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Investigative Study on Science and Engineering of Interim and Long Term Measures for Disposal of Municipal Solid Waste in India

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ABSTRACT: Scientific disposal of municipal solid waste (MSW) in an environmentally acceptable manner has emerged as an intriguing and challenging task for city administrations across the country. This situation has arisen due to missing rules-regulation and government policy matters till as late as Sept. 2000, when MSW rules 2000 were enacted. Since then, after lapse of 14 years, the country does not have scientific disposal of MSW for more than 26000 MT / day out of current MSW quantities of 170400 MT / day from 377 million urbanites. The per capita generation of waste in India is still modest at 452 g (Av.) which $\frac{1}{4}$ th to $\frac{1}{3}$ rd as compared to US-UK. About 85% of the urban local bodies are yet to have proper MSW treatment and disposal facilities. To faster the speed of proper disposal mechanism for renewing 144400 MT /day, one can get into quick action mode by adopting the practicable interim to medium term MSW disposal through “Land Fill Bioreactor Gas Recovery” as demonstrated by the authors of this study. Full scale MSW disposal (550 MT /day) experiment designed, developed and operated at Turbhe land fill site of Navi Mumbai during April 2008 to March 2011 revealed important findings. Three year’s MSW weighing 0.725 million M.T. could be disposed off in the engineered land fill cell No.3 with land area of 41000 sq.m. having land filling depth of 20 m. The land fill cell has compacted clay and HDPE bottom liners of 1.5 mm thickness with perforated HDPE net work for leachate collection and re-use. Incoming MSW was subjected to recovery of dry recyclables mainly plastics, woody material and glass – metals to the extent of 10%. Remaining waste was land filled in layer by layer with daily earth cover. The Capex worked out to Rs 75.00 million and daily Opex @ Rs 125.00 per MT of MSW. The methane gas recovery data revealed that 3.29 million cu.m. gas was generated in this cell, which has potential commercial value of Rs. 44.80 million per year. Such yield can be obtained for average period of 7 years. During the operating phase of the “LFG Cell”, there was enough time for planning and execution of full scale multiple technology processing project for 600 MT / day that begin operating from Aug 2012 is functional currently (March 2015). With MSW filled up in the closed bio reactor cell, there has been no visible nuisance of MSW and creation of Garbage Mountain that attracts public protests and penalties from monitoring authorities. This experiment shows the pathways to all ULBs having population of one million plus.

KEYWORDS: Municipal Solid Waste, Disposal Mechanism, Turbhe, Navi Mumbai, Land Fill Bioreactor Gas Recovery.

I. INTRODUCTION

Scientific processing treatment of Municipal Solid Waste is integral part of waste handling, storage, transportation and disposal so as to minimize ill effect on environment so also to keep such disposal costs at the lowest minimum through recovery of usable resources, rather than burying these. Current waste quantities of 484 /g / capita / day in Navi Mumbai are in line with similar other cities. With its population base of 1.27 million, the total MSW from the city was

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615 MT /day. The waste processing treatment adopted by Municipal Corporations in Chandigarh, Jaipur, Faridabad, Lucknow, Nashik, Hyderabad, Vijayawada reveal that there are several ambiguities regarding success of high technologies like Incineration, bio methanation, RDF alone or composting alone. This led to thinking of alternative approach for waste treatment by the authors of this paper. The chosen approach focused on Bio reactor Land Fill Gas recovery under controlled conditions. While Navi Mumbai Municipal Corporation's (NMMC's) entire waste during April 2008 to March 2011 could be treated through "LFG" without visible eye sore and other pollution problems, this paved way for proper planning and execution of multiple technology of Composting plus RDF Plus plastic recycling treatment and further add one of bio-methanation of pure organic waste stream.

II. REVIEW OF LITERATURE

Waste generation in Indian cities is on the increase on account of rise in the income, changes in life style and improvement in living standard. Beede and Bloom(1995) [1] estimated municipal solid waste will increase at an annual growth rate of 2.70 % in 2010s. Mensah and Whitney (1991) [2] and Benavides(1992) [3] observed waste disposal in mixed form along with other wastes is a serious pollution problem and threat to human health and ecological damage. For disposal of MSW, Crowley (2003) [4] reported quick rise of incineration technology in 80s and early 90s and also reported achievable objectives of bio reactor land fill for acceleration of waste stabilization, methane generation and volume reduction. Johnnessen(1999) [5] observed excessive quantities of leachates and gases from land fill bio reactors that required effective control mechanism.

Maier (1998) [6] reported stability as an important parameter for designing of Land Fill bioreactor. Accordingly to Johannessen (1999) [5] there are 5 important phases of Land Fill bioreactor that may last for up-to 10 years with peak in 4 to 8th years. Comparative Land fill bio reactor in Indonesia with 0.70 million MT capacity cost of Rs. 346.30 million with average operational cost of Rs 1280.00 per MT. Offset from scale of electricity was Rs.417.00 per MT leaving a deficit of Rs. 863.00 as tipping fee.

III. MATERIALS AND METHODS

Key material is mixed heterogeneous municipal solid waste generated from residential and commercial zones given in the table 1.

Table 1. MSW quantities from different zones of Navi Mumbai Municipal Corporation's

Sr. No.	Zone Area	Quantity of Waste Kg /day	Av.Per Capita g /day
1	Belapur	89185	618
2	Nerul	88470	512
3	Vashi	100210	704
4	Turbhe	85775	607
5	Koparkhairane	103330	562
6	Ghansoli	37315	265
7	Airoli	59200	356
8	Digha	21655	327
Sub Total / Av.		585140	494
9	Agriculture market waste	42125	–
10	MIDC canteen's waste	19735	–
Total		650000	

Note : i) Range of variation 600 to 680 MT /day.
ii) 74% waste generation was from residential areas, 9% from hotels and restaurants.

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Second important material is land area and basic infrastructure. Total area of the site is 26 hectare out of which 8 hectare is devoted to civil and structural work for waste receiving, sorting, sanitization treatment and removal of recyclables. The 4 hectare is under greenification and 14 hectare for construction of engineered sanitary land fill cells.

The Land Fill Bio reactor cell No.3 was devoted to the present study. This cell has surface area of 41000 sq.m. with depth plus height of 20 m. Cell was constructed as per requirement of MSW Rules 2000, with bottom and side liners, leachate collection net work and gas collection pipe line connected to gas flaring device with measurement of gas flaring.

Month wise quantity of MSW deposited in the LFG is given in table 2.

Table 2. Month wise quantity of MSW deposited in LFG Cell No.3 at Turbhe, Navi Mumbai.

Sr. No	Month /Year	MSW Qty. MT	Sr. No	Month /Year	MSW Qty. MT
1	April 2008	15525	19	Oct. 2009	22405
2	May 2008	16600	20	Nov. 2009	19619
3	June 2008	21125	21	Dec. 2009	18206
4	July 2008	22524	22	Jan. 2010	18151
5	Aug. 2008	22661	23	Feb. 2010	17250
6	Sept. 2008	21716	24	March 2010	18619
7	Oct. 2008	19138	25	April 2010	18543
8	Nov. 2008	17215	26	May 2010	19344
9	Dec. 2008	18366	27	June 2010	22754
10	Jan. 2009	18049	28	July 2010	23556
11	Feb. 2009	15827	29	Aug. 2010	24990
12	March 2009	17061	30	Sept. 2010	24658
13	April 2009	17254	31	Oct. 2010	25299
14	May 2009	17757	32	Nov. 2010	23141
15	June 2009	19272	33	Dec. 2010	21567
16	July 2009	20340	34	Jan. 2011	21249
17	Aug. 2009	23277	35	Feb. 2011	19185
18	Sept. 2009	23128	36	March 2011	19181
Total :					724552

Composition of MSW deposited in the LFG Cell No.3 are listed in the table 3.

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Table 3. Composition of waste deposited in the LFG Cell No.3

Sr.No.	Waste stream	Percentage (%) Content
P.A. 1	Short term bio degradable Residues of Food Waste, Fruits, Vegetables, Flowers	42.00
2	Grassy matters	5.00
3	Fish, Meat, bones	4.80
4	Soft papers	3.00
Sub Total (A)		54.80
B.	Medium and long term biodegradables	
1	Tree twigs, palm leaves, coconut shells	4.50
2	Corrugated boxes, jute, rags	3.00
3	Woody materials & bamboo products	3.00
4	Textiles	8.00
Sub Total (B)		18.50
C.	Inerts and Miscellaneous	
1	Stone, bricks, sand	8.00
2	Diapers, Sanitary napkins	3.00
3	Others	2.70
Sub Total (C)		13.70
Grand Total		87.00

Note: Average of 13% materials was removed by the recyclers' net work prior to land filling.

Other Tools Tackles and Equipments : The waste receiving site is well equipped with Payloaders, Pocklane, Wheeldozer, water tanker, sanitary spray baling system, weigh bridges and site laboratory.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

Quantity of land fill gas (methane) measured and flared during 1st June 2010 to 30th June 2011 and 1st Jan 2011 to 30th June 2011 is summarized in the table 4;

Table 4. Record of methane gas flaring at Turbhe LFG Cell No.3

Sr. No.	Period	Methane gas flaring cu.m.	Sr. No.	Period	Methane gas flaring cu.m.
1	1 st Jan to 31 st Jan 2010	17608	7	1 st Jan to 31 st Jan 2011	22010
2	1 st Feb to 28 th Feb 2010	15904	8	1 st Feb to 28 th Feb 2011	19880
3	1 st March to 31 st March 2010	22010	9	1 st March to 31 st March 2011	22010
4	1 st April to 30 th April 2010	21300	10	1 st April to 30 th April 2011	21300
5	1 st May to 31 st May 2010	22010	11	1 st May to 31 st May 2011	22170
6	1 st June to 30 th June 2010	17040	12	1 st June to 30 th June 2011	21300
Total:					244382

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Gas Yield:

This gas yield comes to average rate of methane flaring of 142 cu.m. per hour, 3408 cu.m /day or 1.244 million cu.m.per year as 60% CH₄ .By weight it is 485160 kg /year.At the current market price(subsidized) of Rs 40.00 per kg, it is worth Rs19.40 million per year. In 7 years of active gas generation this will be worth Rs135.80 million.

Compost Recovery:

It is expected that 0.75 million MT waste deposited in the LFG Cell No 3 will yield about 12% good quality organic fertilizer or compost after its aerobic treatment in windrows. This compost quantity will be 87000 metric tons. This can be sold @ Rs1500/- Per MT on Ex-factory basis, with revenue generation of Rs 130.50 million.

Total Revenue potential:

From bio gas	Rs. 135.80 million
From Compost	Rs. 135.50 million
Total	Rs. 271.30 million

Capex and Opex costs:

For construction of LFG Cell	Rs. 75.00 million
O&M cost of MSW land filling @ Rs 125/- Per MT x 0.725 million	Rs. 90.63 million
Other operating expenses At the tipping Floor @ Rs 100/- Per MT	Rs. 72.50 million
Total expenses	Rs.238.30 million

Cost saving to NMMC:

Rs271.30 (-) Rs238.30	Rs. 33.00 million
Further cost avoided as Possible Tipping @ Rs400/- Per MT	Rs. 290.00 million
Overall cost saving to NMMC Yet Scientific treatment of MSW:	Rs.323.00 million

DISCUSSION:

Outcome of the Land Fill Bio reactor experiment with Methane gas recovery as interim to medium term approach reveals very important gains in terms of avoidance of garbage mountain, problems of pollution, mal-odors,pathogens,flies and vultures.

Nearly 0.725 million MT MSW (av.of 662 MT/days has been successfully treated and disposed off in LFG cell for 3 years (April 2008 to March 2011) with positive gains of Methane and Compost having revenue potentials of Rs 271.30 million.

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After discounting for Capex-Opex and other costs, there has been positive gain of Rs. 33.00 million and tipping fee avoidance of Rs 290.00 million. The experiment further reveals that about 600 to 700 M.T. per MSW can be managed by having just 3 LFG Cells of 4.10 hectare each and 8 ha further area for basic infrastructure and processing facility. Johnnessen (1999) [5] have carried out LFG experiments at 4 locations with useful results. The biggest advantage is that urban local bodies can achieve scientific treatment and disposal within 4 months gestation period and ensure garbage free city and its surroundings. The advantages of bio reactor land fill for waste stabilization and viability of LFG was endorsed by Pacey et al (1999) [7].

V. CONCLUSION

Land Fill bioreactor with methane gas recovery as ongoing waste treatment and potential to recover compost at the end of 7 years is practical and cost effective technology worth replicating in cities with population of 1.00 million plus.

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BIOGRAPHY



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