Evaluation of MSW Management in the Pursuit of Climate Change Mitigation by Landgem Model in Chidambaram Town

D.Deepa, K.S.Dhivya, K.Sasireka

Abstract: The majority of municipal solid waste is dumped into unregulated waste sites and into the atmosphere produced methane. Dumping of solid waste in open land and landfilling adds more to climate change, particularly global warming, as greenhouse gases (GHGs) are emitted from landfill. It is highlighted as the most commonly used and considered the most appropriate and easy mechanism, particularly for tropical countries such as India. During the estimation of the quantity of GHGs from landfill, a number of techniques have been used. The current research focuses on the amount of methane emitted by LandGEM models from the Chidambaram site. It is an automated tool for estimating total emission concentrations, methane, CO2, NMOCs and individual air pollutants from the MSW depots. The emission of methane using landGEM model for the period of 25 years from 2015 to 2040 has been calculated to add to 1504 tons.

Keywords : GHG(Green House Gases), Methane Emission, MSW (Municipal Solid Waste), landGEM Model, MCF (Methane Correction Factor), DOC(Decomposable Organic Carbon).

I. INTRODUCTION

The quantity of garbage produced has also risen with the growing population. It is the responsibility of the municipal authorities to implement the MSW 2000 rules[1]. To this end, municipal officials must provide all facilities such as services and infrastructure from collection to MSW disposal, i.e. collection, segregation, storage, transportation, treatment and disposal of strong municipal waste. Growth in population has increased the quantity of waste generation, resulting in a decline in environmental and public health quality. Increasing the volume of solid waste generation, particularly Municipal Solid Waste (MSW), is a matter of severe concern, particularly in urban regions. Urban local authorities should be accountable for appropriate techniques of collecting and disposing of solid waste. Population growth, urbanization and industrialization have resulted to an rise in solid waste generation worldwide [2]. The rate of waste generation is thought to be an index of socio-economic growth and a country's financial prosperity [3].

This is obvious because in developing nations where there is an increase in the unplanned urbanization of the towns, the rate of waste generation is more significant. It was estimated that MSW produced around 1.3 billion MT worldwide in 1990. Currently, the world's annual solid waste output can be 1.6 billion MT. The content of organic carbon and nitrogen influences GHG emissions, which are interactive and interdependent. The literature available shows that N2O sources include methanotrophs (methane oxidizing bacteria). The MSW management is at a critical stage as the proper facilities for treating and disposing of the larger quantities of MSW produced daily in metropolitan towns are not available. Unwritten disposal has negative repercussions on all environmental and human health components [4]. The survey is designed with unique emphasis on Landfill with and without gas retrieval systems to assess the technical alternatives of leadership in MSW for emissions of GHG [5]. The research will have a case study validated in Chidambaram Town for the LandGEM MSW Model.is is an International reputed journal that published research articles globally.

Revised Manuscript Received on September 06, 2019

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II. PEXPERIMENTAL METHODOLOGY

A The MSW will grow considerably in the near future as it strives to achieve an industrialized nation [6]. The approach of a broad body of work to assess the current and potential future climate impacts of waste scenarios is the life-cycle assessment (LCA). All the while LCA is a useful technique for direct and indirect waste systems assessment [7 -10]. LCA studies are carried out more comprehensive data bases are acquired for waste management and not only products [11-13]. Ineffective solid waste management together with a growing population deteriorates the environment. The Municipal Solid Waste (Management and Management) Rules for 2000 provide for the best practices of the management of strong waste to be adopted by all municipalities [14 - 17]. As the population increases, the volume of waste produced also increases. It's up to the municipal officials to apply the MSW 2000 guidelines for effective msw management [18-22]. To do this, municipal officials must provide all services including collection, segregation, storage, transportation, treatment and disposal services and infrastructure for the collection, disposal of MSW [23-26].

A. Study Area

The location of Chidambaram is 11 ° 23'16."5 "N latitude, longitude 79 ° 41"E. It lies within 150 kilometers (93 miles) from Chennai district in Cuddalore, South Indian state, Tamil Nadu. Since1998, This town is functioning as Selection Grade Municipality. It has roughly 64,000 inhabitants and produces 34 mt / day solid waste. In Thandeswara, nallur villlage, Chidambaram municipal solid waste dumpyard is 3 km from Chidambaram. It's got 4,5 acre dumpsite. If leachate migrates into ground water, it can represent an environmental issue. Thandeswara nallur from various sources with a range of 4,58 acres are shown in the following Table.III. There is no mechanism for gas collection and composting. The transport of dumper trucks, mini tippers, tractor trolleys, and weapons ,rolls is used to transmit waste. Cars depend on the physical layout of accessible highways and labor costs. Both manual charging and tractor loader carry these cars. Tractor loader use is inefficient, time consuming, and generates health concerns. Figure 1 shows the image perspective of the dump site.

Figure 1. Thandeswara nallur MSW dump site.

B.LandGem Model

Methane emissions are evaluated by various techniques, including field experiment, site assessment and mathematical modeling. LandGEM is a Microsoft Excel-based software application that uses the first-rate equation below for calculating methane and LFG manufacturing predictions.

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10}\right) e^{-kt_{ij}}$$

ation rate

i = Yearly time increment

n = Difference (year of the calculation) – (initial year of waste acceptance)

j = 0.1 year time increment

k1 = the methane generation constant (1/yr)

L0 = the potential methane generation capacity (m3/Mg)

Mi = the mass of solid waste disposed in the ith year (Mg)

tij = age of the jth section of waste mass Mi disposed in the ith year (decimal years)

The required inputs are the opening and closing of the waste year, the annual rate of waste acceptance from the opening t o the closing year, constant methane generation k, L0, potent ial concentration of NMOCs and methane proportion in biog as, for the estimation of emissions of methane.

C. Model Parameter:

Methane Generation Constant (K).

GHGs are obtained from the Landfill is the result of three processes namely evaporation of organic compounds, chemical reaction of organic compounds, aerobic and anaerobic reaction of microbes. Quantity of emission of methane is based on waste nature and microbial reaction. Third process, which produces biodegradation of organic waste and traces of other compounds, which consists of methane and carbon dioxide. Deposit methane generation is based on strong waste pH, heat and moisture content. For specific site conditions the k1 value is obtained from the following equation,

$k1 = 3.2 \times 10^{-5}$ (average yearly rainfall) + 0.01

In general the assumed value of methane generation rate is ranges from .01to 0.21 $year^{-1}$. For special conditions such as bioreactor landfill the value 0.3 $year^{-1}$ was reported.

Potential Methane Generation Capacity (Lo):

CH_4 generation capacity is influenced by quantity of biodegradable waste which is dumped in the landfill and calculated from the following equation

Lo = Docarbon * Docarbon factor * CH4cf * f * 16/12

Docarbon = Degradable organic carbon.

Docarbon factor = Degradable organic carbon factor.

CH4cf = methane correction factor.

f= the fraction of methane in landfill.

Biodegradable organic carbon can be calculated by a equation provided in the IPCC model. The assumed value of degradable organic carbon factor is 0.623 and it is purely depend on temperature and assumed as 24.5 ˚C. Methane correction factor is influenced by site conditions and management techniques. Fraction of methane in landfill is assumed as 0.6which is the default value in the IPCC guidelines. Table. 1 shows the standard assumed methane capacity values.

Table I. Default values of methane generation constants.

Landfill Parameter	Value
Open Year	2015
Expected Closure Year	2040
Actual Waste Acceptance Rate for 2015	10220
Annual Increase Applied to Waste Acceptance Rates for 2015to 2040	1.3%
Methane generation rate k	0.05
Potential Methane Generation Capacity, LO	$170m^3$/Mg
Methane Content	50%

III. RESULTS AND DISCUSSION

A. Population Vs Waste Generation

From the Table. II, it was observed that there was a gradual increase of population from 1981- 2011 and the population growth rate was found to be 0.06%. This may be due to number of inhabitants in the town is stable. Solid waste generation in Chidambaram based on the various sectors as shown in Table. III and it was found to be 28tons/day. Estimated rise in waste generation (or reduce) by year (x) is 1.3 percent and the proposed waste generation life (in years) is n 25 years. The formulation can be used to calculate waste generation after n years

W= W (1 + x *1/100) n (tons per annum) =709.1 tons

Table II. Population data of chidambaram.

Year	Population
1971	48819
1981	55920
1991	58740
2001	60733
2011	62168

Table III. Various sectors in Chidambaram Town.

Residential	1550
Middle school	3
Higher secondary school	10
High school	1
Slaughter house	1
Fishmarket	1
Vegetable market	3
Marriage mall	20
Hotel & lodge	48

B. Landfill Capacity

The landfill capacity (Ci) was calculated by the formula
$Ci_1 = Vw_1 + Vd_1 + Vc_1 - Vs_1$ (cu.m.)
Where Ci_1= landfill capacity
Vw1= total waste volume for n years
Vd1= total daily coverage volume for n years
Vc1= Total volume necessary for the liner system and cover system components.
Vs1= volume is probable to be accessible for settlement within 10 years

$Ci_1 = 4451054.228\ m^3$

C. Landfill Height and Area

The below equations are used to find out the area and height of land fill.
$Hi = Ci_1 / 0.9\ Ar$ (m) (applicable for landfill area type)
$Ai = Ci_1 / Hi$ (sq.m.) (applicable for landfill area type)
From the equations it was found that height of landfill is 20m and area of landfill is 63.24 acres.

D. Waste Acceptance Rate

The model neither makes it possible to edit default parameters for complete waste gasses, methane, carbon dioxide or NMOCs or to alter current names of pollutants. We should enter the yearly acceptance rates indicated in the Waste Acceptation Table for every year as shown in Table.IV. The default Waste Acceptance Tariff unit of measure is megagrams per year. If the acceptation rate is in megagrams per annum, LandGEM calculates and displays the acceptation rate in short-tons per annum and vice versa automatically. Factors for the emission of landfill gas were created using U.S. empirical information.

Table IV. Waste Acceptance Rates.

ENTER WASTE ACCEPTANCE RATES		
Input Units:	***Mg/year***	
Year	**Input Units**	**Calculated Units**
	(Mg/year)	***(short tons/year)***
2015	10,220	11,242
2016	10,353	11,388
2017	10,487	11,536
2018	10,624	11,686
2019	10,762	11,838
2020	10,902	11,992
2021	11,044	12,148
2022	11,187	12,306
2023	11,333	12,466
2024	11,480	12,628
2025	11,629	12,792
2026	11,780	12,958
2027	11,933	13,127
2028	12,089	13,297
2029	12,246	13,470
2030	12,405	13,645
2031	12,566	13,823
2032	12,730	14,002
2033	12,895	14,184
2034	13,063	14,369
2035	13,232	14,556
2036	13,404	14,745
2037	13,579	14,937
2038	13,755	15,131
2039	13,934	15,327
2040	14,115	15,527

E. Methane Estimation

Table. V shows the methane estimation via LandGem model. The deposit site has almost reached its maximum capacity so that no waste store will be installed after 2040. The first year of waste deposit assumes that biogas manufacturing does not exist. In the literature the methanogenesis stage is certainly noted to begin at least 2-6 months after waste has been tipped. Waste degradation relies on a range of variables: waste type, waste humidity, weather conditions, waste covering material, etc. In order to simplify computations, LandGEM fails to take all these parameters into consideration in order to set the start of methanogenesis. According to the model yield, in 2015 the dumping plant generated zero emission of methane gas due to the starting period of landfill. In 2016 the total waste generated was 10352.86 megagram and the total of biogas emission was 5.667E+01megagram per year. Over the years, the production of biogas is expected to develop until 2040, when it reached 1.004E+03am per year.

Table V. Methane Emission from landGEM model.

Year	Waste in Megagram	Emission of CH_4 in Mg/year
2015	10220	0
2016	10352.86	5.67E+01
2017	10487.45	1.11E+02
2018	10623.78	1.64E+02
2019	10761.89	2.15E+02
2020	10901.8	2.64E+02
2021	11043.52	3.12E+02
2022	11187.09	3.58E+02
2023	11332.52	4.02E+02
2024	11479.84	4.46E+02
2025	11629.08	4.88E+02
2026	11780.26	5.28E+02
2027	11933.4	5.68E+02
2028	12088.54	6.06E+02
2029	12245.69	6.44E+02
2030	12404.88	6.80E+02
2031	12566.14	7.16E+02
2032	12729.5	7.51E+02
2033	12894.99	7.85E+02
2034	13062.62	8.18E+02
2035	13232.44	8.50E+02
2036	13404.46	8.82E+02
2037	13578.72	9.14E+02
2038	13755.24	9.44E+02
2039	13934.06	9.75E+02
2040	14115.2	1.00E+03

The peak output occurs one year after closure of the waste dump, as was apparent from all the research using this model. Biogas production may declines exponentially after 2040. This fast decrease in the manufacturing of biogas is made clear by the reality that less and less waste is being depleted. According to the LandGEM, at least 1.500E+01megagram of methane gas emission generated. Emission of CH4 was expected to be manufactured from 2015 to 2040 in the range of 1.004E+03 megagram.

F. Graphical Results

In any first-order decay-based model, estimated rates of waste disposal are the main determinants of LFG generation. LandGEM does not adjust annual estimates of waste disposal to reflect the waste composition. The graph shows that the gas produced in landfills is significantly different. Figure. II gives different gas emissions from waste disposal.

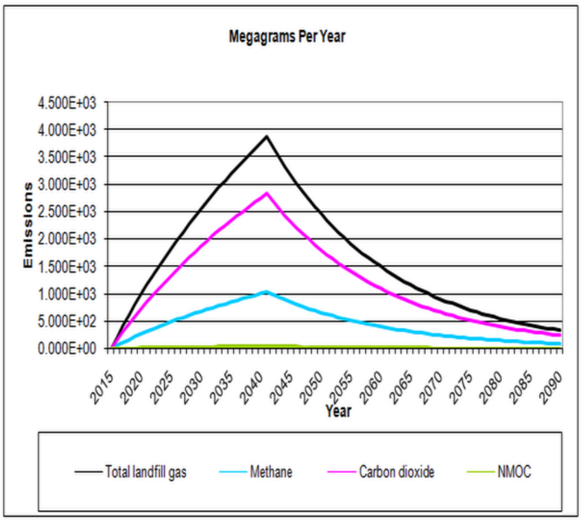

Figure II. Graphical outputs of LandGEM model.

IV. CONCLUSION

A MSW Management is a serious environmental concern and has become a major health and environmental threat in India with urbanization and expanding cities. It is the time for planning integrated facilities incorporating appropriate technologies to establish MSW management facilities. The global agenda on Climate Change Mitigation warrants the planners to address the GHG emissions from any such facility. This research work took effort in addressing this need with a due diligence study, as case study on Chidambaram town. In the presently study, different technological options for MSW management were discussed with the methodologies as recommended by Intergovernmental Panel on Climate Change (IPCC) reports.

A detailed due diligence study was run on the prevailing methods and facilities in Chidambaram for MSW management and a conceptual design was made on the Landfill facility for Chidambaram. LandGEM model were used to assess the Methane generation from the landfill and it was estimated at 1150 Mg/year for the creting period of 25 years. Hence, it can be concluded that there is a potential of 1000 Mg of Methane per year from the MSW of Chidambaram, if managed in a regulated Landfill properly. This will enable Chidambaram to manage its MSW scientifically with an added advantage getting saleable carbon credits.

REFERENCES

1. Elena friedrich, cristina trois, “quantification of greenhouse gas emissions from waste management processes for municipalities – a comparative review focusing on africa”. 2011, PP- 2347-2353.
2. Luis f. Diaz per bakken president, calrecovery, inc. Director, etc et al., “united nations environment programme, solid waste management” volume 1 ,2005..
3. Luis f. Zeler d., yetis u¨., demirer g.n, “life cycle assessment of municipal solid waste management methods: ankara case study of environmental engineering”, environmental international 32, 405-411,2005.
4. Peterson obara magutu and cliff ouko onsongo, “operationalising municipal solid waste management”volume ii, 2004..

Retrieval Number K24290981119/2019©BEIESP
DOI: 10.35940/ijitee.K2429.0981119

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5. Ranjith kharvel annepu , nickolas j. Themelis , "sustainable solid waste management in india",2012.
6. Msw management rules , govt. Of india, available online at cpcb website, 2016.
7. Ganev i. And naydenova i. Evaluation of potential opportunities for electric power generation from landfill gas at "tsalapitsa". Serbian journal of electrical engineering, vol. 11, no. 3, october 2014, 379-390, 2014.
8. Medina m. A. P. And forten r. R. C. Estimating methane gas emissions from solid waste generated by households in an urban village in bukidnon, philippines. American-eurasian j. Agric. & environ. Sci. 15 (5): 837-842, 2015.
9. Ramachandra t. V., k. Shwetmala and t. M. Dania carbon footprint of the solid waste sector in greater bangalore, india. Assessment of carbon footprint in different industrial sectors, volume 1, part of the series ecoproduction pp 265-292, 2014.
10. Scarlat n., motola v., dallemand j.f., monforti-ferrario f., mofor l. Evaluation of energy potential of municipal solid waste from african urban areas. Renewable and sustainable energy reviews 50:1269–1286, 2015.
11. Sridevi h., shreejith k., ramachandra t. V. Comparative analysis of greenhouse gas emissions from major cities of india. International journal of renewable energy and environmental engineering. Vol. 02, no. 01,2014.
12. Luthra a. "waste-to-energy and recycling." economic & political weekly 52- 2017.
13. Tan st, lee ct, hashim h, et al. Optimal process network for municipal solid waste management in iskandar malaysia. J cleaner prod; 71 :48–58,2014.
14. Ngoc un, schnitzer h. Sustainable solutions for solid waste management in southeast asian countries. Waste manage. ; 29 :1982–1995, 2009.
15. Kumar s, gaikwad sa, shekdar av, et al. Estimation method for national methane emission from solid waste landfills. Atmos environ; 38: 3481–3487,2004.
16. Brunner ph, rechberger h,practical handbook of material flow analysis. Boca raton (fl): crc press; 2012.
17. Solorzano-ochoa g, de la rosa da, maiz-larralde p, et al, open burning of household waste: effect of experimental condition on combustion quality and emission of pcdd, pcdf and pcb. Chemosphere, 87:1003–1008, 2012.
18. Lemieux pm, lutes cc, santoianni da. Emissions of organic air toxics from open burning: a comprehensive review. Prog energy combust sci. ;30:1–32, 2004.
19. Damanhuri e, wahyu im, ramang r et al, evaluation of municipal solid waste flow in the bandung metropolitan area, indonesia. J mater cycles waste manage. ;11 :270–276, 2009.
20. Permadi da, kim oanh nt, assessment of biomass open burning emissions in indonesia and potential climate forcing impact. Atmos environ. ;78 :250–258,2013.
21. Ramanathan v, chung c, kim d, et al., atmospheric brown clouds: impacts on south asian climate and hydrological cycle. Proc natl acad sci u s a. ;102: 5326–5333, 2005.
22. Noor zz, yusuf ro, abba ah, et al, an overview for energy recovery from municipal solid wastes (msw) in malaysia scenario. Renewable sustainable energy rev. ; 20 :378–384, 2013.
23. Lino fam, ismail kar, analysis of the potential of municipal solid waste in brazil. Environ dev ; 4 :105–113, 2012.
24. Jica. Laos pilot program for narrowing the development gap toward asean integration, progress report 1: supplement 2 (luangprabang). Vientiane, laos; 2012.
25. Shrestha rm, kim oanh nt, shrestha rp, et al. Atmospheric brown clouds (abc) emission inventory manual. Nairobi: united nations environment programme; 2013.
26. Karak t, bhagat rm, bhattacharyya p, municipal solid waste generation, composition, and management: the world scenario. Crit rev environ sci technol. ;42:1509–1630, 2012.

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