transportation and no proper system for secondary collection. Road leading to final dumping yard is in very bad condition.

Acknowledgement

I acknowledge, the financial assistance given by the authorities of Indian Council of Social Science Research (ICSSR) for the Minor Research Project, the authorities of the Madurai Kamaraj University, all Officials of Madurai Corporation Office and Statistical Department for their help, co-operation and providing the required data and to Dr. K. Lakshmi, for her guidance.

Conflict of Interest

The author declares that she has not conflict of interest.

References

1) Abdel-Shafy, H. I., & Mansour, M. S. (2018). Solid waste issue: Sources, composition, disposal, recycling, and valorization. Egyptian Journal of Petroleum .
2) Central Pollution Control Board Central Zonal Office. (2010-11). Report On Status Of Municipal Solid Waste Management In Jodhpur City. Bhopal: Central Pollution Control Board.
3) Corporation of Madurai . (2021 (updated)). Solid Waste Management. Retrieved October 17, 2017, from Corporation of Madurai : https://www.maduraicorporation.co.in/aboutus/solid-waste-management
4) Corporation of Madurai . (undated). Solid Waste Management for Madurai Corporation . Madurai: Govt. of Tamil Nadu.
5) CPR Environmental Education Centre. (2020 (modified), November 12). Municipal Solid Waste Management.Retrieved May 16, 2023, from Vikaspedia: https://vikaspedia.in/energy/environment/waste-management/municipal-solid-waste-management
6) Dehghanifarda, E., & Dehghani, M. H. (2018). Evaluation and analysis of municipal solid wastes in Tehran, Iran. MethodsX , 312-321.
7) e-Krishi Shiksha. (2013). Environmnetal Science. Retrieved 10 17, 2018, from ecoursesonline: http://ecoursesonline.iasri.res.in/
8) Fadhullah, W., Imran, N. I., Ismail, S. N., Jaafar, M. H., & Abdullah, H. (2022). Household solid waste management practices and perceptions among residents in the East Coast of Malaysia. BMC Public Health , 22:1.
9) Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. Waste Management , 220-232.

10) Ikiara, M.M., Karanja, A.M., Davies, T.C. (2004). Collection, transportation and disposal of urban solid waste in Nairobi. In I. P. Baud, Solid Waste Management and Recycling. . Dordrecht.: GeoJournal Library, vol 76. Springer.
11) Jamal, H. (2016, January 16). Types of Solid Wastes - Based on Origin and Composition. Retrieved October 17, 2018, from Urban Waste Management: https://www.aboutcivil.org/types-of-solid-wastes
12) Ministry of Housing and Urban Affairs. (undated). Guidelines for Preparation of Detailed Project Reports and Selection of Technologies for Processing and Final Disposal of Municipal Solid Waste Using 12th Finance Commission Grants. Delhi : Govt. of India .
13) Ndhlovu, L N. (2018). Investigating the effectiveness of a community based approach towards solid waste management in Windhoek's Okahandja Park. Retrieved October 10, 2018, from UNAM University of Namibia: https://repository.unam.edu.na/handle/11070/2321
14) Ogawa, H. (undated). Sustainable Solid Waste Management. 7th ISWA International Congress and Exhibition, Parallel Session 7, "International Perspective. Kuala Lumpur, Malaysia: WHO Western Pacific Regional Environmental Health Centre (EHC),.
15) Sharholy, M., Ahmad, K., Mahmood, G., & Trivedi, R. (2008). Municipal solid waste management in Indian cities – A review. Waste Management 28 , 459–467.
16) Vasanthi, P., Kaliappan, S., & Srinivasaraghavan, R. (2008). Impact of poor solid waste management on ground water. Environ Monit Assess , 227-238.
17) WHO. (2023). Guidance on solid waste and health. Retrieved May 20, 2023, from World Health Organisation: https://www.who.int/tools/compendium-on-health-and-environment/solid-waste
18) World Bank. (2022, February 11). Solid Waste Management. Retrieved May 16, 2023, from worldbank.org: https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management
19) World Bank. (2023). Trends in Solid Waste Management. Retrieved May 16, 2023, from worldbank.org:https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html