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Landfill Biogas production process

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Abstract. 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 biogas-process can be devided 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.

Keywords: one, two, three, etc. (Use “keywords” style)

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 [11].

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 [5]. Landfill gas is a water saturated gas mixture containing about 40-60% methane, with the remainder being mostly carbon dioxide (CO_2). Landfill gas also contains varying amounts of nitrogen, oxygen, water vapor, sulfur and a hundreds of other contaminants. Inorganic contaminants like mercury are also known to be present in landfill gas [4]. 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 [14]. 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% [14]. 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 affect on them.

2. Landscap Biogas production

Landfill gas is produced by wet organic waste decomposing under anaerobic conditions in a landfill. Biogas is a fuel gas (CH4 and CO2) obtained by anaerobic fermentation of biomass like: manure, sewage sludge, municipal solid waste [8]. 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 devided into three steps: hydrolysis, acidification, and methane formation (Figure 1) [12]. Three types of bacteria are involved.

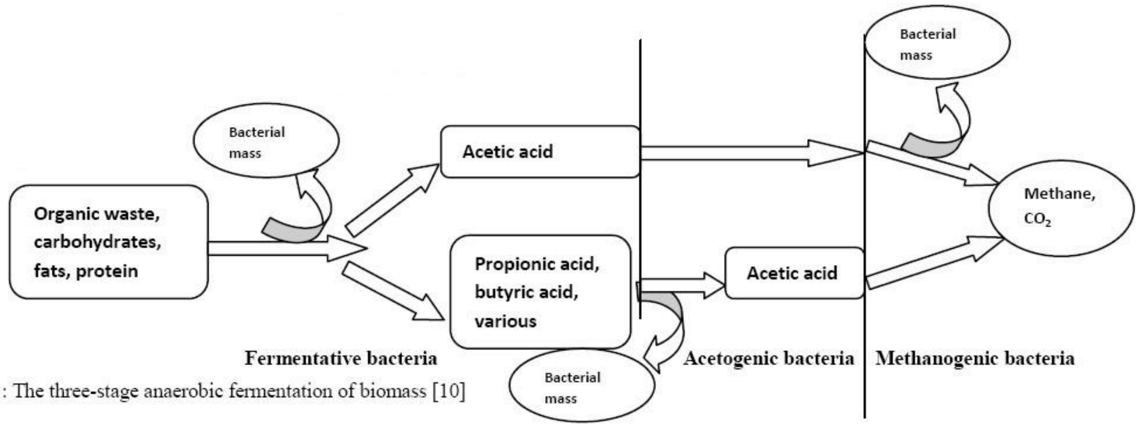

Figure 1: The three-stage anaerobic fermentation of biomass [10]

2.1. Hydrolysis (en-biogas)

In the first step (hydrolisis), 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 [11].

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 [9].

2.2. Acidification

MSW contains a significant fraction of ligno-cellulosic material. Theacidification of these materials influences the biogas yield [11].

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 [5].

2.3. Methane formation

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 anaerobic conditions are provided. They are obligatory anaerobic and very sensitive to environmental changes [5]. For vital functions of these bacteria that consume hydrogen also, stable temperature mode is very important [3].

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 [1]. In a study was observed that household waste after source separation yields 494 m3 of methane per tonne of solid waste [15].

Although landfill sites are the sources of methane, the landfill gas needs to be purified to increase the methane concentration [6].

To increase the biogas yield, also presorting and pretreatment are usually conducted. Hence, it has been reported that in a biomethanation process, 30% of the total expenditure is incurred in presorting and pretreatment [7].

2.4. Symbiosis of bacteria

Methane- and acid-producing bacteria act in a symbiotical way. On the one hand, acidproducing 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 [5].

- **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 [5].

- **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, sulfur, 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.

- **Batch-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.

- **pH 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 (CO_2 - HCO_3^-) and ammonia-ammonium (NH_3 - NH_4^+), 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.

- **Inhibitory 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 biomethanogenesis. Lead at the concentration of 10 μg/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 [13].

- **Nitrogen inhibition and C/N ratio**

Nitrogen inhibition

All substrates contain nitrogen. For higher pH values, even a relatively low nitrogen concentration may inhibit the process of fermentation. Noticeable inhibition occurs at a nitrogen concentration of roughly 1700 mg ammonium-nitrogen (NH4-N) per liter substrate. Nonetheless, given enough time, the methanogens are capable of adapting to NH4-N concentrations in the range of 5000-7000 mg/l substrate, the main prerequisite being that the ammonia level (NH3) does not exceed 200-300 mg NH3-N per liter substrate. The rate of ammonia dissociation in water depends on the process temperature and ph value of the substrate slurry.

C/N ratio

Microorganisms need both nitrogen and carbon for assimilation into their cell structures. Various experiments have shown that the metabolic activity of methanogenic bacteria can be optimized at a C/N ratio of approximately 8-20, whereby the optimum point varies from case to case, depending on the nature of the substrate [5].

3. Result and discussion:

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. According what was mentioned above microorganisms activity is crucial factor in this process which needs special situation such as being enough nutrient for them so that analyses are recommended on a case-to-case basis to determine which amount of which nutrients, if any, still needs to be added.

Also there is an important point that Some solids do not digest and accumulate at the bottom, so the design of the digester should allow for their removal.

Gas yields are directly correlated with the decomposition rates. Each substrate has a specific gas yield expressed in litres of biogas produced per kg of decomposed organic matter. In case of pre-sorted bio-wastes, average gas yields can be calculated.

To increase the biogas yield, also presorting and pretreatment are usually conducted.

Also the landfill gas needs to be purified to increase the methane concentration.

Optimizing the process parameters retention time - process temperature – substrate quality- volumetric load determine, among others, the cost efficiency of the biological processes. But as each m3 digester volume has its price, heating equipment can be costly and high quality substrates may have alternative uses, the cost-benefit optimum in biogas production is almost always below the biological optimum.

4. REFERENCES

[1] A.D. Bhide, S.A. Gaikwad and B.Z.. Alone, In: Proceeding of International Workshop on Methane Emissions from Waste Management, Coal Mining and Natural Gas Systems. USEPA Workshop. 1990.

[2] E. Morgenroth, R. Kommeda and P. Harremoes, ‘ Processes and modeling of hydrolysis of particulate organic matter in aerobic wastewater treatment – a review,’ Water Science and Technology, Vol. 44 (6), pp. 25–40, 2002.

[3] Electronic publication: biogas plant. ZORG (clean energy)

[4] Electronic publication: Primer on land fill Gas as Green Energy

[5] Electronic publication: Biogas Digest. GTZ project Information and Advisory Service on Appropriate Technology (ISAT). (Available from: http://www.gtz.de.dokumente/en_biogas_volume _pdf)

[6] Electronic publication: Estimates of US Biomass Energy Consumption, 1992, May 1994, <tonto.eia.doc.gov>.

[7] G. Barbiroli, “Technological innovation and cost of municipal solid waste treatment,” In: Curzio, A.Q. et al. (Eds.), Management of Municipal Solid Waste in Europe, p. 72. 1994.

[8] G.D. Zupancic, N. Uranjek-Zevart and M. Ros, ‘Ful-scale anaerobic co-digestion of organic waste and municipal sludge. Biomass and Bioenergy,’ Vol. 32, pp.162-167, 2008.

[9] G. Y. S. Chan, L. M. Chu and M. H. Wong. “Effects of leachate recirculation on biogas production from landfill co-disposal of municipal solid waste, sewage sludge and marine sediment,”J. Enviromental pollution. Vol. 118, Issue 3, pp 393-399, August 2002.

[10] H. Märkl, Mikrobielle, "Methangewinnung; in: Fortschritte der Verfahrenstechnik", Düsseldorf. Vol. 18, pp. 509,, Production and Utilization of Biogas in Rural Areas of Industrialized and Production and Utilization of Biogas in Rural Areas of Industrialized and Developing Countries, Schriftenreihe der gtz, No. 97, p. 54; after FRG

[11] J.K. Bhattacharyya, S. Kumar and S. Devotta, “Studies on acidification in two-phase biomethanation process of municipal solid waste,” Waste Management. Vol. 28, pp. 164–169. 2007.

[12] M.A. Barlaz, , R.K. Ham and D.M. Schaefer, “Methane production from municipal refuse: a review of enhancement techniques and microbial dynamics,” Critical Reviews in Environmental Control, VOL. 19 (6),pp. 559–584. 1990.

[13] R. Nandan, V. Tondwalkar and P. Kumar Ray. ‘Biomethanation of spent wash: Heavy metal inhibition of methanogenesis in synthetic medium,’ J. Fermentation and Bioengineering. Vol. 69, (5), pp. 276-281. 1990.

[14] S. Ras, A. Veijanen and J. Rintala, “Trace compounds of biogas from different biogas production plants”, J. Energy. Vol. 32, Issue 8, , pp. 1375-1380. 2007.

[15] T.L. Hansen, J.E. Schmidt, I. Angelidaki, E. Marca, J.C. Jansen, H. Mosbaek and T.H. Christensen, “Method for determination of methane potentials of solid organic waste,” Waste Management. Vol. 24, pp. 393–400. 2004.