Design and Operation of Solid Waste Management in Chennai for Efficient Environmental, Health and Safety

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Abstract— Solid Waste Management (SWM) is a sorted-out procedure of capacity, gathering, transportation, preparing and transfer of strong decline residuals in a built clean landfill. It is an incorporated procedure containing a few accumulation strategies, differed transportation equipment's, capacity, recuperation components for recyclable material, decrease of waste volume and amount by techniques, for example, Composting and Landfill. In this project, design of Landfill and Composting units for MM Nagar Municipality which comes under Ward Number 14 was considered. Location of the unit is near to MM Nagar. The dimension of Landfill unit is 810 × 1010 m and we require 54 windrows for composting waste. After collecting preliminary data from MM Nagar about population and amount of waste generated per person, we did characterisation of waste and from the results we concluded that 70% of the waste generated is bio-degradable and 30% is non bio-degradable. Bio-degradable waste can be separated into recyclable (40%) and composting (30%). Non-bio-degradable waste will go into Landfill. The Implementation of Municipal solid Waste (MSW) Management is an important component of the Government of India's "Swachh Bharat Mission" (SBM). Solid Waste Management is a required capacity of Municipal Corporations, Municipalities and other neighborhood bodies in India. Because of rise in populace, urbanization, change in way of life and utilization design the issue of strong waste administration in urban territories is expanding.

Keywords: Landfill, Composting, Solid Waste Management

I. INTRODUCTION

The expansion in age of solid waste is just the consequence of the quickly developing human populace and the received present day way of life; the significant increment in the strong waste age coming about into the defilement of air, water and land assets. Civil strong squanders, ordinarily known as refuse or trash, are the strong squanders created from various regions. A portion of these squanders have been demonstrated to be very lethal and irresistible. The uncontrolled and informal dumping of such squanders has realized a rising number of occurrences of perils to human well-being. Defilement of surface and ground water emerged progressively genuine human well-being hazard.

Understanding the requirement for appropriate and logical administration of strong waste and dependent on the proposals of the different boards of trustees and of the Supreme Court Committee the Ministry of Environment and Forests told the Municipal Solid Waste (Management and Handling) Rules, 2000 under the Environment (Protection) Act of 1986. The target of these Rules was to make each civil specialist in charge of the execution of different arrangements of the Rules inside its regional zone and furthermore to build up a compelling framework for gathering, stockpiling, isolation, transportation, handling and transfer of Municipal Solid Wastes (MSW). The unpredictable dumping of metropolitan strong squanders in water bodies and low-lying regions is a typical practice pursued by the greater part of the districts with no thought of its impact on the earth. In addition, the absence of the essential data in regards to age, gathering, transportation and transfer of strong waste was noted. The expansion in age of strong waste is just the aftereffect of the quickly developing human populace and the received present day way of life; the generous increment in the strong waste age coming about into the sullying of air, water and land assets. Civil strong squanders, normally known as junk or trash, are the strong squanders created from various regions. A portion of these squanders have been demonstrated to be very lethal and irresistible. The uncontrolled and informal dumping of such squanders has realized a rising number of episodes of perils to human well-being. Sullying of surface and ground water emerged progressively genuine human well-being hazard.

The unpredictable dumping of civil strong squanders in water bodies and low-lying zones is a typical practice pursued by the greater part of the regions with no thought of its impact on nature. Also, the absence of the essential data with respect to age, gathering, transportation and transfer of strong waste was noted.

The poor routine with regards to non-isolated waste, containing some lethal material, synthetic compounds and creature bodies/squanders and so on going into the metropolitan waste stream end up in the landfills, which fill in as dump yards and dump destinations. The waste is being arranged in an informal way, which causes genuine ecological issues. Numerous bugs and rodents are pulled in to landfills and can bring about hazardous maladies. It can cause sicknesses and ailment in the networks living around the landfill. Hazardous synthetic compounds can saturate the ground water framework. In an ineffectively created landfill, it is hard to shield the risky synthetic substances from draining out into encompassing territory.

Treating the soil expands generally speaking waste redirection from conclusive transfer, particularly since as much as 70% of the waste stream in low-and centre salary nations is compost able. It improves reusing and burning tasks by expelling natural issue from the waste stream. It delivers an important soil change—vital to manageable agribusiness, adaptable for usage at various levels, from family unit endeavours to enormous scale brought together offices.

It tends to be begun with almost no capital and working expenses. It tends to critical well-being impacts coming about because of natural waste, for example, diminishing Dengue Fever and gives a magnificent chance to improve a city's general waste gathering program. It can incorporate existing casual segments engaged with the accumulation, detachment and reusing of squanders.

Landfill has numerous favourable circumstances that it can create vitality and can be gotten by the change of landfill gas. The waste results of landfills can be utilized as immediate fuel for ignition or by implication they can be

prepared into another fuel. Landfill is a particular area for waste affidavit that can be checked. In appropriately structured landfills the waste can be prepared and every recyclable material can be utilized before shutting. Natural material can likewise be isolated from an appropriately structured landfill which can be utilized for manure or generation of petroleum gas.

Cha Yang (2011) with the fast and enormous increment of waste amounts, China, outperformed the USA as the world's biggest civil strong waste (MSW) generator since 2004. The wonders and basic issues of MSWM in China propelled this paper to research and break down the MSWM in a urban region of China. Contrasting and the expanding rates of MSW age, little has been finished concerning the civil strong waste administration (MSWM). Not just the neighborhood government and specialists are in charge of the MSWM, yet in addition the people are assuming a critical job in MSWM. A coordinated waste administration framework ought to be worked so as to improve the all-encompassing MSW framework and lessen the waste generation. The point of the examination is to research and investigate the ebb and flow status and issues of MSWM in an urban zone of China and to dissect to what degree a reasonable decrease of the MSW can be executed and the executives frameworks to be improved sooner rather than later. In this investigation, two contextual analyses of Shanghai and Linköping are utilized and contrasted with investigate the difficulties and possibilities for improving the MSWM framework in China. The outcome showed that lacking offices and framework, less trend setting innovation, inadequate open interest, low attention to ecological assurance, issues in arrangement and laws are the significant hindrances for the improvement of MSWM. Including universal natural collaboration exercises, arranging a feasible and far reaching arrangement and structure for MSWM, presenting monetary impetus approaches, advancing the limits of waste administration innovations, raising open ecological mindfulness are accepted to be suitable answers for improve the MSWM framework in China.

Constant financial exercises, fast urbanization, populace development and the ascent of expectations for everyday comforts have enormously quickened the age of city strong waste (MSW). This postures significant difficulties for governments, common society and private divisions to ensure and advance the earth and supportable improvement. Johannesburg Declaration on maintainable improvement has announced to "advance and fortify the related and commonly strengthening mainstays of manageable advancement: financial improvement, social advancement and ecological assurance at the nearby, national, provincial and worldwide levels" (WHO, 2002). The Basel Convention adds to feasible advancement in point of "ensure human wellbeing and the earth against the unfriendly impacts coming about because of the age, the executives, transboundary developments and transfer of unsafe and different squanders" (UNEP,1992). Additionally, UN commission on economic improvement likewise thinks about waste as one centre territory. In the Millennium Declaration, UN intended to limit the age of squanders, anticipate illicit transboundary developments of dangerous squanders and deal with the losses in a reasonably solid way (UN, 2000). These universal understandings feature the significance of compelling metropolitan strong waste administration (MSWM) and the critical job of waste administration in monetary and social improvement of a nation.

Surat (Gujarat): Surat's sporadic development between the 80's and the 90's brought about a noteworthy administration hole in the field of strong waste administration (SWM). It brought about one of the significant pandemics as Plague in the year 1994, which was most likely the most exceedingly terrible in the nation in decades. As Plague was viewed as an appearance of the administration ineptitudes identified with strong waste and seepage the board, the city organization reacted with a noteworthy neatness drive and a total technique to further deal with its loss in logical way. Major authoritative changes like; re-masterminding the six zones into 52 sterile wards to increase better control, standard observing of waste administration administrations, coordinated inclusion of all the aggravation focuses by sweepers, looking for help from private organizations in looking after neatness, giving waste administration administrations, ghetto improvement, and a responsive waste administration framework diminishing time slack in conveyance of administrations, and so on., were a portion of the significant activities taken by the city. Surat Municipal Corporation (SMC) surveyed the issues and difficulties of executing a coordinated framework, by dealing with perspectives like recovery of the current sterile staff, and resource usage. SMC is additionally investigating modern waste administration activities by embracing better advancements, for example, squander than vitality utilizing waste gasification. SMC actualized some portion of the incorporated waste administration framework through assets from JNNURM, and part with open private organization (PPP). JNNURM generously activated private area interest in Surat. The SWM venture under JNNURM was focussed on fortifying the essential and optional accumulation, transportation, advancement of exchange stations (TS) and improvement of sterile landfill site. Surat Municipal Corporation (SMC) selected to build up its treatment offices through PPP as the private party acquires mastery in waste treatment advancements, just as spreads real hazard identified with the supportability of the plant tasks. SMC presented 'Time Place Movement' for the gathering and transportation framework which is a spearheading activity wherein accumulation vehicles need to move as per the time timetable, and regions of inclusion and number of units are allocated to it. The accumulation proficiency of Surat has improved from 40% in the year 1995 to 97% by and by, while the house-to-house gathering inclusion has improved to 92%. The city's methodology towards waste dealing with instrument through current semi shut sort mechanical exchange station has motivated numerous Urban Local Bodies (ULBs) to receive comparable framework. The 6 TS handle the whole 1400 TPD of waste produced in Surat, without irritating the customary way of life of the city, despite the fact that a portion of the TS are found near delicate zones, for example, private and institutional territories, (for example, a school or an open structure). The SMC's way to deal with the development and the board of TS with PPP is one more case of reasonable utilization of private segment's aptitude in

covering hazard where the mechanical segments host been introduced by the private gathering while the common developments were finished utilizing JNNURM reserves. SMC creates near 1400 TPD of waste out of which by and by 400 TPD is treated in its waste treatment plant created and oversaw in association with a private office. A 600 TPD waste to vitality plant is in the pipe line where work has been granted and an understanding among SMC and private office is as of now set up. The 600 TPD plant will process blended waste to create astounding Syngas which will further be utilized for age of 8 MW of power to be offered to the nearby matrix. Aside from this, a 400 TPD incorporated Surat SWM Project under JnNURM.

Andhra Pradesh: The Implementation of Municipal solid Waste (MSW) Management is an important component of the Government of India's "Swachh Bharat Mission" (SBM) -component IV. Therefore, the Government of Andhra Pradesh (GoAP) proposes to strengthen the MSWM system covering collection, segregation, recycling, transportation processing and disposal including options for composting and Waste to Energy (WTE), disposal in all 110 Urban Local Bodies (ULBs) in Andhra Pradeshso as to comply with the service level Benchmarks of the Government of India (GoI). APUFIDC is a Government of AP entity and the Nodal agency for the development of the projects in Urban Infrastructure and proposes preparation of Detailed Project Reports for the 110 ULBs cluster-wise. The DPRs shall comply with the Municipal Solid Waste (MSW) (Management and Handling Rules 2000) and draft Rule 2015 under the aegis of the Environment Protection Act 1986 and the guidelines issued under this rule, time to time. The Present assignment is for the preparation of Solid Waste Management (SWM) Detailed Project Report (DPR) for Cluster-III that is Krishna and Guntur Districts and a total of 23 ULBs for a design period of 25 years.

Canada: Natural waste makes up about 40% of the private waste in Canada. Districts can't sensibly achieve preoccupation targets more noteworthy than half without initiating some kind of private organics gathering program (FCM, 2009). Progressively, regions are gathering source-isolated organics (SSO) from homes, and a couple of districts gather SSO from chose organizations, for example, cafés, lodgings, and supermarkets. One of the most significant choices in arranging an organics recuperation program is the decision of handling innovation that will effectively meet the network's preoccupation needs. A few advances are more appropriate than others, contingent upon the organization and amounts of natural material to be dealt with. The procurement of a decent information of the network's natural waste stream, including organization, amounts and sources, is consequently a basic initial phase in the arranging procedure.

II. METHODOLOGY

A. Collection Components

1) Gathering Focuses:

These influence such accumulation framework segments as team size and capacity, which at last control the expense of accumulation. Note that the gathering focuses rely upon region and might be private, business or modern.

2) Accumulation Recurrence:

Climatic conditions and necessities of a territory just as holders and expenses decide the gathering recurrence. In hot and moist atmospheres, for instance, strong squanders must be gathered at any rate two times every week, as the breaking down strong squanders produce awful scent and leachate. Furthermore, as private squanders as a rule contain nourishment squanders and other putrescible (spoiling) material, visit accumulation is attractive for wellbeing and tasteful reasons. Other than atmospheres, the nature of strong waste compartments on location additionally decides the gathering recurrence. For example, while fixed or shut compartments permit accumulation recurrence as long as three days, open and unlocked holders may require day by day gathering. Gathering productivity to a great extent relies upon the demography of the region, (for example, salary gatherings, network, and so on.), where accumulation happens. While choosing gathering recurrence, thusly, you should think about the accompanying: cost, e.g., ideal gathering recurrence decreases the expense as it includes less trucks, representatives and decrease in all out course separate; extra room, e.g., less regular accumulation may require more extra room in the region; sanitation, e.g., visit accumulation diminishes worries about wellbeing, security and disturbance related with put away deny.

B. Capacity Holders:

Proper compartment determination can spare accumulation vitality, increment the speed of gathering and lessen team measure. In particular, holders ought to be useful for the sum and kind of materials and gathering vehicles utilized. Holders ought to likewise be strong, simple to deal with, and affordable, just as impervious to consumption, climate and creatures. In local locations, where deny is gathered physically, institutionalized metal or plastic compartments are regularly required for waste stockpiling. At the point when motorized accumulation frameworks are utilized, holders are explicitly intended to fit the truck-mounted stacking instruments. While assessing private waste compartments, think about the accompanying: effectiveness, i.e., the holders should help expand the general accumulation proficiency. accommodation, i.e., the compartments must be effectively reasonable both for occupants and accumulation group. similarity, i.e., the compartments must be good with gathering hardware. general wellbeing and security, i.e., the compartments ought to be safely secured and put away. possession, i.e., the metropolitan proprietorship must ensure similarity with accumulation gear.

C. Accumulation Team:

The ideal group estimate for a network relies upon work and gear costs, gathering strategies and course attributes. The size of the gathering group likewise relies upon the size and sort of accumulation vehicle utilized, space between the houses, squander age rate and gathering recurrence. For instance, increment in waste age rate and amount of squanders gathered per stop because of less successive accumulation bring about a greater group measure. Note additionally that the gathering vehicle could be a mechanized vehicle, a cart or a trailer towed by a reasonable prime mover (tractor, and so forth.). It is conceivable to change the proportion of gatherers to

accumulation vehicles with the end goal that the team inactive time is limited. In any case, it is difficult to execute this measure, as it might bring about a cover in the team gathering and truck inactive time. A powerful accumulation group estimate and legitimate workforce the board can impact the efficiency of the gathering framework. The team measure, generally, can greatly affect by and large gathering expenses. In any case, with increment in accumulation costs, the pattern as of late is towards: decline in the recurrence of gathering; increment in the reliance on occupants to sort squander materials; increment in the level of robotization utilized in accumulation. This pattern has, truth be told, added to littler groups in districts.

D. Gathering Course:

The accumulation program must consider the course that is effective for gathering. Gathering vehicles helps reduction costs by decreasing the work consumed for accumulation. Legitimate arranging of gathering course additionally helps moderate vitality and limit working hours and vehicle fuel utilization. It is essential in this manner to create definite course arrangements and accumulation plans for the chose gathering framework. The size of each course, in any case, relies upon the measure of waste gathered per stop, separate between quits, stacking time and traffic conditions. Hindrances, for example, railroad, dikes, streams and streets with overwhelming traffic, can be considered to gap course regions. Steering (arrange) investigations and arranging can improve the probability of all avenues being overhauled similarly and reliably help bosses find or track teams rapidly give ideal courses that can be tried against driver judgment and experience.

E. Transfer Station:

Move station is a transitional station between definite transfer alternative and accumulation indicate all together increment the proficiency of the framework, as gathering vehicles and team stay nearer to courses. On the off chance that the transfer site is a long way from the gathering zone, it is reasonable to have an exchange station, where littler accumulation vehicles move their heaps to bigger vehicles, which at that point pull the waste long separations. In certain cases, the exchange station fills in as a pre-handling point, where squanders are dewatered, scooped or packed. A unified arranging and recuperation of recyclable materials are likewise done at exchange stations. The unit cost of pulling strong squanders from an accumulation territory to an exchange station and afterward to a transfer site diminishes, as the size of the gathering vehicle increments.

The current model has been contemplated with different angles covering natural, social, hierarchical, specialized and monetary possibility. The contrived framework is modified to the neighbourhood condition, is in-accordance with the fitting worldwide advances/socially suitable accepted procedures. A productive framework being able to gather, oversee and arrange strong waste appropriately need to embraced. The planned framework will be altered to the territory's prerequisites and weaknesses. A reasonable framework, offers final results of gathered waste fit as a fiddle of vitality and manure (fertilizer) and is anything but difficult to keep up in-accordance with the worldwide guidelines.

The methodology carried out for the project is shown in figure 2.1

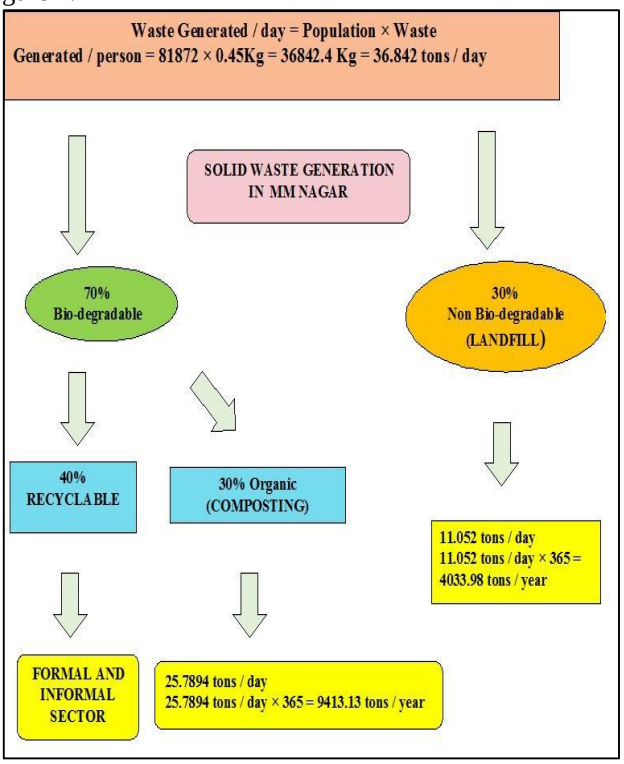

Fig. 2.1: Flow chart on methodology

1) Reference to codes and standards

Sl.No.	Code book/Reference	Rule / Organization
1)	SWMS 2000 (MOEF)	Solid Waste Management Rules, 2015
2)	CPCB	Central Pollution Control Board

Table 2.1: Reference to codes and standards

III. EXPERIMENTAL STUDY

A. Characterization of Solid Waste

Characterization of solid waste in following table 3.1

Sl. No.	Waste generation	% to total
1	Residence	58
2	Commercial	21
3	Restaurants / Hotels/ Marriage halls / Schools and others	12
4	Markets	5
5	Hospitals and Clinics (collected separately)	4
	Total	100

Table 3.1: Characterization of Solid Waste

B. Chemical Composition of Solid Waste

Chemical analysis of solid waste is shown below in the table 3.2

Sl. No.	Items	% Value
1	Moisture content	47.00%
2	Ph Value	6.20% to 8.10%
3	Volatile matter at 550 °C	42.62%
4	Carbon	24.72%
5	Nitrogen content	0.88%

6	Phosphorous as P_2O_3	0.44%
7	Potassium as K_2O	0.89%
8	C / N Ratio	29.25
9	Calorific Value in KJ/Kg	2594

Table 3.2: Chemical Analysis of solid waste

The dumping yard and collection of waste in Potheri is mentioned in Figure 3.1

Fig. 3.1: Dumping Yard

C. Components of Waste

Components of waste is shown below in the table 3.3

Sl. No.	Composition	% to total by weight
1	Paper	8.38%
2	Rags	3.11%
3	Organic Matter	51.34%
4	Plastics	7.48%
5	Metals	0.19%
6	Rubber & leather	0.19%
7	Inert	26.01%
8	Glass	0.29%
9	Coconut	2.48%
10	Bones	0.01%
11	Wood	0.50%

Table 3.3: Composition of Waste

Chemical Analysis of solid waste can be done by 2 methods:

1) Proximate Analysis
2) Ultimate Analysis

D. Solid Waste Analysis

Solid Waste Analysis is a partitioning of compounds in a feed into six categories based on the chemical properties of the compounds. The six categories are:

1) Moisture
2) Ash
3) Proteins
4) Lipids
5) Fibre
6) Nitrogen-Free Extracts (Digestible Carbohydrates)

If solid wastes are to be used as fuel, the four most important properties to be known are:

– Waste analysis

1) Moisture (loss at 105°C for 1 h)
2) Volatile matter (additional loss on ignition at 950°C)
3) Ash (residue after burning)
4) Fixed carbon (remainder)

– Ultimate analysis, percent of C (carbon), H (hydrogen),O (oxygen), N (nitrogen), S (Sulphur), and ash.
– Heating value

E. Extreme Analysis

A definitive investigation of a waste segment regularly includes the assurance of the percent C (carbon), H (hydrogen), O (oxygen), N (nitrogen), S (sulfur), and cinder. On account of the worry over the outflow of chlorinated mixes during ignition, the assurance of incandescent lamp is regularly incorporated into an extreme investigation. The consequences of a definitive examination are utilized to portray the synthetic organization of the natural issue in MSW. They are additionally used to characterize the best possible blend of waste materials to accomplish reasonable C/N proportions for organic change forms.

IV. RESULT AND DISCUSSIONS

A. Calculation of Population

Population of MM Nagar is calculated using Arithmetic mean method.

For the Years 2001 and 2011, population data was taken from Census department

For the years 2021,2031,2041, population was calculated from Arithmetic Mean method.

1) Arithmetic Mean Method

$Pn = Po + nx$

Pn = Population of nth decade

n = number of decades

P_0 = present population

x = Difference in population of 2 decades

The population data is shown below in table 4.1

Sl. No.	YEAR	POPULATION	SOURCE
1	2001	48,463	Census department
2	2011	81,872	Census department
3	2021	1,15,281	Arithmetic mean method
4	2031	1,48,690	Arithmetic mean method
5	2041	1,82,099	Arithmetic mean method

Table 4.1: Population Data

B. Landfill Calculation

1) Assumptions:

1) Increment in waste generation rate = 2%per annum
2) Floating population =10%

As of today, in MM Nagar, average waste generated per person per day is 450 grams.

That is,

$81872 \times 0.450 = 36842.4$ kg

$= 36.842$ tons/day

Out of this,

– 70% Waste is biodegradable and rest 30% waste is non-biodegradable.
– Non bio degradable waste (30%) will go in landfill.
– Out of 70% biodegradable waste, 40% will go for recycling and remaining 30% will go for composting.

C. Calculation of Waste Generation of Landfill

1) For the year 2011

Average waste generated per person per day = 450 grams (MM NAGAR MUNICPALITY OFFICE)

2) For the year 2021

30% of 450 grams = 135 grams = 0.135 kg
0.135 × 0.02 = 2.7×10-3
2.7×10-3×10 = 0.027 kg
0.135 + 0.027 = 0.162 kg 24

3) For the year 2031

0.162 × 0.02 = 0.00324 kg
0.00324 ×10 = 0.0324 kg
0.162 + 0.0324 = 0.1944 kg

4) For the year 2041

0.1944 × 0.02 = 0.00388 kg
0.00388 ×10 = 0.03088 kg
0.1944 + 0.0388 = 0.2332 kg

Waste generated per person per day is shown below in table 4.2

Sl. No.	YEAR	Waste Generated (per person/day)
1	2011	0.135 kg
2	2021	0.162 kg
3	2031	0.1944 kg
4	2041	0.2332 kg

Table 4.2: Waste generated per person per day

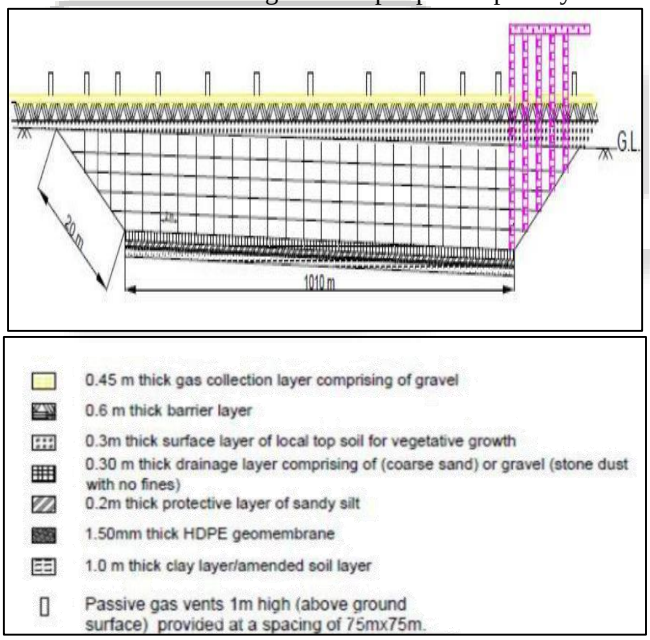

Fig 4.1: AutoCAD layout of landfill

D. Composting

Waste generated per person per day= 36.842 tons / day
Out of this, 70% is biodegradable.
So, now biodegradable waste = 25.7894 tons / day
Biodegradable waste/ year = 9413.131 tons / year
40% of biodegradable waste (70%) will go for recycling.
30% of leftover biodegradable waste will go for composting.
So, 0.30 × 9413.131 = 2823.93 tons / year for composting.
2823.93/365=7.73 tons (approx. 8 tons)
It takes 2 months for composting waste.
60×8=480 tons
1 windrow capacity = 9 tons
480/9=53.33 (approx. 54 windrows)

Dimensions of Landfill
Length of composting pit = 12 feet = 3.65 m
Breadth of composting pit = 6 feet = 1.82 m
Height of composting pit = 5 feet = 1.524 m
Size of 1 pit = 360 cubic feet = 10.123 m3
The layout of 2D windrow is shown in following figure 4.2 and figure 4.3

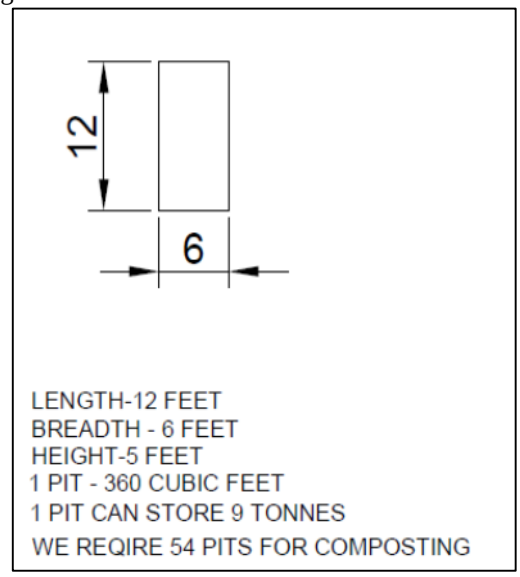

Fig. 4.2: 2D of windrow layout

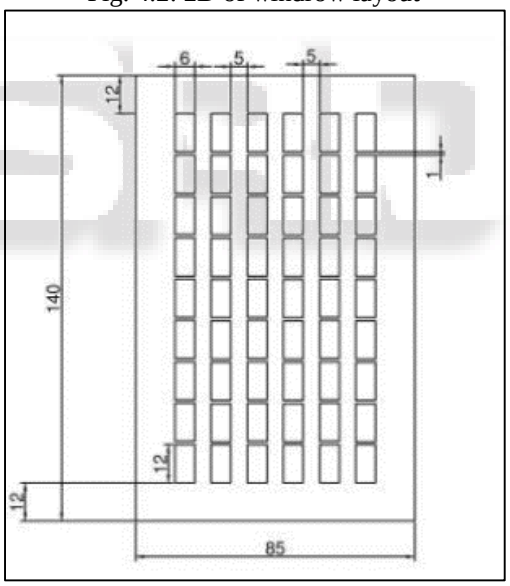

Fig. 4.3: Cross section of composting unit

V. CONCLUSION

Design of Landfill and Composting Unit for MM Nagar for the next 30 years. Design may change with increase and decrease in population of the area. The units are planned to be constructed near MM Nagar. The plan has been made by considering per capita waste generated per day. Population of MM Nagar is calculated using Arithmetic mean method. In this project, design of Landfill and Composting units for MM Nagar Municipality which comes under Ward Number 14 was considered. Location of the unit is near to MM Nagar. The dimension of Landfill unit is 810 × 1010 m and we require 54 windrows for composting waste. After collecting preliminary data from MM Nagar about population and

amount of waste generated per person, we did characterisation of waste and from the results we concluded that 70% of the waste generated is bio-degradable and 30% is non bio-degradable. Bio-degradable waste can be separated into recyclable (40%) and composting (30%). Non bio-degradable waste will go into Landfill.

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