What India Needs: Landfill Gas Recovery and Its Utilization.

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Abstract

Solid waste disposal sites are not often seen as opportunities for energy solutions in India. The waste that is disposed in open dumps and landfills generates methane and other gases as it decomposes. The proper estimation of Landfill Gas is important to chalk out a strategy to improve landfill safety, generate electricity, reduce greenhouse gas emissions, and to earn carbon emission reduction credits. The Chinese Gas Model has been used to analyse the energy feasibility of dumpsites due to similar geographic and sociological circumstances in both countries.

The technical and economic constraints of dealing with landfill gas recovery and their solution is dealt.

Keywords: Landfill gas recovery, solid waste, Chinese Gas Model, Greenhouse gases.

1. Introduction

As India is developing, the per capita consumption of resources is also increasing. This directly enervates the municipal solid waste production. The cities in India are developing at a fast pace along with its population. With increase in solid waste, the landfill gas is also increasing. India is one of the largest producers of landfill methane in the world. Hence it's important that studies be done on the viability and methodologies of tapping into this renewable source of energy. In its 2009-10 Annual Report the Ministry of New and Renewable Energy (MNRE) estimated that approximately 55 million tonnes of MSW are generated in urban areas of India annually. It is estimated that the amount of waste generated in India will increase at a rate of approximately 1-1.33% annually. The use of LFG to produce energy will also reduce pollution in and around the landfill sites and water bodies.

2. Landfill Gas Recovery

The waste deposited in a landfill gets subjected, over a period of time, to anaerobic conditions and its organic fraction gets slowly volatilized and decomposed. This leads to production of landfill gas containing about 45-55% methane, which can be recovered through a network of gas collection pipes and utilised as a source of energy.

Landfill gas starts accumulating within months after disposal of the wastes and lasts for almost 10 years, depending upon the constituents of the waste, such As methane along with nitrogen, carbon di oxide, oxygen (insignificant quantities) and the moisture availability. The municipal solid waste generated in major Indian cities is mainly rich in organic matter, due to the presence of food, fodder, sanitation waste. [6]

The landfill has the potential to generate 15-25l/kg of gas per year over its operational period. The collected gas from large landfills can be effectively utilized as a clean fuel for power generation and gas collected from smaller landfills can be supplied to appropriate industries located in the vicinity of the site for direct use of gas in such as internal combustion engines, gas turbines, micro turbines, steam boilers, and other facilities.

The gases tend to escape through the vent and crevices, if not provided with a suitable outlet. The difference in pressure gradient and concentration gradient also causes the escape of the gases from landfill. This untapped gas can cause global warming due to its greenhouse properties.

The primary objective should be to discuss the potential and feasibility of the landfills in India.

The important **chemical parameters** to be considered for determining the energy recovery potential and the suitability of waste treatment through biochemical or thermo-chemical conversion technologies include: -

> Volatile Solids, Fixed Carbon content, Calorific Value, C/N ratio (Carbon/Nitrogen ratio), toxicity. [4]

3. Potential and feasibility of landfill gas in selected Indian cities

Before investing on construction of wells and other methodologies for landfill gas to energy projects, it is important that we study the feasibility of the methane emissions.

Already the municipal corporations of cities like Delhi, Ahmedabad, Kolkata, and Greater Mumbai have undertaken studies on methane emissions from existing dumpsite.

In India, all the waste collection sites are open dump. The municipality of Delhi with the help of World Bank carried out a feasibility study at Okhla landfill site in Delhi. US EPA is working with the local government at Deonar and Gorai Landfill sites in Mumbai, Dhapa in Kolkata, Pirana Landfill site in Ahmedabad, and Uruli Devachi landfill site in Pune have also been studied for their LFG feasibility.

TABLE 1: The LFG Utilisation potential in Indian cities [2] [3] [7]

Cities	Quantum of waste generated (TPD)	Quantum of waste supplied to the dumpsite(TPD)	Area for landfill (existing) hectare	Energy potential MW
Ahmedabad	2300	1800	13	1.3
Delhi	6800	6400	42.4	8.4
Greater Mumbai	6500	6500	150.8	5.6
Lucknow	1198	1050	4	nil
Pune	1300	1000	43	0.7
Kolkata	4000	3700	115	2.0
Chennai	3500	3250	160	2.0

To check for the feasibility of the landfill gas recovery from the above mentioned cities and there dumpsites, we need to take into account the following [1]:

- The lifespan of landfill site
- The ratio of waste generated to the waste supplied at the dumpsite
- Technological know-how and its accountability in comparison to the energy produced.
- Rate of decay of organic matter
- The potential methane generation capacity.

Thus, a proper methodology needs to be put in place to tap into the potential of different landfills in India

4. Methodologies of landfill recovery

Every methodology undertaken needs to primarily satisfy the above mentioned requirements of feasibility for proper estimation of energy potential.

The Chinese landfill gas model developed by the US EPA, which is an estimation Tool for landfill gas generation and recovery from sites. The Chinese model can be successfully used in India because of similar geographical and climatic conditions along with equivalent population pressure on the landfill site.

The model selects recommends value for input variables, including methane generation rate constant (k), potential methane generation capacity (L_0), collection efficiency, and fire discount factor and estimates generation and recovery rates.

The model employs a first order decay exponential decay function that assumes:

- It requires 6 month time for LFG generation after the placement of waste.
- LFG generation decreases exponentially as the organic matter gets consumed
- LFG generation is at its peak following a time lag representing the period before the methane generation.

For sites with known (or estimated) year to year solid waste disposal rates, the following equation can be used: [5]

$$Q_{M=} 1/C_{CH4} \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o (M_i/10)\, e^{-kt}ij \quad (1)$$

Where,

Q_M = maximum expected LFG generation flow rate (m^3/yr.);

i = 1 year time increment

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

j = 0.1 year time increment

k = methane generation rate (1/yr.);

L_0 = ultimate methane generation potential (m^3/Mg);

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

t_{ij} = age of the jth section of waste mass disposed in the ith year (decimal years).

C_{CH4} = methane concentration (volume fraction).

Methane generation rate constant, k determines the rate at which methane is generated from waste. The higher the value of k, faster is the methane generation, when the landfill is active and then declines over time. The value of k is a function of the following factors:

- waste moisture content,
- availability of nutrients for methane-generating bacteria,
- pH,
- Temperature. [4]

Table 2: Methane generation rate (k)

Climatic Zone	k (per year)
Cold and dry	0.04
Cold and wet	0.11
Hot and wet	0.18

The recommended L_0 value for the three climatic zones is shown in Table 2 below.

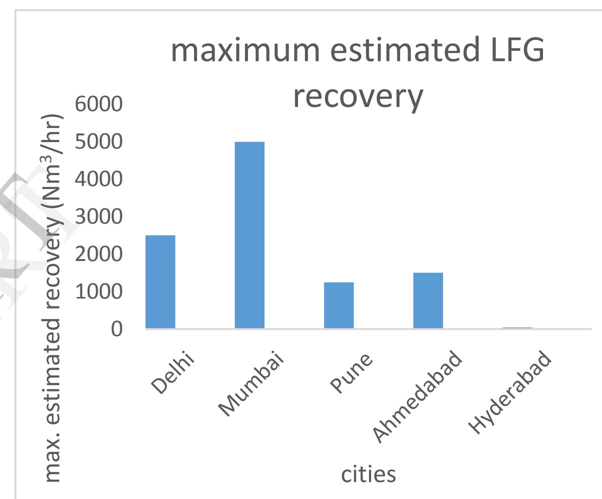
Table 3: Ultimate methane generation potential (L_0)

Climatic Zone	L0 (m3/Mg)
Cold and Dry	70
Cold and Wet	56
Hot and Wet	56

Table 4: LFG model input variable

Input Variables	Pune	Delhi (Okhla)	Hyderabad	Mumbai (Deonar)	Ahmedabad (Pirana)
Annual Precipitation (mm/yr)	704.2	706	796	2130	820
Ultimate methane generation potential (Lo) in m3/ton	70	70	56	56	56
Methane generation rate constant (k) in per year	0.04	0.04	0.18	0.18	0.18

Chart 1: Maximum Estimated LFG recovery



The above chart shows how the feasibility of landfills in different city varies on the basis of maximum estimated recovery.

The Deonar landfill in greater Mumbai is the most feasible site for the LFG production. The three accumulated landfill site comes in second after Mumbai in LFG recovery.

The landfill site in Hyderabad has the lowest energy recovery among Indian cities.

Proposals for betterment of energy utilisation from landfills

- Improved methods of solid waste collection
- Better funding from the government.
- Scientific breakthroughs
- Better models for fuel recovery
- Propaganda in different media

It is not only important to come up with new ideas and technologies to help use the energy from already existing Landfills but also to come up with better planning and investment on the future landfill sites.[4]

Conclusion

The study concludes that there is significant energy utilization potential from existing urban landfills in India. There is an urgent need to examine potential uses for Landfill gas including on-site use for small processes. The construction of regional landfills in place of scattered open dumps is required to properly manage the environmental impacts of Landfill gas. It also discusses the ways of using an old landfill and also discusses the gas recovery model adopted in China, in reference to that of India.

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