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Methane Gas & Electricity Generation from Pirana Landfill Site, Ahmedabad

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Abstract: Emitted gasses from the landfills are one of the significant sources of air pollution in India. Meanwhile, the reduction, control and recycling of such gasses is of great importance from hygienic and global perspectives. Pirana landfill site has been a dumping place for the past 37 years. The average amount of wastes disposed at the site is approximately 4000 Tons per day. The purpose of this study is calculation CH4 (Methane). Through gas-recovery and extracting energy from landfills with 75 percent efficiency, the generation rate of greenhouse gases will reduce to around 557,633 tons of CO2 equivalent in Ahmedabad.

Keywords: Pirana landfill site, Landfill gas models, Methane (CH_4) gas, MSW characteristics, Energy

I. Introduction

Climate change is a serious environmental issue facing the world today, and developing countries are reported to be the ones that stand to suffer the most damages. **[3]** The world is becoming warmer as it experiences the extremes of global climate change. Landfill sites containing wastes undergoing biological decay, specifically in an advanced methanogen stage of decomposition, typically emit high volumes of landfill gas. Landfill gas is widely known to comprise carbon dioxide and methane in part percentages ranging from 40 to 60%. According to the Kyoto Protocol, there are six gases that have been listed as being particularly harmful greenhouse gases (GHG): carbon dioxide (CO2) , nitrous oxide (N2O), hydro fluorocarbons (HFCs), per fluorocarbons (PFC's) and sulphur hexafluoride (SF6), methane (CH4). Approximately 70% of methane emissions are anthropogenic (e.g., agriculture, natural gas activities, landfills, etc.) and 19% of these are attributed to landfill gas generation. **[7][8]** Large amount of methane and other gases are generated from solid waste which can be used for replace other energy so it should economically beneficial to the nation. An India is a country where large amount of solid waste is generated which can be convert in to gas or energy for sustainable environment. At present, generation of methane gas from landfill site having no use. If it is converted in to any energy form, it will become valuable source of energy to country and it will economically beneficial to the nation.

II. Pirana Landfill Site Basic Data

Pirana Landfill is located near Narol- Sarkhej road (NH-228) in the South and Piplaj -Pirana road (SH 142) in the West directions of city Ahmedabad. Currently, Pirana receives all the municipal solid wastes of Ahmedabad. The land-filling operation in Pirana started around 1980. The average quantity of wastes disposed at the site today is approximately 4000 (Tons/day). In order to estimate the landfill gas generation through landfill gas models, it is necessary to collect information pertaining to the amount, location, and time of placement for the incoming wastes during the history of the landfill operation. **[1]**

2.1. Pirana landfill site characteristics

Following are the characteristics of Pirana landfill site.

2.1.1. Waste Areas and Depths

The area is approximately 84 hectares in size.65 hectares land has been used up so far for the disposal of waste since 1980. The average depth/height of the waste is 22 meters.

2.1.2. Moisture Content of Dumped Wastes

Moisture content tests of waste streams delivered to Pirana have a range of 50 – 60%.

2.1.3. PH of the Landfill

The Area would appear to display a pH value of 7.3 to 7.9.

2.1.4. Climatic Situation

The approximate annual rainfall is 782mm, the annual average temperature is approximately 30 degree Celsius, the evaporation rates are estimated as 3,000mm per annum, the humidity ranges from 16% in the summer months to 35% in the winter, and the average is about 15%.

2.1.5. Waste Temperature

Unknown, but gas temperature appears to range from 35 to 45 degree Celsius.

2.1.6. Elevation

53 to 55 meters above the mean sea level.

III. Sampling Details

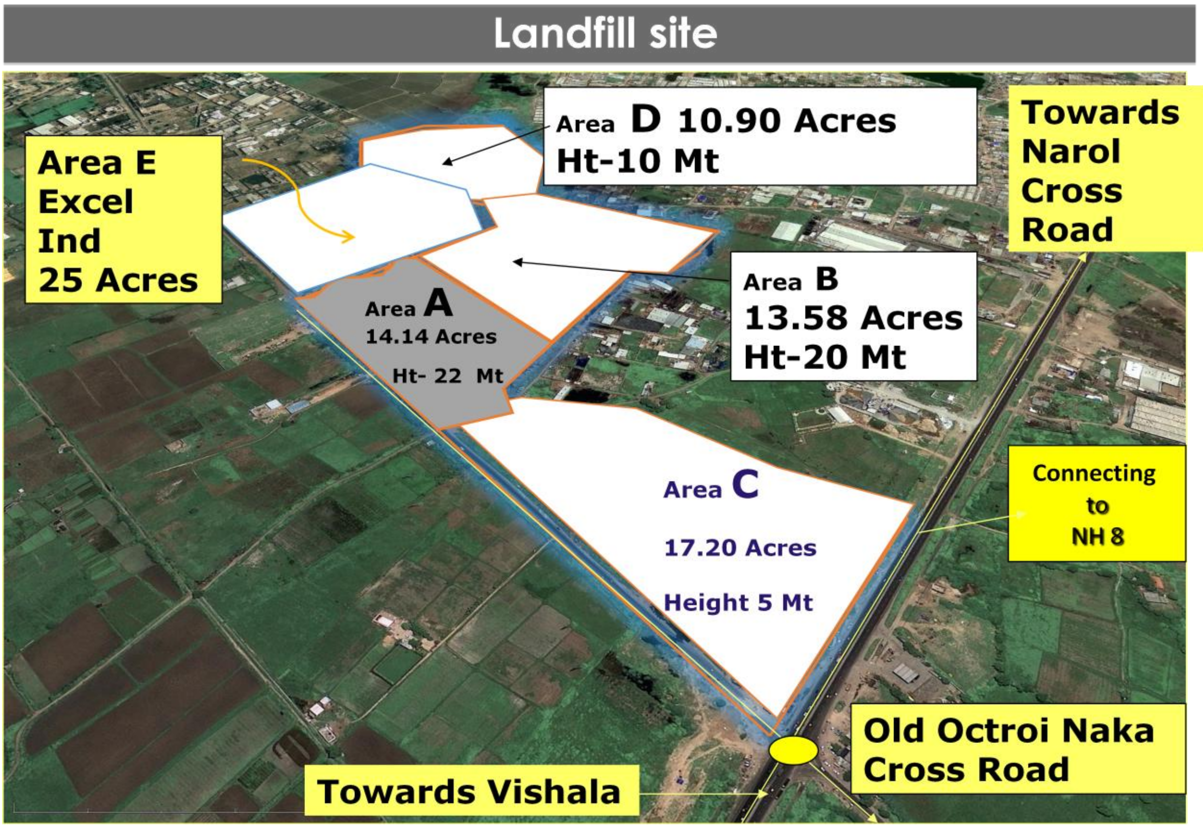

Figure 1.Sampling Location

The sample is collected from Area **C** of the Pirana landfill site which is having appropriate area of 17.20 acres and height 5 m. Five samples having weight of 1 kg are collected from different part of this **C** area. These all 5 samples are mixed out and then physical and chemical characteristics test have been done in the laboratory.

Table 1. Sample Results

SR NO.	PARAMETERS	RESULTS
1	PH	7.9
2	Temperature	43· C
3	Organic carbon	0.377 %
4	Moisture content	0.15 %
5	Biodegradable (segregation)	0.2 %
6	Non-biodegradable waste (non-recyclable) (segregation)	69.70%
7	Non-biodegradable waste (recyclable) (segregation)	0.59 %
8	Degradable organic carbon	0.2 %

9	Fixed organic carbon	0.18 %
10	Bulk density	1864 kg/m^3

In below there is data sheet of fresh garbage segregation which is carried out by AMC **[2]**

Table 2. Amc Reports

SR NO.	Garbage Contents	Weight[Kg]	% Content [W/W]
1	Easily degradable	54.20	54.20
2	Wooden materials	4.50	4.50
3	Coconuts	4.10	4.10
4	Plastics	8.30	8.30
5	Stones	6.20	6.20
6	Cloths	4.30	4.30
7	Metals	0.50	0.50
8	Rubbers	5.30	5.30
9	Glass/Ceramics	2.40	2.40
10	Sand	10.15	10.15

IV. Types of Landfill Gas Models for Methane Emission

1. Zero order model

In this kind of model gas generated from landfills is remained steady against time. On this basis, waste age and waste type has no effect on gas production. **[5]**

2. First order model

These models have been considered quality of waste (i.e., moisture content, carbon content, age of waste and ability of waste to be digested), waste quantity and condition of landfill implicitly. In the order words, the effect of depletion of carbon in the waste through time is accounted for in a first-order model. **[5]**

3. Second order model

The second-order model describes the complex reactions during degradation of the waste, using a large number of first-order reactions with different rates. Being a complex system of different reactions, landfill gas generation can be modeled using the second order kinetics model. **[5]**

V. Calculation Of Methane Gas From Landfill Gas Models

Daily 4000 ton waste is dumped on Pirana landfill site, out of which, as per agreement with AMC, approximate 1000 ton waste is picked up by different companies for treatment. For the purpose of methane gas emission, as mention below, different models have been considered for remaining 3000 TPD dumped waste. Here are the models which used for methane gas generation from Pirana landfill site. Here are four model for calculation for methane emission. **[2]**

1. TNO model

The effect of depletion of carbon in the waste through time is accounted for in a first-order model LFG formation from a certain amount of waste is assumed to decay exponentially in time. The TNO model calculates LFG production based on the degraded organic carbon in the waste. The first-order model can be described mathematically by $\boldsymbol{\alpha_{t=}\zeta 1.87AC_o k_1 e^{-k1t}}$

Where,

$\boldsymbol{\alpha_t}$ = Landfill gas production at a given time [m^3LFG.y^{-1}]

ζ = Dissimilation factor 0.58 [–]

1.87 = Conversion factor [m^3LFG.kg$C^{-1}{}_{degraded}$]

A = Amount of waste in place [Mg]

$\boldsymbol{C_o}$ = Amount of organic carbon in waste [kg C. Mg $waste^{-1}$]

$\boldsymbol{k_1}$ **=** degradation rate constant 0.094[y^{-1}]

t = time elapsed since depositing [y] **[4]**

This model forecast for upcoming many years. In the case of pirana landfill site the amount of waste dumped is taken as 1080000MT/year, which produced the methane gas $4.09x10^{11}$ m^3 / year using TNO model.

2. Land-Gem model

Land-GEM determines the mass of methane generated using the methane generation capacity and the mass of waste deposited.

Land-GEM can be described mathematically by

$$Q_{CH_4} = \sum_{i=1}^{n} k\, L_0 \;\; M_i(e^{-kt})$$

Where,

Q_{CH4} = Methane emission rate [m^3 CH_4.y^{-1}]

k = Methane generation constant (default = 0.04) [y^{-1}]

L_o = Methane generation potential (default = 100) [m^3CH_4.Mg $waste^{-1}$]

M_i = Mass of waste in i^{th} section [Mg]

t_i = Age of the i^{th} increment or section [y^{-1}]

n= (year of calculation)-(initial year of waste acceptance) **[4]**

In the research work of Pirana landfill the results were observed is approx 153550000 m^3/year methane gas production by Land-GEM model.

3. EPER GERMANY model

The EPER model used in Germany is a zero order model and can be described mathematically by

$$Me = M*BDC*BDC_f*F*D*C$$

where,

Me = Amount of diffuse methane emission [Mg CH_4. y^{-1}]

M = Annual amount of landfilled waste [Mg waste, y^{-1}]

BDC = Proportion of biodegradable carbon 0.15 [Mg C. Mg $waste^{-1}$]

BDC_f = Proportion of biodegradable C converted 0.5 [–]

F = Calculation factor of carbon converted into CH4 1.33 [Mg CH4. MgC^{-1}]

D = Collection efficiency for

Active degassing 0.4 [–]

No recovery 0.9 [–]

Active LFG recovery and cover 0.1 [–]

C = Methane concentration 50 [%] **[4]**

In the research work of Pirana landfill the results were observed is approx. $4.85X10^4$ Mg/Year methane gas production by EPER Germany model.

4. IPCC Model

Methane emissions (Gg/yr) = (MSWT*MSWF*MCF*DOC*DOCF*F*16/12-R)*(1-OX)

where,

MSWT: total MSW generated (Gg/yr)

MSWF: fraction of MSW disposed to solid waste disposal sites

MCF: methane correction factor (fraction)

DOC: degradable organic carbon (fraction) (kg C/ kg SW)

DOCF: fraction DOC dissimilated

F: fraction of CH4 in landfill gas (IPCC default is 0.5)

16/12: conversion of C to CH4

R: recovered CH4 (Gg/yr)

OX: oxidation factor (fraction – IPCC default is 0) **[6]**

In this research, the Pirana landfill site at Ahmedabad collects 4000 TPD, which is 1080000 MT / year approximately. The estimated methane gas Generation is 122 Gg/year using IPCC model.

VI. Types of Landfill Gas Models for Methne Emission

1 m^3 CH_4=10 kWh. So, electricity produce by this model is calculated. According to this 203700 kWh , 40.0X10^11 kWh , 15355X10^5 kWh and 512843 kWh electricity will be generated by applying EPER Germany , TNO , Land-Gem and IPCC models respectively from Pirana landfill site.

VII. Conclusion

By this research work it can be concluded that Conversion of generated methane gas of landfill site from solid waste can be emerged as the alternative source of electricity (Power). Huge saving of natural resource like coal become possible which is used in power plant. Our country also import coal for power plants and for that billion of foreign exchange is required but if we start using this alternative source it would be beneficial to our economy. Lead to healthy and sustainable environment and pollution free city in terms of cleanliness.

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