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AN EXPERIMENTAL STUDY ON TREATING OF MUNICIPAL SOLID WASTE LANDFILL LEACHATE USING ANAEROBIC BATCH REACTOR

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Abstract - *In this experimental study, we considered the present municipal solid waste landfills generate biogas and leachate. Due the amount of waste, biogas production represents a very promising way to solve the problem of waste treatment. Furthermore, the solid residuals of fermentation might be reused as fertilizers. Biogas is a fuel gas (CH_4 and CO_2) obtained by anaerobic fermentation of biomass like: manure, sewage sludge, municipal solid waste. Landfill gas is produced by wet organic waste decomposing under anaerobic conditions in a landfill. The whole bio gas process can be divided into three steps: hydrolysis, acidification, and methane formation. landfills gas production is dependant, on the degradation status of the waste material as well as moisture and temperature, all of which may vary greatly in different parts of the landfill body.*

Key Words **- Municipal solid waste, Leachate, Inoculum, Biogas, Biological Oxygen Demnad, Specific Methanogenic Activity**

1. INTRODUCTION

Municipal solid waste (MSW) contains a significant fraction (30–50%) of organics. It can be a useful resource if this organic fraction could be used for power generation. Beside, Rapid exhaustion of conventional energy sources has necessitated the search for alternate energy sources [1]. Present municipal solid waste landfills generate biogas and leachate. Due the amount of waste, biogas production represents a very promising way to solve the problem of waste treatment. Furthermore, the solid residuals of fermentation might be reused as fertilizers [2]. Landfill gas is a water saturated gas mixture containing about 40-60% methane, with the remainder being mostly carbon dioxide (CO2). Landfill gas also contains varying amounts of nitrogen, oxygen, water vapour, sulphur and a hundreds of other contaminants. Inorganic contaminants like mercury are also known to be present in landfill gas [3]. The composition of biogas varies depending upon the origin of source for example the amount of hydrogen sulphide in the landfill gas varied from 36 to 115 ppm and in the farm biogas from 32 to 169 ppm, while hydrogen sulphide was not detected in the gas from the sewage digester [4]. Biogas from sewage digesters usually contains from 55% to 65% methane, from 35% to 45% carbon dioxide and <1% nitrogen, biogas from organic waste digesters usually contains from 60% to 70% methane, from 30% to 40% carbon dioxide and <1% nitrogen while in landfills methane content is usually from 45% to 55%, carbon dioxide from 30% to 40% and nitrogen from 5% to 15% [4]. Because of land fill gas (biogas) hazardous it is necessary to study about it to have a plan to use land fill biogas without any environmental problems. This causes to provide a qualified situation for both production and the best way using of biogas. Purpose of this study is to review the stages of biogas creation and what effect on them. Landfill gas is produced by wet organic waste decomposing under anaerobic conditions in a landfill. Biogas is a fuel gas (CH_4 and CO_2) obtained by anaerobic fermentation of biomass like: manure, sewage sludge, municipal solid waste [5]. Fermentation of biomass is performed by special microorganisms.

Biogas microbes consist of a large group of complex and differently acting microbe species, notable the methane-producing bacteria. The whole biogas-process can be divided into three steps: hydrolysis, acidification, and methane formation (Figure 1.1) [6]. Three types of bacteria are involved. Every landfill site is unique in its setting in relation to surrounding groundwater and surface water. Monitoring programmes should therefore be tailored to match site-specific conditions and to reflect an understanding of the design philosophy and engineering controls. Risk assessment is based on the development of a site conceptual model which aids identification of source-pathway-receptor relationships. The vulnerability of individual receptors is evaluated against the hazard posed by a source (i.e. landfill leachate) and whether or not there are any migration pathways which can allow contaminants to migrate from the source to the receptor. Harmful substances contained within a waste body represent the hazard or source of risk to groundwater and surface water receptors. It is important to realise that groundwater and surface water are both pathways and receptors. The design of monitoring programmes should be based on the source-pathway-receptor linkage. This requires an understanding of waste, landfill engineering, the nature of the surrounding hydrogeological environment and the nature of surrounding surface water. It isthe task of those responsible for designing the monitoring programme to gain thisunderstanding. In cases of uncertainty, a precautionary approach should always be followeduntil the uncertainty has been resolved. A waste management licence or Pollution Prevention Control (PPC) permit will contain conditions to provide assurance

that the landfill operation does not cause harm to human health or the environment. This will normally include a requirement for a monitoring programme. There are many types of monitoring which may be undertaken at landfill sites however, this guidance only relates to the monitoring of groundwater, surface water and leachate at landfill sites. onitoring is a long-term commitment accompanying the development, operation and post closure management of all landfill sites. Landfill sites containing biodegradable or other polluting wastes may need to be monitored for periods of up to 50 years or more aftercompletion of landfilling. To ensure consistency and long-term reliability of monitoring records, monitoring programmes should be implemented so that to obtain authentic results.

2. HEADING 2

2. MATERIALS AND METHODS

2.1 Procedure Conducted at Laboratory

The analysis of static BMP (discontinuous or batch analyses) will conducted in the laboratory using a controlled environment to simulate the conditions found an anaerobic digestor. The biomass to be assessed willfirst analyse and then mixed with a "hungry" inoculum, that is a pre-digested organic substrate coming from plant which already uses the biomass to be evaluated, and a salt solution (to block the production of acids and provide micro-nutrients which are essential for the proper development of the bacterial flora). The pre-digestion of the inoculum has the purpose of reducing the production of non-specific gas, thus diminishing its effect on the final result. The pre-digestion of the inoculum occurs without the addition of any nutrients at 35°C ± 2°C for about 7 days. To avoid the inhibition of the inoculum at the start-up stage, excessive quantities of volatile solids (VS) with respect to those in the inoculum must be avoided. The ratio between the volatile solids of the substratum for analysis and those in the inoculum must at least be greater than 0.5 [3]. The mixture is put into a small digestor, a glass bottle with a total volume of about 2,200 ml (about 70% full). This is then placed in a thermostatic cabinet where the process temperature is kept constant. The biogas composition depends on the chemical composition of the substances present in the substrate and the physical/chemical parameters of the test. Methane content normally varies between 50% and 80% in volume, while carbon dioxide tends to be in a range between 20 and 50%. The biogas normally also contains low concentrations of hydrogen, ammonia, hydrogen sulphate and other trace gases. The static BMP test is normally continued until the marginal daily production is more than 1% of the entire accumulated production [2]. Measurements are continued throughout and the accumulated production curve also provides important information relating to the degradation speed.

2.2 Procedure for Mixing

Batch digestions will performed in 160 mL non-stirred glass serum vials (100 mL working volume) at 38 WC. Basic anaerobic (BA) medium will use according to Angelidaki et al. Cellulose was added to the test medium as the sole carbon source in the digestion experiments (10 g L_1, 50μm particle size, Sigma cell, Sigma, USA). Inoculum will be collected from anaerobic digesters at WWTP in Queensland Australia, specific Methanogenic activity of the inoculum was 0.2gCOD CH4gVS. Inoculum volumes will be 10, 20 and 50% resulting in inoculum substrate ratios of 0.4, 0.8 and 2 respectively. Bottles will be flushed with 100% N2 gas for 3 min , sealed with a rubber stopper retained with an aluminium crimp cap and stored in temperature-controlled incubators. Tests will be mixed by inverting once per day. Blanks contained inoculum and medium without the substrate. The pH of the combined media and inoculum at the start of the experiment was adjusted to pH 7.2 using HCl (1 mol/L); pH will also controlled during the tests. All tests willbe carried out in triplicate, and all error will be found out.

2.3 Test Procedure Step by Step Process

Tests were conducted into three phases of hydrolysis, acidification and methane formation. The degradation status of the waste materials will be checked and followed up by the moisture and temperature which may vary to a great extent in different parts of the landfill body.

2.3.1 Hydrolysis (en-biogas)

In the first step (hydrolysis), is a process of breakdown of organic matter into smaller products that can be degraded by bacteria.

Ligno-cellulosic material constitutes the major organic fraction of MSW. Hydrolysis of lingo-cellulosic material is a major factor, which influences the level of the carbon source required for biogas production [7].

In this process the organic matter is enzymolyzed externally by extracellular enzymes (cellulase, amylase, protease and lipase) of microorganisms. Bacteria decompose the long chains of the complex carbohydrates, proteins and lipids into shorter parts. For example, polysaccharides are converted into monosaccharides. Proteins are split into peptides and amino acids.

Result in a study showed that Leachate recirculation reduced waste-stabilization time and was effective in enhancing gas production and improving leachate quality, especially in terms of COD. The results also indicated that leachate recirculation could maximize the efficiency and waste volume reduction rate of landfill sites [8].

2.3.2 Acidogenesis

MSW contains a significant fraction of ligno-cellulosic material. Theacidification of these materials influences the biogas yield [7].

Acid-producing bacteria, involved in the second step, convert the intermediates of fermenting bacteria into acetic acid (CH3COOH), hydrogen (H2) and carbon dioxide (CO2). These bacteria are facultatively anaerobic and can grow under acid conditions. To produce acetic acid, they need oxygen and carbon. For this, they use the oxygen solved in the solution or bounded-oxygen. Hereby, the acid-producing bacteria create an anaerobic condition which is essential for the methane producing microorganisms. Moreover, they reduce the compounds with a low molecular weight into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane. From a chemical standpoint, this process is partially endergonic (i.e. only possible with energy input), since bacteria alone are not capable of sustaining that type of reaction [2].

2.3.3 Acetogenesis

It involves oxidation reaction of the acidogenesis products by micro organisms which produce hydrogen to dispose of the electrons derived from oxidation .

2.3.4Methanogenesis

Methane-producing bacteria, involved in the third step, decompose compounds with a low molecular weight. For example, they utilize hydrogen, carbon dioxide and acetic acid to form methane and carbon dioxide. Under natural conditions, methane producing microorganisms occur to the extent that anaerobicconditions are provided. They are obligatory anaerobic and very sensitive to environmental changes [2]. For vital functions of these bacteria that consume hydrogen also, stable temperature mode is very important [10].

Yield from MSWvaries due to the heterogeneous nature of MSW. Theoretically, estimated values of biogas based on stoichiometry vary between 150 and 265 m3/tone [11]. In a study was observed that household waste after source separation yields 494 m3 of methane per tonne of solid waste [12]. Although landfill sites are the sources of methane, the landfill gas needs to be purified to increase the methane concentration [13]. To increase the biogas yield, also pre-sorting and pre-treatment are usually conducted. Hence, it has been reported that in a biomethanation process, 30% of the total expenditure is incurred in pre-sorting and pre-treatment [14].

2.3.5 Symbiosis of bacteria

Methane- and acid-producing bacteria act in a symbiotically way. On the one hand, acid producing bacteria create an atmosphere with ideal parameters for methane-producing bacteria (anaerobic conditions, compounds with a low molecular weight). On the other hand, methane-producing microorganisms use the intermediates of the acid-producing bacteria. Without consuming them, toxic conditions for the acid-producing microorganisms would develop. No single bacteria is able to produce fermentation products alone. The metabolic activity involved in microbiological methanation is dependent on the following factors [2].

2.3.5.1 Substrate temperature

Anaerobic fermentation is in principle possible between 3°C and approximately 70°C. The rate of bacteriological methane production increases with temperature. Since, however, the amount of free ammonia also increases with temperature; the bio-digestive performance could be inhibited or even reduced as a result. If the temperature of the bio-mass is below 15°C, gas production will be so low that the biogas plant is no longer economically feasible. The process of bio-methanation is very sensitive to changes in temperature [2].

2.3.5.2 Available nutrient

In order to grow, bacteria need more than just a supply of organic substances as a source of carbon and energy. They also require certain mineral nutrients. In addition to carbon, oxygen and hydrogen, the generation of bio-mass requires an adequate supply of nitrogen, sulphur, phosphorous, potassium, calcium, magnesium and a number of trace elements such as iron, manganese etc. "Normal" substrates such as agricultural residues or municipal sewage usually contain adequate amounts of the mentioned elements. Higher concentration of any individual substance usually has an inhibitory effect.

2.3.5.3Batch-type and continuous plants

The retention time can only be accurately defined in batch-type facilities. The effective retention time may vary widely for the individual substrate constituents. Selection of a suitable retention time thus depends not only on the process temperature, but also on the type of substrate used.

2.3.5.4pH value

The methane-producing bacteria live best under neutral to slightly alkaline conditions. Once the process of fermentation has stabilized under anaerobic conditions, the pH will normally take on a value of between 7 and 8.5. Due to the buffer effect of carbon dioxide-bicarbonate (CO2 - HCO3-) and ammonia-ammonium (NH3 - NH4 +), the pH level is rarely taken as a measure of substrate acids and/or potential biogas yield. A digester containing a high volatile-acid concentration requires a somewhat higher-than-normal pH value. If the pH value drops below 6.2, the medium will have a toxic effect on the Methanogenic bacteria.

2.3.5.5Inhibitory factors

The presence of heavy metals, antibiotics (Bacitracin, Flavomycin, Lasalocid, Monensin, Spiramycin, etc.) and detergents used in livestock husbandry can have an inhibitory effect on the process of bio-methanation. Lead, copper, and zinc in decreasing order were found to be toxic to bio-methanogenesis. Lead at the concentration of 10µg/ml completely stopped methane production. Iron did not produce any notable change in the process while manganese stimulated the rate of methane production. The toxicity of lead, copper, and zinc to Methanogenic bacteria and methane production was dose-dependent but the growth of Acetogenic bacteria was impaired at higher concentrations (2.5–10.0 µg/ml) of lead, copper, and zinc. Manganese stimulated the growth of only Methanogenic bacteria, but not that of Non-Methanogenic bacteria or acetic acid production [9].

3. RESULTS AND DISCUSSIONS

3.1 Leachate characteristics

3.1.1 PH

It is observed that in the starting of the experiment, the pH value of leachate was 6.3 which signifies that the leachate is in acidic condition.This shows that the leachate is young because the value of Ph for young leachate should always be less than 6.5.

3.1.2 Biological Oxygen Demand at 20̊

In the initial stage of experiments the value of BOD is found to be 2,024.23 mg/L.

Day 1 DO = 7.1 mg/L

DO after 5 days = 0.33 mg/L

Dilution factors= 299ml

(7.1-0.33)(299) = 2024.23 mg/L

Figure 1 Determination of B.O.D

3.1.3 Alkalinity

The leachate sample collected from MSW landfill leachate was tested for alkalinity. Initial alkalinity was found to be 11200 mg/L.

Figure 2 Alkalinity testing

3.1.4 Volatile Suspended Solids

Percent moisture and volatile solids for each of waste type is given in Table 4.1,along with volatile solids as percentage of total solids (VS/TS)

Figure 3 Muffle Furnace

	Moisture	Volatile Solids	VS/TS
Sludge	**7.69**	**81.7**	**95.66**

Table 1 Percent moisture content,. Volatile Solids content

3.1.5 Preparation of Bottles

Serum bottles were thoroughly washed in tap water. The bottles were dried and placed in an incubator. Total liquid volume of 100 mL was used in order to maintain appropriate liquid to-void ratio for precision and accuracy of results. A serum cap was placed after the bottle was filled to the appropriate volume while simultaneously removing the oxygen from the bottle by flushing nitrogen gas in it. The stoppers were fitted with an aluminium crimp seal.

Figure4 BMP Bottles

3.1.6 Gas Measurements

Glass syringe was used to measure gas volume present in headspace. The plunger was lubricated with water and serum bottles were shaken properly before gas volume measurements were made. The gas volume measurement from serum bottles using glass syringe is shown in Figure

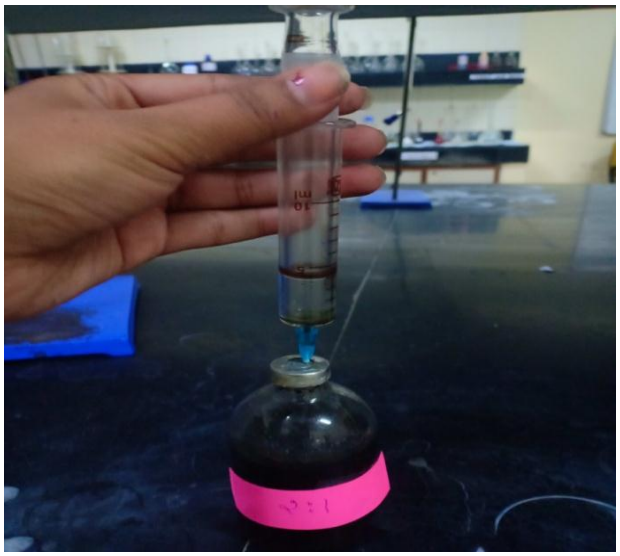

Figure 5 Gas volume measurement from serum bottles using glass syringe

3.1.7 Specific Methanogenic Activity

Specific Methanogenic Activity (SMA) was conducted in order to assess the potential of the anaerobic granular sludge and leachate. Each SMA study consisted of 10 bottles with experiments performed in duplicate. The bottles were charged with different substrate to a sludge ratio of 1:1, 2:1, 0.75:1 and 0.5:1

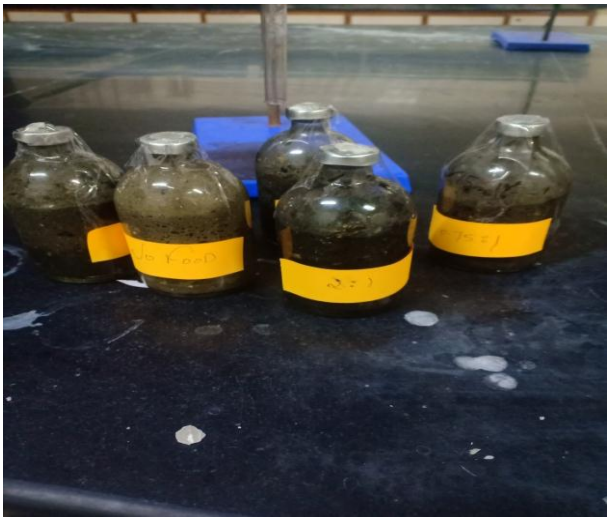

Figure 6 SMA Bottles

Table 2 Cumulative gas production for first set of experiment

F/M ratio	Temperature ºC	Total biogas production (mL)
1:1	19	78
2:1	19	69.2
0.75:1	19	99
0.5:1	19	100
No Food	19	84

4. CONCLUSIONS

- Temperature increase leads in variation of biogas production and leads to increase the biogas amount in the source.
- The biogas is an alternate material which can be used as the burning fuel for sustaining various activities related to burning of gas.
- Biogas production is an useful resource and can act as a green material to reduce the emissions by making use of biogas as an alternative fuel.

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