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Experimental Assessment of Methane Emission in Open Dump Site of MSW

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Abstract-- **Every day, Jabalpur generates approximately 450 tonnes of waste. A major fraction (45%) of total waste is organic or wet waste, which degrades in the natural environment. This study is focused on the estimation of the carbon footprint of household waste generated in Jabalpur city.**

Open dumping and landfilling are the prevalent solid waste disposal practices in Jabalpur. Methane emission potential at these sites was estimated by two methods. Results of the Intergovernmental Panel on Climate Change (IPCC) method, and closed flux box technique were compared. This study is primarily focused on the estimation of total methane emission potential from waste disposal sites in Jabalpur city if it goes to landfill instead of open dumping and its effect on Jabalpur climatic changes. The results from two estimation methods, i.e. theoretical method and flux box experimental method and information collect waste generation rate and total disposed waste amounts at Kathonda disposal sites in Jabalpur.

I. Introduction

In India, managements of municipal of Municipal Solid Wastes (MSW) comprise of five operations viz. onsite storage, collection, transportation, processing and disposal. The solid waste generations varies from 0.1-0.5 kg per capita depending upon the nature of the place, activities and life style of the residents. Till few years back, the community bin collection was in practice. However, after introduction of MSW (Management & handling) Rules, 2000, containerized system is being adopted in many cities. But , "land disposal" through open dumping of MSW is found at large in the country which is convenient and cheapest option of disposal way that does not have any consideration on pollution prevention measures.

The uncontrolled land disposal of MSW results in ground water pollution and creates unhygienic situation in the surroundings or nearby habitats. Foul smell, rodents, flies; stray animals are often attracted by such haphazard dumping of MSW. Methane (CH_4) gas is the most hidden nuisance parameter emerged out of such land disposal. Generally, emission of methane gas is not noticed, which is responsible for health as well as fire hazard. It is also identified as an important ingredient of green house gases (GHG) responsible for global warming.

According to Intergovernmental panel on Climate Change (IPCC), landfill accounts for about 30% of methane emission to the atmosphere. Landfill ranks the fourth largest source for emission of methane gas. In India and other developing Countries, uncontrolled open dumping is a common practice which has been identified as source of methane gas generation. In absence of gas recovery provisions, the atmosphere is likely to be overburden with this green house gas (Methane).Therefore, an attempt has been made for assessment of landfill gases considering various factors in Indian conditions [1].

The variables that influence biodegradation of MSW are identified as; (i) The physico – chemical composition of the wastes viz, organic mass, moisture contents, pH, nutrient status, ingress of air etc, (ii) The in-situ condition like depth of fill, period of filling, compaction and settlement, soil structure, water table etc. and (iii) The atmospheric conditions like temperature, pressure, wind speed and direction, rainfall, seasonal changes etc.

In continuous dumping process, Microbial consortia functioning under aerobic and anaerobic conditions co-exists in the wastes [2]. Density of microbes in MSW is similar to in the dumped waste, but due to subsequent depositions of wastes, the ingress of air is reduced/ exhausted resulting in anaerobic condition.

Microorganisms exist in the wastes which degrade the organic matter to obtain energy for their survival and propagation. Decomposition under anaerobic condition yields energy, Carbon dioxide and water. Under aerobic degradation, approximately 60% of the energy of the substrate is used for synthesis and growth whereas rest is converted to heat [3].The bio- reaction during composting is represented in equation

Microbes + Organic matter → Carbon dioxide + Moisture + Heat energy

In observance with the global efforts on inventorisation of methane emission, municipal solid waste (MSW) landfills are recognized as one of the major sources of anthropogenic emissions generated from human activities.

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In India, most of the solid wastes are disposed of by land filling in low-lying areas located in and around the urban centers resulting in generation of large quantities of biogas containing a sizeable proportion of methane. After a critical review of literature on the methodology for estimation of methane emissions, the default methodology has been used in estimation following the IPCC guidelines 1996. However, as the default methodology assumes that all potential methane is emitted in the year of waste deposition, a triangular model for biogas from landfill has been proposed and the results are compared. The methodology proposed for methane emissions from landfills based on a triangular model is more realistic and can very well be used in estimation on global basis [4].

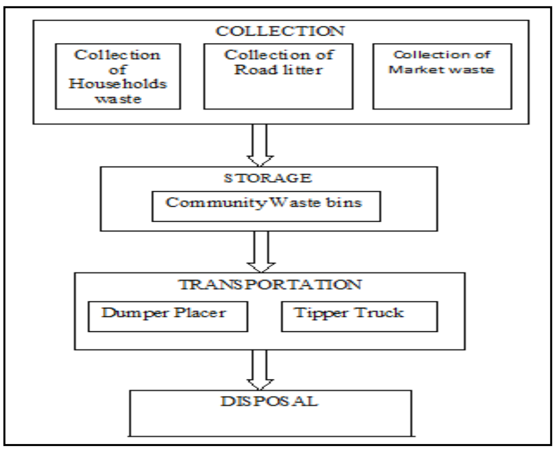

Figure 1: Schematic representation of solid waste management [4]

II. Materials And Methods

Experimental studies were carried out for assessment of methane (CH_4) emission from MSW at landfill sites of Kathonda and Ranital in Jabalpur.

2.1 Method for Determining Methane emission of MSW

In this chapter, different techniques adopted for the estimation of Methane emission are compared along with field experiments to assess the validity of theoretical es timates. Experimental methods have been developed to estimate the emissions from organic waste and composting processes at local levels. There are a number of methods to estimate the carbon footprint in terms of methane emissions from solid waste disposal methods. These methods are broadly classified into

1. Theoretical estimations method
2. Experimental estimations method

2.2 Materials For construction of Experimental Setup

1. A rectangular plastic box Dimension is Length 24 cm x Width 20 cm x Height 18 cm.
2. One Flux Box Top
3. 0.25 mm plastic tube 1 meter
4. A Plastic Syringe 50 ml volume with stopcock fitting and needle for sampling (25 gauge needles are commonly used). Extra syringes and needles are helpful to have with you in the field.
5. 500 ml Plastic bottle
6. Digital Thermometer

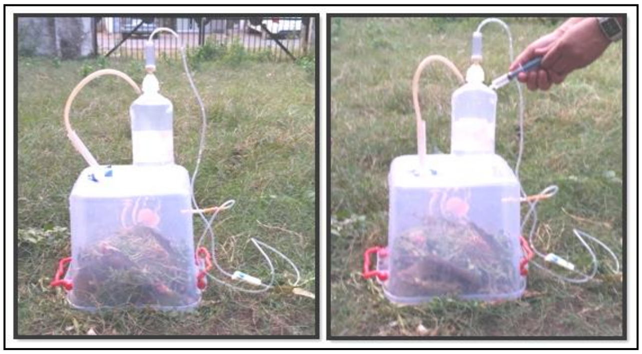

Figure 2: Experimental Setup Flux Box

2.3 Operation of Experimental Setup

1. Measure and record the ambient air temperature per hour in a day.
2. Place the Flux Box on above the 1 Kg Municipal Solid Waste sample and measured by the water displacement method at open dump site Jabalpur.
3. Methane gas Measured in Pasic sealed bottle.
4. Gas measured per hour 7 am to 7:30 pm after in a days in summer Seasons.
5. Analysis the gas emission through the Municipal solid waste in open dumping site.

III. Result And Discussion

Carbohydrates (Cellulose and hemi-cellulose) comprise of 25-40% organic matter. Protein Concentration is mainly 3-9%. Pectin, sugar and starch occur in very low concentration [6]. Methane potential in a landfill site and emissions thereof are two different aspects, but methane emission is related to landfill gas potential. Biodegradation rate is faster in initial stage of dumping and due course of time, gets converted by subsequent disposition of fresh waste while rate of biodegradation is slowed down [7].

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3.1 Methane gas analysis by IPCC Default estimation method

The default method is recommended by the IPCC for the estimation of Jabalpur city and regional emissions. For inventory estimation The Revised IPCC (1996) Guidelines for National GHG Inventories outline two methods to estimate methane emissions from solid waste disposal sites: the default method.

Methods and Data The former default method required total national municipal solid waste (MSW) generation, fraction of MSW disposed in SWDS, CH_4 recovery (if any), oxidation factor (if appropriate) and a CH_4 generation potential (the quantity of CH_4 that could be emitted from a unit of waste) for the inventory year. The CH_4 generation potential is the product of a CH_4 correction factor (accounts for the degree to which the waste degrades anaerobically), the degradable organic carbon (DOC) content of the waste (determined by waste composition), the fraction of the DOC that is dissimilated, and the CH_4 content of gas.

$$CH_4 = MSW_T \times MSW_F \times MCF \times DOC \times DOC_F \times F \times (16/12 - R) \times (1 - OX)$$

MSW_T = Generation of MSW Per day in Jabalpur city = 450 tons / day =164,250,000 kg/year

MSW_F = Collection of disposal site 70% of total MSW per day = 450 x 70/100

= 315 tons/day =114,975,000 kg/ year

MCF = 0.4

Per cent DOC (by weight) = 0.4 (A) + 0.17 (B) + 0.15 (C) + 0.30 (D)

A=paper + rags = 4.18 + 22.14 = 26.32 %
B=leaves +hay +straw = 23+ 13.9 = 36.9 %
C=fruits and vegetables = 60.34 %
D=wood = 1 %

Sample calculation

= 0.4 x 26.32 + 0.17 x 36.9 +0.15 x 60.34+ 0.3 x 1
= 10.53 + 6.28 + 9.05 + 0.3
= 26.16 %
= 0.261
DOC_F = 0.014T+ 0.28 = 0.77
At T= 35°C

F = 0.5
R= 0
OX= 0

CH_4 (mg/m²/sec) = 1 x 0.7 x 0.261 x 0.4 X 0.77 x 0.5 x (16/12 – 0) x (1- 0)

= 0.037 mg/m²/sec

In the estimation of methane emission potential by the IPCC default method, the amount of solid waste that is available for anaerobic degradation and methane generation was assumed as 100 %. The result shows that there were about 0.037 mg/m²/sec.

So total waste per day from dumping site =315 tons = 315000 kg

Total Methane emission from dumping site = 116550 mg.

Table 1:
Emissions per hour in ml

S.NO.	Time	Temperature (°C)	Methane Emission in (ml)
1	7:00 am	25.2	0
2	9:30 am	28.3	10.6
3	12:00 pm	33.5	26.2
4	2:30 pm	39.9	38.4
5	5:00 pm	31	23.1
6	7:30 pm	28	20.5
		Total	118.8

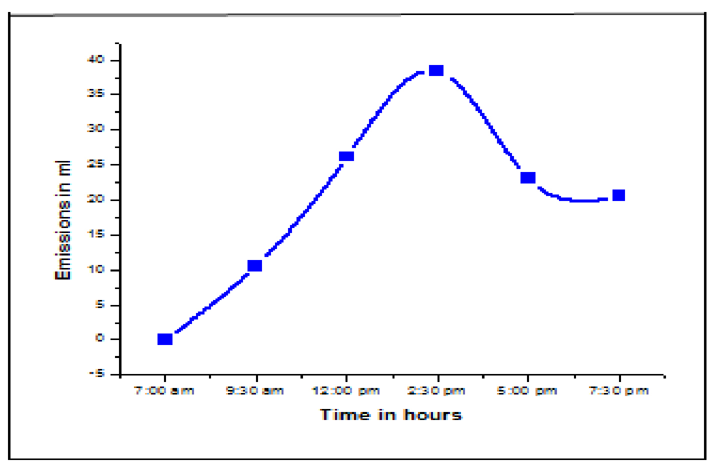

Figure 3: Emissions with respect to Time in hours

IV. Conclusion

The results of the research up to now show that the proposed method of determining methane emissions by means of direct measuring surface gas concentrations is functional and applicable in common practice. The method is many times quicker than flux-box measurements and provides much more precise results than static flux-box. It allows make several hundreds of measurements in one working day, which allows make very extensive on-site direct measurement of methane emissions. This property of researched measurement method allow to make a sufficient set of measurements in a short time interval, that can fit in with an interval of relatively steady atmospheric pressure conditions.

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