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Emission of Green House Gases from Municipal Solid Waste by IPCC Model in Chidambaram

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Abstract: ***Municipal solid waste (MSW) has become a severe environmental threat with more urbanization and a enormous shift in people's lifestyles in our nation over the past two to three centuries.the waste generation of a person towards MSW is increasing unprecedented from 0.6-0.8 kg in the 1990s to more than 1.5 kg and more articles over "use - and-throw" are playing a significant role in our daily operations. Solid waste management eliminates adverse impacts in surrounding and enhances the economic growth and superior value of life. The main emissions from the handling and management procedures of MSW are CO2 and NH3. Consequently, adequate management of MSW becomes essential to offset the GHG (Green House Gasses). Hence Proper management of MSW becomes essential to offset GHG (Green House Gasses), which would otherwise contribute strongly to the domestic anthropogenic GHG budget. This paper is intended to assess techniques for managing MSW in the context of GHG decrease as a Climate Change mitigation project in Chidambaram. IPCC Model projected methane to be 908,1023Mg / year in Chidambaram for a 25-year credit period.***

Keywords: FOD (First order Decay), GHG(Green House Gases), Methane Emission, MSW (Municipal Solid Waste), IPCC Model (Intergovernmental Panel on Climate Change), MCF (Methane correction factor), DOC(Decomposable organic carbon).

I. INTRODUCTION

MSW (Management and Handling) Rules 2000 describes MSW as "trade and suburban waste produced in municipal fields in either strong or semi-solid form excluding industrial dangerous waste but including treated clinical waste." Population growth, increasing urbanization and changing lifestyle and food habits have led to an enhanced amount of waste generation and variety in waste composition[1]. The World Bank's estimate in 1999, Municipal Solid Waste (MSW) from Asia's metropolitan regions would rise from 760,000 tons / day to 1.8 million tons / day in 2025[2,3].

The structure of urban MSW in India is 51 percent organic, 17.5 percent recyclable and 31 percent inertial [4]. The percentage of moisture content in metropolitan MSW is 47 percent and 7.3 MJ / kg (1745 kcal / kg) is the mean calorific value [5-7]. Solid waste management from waste generation to final disposal is required at all stages. An Integrated Solid Waste Management Plan would consist of: understanding current waste management processes, identifying waste management criteria, setting goals for necessary actions, identifying budget demands, coordinating with separate stakeholders, assessing progress on the goals achieved, changing priorities as the plan advances, communicating and coordinating with the internal stakeholders There are a number of processes involved in the efficient handling of waste for a municipality. These include surveillance, collection, transportation, processing, recycling and disposal [8-10].

The main emissions from the handling and management procedures of MSW are CO2 and NH3. During MSW leadership and handling, there is also a significant contribution to the emission of GHG precursors such as ammonia, hydrogen sulphide, etc[11]. Consequently, adequate management of MSW becomes essential to offset the GHG, which otherwise strongly adds the national budget on anthropogenic GHG[12,13]. This thesis is intended to assess techniques for managing MSW in the light of GHG decrease as a climate change mitigation project. GHG emissions from MSW have appeared as a significant fear as post-consumer waste is estimated to account for nearly 5 percent (1.460 mtCO2-e) of total worldwide greenhouse gas emissions [14-17]. Landfills are liable for nearly half of the 2010 methane emissions attributed to the municipal waste industry (IPCC 2007).

Depending on waste composition, climatic circumstances (ambient temperature, rainfall) and waste disposal methods, the amount of methane from landfills varies by nation. The calculation techniques given by the Guidelines of the Intergovernmental Panel on Climate Change were used to calculate emissions and reduction of emissions of GHG and then contrasted the cooperative discharge reduction[18,19].

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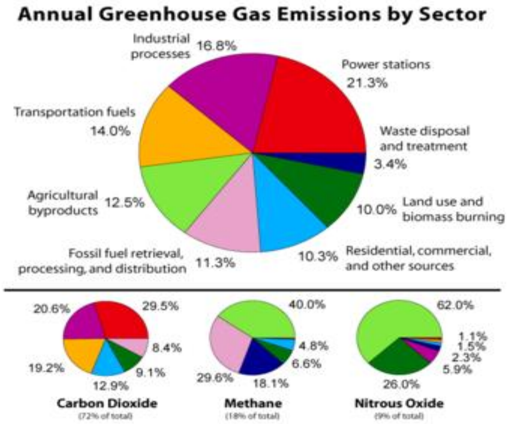

Source: kedar karki. Effect of climate

Figure.1 Annual greenhouse gas emission by sector

II. METHODOLOGY

A. IPCC Methodology: (source: IPCC guidelines 2006, volume 1)

Treatment and disposal of municipal, industrial and other SW produces important quantities of methane. In addition to CH4, solid waste disposal sites also generate biogenic carbon dioxide and non-methane volatile organic compounds as well as lower quantities of nitrous oxide, nitrogen oxides and carbon monoxide. Methane generated at solid waste disposal sites includes roughly 3 to 4 percent to annual worldwide GHG(IPCC, 2014).

The two techniques for estimating SWDS GHG emissions are Tier 1 method and it is also called mass balance method and tier 2 method is called First Order Decay (FOD) method. In this study, the use of the mass balance technique is heavily discouraged as it generates outcomes that are not similar to the First Order Decay technique which generates more precise estimates of annual emissions. Instead of the mass balance technique, this section offers a Tier 1 version of the First Order Decay technique including a straight forward table model with step-by-step guidance and improved default data. With this guidance, all countries should be able to implement the First Order Decay method.

Data of Decomposable Degradable organic carbon from solid waste (source: IPCC guidelines 2006, volume 1)

DDOCmd =W • DOC1 • DOCf1 •MCF1

Where:

DDOCmd = mass of decomposable Degradable organic carbon deposited, Gg

W= mass of deposited waste, Gg

DOC1 = degradable organic carbon in the year of deposition, fraction, Gg C/Gg waste

DOCf1= portion of decomposable Degradable organic carbon that can decompose (fraction)

MCF1 = CH_4 correction factor for aerobic decomposition in the year of deposition (portion)

Although CH_4 generation potential $(Lo)^2$ is not used explicitly in the *Guidelines*, it equals the product of Decomposable decomposable Degradable organic carbon and the methane concentration in the gas (F1) and ratio of molecular weight of methane and Carbon (16/12).

Transformation from Decomposable decomposable Degradable organic carbon L_{od}

Lod = DDOCmd• F1 •16 /12(1)

Where,

Lod = CH_4 generation potential, Gg CH_4

DDOCmd = degradable decomposable organic carbon mass, Gg

16/12(1) = ratio of weight to molecular CH_4/C (ratio)

F1 = methane fraction in generated landfill gas (volume fraction)

Using DDOCma (DDOCm accumulated in the SWDS) from the spreadsheets. Methane generation can be determined by the above equation.

DDOCmd accumulated in the SWDS1 at the end of year T

$DDOCmda_T = DDOCmd_T + (DDOCmda_{T-1} * e^{-k})$

DDOCmd Decomposed At T Year end

$DDOCm\ decomp_T$ = **DDOCmdaT**$_{-1}$ *1- e^{-k}

DDOCmdaT = Decomposable degradable organic carbon accumulated in the SWDS at the end of year *T*, Gg

DDOCmdaT-1 = Decomposable degradable organic carbon accumulated in the SWDS at the end of year (*T*-1), Gg

DDOCmddT = Decomposable DOCm deposited into the SWDS in year *T*, Gg

DDOCmd decompT= Decomposable DOCm decomposed in the SWDS in year *T*, Gg

K = reaction constant,

CH_4 generated from decomposable DDOCmd

The amount of CH_4 formed from decomposable material is found by the product of methane fraction in generated landfill gas and the methane /Carbon molecular weight ratio.

CH_4 Generated From Decayed DDOCmd1

$CH_4\ generated_T = DDOCmd\ decomp_T \cdot F$ •16 /12

Where:

CH_4 generated$_{T1}$= amount of CH_4 generated from decomposable material

DDOCmd1 decomp$_T$ = DDOCmd decomposed in year *T*, Gg

F1= fraction of methane, by volume, in generated landfill gas (fraction)

16/12(1) = molecular weight ratio methane /Carbon (ratio)

B. MSW Management Strategy: Chidambaram

This study is envisaged as a case study with field study as of MSW management in Chidambaram. In phase I the dump sites wire mapped all the quantification of MSW was made. A conceptual design for landfill with gas recovery was made. Chidambaram is located at 11°23’16.5”N latitude , 79°41’E longitude. Chidambaram town is situated in Cuddalore district of Tamil Nadu, at a distance of 150 km from Chennai. Thandeswara nallur site used for landfilling, and having area of 4.58 acre.waste generated per day in Chidambaram is 28 MT, from various sources in Chidambaram given in the following Table 2.

Table.1 Population of Chidambaram

Year	Population
1971	488819
1981	55920
1991	58740
2001	47733
2011	62168

Table.2 various sources that generate MSW in chidambaram

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

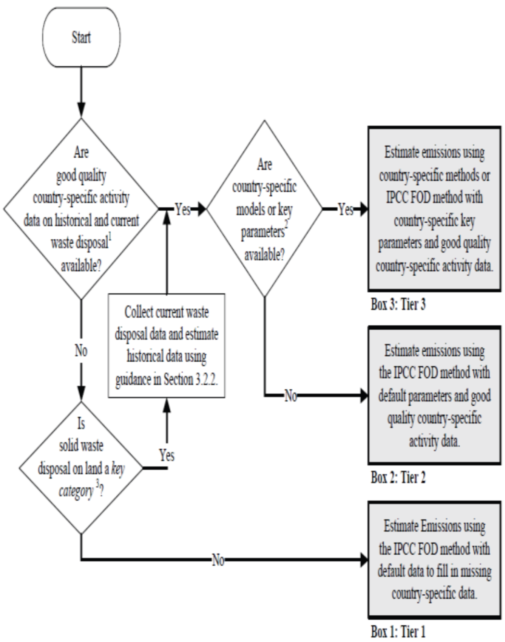

Figure.2 Decision Tree for CH_4 emissions from Solid Waste Disposal Sites

III. RESULTS AND DISCUSSION

From the ipcc model the methane emission is calculated based on FOD method. This method assumes that the degradable organic component in waste decays gradually throughout a few decades, during which methane and carbon dioxide are formed.

The amount of carbon present in the waste is solely responsible for methane emissions. For the first few years the amount of emissions of methane are highest after deposition, and then gradually decline as the degradable carbon. This is due to the carbon in the waste is consumed by the bacteria responsible for the decay. Similarly methane emissions are calculated and throughout waste lifetime, the following results are obtained as shown in Table 3.

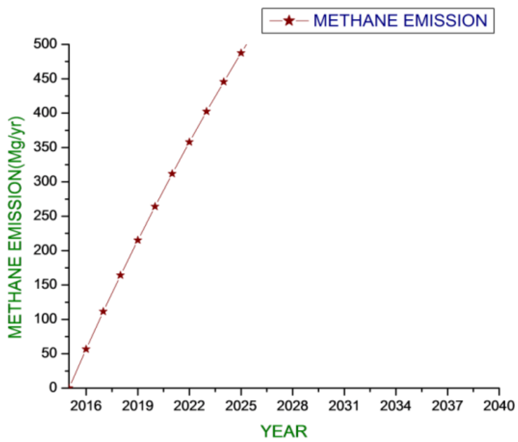

Figure.3 Methane Emission by IPCC model

From the table it was found that methane generation in the year 2016 was 49.5Mg/Yr for the waste 10352.6 Mg and it was increased to 122.5Mg/Yr for the year 2017 for the waste of 10487.5 Mg . Methane forecasting was done for 25 years. It was assessed that the amount of methane generation in the year 2040 was 908.1 Mg/Yr from the waste of 14225.2 Mg. The graph demonstrates the Methane potential of Municipal solid waste by IPCC model for the Chidambaram landfill. It was found that Chidambaram Municipality require delineating 63.24 acres of land mass to develop Landfill to serve its MSW management program for the next 25 years.

Table. 3 Methane gas emissions from landfills

Year	Waste in Mg	DDOCm in Mg	Emission in Mg	Cumulative Mg/Yr
2015	10220	776.72	0	0
2016	10352.86	1525.656	49.60475698	49.60475698
2017	10487.45	2248.295	73.10043229	122.7051893
2018	10623.78	2946.052	95.78710404	168.8875363
2019	10761.89	3620.275	117.7086074	213.4957115
2020	10901.8	4272.249	138.9066967	256.6153041
2021	11043.52	4903.197	159.4211475	298.3278442
2022	11187.09	5514.283	179.2898537	338.7110012
2023	11332.52	6106.62	198.5489208	377.8387745
2024	11479.84	6681.265	217.2327528	415.7816735
2025	11629.08	7239.226	235.3741368	452.6068896
2026	11780.26	7781.464	253.0043225	488.3784593
2027	11933.4	8308.896	270.1530976	523.1574201
2028	12088.54	8822.395	286.8488603	557.0019579
2029	12245.69	9322.794	303.1186877	589.967548

2030	12404.88	9810.887	318.9884012	622.1070889
2031	12566.14	10287.43	334.4826285	653.4710297
2032	12729.5	10753.15	349.6248626	684.1074911
2033	12894.99	11208.73	364.4375181	714.0623806
2034	13062.62	11654.83	378.9419846	743.3795026
2035	13232.44	12092.09	393.1586778	772.1006623
2036	13404.46	12521.09	407.1070875	800.2657652
2037	13578.72	12942.41	420.805824	827.9129115
2038	13755.24	13356.6	434.2726619	855.0784859
2039	13934.06	13764.18	447.5245814	881.7972433
2040	14115.2	14165.65	460.5778086	908.1023901

IV. CONCLUSION

MSW Management is a serious environmental concern and has become a major health and environmental threat in India with urbanization and expanding cities. This research work took effort in addressing this need with a due diligence study, as case study on Chidambaram town and different technological options for MSW management were discussed with the methodologies as recommended by Intergovernmental Panel on Climate Change (IPCC) reports. It was found that Chidambaram Municipality require delineating 63.24 acres of land mass to develop Landfill to serve its MSW management program for the next 25 years. The study considered the assessment of Methane potential of MSW from Chidambaram. IPCC Model estimated the methane for the crediting period of 25 years as **908.1Mg/Year**. 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. Hence, a saleable carbon credit of 21000 (tco2 equivalent) can be generated from the MSW landfill of Chidambaram.

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