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Cost Studies on Box Type Community Compost Plant for South Delhi Municipal Corporation (SDMC), New Delhi

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Abstract:

Solid waste has been created since the start of human progress. Individual creates and throws away huge quantity of solid substances consistently because of quick increment in generation and utilization. In South Delhi Municipal Corporation (SDMC), there has been huge increment in the creation of urban solid waste. Be that as it may, there is an enormous potential for decreasing cost in the methods of disposing MSW. Distinctive waste management techniques can possibly decrease the amount of MSW disposed in landfill.

In present study field characterization of MSW for 40 locations/ areas as a representative of the selected 40 wards in SDMC has been done. A feasibility analysis has been done on a community based box type compost plant of 2 ton /day capacity and plant has been design and proposed to treat generated solid waste for studied areas of SDMC. It has been computed, if total municipal solid waste is treated in community based decentralized plants then total compost produces about 126 tons for all 40 selected locations. Further it generates revenue of about Rs. 123412 in total for all studied wards. It has been also calculated, if required compost plants have been installed in each ward then one time collection not more than INR 62.00/person is required to install all required number of compost plants in each ward. To operate these compost plants, monthly contribution of about INR 10.00/ person is required.

1.0 INTRODUCTION

Solid waste is unwanted & discarded solid fractions, arising due to human activities (Singhania, 2012). Humans have always generated solid waste since the evolution of civilization. Solid waste production is a constantly raising issue worldwide, at national level and for a locality. Society rejects and creates tremendous amount of solid substances frequently because of quick increment in creation and utilization. Further, the immense amount of waste generation raise the issue of input cost land requirement for the treatment and disposal of solid waste and finally related numerous environmental problems aroused in treatment process of such quantity of waste.

The total surface area of earth is around 76096764 km^2 in which land contributes around 22096525 km^2. Population inhabit in approximately area of 18146.718 km^2 of land (Dhanalakshmi, 2011). Currently, the earth has an aggregate human population of 6.055 billion and the aggregate waste produced by them is around 3.86 million metric tons per day. According to the Indian census data 16.7 per cent of the aggregate population of the world is amassed in India, i.e. around 1,027 million individuals. These Indian populations live only in 2.4% of land territory of the earth. This world census normally throws away 580.26 metric tons of solid waste every day (Dhanlakshmi, 2011). It has been evaluated that the Indian metropolitan cities create about 0.35-1.0 kg of waste per capita every day.

1.1 Solid Waste Disposal as Landfill

Landfill is a conventional and one of the overwhelming ways to dispose solid waste in all over the world (Laner *et al.,* 2012). Solid waste landfills are significant source of wide range of pollutants and are of environmental concern (Eggen *et al.,* 2010). Uncontrolled dumping of the MSW is associated with adverse environmental impacts. In India, studies reveal, around 85% to 90% of MSW is disposed of informally in an open land and landfills, making issue to human wellbeing and overall environment (Katre *et al.,* 2012). In spite of vigorous efforts to reduce, recycle and reuse of the solid waste, about 80% of the waste disposed of is in the landfill (Khandelwal, 2007). The two main environmental problems as a result of landfills are emissions into atmosphere as landfill gas emissions (LFG) and infiltration of leachate in to ground water.
Economic development, urbanization and improved living standards in cities enhance the amount and complexity of solid waste (Yeaadla *et al.,* 2003). SWM is not a disconnected phenomenon that can be effectively compartmentalized and solved with innovative technology or engineering. It is specially an urban issue that is firmly related, directly or indirectly, to various issues such as urban way of life, resource consumption patterns, occupations and salary levels, and other financial and social issues (Takele, 2004).

1.2 Objectives of the Study

Study is focusing on an integrated research on following lines:

- Studies on existing solid waste management practices, collection of secondary data and field study
- Studies on decentralized waste management strategies & recommendation

2.0 DECENTRALIZED SWM - COMPOSTING

Decentralization relates to the procedure of devolution of assets and decision making powers through arranged intervention at the local level decided on the basis of a geographical limit. Decentralized Solid Waste Management as a procedure, aims at supplying provisions to a large number of problems and issues given such that activities are able to satisfactorily harness the accountability, association and transparency. Parkinson *et al.,* (2003) suggested that decentralized systems with decentralized approaches are more compatible than centralized systems. More generally, decentralization is also viewed as a method of capacitating the role of local government and democracy as an effective ways of suggesting environmental and human wellbeing (Fragano *et al.,* 2001). Decentralized eco-sanitation system is a promising and maintainable mode in contrast to the century old centralized conventional sanitation framework (Bernard *et al.,* 2012). The decentralized management system includes treatment of urine, co-digestion of faeces & food waste and treatment of horticultural waste & organic fraction of municipal solid waste by ways of composting (Bernard *et al.,* 2012). A decentralized initiative has many indirect benefits. The localized collection and processing of wastes, saves the long transportation distances of wastes towards dumping sites. It reduces the expenditure on imported fossil fuels, traffic congestions, air contamination and road maintenance costs. It also decreases the contamination of ground water through the seepage of leachate (Kokate *et al.,* 2014).
Decentralized solid waste management system is found to be an effective method, which can be implemented to treat the solid waste generated in the city and onsite application of special cultured micro organisms to compost the food and vegetable waste would benefit the community (Gokul *et al.,* 2015). Taking care of decentralized solid waste handling at community level which involves composting as one of the ways reduces the amount of waste brought to the final dumpsite and saves methane discharges from organic waste (Kusumowati *et al.,* 2011). In view

of the prevailing situations, it is high time that the waste management authorities should consider decentralized waste processing centers to manage the waste effectively (Pavan, 2014). On-site composting facilities could have been considered as a viable means to deal with organic fraction of wastes in the small communities. On-site composting facilities allow composting of the generated solid wastes in the surrounding area and then use the output compost within the specific area. The operation and maintenance of the small-scale systems are easy with low cost.

A number of studies have been done on decentralized framework for solid waste management. Hareesh *et al.* (2015) proposed a decentralized system which saves the cost of transportation and suggested utilizing the same for the construction of decentralized compost plant. Sandhya (2015) highlighted the application of a decentralized social engineering approach in municipal solid waste management system that has been practicing successfully across the Alappuzha municipality for the last few years. Wang *et al.* (2011) proposed an idea of communities as renewable resource recovery centres to build a sustainable urban waste management way for the next decade and beyond. It will facilitate an alternate option to sustainable urban waste management not only for Singapore but also many cities around the globe. Gokul *et al.* (2015) designed a sustainable decentralized solid waste composting system to meet the future challenges. Storey (2013) managed solid waste in a decentralized manner relying on simple technology, reducing operational and maintenance cost and aimed at source separation of waste to produce good quality compost. Bernard *et al.* (2012) developed a decentralized source separation design model to estimate the input and output in terms of materials and energy. Tellnes (2010) evaluated the potential for handling the wastes at ward level, thereby reducing the amount of waste to be transported to central treatment and disposal. If this waste is used for energy and nutrient recovery, the decentralization could also become commercially viable. Below table 1 showing different decentralized compost plant in India by citizen initiatives;

Table 1: Citizen Initiative for waste composting in Indian cities (Zurbrugg *et al.*, 2002)

Location	**Composting technique**
Diamond Garden Residents Forum, Mumbai	Box system
Sandu Lane ALM Chembur, Mumbai	Box system
Scientific Handling of Waste Society (SHOW), Bangalore	Box system
Sindh Colony, Pune	Low windrows
EXNOR Ramanathan, Chennai	Box system
Shyam Nagar Slum Mumbai	Compost pit
Pammal, Chennai	Worm composting in boxes
Kalyana Nagar Residence Association, Bangalore	Box system
Residents Initiative for a Save Environment (RISE), Bangalore	Box system
Pammal, Chennai	Vermi-composting
Central Leather Research Institute, Chennai	Pit-composting

Orchid Eocotel, Mumbai	Vermi-composting
Tata Power Colony, Mumbai	Pit-composting

2.1 Decentralized Model - Advantages

About 60% to 70% of the wastes in SDMC wards are in organic nature and biodegradable. By introducing composting, wards can eliminate increasing problem of waste. By deviating up to 80 % of the waste from the landfill disposal to compost plants, which further diminishes the amount of waste that goes to the landfill and lessen disposal costs for the concern authority. Composting also decreases methane emissions, thereby contributes to mitigating green house gas and climate change. In developing nations, big centralized and highly automated composting plants have generally failed to generate competitive compost. These plants have generally been stopped due to higher side operational and maintenance costs. Decentralized composting is carefully separated organic fraction of household wastes in manageable quantities at ward levels and processed same for composting process. In this system low capital cost and skills are required. Comparatively it has less maintenance costs and it uses locally available materials. It may generate employment opportunities for the poor individuals living in urban area. In this case quality of compost is good because waste fractions are separated efficiently comparatively and risks of contamination are reduced. On a small scale decentralized composting allows up to 3 tons of organic waste to be treated every day.

2.2 Box Composting Process

The production of compost completes in stages of due time. Sorted waste is mixed thoroughly followed by filling in compost box for 40-45 days where it loses 40%-50 % of its moisture.

Table 2 giving percentage space allocations for different activity for box composting.

Table 2: Percentage of activity area required inside compost shed (Sinha, 2010)

Activity area	**Area covered inside compost shed (%)**
Reception, sorting, screening and packaging areas	12
Compost boxes	50
Maturing boxes	10
Offices, toilets, wash room, equipments storage	12
Store for finished compost	10
Store for recyclables	6

After 45-50 days this material is transferred in mature box 15-20 days. The decomposed waste is screened and stored and bagged for marketing (Figure 1).

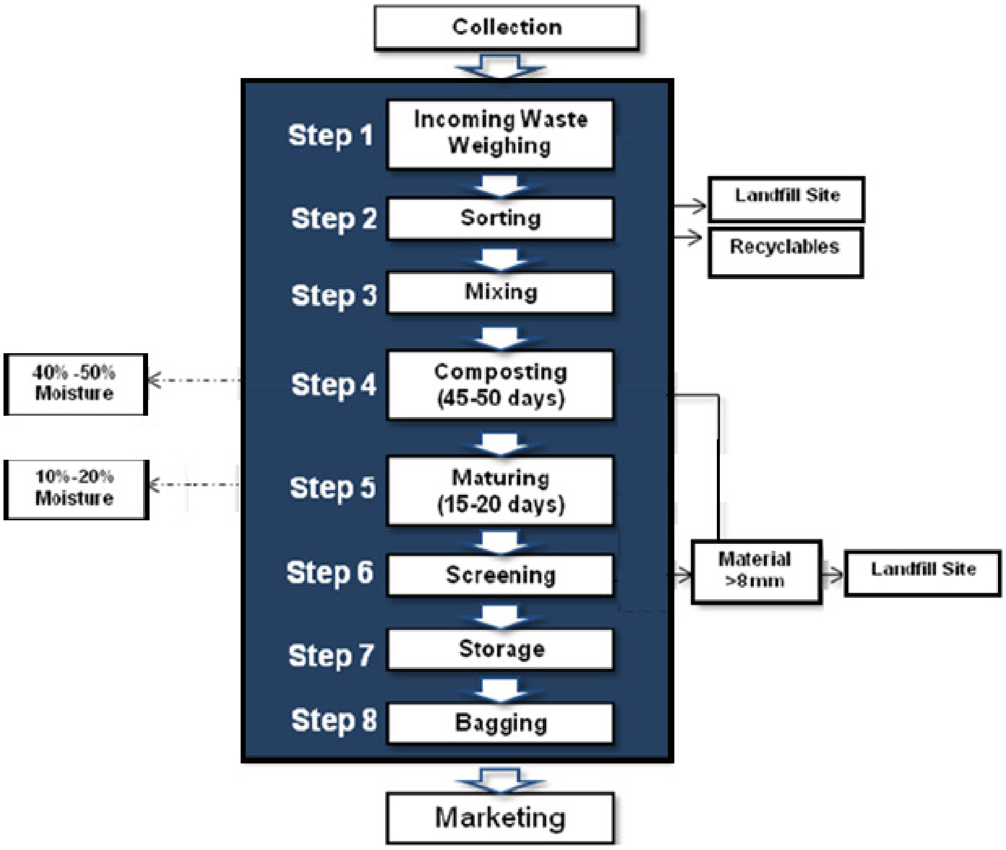

Figure 1: Box composting process (Sinha, 2010)

3.0 South Delhi Municipal Corporation-Study Area

Municipal Corporation of Delhi was broken into South Delhi municipal corporation (SDMC), North Delhi municipal corporation (NDMC) and East Delhi municipal corporation (EDMC) in 2012 (Figure 2). SDMC is managing the population of 5.6 million citizens with a commitment of maintaining, upgrading and advancing civic amenities efficiently with a view to generate a better tomorrow for citizens. SDMC occupies an area of 656.91 km^2 which is subdivided into Central, South, West and Najafgarh zone (Figure 3). SDMC is imparting civic services to highly posh residential, commercial, rural, urban villages, jughi jhopri (JJ), resettlement colonies, regularized and unauthorized colonies. There are 104 wards under SDMC. In SDMC area, 388 approved colonies, 86 rural villages, 81 urbanized villages, 111 unauthorized colonies, 252 unauthorized regularized colonies and 32 jj resettlement colonies are counted. Out of 1038 colonies, 221 in Central zone, 185 in South zone, 241 in West zone and 391 in Najafgarh zone in SDMC area *(MCD, 2014).* There are more than 13 lakh houses and population of 65 lakh in areas under the boundary of the South Delhi municipal corporation. Daily waste generation is 4238 metric tons, which is projected as annual increment of 120 metric tons per year (Mail online, 2014).

SDMC has commissioned 22 green waste management centres in their zones to make the entire area under its jurisdiction free from green waste. SDMC areas generate 20-25 metric tons of green waste daily. Corporation has total of 19 wood chipper machines for the all four zones for recycling of the green waste. The machines produce powder on shredding, which can be used in production of manure and can be utilized in parks. Presently, SDMC is paying Rs 1727/ ton for transportation work.

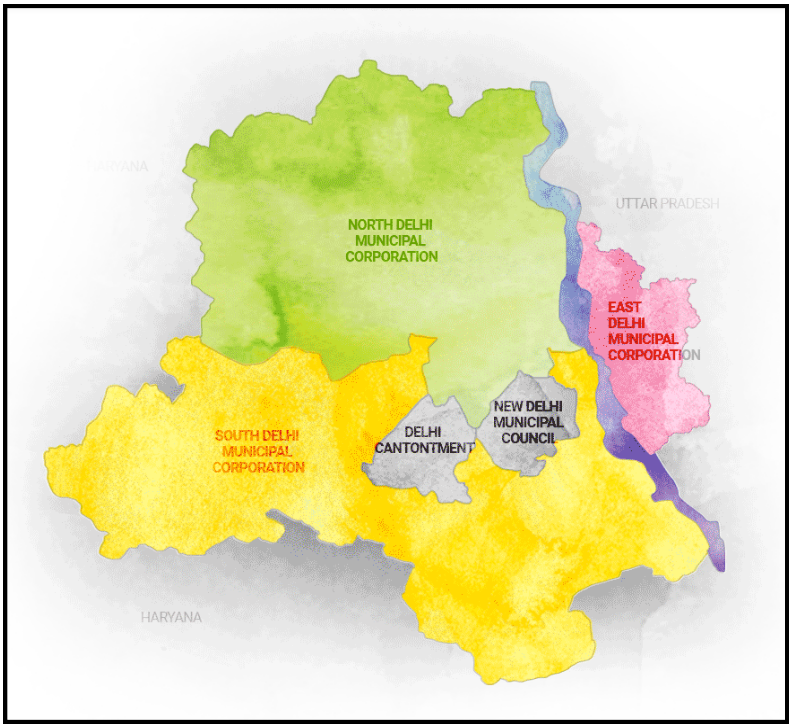

Figure 2: Showing area under SDMC (News18, 2017)

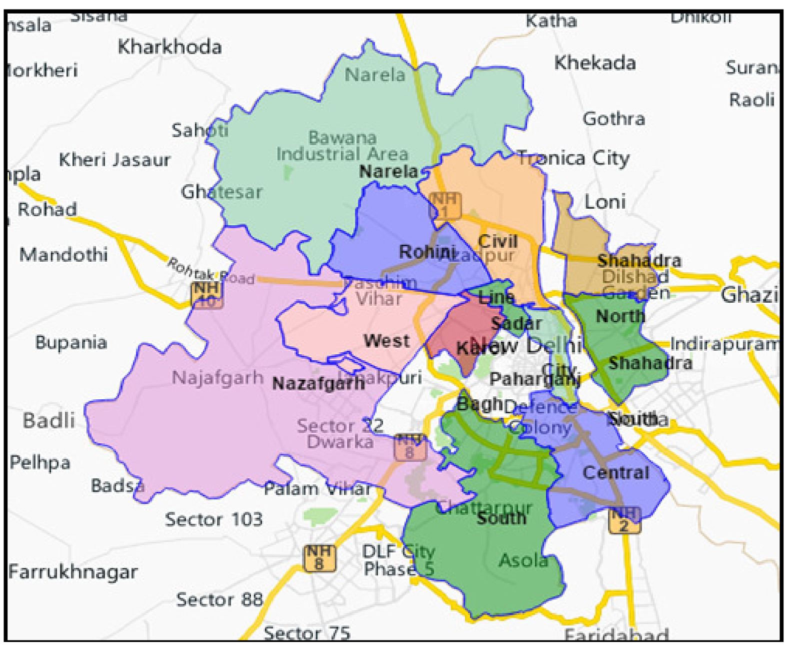

Figure 3: Showing zones under SDMC (MCD, 2014)

Below table 3 is showing results of waste composition study on different income group by COBI (2004);

Table 3 Properties and Composition of Solid Waste under SDMC area (COBI, 2004)

Location	Area type	Biodegradables	Recyclables
Hauz khas	High income group (HIG)	71.9	23.1
Vikaaspuri	Medium income group (MIG)	75.9	21.1
Sadhnagar	Low income group (LIG)	63.2	16.6
Ring road, opposite nagla machi village	JJ cluster (JJC)	72.2	16.2
Okhla veg Table market,	Vegetable market (VEM)	97.2	2.3
Najafgarh road, motinagar to drain culvert	Street sweeping (STS)	28.4	12
Indian institute of foreign trade	Institutional area (INA)	59.7	33.8
Nehru place	Commercial area (COA)	15.6	68

Corporation is ensuring door to door collection of garbage/solid waste, their transportation at landfill sites and waste-to-energy plants. Corporation is constructing state-of-the-art transfer stations to increase the efficiency in collection of waste and quick removal of garbage with the timely availability of garbage transport vehicles. Removal of garbage from transfer stations to terminal disposal sites will be easy at night as there will be less traffic on the roads. Presently, corporation has taken decision to convert dhalaos into much-needed public toilets. Following table provides the data on no. of vehicles available in SDMC area (Table 4).

Table 4: Vehicles for Solid Waste Management in SDMC (MCD, 2014)

Name of the vehicle	No of vehicles
Truck-tipper having capacity $8m^3$	138
Tractor-trailer	40
Refuse collector/compactor having capacity $14m^3$	26
Dumper-placer/bins having capacity 1100ltrs	1151
Front end loaders	30
Auto tipper	256
PVC bins having capacity 200ltrs	800

Total no of waste receptacles in SDMC area are 5137. Table 5 below shows waste receptacles in different zones of SDMC.

Table 5: Waste receptacles in SDMC Delhi (MCD, 2014)

Zone	Dustbin/ Dhalaos + Trolleys	Open sites
Central Delhi	244	75
South Delhi	374	72
West Delhi	213	14
Najafgarh	68	135

4.0 Design of Decentralized Box Compost Plant

After studying cost and emissions generated from different location and sources for different waste management technologies and scenarios, box type compost plant is designed and comparison has been done for cost saving.

For designing of compost plant waste density 500kg/m^3 has been considered. Waste input of 3 tons/day as plant capacity is assumed.
For pre composting cycle @50 days, total waste will arrive to compost box =
@3 tons/day x 50 days = 150 tons
So total capacity of box is required = 150x1000/500 = 300m^3
Consider, total composting process takes 50 days
Considering 15 tons/day compost box capacity
Required total number of compost boxes are = (150tons/day)/ (15tons/day) = 10 nos.
Consider size of each box as 15 x 2 x 1
Take L=15 m, W=2 m and height 1 m
If every day 20 cm waste layer is spreaded then each 15 ton/day compost box will fill in 5 days,.
Designing of maturing box capacity:
After completing 50 days resident time in a compost box, 15 tons of waste in each compost box will release moisture and its weight will be = 15 x 50% = 7.5 tons
7.5 tons of decomposed dry wastes will arrive to the maturing box.
So required size of maturing box = 7500/375 = 20 m^3
Consider 15 days as residence time in a maturing box, total numbers of compost boxes required are of volume 20 m^3 and in 3 numbers
Consider size of maturing box = 5 x 4 x 1
It is assumed that the first compost box will be vacant on the 50th day and matured compost will be taken in 50th-65th day.

In the figure 4, location 1 is designed open platform which can be used as a sorting and mixing of input organic waste after collection of organic waste and it first comes to this area and after sorting and mixing of the organic input it goes to the compost boxes (location 2). After 45-50 days as residence time in the compost box, decomposed organic substance is then arrived to location 3 (maturing box). After 65-70 days the matured and decomposed product is dried utilizing sun light or blowers. Then the final product is screened and bagged again in location 1. From location 1, packaged compost is stored in location 4 for time till sell.

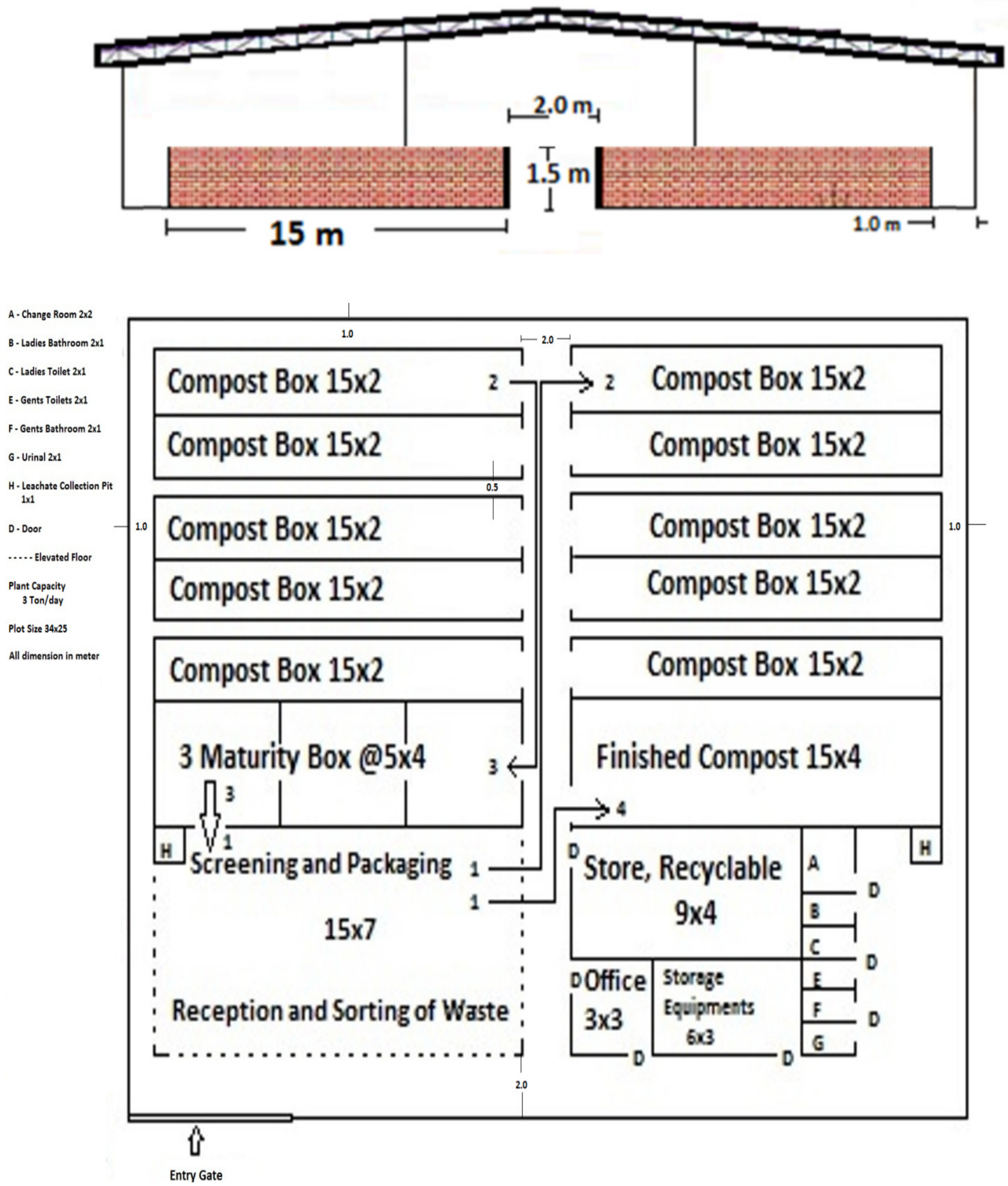

Figure 4: Elevation and plan of proposed compost plant

A study is performed to compare the benefits if community based compost plant installed in study area in integration with landfill site. Below table 6 shows results of proposed community compost plant for studied 40 wards of SDMC. The proposed community compost plants produces total about 126 tons of compost which generates revenue of about Rs. 123412.

Table 6: Results of proposed decentralized box compost plant

Sr. no.	Particulars	Amount
1	Running cost	335580 (INR)
2	Investment cost	103855869 (INR)
3	Biodegradable waste	505.80 (Tons)
4	Produced compost	126.45 (Tons)
5	Compost revenue	123412 (INR)

It has been also calculated, if required compost plants have been installed in each ward then one time collection not more than INR 62.00/person is required to install all required number of compost plants in each ward. To operate these compost plants, monthly contribution of about INR 10.00/person is required (Table 7).

Table 7: Collection requirement at ward level

Ward No.	Total Population (2011)	Total cost	Total revenue	Running cost required/ month	Collection required per month	Investment required	One time required collection
30	52776.24	28863.44	17592.56	338126.3	6.406791	2288203	43.35668
32	52412.24	29993.1	27390.83	78068.15	1.489502	2505139	47.79683
42	47537.99	30058.41	22671.13	221618.5	4.661925	2772952	58.33128
57	52269.53	32227.98	15332.78	506856.2	9.696971	2903328	55.54531
97	51859.81	33853.32	20946.59	387201.9	7.466319	3210164	61.90081
103	47603.5	30312.78	20842.3	284114.3	5.968348	2814073	59.11484
105	46498.09	29131.96	13274.12	475735.3	10.23129	2663715	57.28654
106	53129.53	34388.07	19271.89	453485.2	8.535463	3237880	60.94313
112	45526.82	28560.19	19909.19	259530	5.700595	2616002	57.46067
117	48810.83	31108.3	19422.79	350565.2	7.182119	2889694	59.2019
122	54556.27	29293.16	19024.41	308062.6	5.646694	2270384	41.61545
127	44956.96	28881.32	13503.4	461337.7	10.26176	2700677	60.07252
129	52190.9	29633.13	25863.97	113074.7	2.166559	2453665	47.01327
131	48219.38	27017.95	21559.89	163742.1	3.395773	2203980	45.70735
133	50483.13	27583.94	17499.62	302529.6	5.992688	2184386	43.26962
136	57790.46	33041.92	31592.82	43472.76	0.752248	2757169	47.70977
137	52718.54	29878.59	30195.05	-9493.73	-0.18008	2469292	46.83915
140	53253.53	28833.95	17883.17	328523.4	6.169044	2257897	42.39901
141	47182.97	25334.6	14382.67	328557.7	6.963481	1963541	41.61545
144	46611.27	29707.02	19472.64	307031.4	6.587065	2759475	59.2019
156	46728.05	29316.94	20165.48	274543.9	5.875355	2685025	57.46067
158	45133.08	28957.17	26610.16	70410.33	1.56006	2707329	59.98545

160	47533.51	31003.72	16711.77	428758.3	9.020127	2938225	61.81375
161	43423.26	27878.65	30940.46	-91854.5	-2.11533	2608545	60.07252
164	46296	30794	25835.62	148751.2	3.213047	2966525	64.07735
165	45113.78	29504.56	29049.99	13637.19	0.302284	2804362	62.16199
171	50425.94	32890.15	18174.47	441470.3	8.754826	3117016	61.81375
172	46593.89	28977.89	20939.86	241141	5.175377	2632694	56.50299
174	47778.19	26390.08	14741.65	349452.9	7.314067	2117260	44.31436
181	48258.37	27567.49	27293.52	8219.251	0.170318	2298194	47.6227
182	47400.09	26628.31	25067.7	46818.05	0.987721	2178913	45.96853
183	50825.91	27465.37	19881.75	227508.7	4.476235	2146118	42.22488
184	44845.05	28802.91	17368.19	343041.4	7.649484	2693955	60.07252
190	48511.65	31617.74	16947.78	440098.8	9.072022	2994464	61.72669
193	48454.76	30640.82	20985.42	289661.9	5.977987	2826428	58.33128
196	47580.43	29921.82	20496.58	282757	5.942717	2746430	57.72185
197	41855.32	26260.07	16422.17	295136.8	7.051357	2405035	57.46067
200	45437.5	24983.75	20624.22	130786	2.878371	1993755	43.87905
203	47478.62	27660.88	22474.16	155601.8	3.277302	2356132	49.62512
206	49551.67	30350.78	21373.02	269332.6	5.43539	2717851	54.84882

5.0 Conclusions

Humans generated solid waste since the evolution of civilization and landfills are part of an integrated system for the management of MSW. Landfills can provide safe and cost-effective disposal of MSW when carefully designed and well managed. Incineration is a sound management practice but under particular emissions control conditions. At present, these are not popular in India due to limited capital and technical resources. Composting can reduce landfill gas and leachate risks at the landfill by diverting organic biodegradable matter from the landfill. Composting is more cost-effective if these operations close to the site of waste generation. An integrated MSWM system has priority or combination of its waste management options according to materials recovery/recycling, composting, incineration, and landfilling. There are following conclusions having made based on analysis:

- A decentralized waste management system especially community compost plant may be a feasible options to treat increasing waste and only residue can divert towards centralized landfill.
- A feasibility analysis has been done for a community based decentralized compost plants of each 2 ton /day capacity. This generates revenue of about Rs. 123412 on sale of compost.
- It has been also calculated, if required compost plants have been installed in each ward then one time collection not more than INR 62.00/person is required to install all required number of compost plants in each ward. To operate these compost plants, monthly contribution of about INR 10.00/person is required

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