MUNICIPAL SOLID WASTE MANAGEMENT OF KOLHAPUR CITY, MAHARASHTRA, INDIA: A CASE STUDY; CURRENT PRACTICES AND CHALLENGES

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Abstract: Municipal Solid Waste Management (MSWM) involves activities related to generation, storage, collection transfer & transport, processing, recovery and disposal of solid waste. This paper presents an overview of current solid waste management activities of Kolhapur City, Maharashtra, India. The city has population 5,49,283 according to census 2011 and area of the city is 66.83 sq. km. The city has average population density of 8219 persons per sq. km. Presently, municipal solid waste generation in the Kolhapur city is around 180-200 tons/d. Till December 2018, the municipal solid waste generated in the city was dumped on open land at Kasba Bawada, Kolhapur. After dumping there has no any treatment provided to the waste. But now due to bio-methanation plants and RDF plant, the municipal solid waste is quite managing properly by Kolhapur Municipal Corporation (KMC). Still some field problems are observed which are, the collection process is deficient in terms of manpower, vehicle availability, transportation, bin capacity, etc. Thus contributing to the inefficiency of the system have been found due to lack of suitable amenities (equipment and infrastructure), inadequate management, technical skills, for poor collection and transportation of municipal solid wastes. Some efforts are observed from local residents to manage organic waste at source level.

IndexTerms - Municipal solid waste management, Solid Waste Composition, Solid waste collection, Kolhapur City

1. INTRODUCTION

Waste can be defined as unwanted item, discarded in 'throwaway society' in the traditional view. It is also something to be removed as far away from as possible and preferably 'not in my backyard'. Solid waste is arising from domestic, trade, commercial & public services and used to illustrate non-liquid waste material. Municipal Solid waste includes wastes generated from residential, institutional, commercial, offices, hotels, shops, schools, municipal gardens, streets, construction and demolition process, and other recreational areas [1].

The generation of Municipal Solid Waste (MSW) is a large in terms of volume. The MSW generation is 8778 tons/day, 6000 tons/day, 3799 tons/day in Bankok, Jakarta, Kuala Lumpur, respectively [4]. This in turn, results several problems related to health and environment, such as, spreading communicable diseases, bad odors, nuisance, water pollution, soil pollution, air pollution, and others.

Kolhapur city, India has generated 180-200 tons/d MSW. Recently, Kolhapur has facing enormous challenges in solid waste management including not only the collection, transfer, and final disposal of waste, but also a lack of public awareness for segregation of the municipal solid waste at source, slapdash urbanization and introduction of e-waste materials to MSW. The main objective of the study is to review existing MSWM practices, measure solid waste generation and its composition. In this study, we quantified solid waste production and analyzed its composition in order to recommend appropriate methods of management. Furthermore to this, we analyzed gaps in regards to waste management directive, technologies and infrastructure, capacity building and participation of stakeholders.

2. KOLHAPUR CITY, MAHARASHTRA, INDIA

Kolhapur city is known as 'Dakshin Kashi' as it is a seat of Goddess Mahalaxmi; one of the shaktipeeths mentioned in Indian mythology. The city attracts around 30 lakhs tourist per year. Chatrapati Shahu Maharaj was an architect and founder of modern Kolhapur city. Kolhapur is one of the growing cities in Maharashtra. The district has the highest per capita income in the state of Maharashtra. Kolhapur has a distinct culture, developed as a result of its rich history and its quality of people who have been front-runners in various fields. Kolhapur is famous in the country for its production of jaggery, Kolhapuri chappals, silver jewelry, and Indian wrestling. There are nine industrial estates in Kolhapur, with 1207 functioning units [6].

Kolhapur city is located at south-west part of Maharashtra. On the western part of city lies a range of Sahyadri Hills. The city is situated on the banks of river Panchaganga. The climate of Kolhapur is cool and humid. Average temperature ranges between 12° - 35°. Latitude and longitude co-ordinates of Kolhapur city are 16° 42´ N and 74° 14´ E and its elevation is 550 meters above mean sea level [6] (Fig. 1).

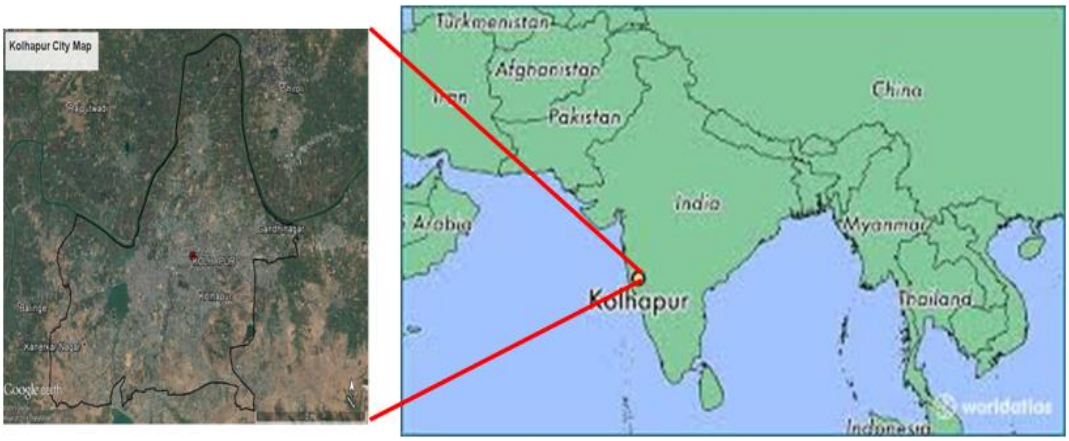

Fig. 1. Map of Kolhapur City

3. METHODOLOGY

The study was carried out in Kolhapur City, Maharashtra, India. For waste management government, private, and NGO organizations are working. This study includes a detailed survey and study of several collection points and the final dump site at Kasba Bawada, Kolhapur. Detailed investigations and survey were performed to evaluate the exiting management of solid waste in Kolhapur.

For this study, the data was collected from 12 departments of Health-Sanitation and MSW management, of KMC. Relating to present waste management practices, current issues, and constraints, the staff and executives of the Health-Sanitation and MSW management department, KMC were interviewed and asked to fill out the surveys. Scavengers, drivers, and waste collectors were interviewed at their respective workplaces, too.

The non-governmental organization (Ekati Santha, Kolhapur) involved in the MSWM of the city, especially in collection & processing of waste were also interviewed in depth. The data collected from the interviews, surveys, investigation and field work was processed and reviewed. Qualitative data were obtained from the personal interviews, expert comments, and public surveys. Along with this, we personally have performed field experiments at dump site (Kasba Bawada, Kolhapur) for compositions of MSW.

4. RESULTS AND DATA ANALYSIS

4.1 Waste Generation Sources

Due to economic development of Kolhapur city, the life style of the people is changing which leads to increased amount of solid waste generation. Population growth is directly proportional to solid waste generation. As population increases the solid waste generation also increases. To make proper solid waste management plan, the population growth rate of Kolhapur City for next twenty years and sources of waste generation was first determined which showed in Table 1 and Table 2, respectively.

Table 1. Population Projection for Kolhapur

Sr. No.	Horizon Year	2018	2023	2028	2033	2038
1	As Per National Average Growth Rate	617108	665555	714002	762449	810896
2	Incremental Increase Method	595105	626391	656473	685352	713027
3	Arithmetic Increase Method	597970	632746	667523	702299	737075
4	Geometrical Increase Method	614363	665518	720932	780961	845988
5	Exponential Method	614070	664974	720097	779790	844431
	Population (Average II, AI & GI)	602479	641552	681643	722871	765363

(Source: TATA Consulting Engineers Ltd. DPR)

Table 1 shows an exponential rise in population with year and the direct proportionality of waste generation will be possible with total increasing population. This enhancement in the MSW generation can be attributed to increasing population in future.

The following Table 2, shows the existing number of sources of MSW in Kolhapur City which generates the MSW around 180-200 tons/day. From the Table 1 and 2 suggested that, in the next twenty years there will be increases in the MSW as proportional to population growth.

Table 2. Sources of Waste Generation

Sr. No.	Sources of Waste Generation	Numbers
1	Households	132000
2	Marriage Halls	95
3	Schools	176
4	Colleges	32
5	Other Institutes (Government & private)	270
6	Hospitals	811
7	Restaurants & Hotels	274
8	Roadside Eateries	622
9	Commercial Shops (0-500 sq. ft.)	1432
10	Commercial Shops (500-1000 sq. ft.)	496
11	Commercial Shops (greater than 1000 sq. ft.)	110
12	Chicken and Mutton Shops	387
13	Fruit and Vegetable Shops	15 markets

(Source: TATA Consulting Engineers Ltd. DPR)

4.2 Waste Characterization

Different components of MSW have been classified into compostable and recyclable was conducted at the dump site. The percentage of compostable matter is found more in MSW. Other important constituents viz. paper, textile, and plastic are significantly found in MSW. The rest of waste contains are glass, leather, rubber, wood, inert materials (dirt, bricks, stones, etc.), and other materials. Quantitative figures of the solid waste composition of Kolhapur City are shown in Table 3.

Table 3. Average Solid Waste Characterization (wet weight basis)

Sr. No.	Component	%
1	Compostable matter	55.58
2	Textile	10.31
3	Plastics carry bags	9.89
4	Paper	6.93
5	Plastic materials (empty cans, bottles)	3.79
6	Glass	3.58
7	Inert	2.6
8	Sanitary Waste/ Dippers	2.33
9	Leather/Rubber	1.56
10	Metal	0.9
11	Others	3.19

From the percentage of components indicate that almost 55.58% (by weight) of the organic waste followed by textile is 10.31%; Plastics carry bags is 9.89%; paper 6.93%, plastic material is 3.79%; and glass 3.58% remarkable found in the waste as shown in fig. 1

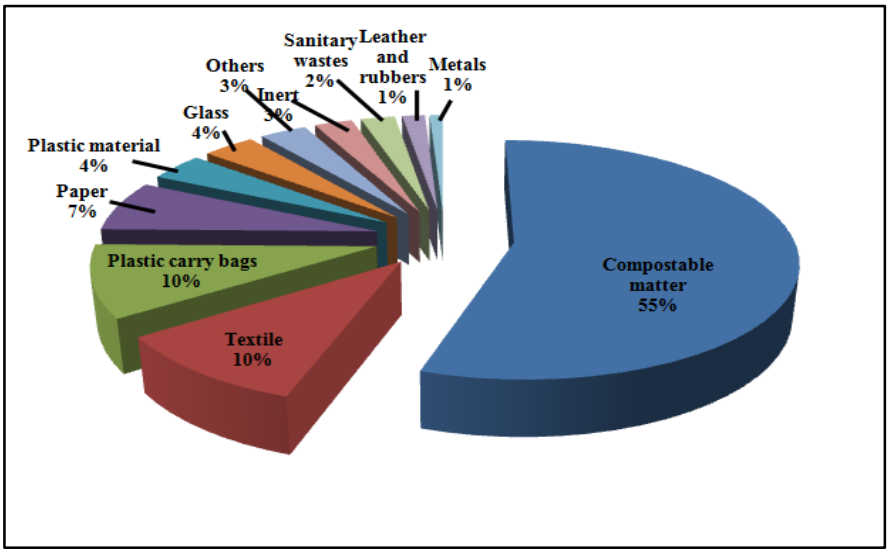

Fig. 2. Components MSW in Percentage (Wet Weight Basis) at Dumpsite in Kolhapur City

4.3 Collection and Storage of Solid Waste

Daily collection of solid waste is very important as decomposition of organic waste takes place very rapidly resulting in unhygienic conditions. Hence KMC has been offered daily door-to-door collection system of solid waste to avoid excess storage of waste at household and simultaneously KMC have generated awareness among the people for segregation of solid waste at source. Currently KMC collects municipal solid waste by following methods i) Primary waste collection, ii) Secondary waste collection and iii) Direct waste collection.

a. Primary Waste Storage at Source

Primary waste generated in households is stored in waste bins. No segregation is done at source level. Commercial establishments store their waste outside the shop in carry bags every night. Unauthorized markets (Pheriwale) often dump their waste on road sides. Hotels and Restaurants have their own bins for storage of waste (Fig. 2 A and B).

Fig. 3. Primary Waste Storage at Household

b. Primary Waste Collection System

Primary waste collection is done by KMC waste workers by using tricycles. Residents have to handover the waste to Safai Karmacharis (Fig. 3), when they arrive. Mostly tricycles are provided with bells, otherwise whistles are given to workers. Household waste collection practiced in morning shift only. Workers move on to their respected areas with tricycles to collect the waste from households from 7:30 am onwards. This activity continues till 12:30 pm.

Fig. 4. Safai Karmachari with Tricycle for Primary Waste Collection

c. Secondary Waste Storage System

Waste from tricycles collected from households is transferred in secondary storage metallic containers shown in fig.4. The waste generated by roadside eateries collected and dump in secondary storage container by KMC sweepers daily. Schools, colleges and other institutes (Government & private) dump their waste in secondary storage containers by their own. Waste generated by unauthorized markets (pheriwale) is collected by road sweepers and transfer to secondary containers at daily night.

Fig. 5. Secondary Waste Storage Container

d. Secondary Waste Collection System

The waste from secondary storage containers is unloaded mechanically to refuse compactors for further transport to disposal site. Secondary waste collection is done in three shifts, morning shift from 6:00 am to 2:00 pm, afternoon shift from 2:00 pm to 10:00 pm and night shift from 10:00 pm to 6:00 am. Refuse compactors (RC) vehicles (Fig. 5) are used in all three shifts for secondary waste collection and transportation. Major amount of waste is collected by RC vehicles in the city.

Fig. 6. Secondary Waste Collection by RC Vehicle

e. Container Tracking System (CTS) Software for Secondary Waste Collection

Container Tracking System (CTS) software (Fig. 20) is made by KMC, for monitoring secondary waste collection. This system is based on GIS. The CTS software system was a requirement of 'Swachh Sarvekshan'. One successful year has completed for this tracking system. For that, first all the existing containers are located along with their latitude and longitude on the map by KMC. 'AND LOCATION' free cost application is used for development of CTS tracking system. This application maintains 5 m accuracy. The color coding is selected as follows. Blue color indicates total number of containers in city, yellow color indicates targeted containers, green color indicates collected containers and red color indicates pending containers of that day. This application is only for administrative purpose. Every sanitary inspector had given their waste transportation routes in the respective wards. Those routes have to follow by respected RC vehicles for waste collection. There are total 12 boroughs in Kolhapur city controlled by 12 Sanitary Inspectors. To run CTS, KMC has given 12 android mobiles to each sanitary inspector. Only sanitary inspector can login this application to capture the photos of containers. Photos of fully loaded containers and empty containers are taken and automatically uploaded by the application. Buffer zone of 100 m is given to capture photos of the respected containers. Sanitary inspector is responsible for secondary collection of containers in respected wards. If the collection of containers of that day is pending then 2 days are given for completion of the pending work. Still sanitary inspector if failed to follow the given schedule then Rs. 500 /- penalty per day have to pay. Team is formed to inform the daily report of CTS to Chief Sanitary Inspector. Due to daily monitoring and reporting, there is control on secondary waste collection of Chief Sanitary Inspector. 95 to 100% waste collection and transportation takes place daily. No modification has been required till date in the CTS because it is running successfully.

Fig. 7. Daily CTS Application Report for Secondary Waste Collection

f. Direct Segregated Waste Collection System

Segregated waste from hotels and restaurants are regularly collected by KMC in the morning by dumper shown in fig.6. This waste collection is carried out through NGO "Ekati Sanstha" and for this activity only male workers are assigned. Waste generated by Chicken and Mutton Shops are also collected by KMC with dumper at night and early morning. Special workers are assigned for cleaning and collection of organic waste (flowers, garlands etc.) from Mahalaxmi Temple. A separate dumper is provided by KMC for daily collection of organic waste of temple. Waste from recreation halls are collected by KMC with dumper. All these dumpers transport the collected waste to disposal site. Seven dumpers are used for morning shift which collects around 28 tons of waste in two trips. Two dumpers are used for afternoon shift which collects around 8 to 10 tons of waste in two trips which contains tree cuttings, gutter slurry and dead animals. No dumper provision is there for night shift.

Fig. 8. Direct Segregated Waste Collection from Hotels & Restaurants

g. Street Sweeping and Drain Cleaning

KMC has two road sweeping machines of capacity 2.5 ton each. These machines are assigned for cleaning of major roads only. This work is awarded to private agency; Viraj Contractors (Street sweeping). The time allotted for sweeping machines is daily in between 9:30 pm to 6:30 am due to heavy traffic on major roads at day time. The waste collected by the sweeping machines is directly dumped at dumping site. KMC street sweepers cleans other remaining roads and gutter slurry (Fig. 7. A & B). They use coconut brooms, shovel, mattock, hoe and urea bags for cleaning of roads and gutters.

Fig. 9. A) Street Sweeping and B) Drainage Cleaning by KMC

4.4 Transfer Station Details

There is no transfer station in Kolhapur city. There is no need of transfer station for MSWM as the distance of dumpsite from city is 5.5 km so it is feasible for direct transportation of the waste.

4.5 MSW Transportation System

Optimum routes of waste transportation are fixed based on waste loads of containers and traffic loads on the roads. Heavy loaded containers are collected twice a day, medium loaded containers are collected once a day, while low loaded containers requires alternate day collection. Several types of motorized and non-motorized transport vehicles are being used in city for collection and transportation of municipal solid waste. Daily waste transportation carries out in the city. Total 230 tricycles are used for door to door waste collection and transportation. These tricycles are unloaded into metallic containers (secondary waste storage system). RC vehicles are being used for secondary waste collection and transportation. Dumpers are being used for collection and transportation of waste from special areas (Mahalaxmi temple, hotels, restaurants, chicken & mutton shops, and recreation halls). During morning shift seven dumpers makes fourteen trips and six RC vehicles makes twelve trips for transportation of waste. In afternoon shift two dumpers makes four trips and six RC vehicles makes twelve trips. No dumper is being used in night shift but six RC vehicles makes twelve trips during night shift. Fully loaded dumpers and RC vehicles are then taken to disposal site. Following Table No. 4 and fig. 8 (1-6) gives details of vehicles in KMC for MSWM activities.

Table 4. Existing Vehicles in KMC for MSWM Activities

Sr. No.	Vehicles	Numbers	Capacity	Remark
1	Tricycle	510	90 kg	6 bins-capacity of each bin is 15 kg
2	Refuse Compactor (RC)	14	8 ton	Only for secondary transportation
3	Dumper (Hyva)	2	20 ton	Use for sand & aggregates transportation. If required use for MSW transportation.
4	Cargo	5	10 ton	Segregated waste Collection from special areas
5	JCB	2	-	Use as per requirement
6	Tractor	1	1 brass	Given to NGO (Ekati) for segregated waste collection by KMC

Fig. 10. KMC Vehicles (1-Tricycle, 2- RC, 3- Dumper, 4-Cargo, 5-JCB, 6-Tractor) for MSWM Activities

KMC has its own garage at Subhash stores in Udyam Nagar for all types of vehicles including solid waste collection and transportation, where all vehicles undergo maintenance, washing and parking shown in fig. 9.

Fig. 11. Operation and Maintenance Facility of KMC

4.6 MSWM Ward wise Details

MSWM is under authority of Chief Sanitary Inspector of KMC. Twelve sanitary inspectors control MSWM of their respective twelve boroughs. There are total eighty one electoral wards in twelve boroughs. The names of twelve boroughs are A1, A2, A3, B, C1, C2, D, E1, E2, E3, E4 and E5. These 12 boroughs include 81 electoral wards. Total 81 mukadams are assigned for each electoral ward. Field work is done by mukadams under supervision of sanitary inspectors. Total numbers of containers are 756 in the city out of which 49 are damaged and sent for repair. One dumper and one JCB are provided for each ward once in a week for special type of waste collection like tree cuttings, gutter slurry collection etc.

Table 5. Ward wise Details of MSWM of KMC

Sr. No.	Boroughs	Electoral wards	Types and number of vehicles	Number of containers	Number of workers
1	A1	47,48,49,54,55	Tricycle - 07 RC - 01	21	95
2	A2	56,57,69,70,75,76	Tricycle - 16 RC - 01 Tractor - 01	45	118
3	A3	71,73,74,79,80,81	Tricycles - 28 RC - 01	69	95
4	B	33,43,44,45,46,58,59,60,67,68,77,78	Tricycle - 08 RC - 01	102	159
7	C1	26,27,32	Tricycle - 07 RC - 01 Dumper - 02	26	84
6	C2	28,29,30,31	Tricycle – 08 RC - 01	17	57
7	D	50,51,52,53,72	Tricycle - 09 RC – 01 Tractor - 01	38	89
8	E1	40,41,42,61,62,63,65,66	Tricycle - 19 RC - 01	81	132
9	E2	24,25,34,35,36,37,38,39	Tricycle -18 RC - 01	77	168
10	E3	7,10,11,14,15,16,17	Tricycle - 16 RC - 01	73	132
11	E4	1,2,3,4,5,6,12,13	Tricycle - 16 RC - 01	72	123
12	E5	8,9,18,19,20,21,22,23,64	Tricycle -18 RC - 01	86	145

4.7 MSW Processing System

KMC has initiated a good step towards managing segregated MSW. There are four plants which work on segregated waste.

a. Paris Organic Compost

KMC has started organic composting plant ‘PARIS’ for Sambhaji Nagar and Tapovan area, from 2017. Awareness program was conducted by KMC for segregation of dry waste and wet waste. KMC is managing the waste from 1400 houses with the help of NGO Ekati in this area (Fig. 10). Solid waste collection and processing of segregated waste is carried out by NGO Ekati at Mailkhadda, Sambhaji Nagar area. KMC has provided land, shed, electricity, water facility and tractor for transportation of wet waste to the NGO Ekati for processing of waste. Four tricycles are used for collection of segregated waste. Two female workers are assigned per tricycle. There are total 8 female workers and 1 supervisor is allocated for collection of waste. Only this area is container free area in the city.

Fig. 12. Waste Collection by NGO ‘Ekati’ Workers

Segregated wet waste was collected and sent through tractor to the processing site (Fig. 11 A) and B)). Dry waste is stored and sent to plastic collection point near Market yard once in a week. Around 80% people are segregating waste at household level. Remaining waste segregation is done by these female workers at the time of collection. Daily around 700-800 kg wet waste is collected and processed. 4 female workers and 1 supervisor are working at processing plant. At processing plant female workers again segregate the transported waste.

Fig. 13. Waste Segregation by NGO Ekati Workers

Organic Waste Convertor (OWC)-130-Composting machine is used for cutting and mixing of wet waste which is shown in Fig. 12. At one time 40 kg of wet waste feed to OWC machine. This machine takes 5 minutes for cutting and 5 minutes for mixing of waste. Then the waste is kept for decomposition in trays for 10 days. The capacity of one tray is 20 kg. In 24 hours, 3 times water is sprinkled and 1 tea spoon of culture is added in trays. After 10 days the decomposed waste from trays is added again to OWC machine for further size reduction and is sieved. The ready compost is packed in 1 kg, 10 kg, 15 kg and 20 kg packaging. The rate of compost is Rs. 30 / kg. Monthly salary of NGO Ekati workers is made by selling the compost.

Fig. 14. A) OWC Machine and B) Composting Trays

b. Puikhadi Biogas Plant

KMC has started Biogas plant for the segregated waste collected from, Fulewadi, Nana Patil Nagar, Saneguruji Vasahat, Jivaba Nana Park and Salokhe Nagar from 2017. KMC had taken many awareness programs, personal visits to apartments, houses for waste segregation and oral information through tricycle workers before commissioning the biogas plant.

KMC collects and transport the wet waste to the biogas plant (Fig. 13 A-D) in two trips daily. One tractor is provided for collection of wet waste. KMC has given contract of biogas process to 'M/s. Enprotech Solutionst, Pune'. KMC has provided land, shed and water facility to the company. The company has assigned four female workers and one supervisor on site. The capacity of biogas plant is 5 tons. Wet waste comes from households and hotels of five wards and Mahalaxmi Temple. Segregation of waste takes place at collection point and again at biogas plant. The quantity of household wet waste is around 2 tons and 3 tons waste from temple and hotels. 5 Tons daily feed of organic waste produces 80 cum of biogas and 100 KWH of electricity. The biogas plant is self sustainable for electricity. Presently the electricity generated at biogas plant is used for weighing machine, mixer, exhaust fans and tube lights at site. In future the electricity generated will be use for street lights in Puikhadi area.

Fig. 15. A) Weighing Machine, B) Mixer, C) Small Dome and D) Large Dome

c. Bio-Methanation Plant and Refuse Derived Fuel (RDF) Plant At Kasba Bawada

Bio-methanation plant and RDF plant are located on same site at Kasaba Bawada shown in Fig. 14 A-D. KMC has awarded both the plants to Kolhapur Green Energy Pvt. Ltd. Bio-methanation planthas startedin operation from January 2019. The capacity of bio-methanation plant is 30 tons/day.30 tons/day of biodegradable waste feed generates around 200 KW/day of electricity. The generated electricity is in use for all operations of bio-methanation plant, some operations of RDF plant like belt conveyor, blower & trommel and street lights at site.

The plant has two parts:

1) Continuous Stirring Type Reactor (CSTR) of capacity 25 tons/day.

2) Upflow Anaerobic Sludge Blanket (UASB) of capacity 5 tons/day.

Segregated waste collected from hotels is carried by dumpers to the plant daily. The waste is unloaded on platform and again manual segregation is done to separate remaining non-biodegradable waste. Then the waste is send to shredder for crushing, and then to mixer. Mixer ensures proper mixing of organic materials. Crushed waste is then feed to CSTR tank. The feed is given from bottom to top. The volume of CSTR tank is 1600 cum. In CSTR tank, gas generation and sludge formation takes place. Generated gas is stored in balloons. Then the gas is cleaned in scrubber and then sent to generator for power generation. Sludge is dried in pits and used as manure. In UASB feed is given from top to bottom. The leachate generated form platforms of CSTR and from RDF plant is feed to UASB tank. The volume of UASB tank is 250 cum. Generated gas accumulates at upper part of the tank whereas sludge settles at bottom. After scrubbing, the cleaned gas is sent to generator for electricity generation. Sludge is dried in pits and used as manure.

Fig. 16. A) Waste Collection Platform, B) Shredder-Mixer, C) UASB D) CSTR

RDF plant has started in operation from January 2019 at Kasaba Bawada. The plant is designed for capacity of 170 tons/day. The RDF plant is designed for segregated dry waste. But mixed municipal solid waste, without segregation is feed to RDF plant, as no segregation practice is at source level. RDF plant includes mechanical operations only. Three outcomes generates from RDF plant, which are 1) Organic materials, 2) Inert materials and 3) RDF. 170 tons/day of mixed waste feed produces around 60 tons/day of RDF. Plant produces two types of RDF, which are 1) Grade-1 < 50 mm size and 2) Grade-2 > 50 mm size. These sizes of RDF are produced as per demand of purchaser. The calorific value of both grade RDF are almost same. RDF plant uses 40-50 % electricity from bio-methanation plant (Fig. 15 A and B).

Fig. 17. A) Infrastructure of RDF Plant B) Final RDF

4.8 Dumping Site at Kasba Bawada

Waste from all over the city is being dumped at Kasba Bawada (Fig. 16 A and B) without any processing till end of 2018. Windrow composting was in practice from 2002 to 2007 for organic waste. The name of the plant was ZOOM PRAKALP. The project was not feasible economically for the company, so the plant was shut down within 5-6 years.

After 2007 no processing is done on waste and the waste is directly dumped at Kasba Bawada dumpsite. Around 5 to 6 lakh tons of waste is accumulated at dumpsite till now. At present approximately 60 feet of waste heaps are generated on dumpsite. These waste heaps are continuously burning and creating heavy air pollution in surrounding areas. Most of the waste is converted into inert material after burning. KMC uses water tankes to control the burning on dumpsite to avoid potential explosion. Daily fresh mixed waste generates leachate and this leachate percolates in the dumping ground. Mostly leachate problem is more severe in rainy season. Some of the portion of dumping land was concreted for operation of ZOOM PRAKALP. But due to increasing quantity of dumping waste, it covered around 14 acres of land creating many environmental problems. From January 2019, Waste to Energy (WTE) plant has been in practice for 200 tons/day municipal waste. RDF plant is designed for 170 tons/day and bio-methanation plant is designed for 30 tons/day.

Fig. 18. Dumping Site

4.9 Waste Management Practices at Source Level

a. Society Level Practice

Om Mitra Parivar, Nagala Park (Fig 17 A and B) has started proper municipal solid waste management at society level in Nagala Park area. For the development of this project, society had generated funds by their own. Total expenditure for the project was around Rs. 400,000/-. The plant is in working condition from February 2019 successfully till date. The segregated organic waste collected from 450 households is converted into compost. Segregated waste collection is done by one male worker of KMC along with a tricycle and with help of three female workers of NGO Ekati. Daily door to door waste collection, segregation and processing is carried out by these workers. The collection of waste from 450 households requires two trips of tricycle. Daily wet waste collection for composting is around 250 kg. 100 % segregation of waste is expected for better composting but only 70 to 80% segregated waste is collected. Remaining segregation of waste is carried by female workers of NGO Ekati. Om Mitra Parivar had made 30 pipe chambers for 30 days composting. For that they used 750 mm diameter cement pipes. 2.5 m length cement pipe cut into equal three parts to make three pipe chambers. Daily collected wet waste is filled in respected chambers on which culture is added. In order to maintain aerobic condition for composting mesh lid is provided on chamber. 28 to 30 days requires for complete decomposition process of waste. Dry waste is sent to nearby container by the workers.

Some people has negative approach towards this project as they think that project may cause mosquito breeding, foul smell and rodents in this area. They are not ready pay Rs. 50/- per month for the NGO Ekati workers. Wages are made by selling ready compost to the NGO workers. It is a good practice at society level because daily 250 kg wet waste is processed at source level.

Fig. 19. Society Level Waste Management

b. Apartment level practice

Anantpuram Apartment, Shahu Market Yard (Fig. 18 A and B) is the first 11th storied apartment in Kolhapur city. Presently 100 families are staying in apartment. Proper MSWM system is provided by the promoter & builder of the apartment. For each and every families, two buckets are provided for dry and wet waste storage. Workers of the apartment collect the waste from each family. Wet waste is sent for composting pit whereas dry waste is sent nearby containers of KMC. Daily around 140-150 kg of wet waste is processed by composting in the apartment itself. Volume of composting pit is 217 cuft. Seven compartments of equal sizes are constructed within it. Each compartment is named by days of week. Everyday wet waste is dumped in to respective compartments. Culture and cow dung slurry is added daily on waste. Each compartment fills up to its full capacity once in 6 months. Compost is ready after 6 months. After that the waste is emptied from the compartment and dry leaves from garden are added to it. Ready compost is used for gardening in the same premises. It is a good practice at apartment level because daily 150 kg of wet waste is processed at source level.

Fig. 20. Compost Pits at Anantpuram Apartment

c. Individual Level

Dr. Devdhar family from Nagala Park (Fig. 19 A and B) is managing their wet waste at household level since last 18 years. They are practicing vermicomposting to treat organic waste. They had made four vermicomposting pits. The kitchen waste and garden waste is placed in these pits for processing. Compost becomes ready within 3 to 4 months for use. Each vermicomposting pit makes 30-40 kg of compost. This ready compost is used for gardening purpose. This is a very good practice at household level because generated wet waste is processed at source level.

Fig. 21. A) Vermicomposting Pits B) Ready Compost (Household Level)

5. CONCLUSION

Existing MSWM system of KMC is explained in detail in the present study. After studying the existing system, following conclusions are made:

1. Kolhapur Municipal Corporation (KMC) is trying its best to overcome the MSWM problems by applying new technologies through private agencies.
2. Use of Container Tracking System (CTS) software found very useful for secondary waste collection. Around 95-100 % of secondary waste collection is achieved by applying this sophisticated software system.
3. Main source of MSW found is domestic waste and its generation is in high amount due to lack of public awareness.
4. The amount of household waste is around 80-85 % in total MSW of Kolhapur city. People are not willing to segregate organic and non-organic waste at source and store them separately.
5. The newly developed RDF plant by KMC requires segregated dry waste for production of good quality of RDF. But KMC is providing mixed waste to the RDF plant as segregation doesn't take place at source level. This results in poor quality of RDF. The final RDF produced is having high moisture content, so ultimately having low calorific value of RDF.
6. Two Bio-Methanation plants of KMC (Puikhadi and Kasba Bawada plant, Kolhapur) are working very well. The electricity generated from these plants is used for the operations of the plants itself and it is also proposed the use of it for street lights in the respective areas.
7. For both the Bio-Methanation plants, 100 % segregated organic waste from households and from hotels are provided by KMC with the help of NGO 'Ekati Santha'.
8. In two electoral wards of KMC, segregated organic waste is collected and converts it into organic manure with the help of NGO 'Ekati Santha' (PARIS Organic Compost). This is a very successful model of waste conversion at source. So KMC can apply such successful models in remaining wards of the city to reduce the burden of organic waste in the total MSW.
9. Due to lack of proper lining at dumpsite, the leachate generated from dumpsite directly percolates in the subsoil and in rainy seasons it pollutes surface water severely.
10. Existing dumpsite causes nuisance, bad odours, air pollution, soil pollution, water pollution and several communicable diseases to the residents in surrounding areas.
11. Existing infrastructure of MSWM system of KMC lacks in many areas. Number of vehicles for collection and transportation of waste are less, inadequate repair and maintenance of containers for storage of waste and insufficient number of waste workers for collection and segregation of waste. That's why KMC requires taking help from NGOs / private sectors. As KMC is lacking in many areas, it becomes a huge burden on KMC to manage the municipal solid waste properly.
12. There is need for increasing awareness and motivation in public for waste segregation at source and then making it compulsory for residents to store segregated waste at source only.

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