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Biomethanation and Vermiculture Technology for the Horticultural Waste Management in Jabalpur, M.P.

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ABSTRACT

Biomethanation is a mechanism to receive "biogas". It is a clean, effective and a strong fossil-fuel substituent. In this paper we will discuss the optimum production of Biogas from different mixing ratios of horticultural waste (HW), cow dung (CD) and poultry waste (PW) using gravel filter as well as analyzing the biofertilizer and vermicompost. Horticultural waste / cow dung mixing ratios are (HW, CD) 1:1, 1:2, 1:3. The results showed that the co-digestion greatly affected the production of biogas and the yield of methane. Maximum production of biogas is seen in the ratio 1:1. Likewise, the mixing ratios of cow dung, poultry waste and horticultural waste are also defined in order to evaluate the product's improvement. The higher yields of biogas from the ratio 1:1:1 (CD, PW and HW) were achieved. Gravel filter was used and wash water from various ratios of waste was collected and analyzed and then vermicomposting of the decomposed waste using earthworms was performed and this vermicompost analysis was also performed.

***Key words*: Horticultural waste, Anaerobic digestion, Cow dung, Poultry waste**

There are different kinds of renewable energy sources in the present scenario from which electricity can be produced and demand can be met. Biogas is one of the major renewable energy sources. It has been accepted in the past two decades as one of the best options for fossil fuels because we still use renewable waste at the same time [1]. Biogas is a colourless, flammable gas derived from a variety of substrates such as animal manures, fruit waste, food waste, flowers, energy leaves crops etc. It primarily contains methane gas, carbon dioxide and traces of other gases such as nitrogen, hydrogen sulphide, ammonia, water vapour, etc. Anaerobic digestion is a biological multi-stage process in which the organic carbon is converted into carbon dioxide and methane [2]. It consists mainly of hydrolysis, acidogenesis, acetogenesis and methanogenesis in four stages.

Hydrolysis is a mechanism in which anaerobic bacteria break down complex organic molecules such as proteins, lignin, cellulose lipids into soluble monomers, such as amino acids, fatty acids and sugar [3]. The process that followed the hydrolysis is known as acidogenisis or fermentation. The monosaccharides and amino acids produced by the hydrolysis process are converted into simpler products such as hydrogen, acetate and carbon dioxide, such as volatile fatty acids (VFA), sugars, amino acids and fatty acids [4]. Acetogenesis is the conversion into acetate and hydrogen of some fermentation materials, such as VFAs with more than two carbon atoms, alcohols and aromatic fatty acids, by obliging bacteria containing hydrogen. Methanogenesis is methane formation by the bacteria known as methanogens [5]. That is the final step in the biomethanation process. Methanogenesis is a type of anaerobic respiration in microbes. Methanogens do not require oxygen to actually breathe oxygen which inhibits methanogen's development [6]. They transform acetate and hydrogen to methane and carbon dioxide. Secondly, the analysis of the wash water that comes out of the gravel filter is collected and placed in bottles and then the analysis of that water was completed. Thirdly, Vermicomposting is performed using Earthworms *'Eiseniafoetida* and the vermicompost analysis is completed.

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MATERIALS AND METHODS

Different techniques are used for waste disposal such as landfills, incineration or burning, pyrolysis, recycling or reuse, composting, briquetting and vermicomposting. Vermicomposting is the most effective, economical and environment friendly method and the whole process of vermicomposting using earthworms and vermicompost analysis was also discussed in this paper. The mechanism by which organic matter in waste is converted by microbes into methane gas and manure in the absence of air through a method known as anaerobic digestion. Bio-methanation is the anaerobic digestion of biodegradable organic waste in an enclosed space under controlled conditions of temperature, humidity, pH, etc. Function parameters for biomethanation are:

1. Temperature
2. pH
3. Hydraulic Retention Time
4. Nutrients
5. Designing a reactor

Temperature

Basically, there are three optimized temperature ranges, namely 50-60°C thermophilic, 32-35°C mesophilic and 20°C pyschophilic. Any slight variation in digester temperature affects the biological activity of anaerobic bacteria thereby reducing and affecting biogas production. To avoid the negative effects on the production of the biogas, constant temperature is required. At thermophilic temperature the growth rate of the microbe increases. Temperature rise also increases the toxicity of ammonia. Passive solar heating, underground digester and combination of both can be used are some options to increase heating within the reactors in rural areas. Black-coated digesters adsorb heat and help digesters keep temperature.

pH

Biomethanationis most successful in the pH range of 6.5-8.5. pH should be within the target range because it directly affects microbe development. The optimal pH of methanogenesis is around pH 7.0, it has been stated that the optimum pH of hydrolysis and acidogenesis is between 5.5 – 6.5. The difference in pH allows the biomethanation process work effectively in two stages, one hydrolysis / acidogenesis and another is acetogenesis/methanogenesis separately. If pH is below 6.5, then methanogenic activity is toxic. So, keeping the pH range is very important for efficient gas production. Calcium hydroxide can be used to preserve pH.

Hydraulic retention time

Most anaerobic systems are planned for a fixed number of days to hold the waste. The amount of days the substance remains in the digester is called Hydraulic Retention Time. In tropical countries such as India, HRT ranges from 25 to 50 days and depends on the country's weather conditions.

Nutrients

The key nutrient needed by bacteria in the digester is carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium from these nitrogen (N), phosphorus (P) potassium (K) which is always in short supply and should therefore be added along with cow dung in order to obtain the full output of extra raw material rich in phosphorus and nitrogen. Methane forming bacteria have unique demands for growth. Specific metals such as nickel, cobalt, molybdenum and iron have been shown to be required for optimal growth and methane production.

Reactor design

Different types of digesters are used in anaerobic processes, such as single-stage or two-stage digesters, wet or dry digesters, batch processes or continuous phase digesters, high-rate digesters or digesters incorporating various approaches. Variations in gas output can be seen over time, and multiple units must be run simultaneously to keep the constant supply of the gas.

Methodology of analysis to this study

Horticultural waste: Horticultural waste has been obtained from various sources in and around Jabalpur and all these wastes is grinded and processed into a 5-7 mm slurry for digester feeding.

Digestion slurry preparation

Horticultural waste was collected, weighed and thoroughly mixed in the ratio of cow dung: horticultural waste (HW) 1:1, 1:2, 1:3 and also in the ratio of cow dung (CD): poultry waste (PW) Horticultural waste (HW) 1:1, 1:2, 1:3, diluted with distilled water in order to retain pH and properly mixed to achieve homogeneous conditions. The prepared slurry was fed in digesters for 28 days of hydraulic retention time (HRT) to determine the effect of mixture ratio, depending on the respective ratios. Both these mixtures were fed into 10 litres of digesters in various ratios, within which the use of gravel filter is used to collect the wash water coming out of it. The volume of produced gas was measured by water displacement method.

Data collection

The quantity and volume of biogas produced in this study were calculated using the water displacement process. Data were collected daily.

Observations

Six observations were made feeding the digesters with different mixing ratios of HW: CD and CD: PW: HW: While feeding the digesters, the digesters were left for anaerobic digestion and the gas began to be produced. Period for HRT was 28 days. The gas produced was permitted to flow through the gas pipe and accumulate above the water surface in the gas collector. The volume of gas is determined directly by the amount of the water collected in the water collector. It was examined that the maximum output was seen in ratio 1:1 then in ratio 1:2 and finally in ratio 1:3. Similarly, the maximum output was seen in ratio 1:1:1, then in ratio 1:1:2 and finally in ratio 1:1:3. Horticultural waste decomposed after gas processing. The vermicomposting of the same decomposed horticultural waste was done using *'Eiseniafoetidia'* earthworms. The whole process was done in an earthen jar, waste and earthworms were placed within it and water was poured into it. It has been found in the entire process that earthworms only live in the ratio 1:1 since their pH and all the conditions and the requirements are sufficient enough for the earthworms to live. The process takes about 10-15 days and is finally obtained with vermicompost. Analysis of vermicompost has been completed.

RESULTS AND DISCUSSION

Gas production

Gas production from the ratio CD: PW: HW

The quantity of water displaced is equal to ml of the gas produced. Gas production for 1:1 begins from the 8th day of digestion and is observed on the 20th and 21th day of maximum production. Gas production decreases following 25th day of activity due to drop in temperature. Gas production for 1:2 begins at 11th day and on 17th and 18th day the maximum production is observed. Likewise, gas output begins from 17th day for the ratio 1:3 and maximum gas production is observed on 23rd and 24th day [7-10].

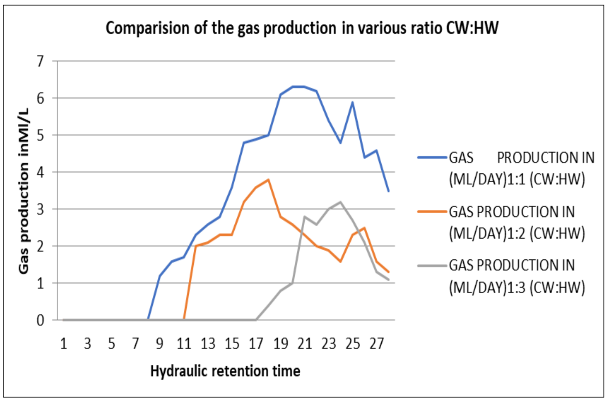

Fig 1 Operating days (Hydraulic retention time) VS gas production in ml/day (CD:HW)

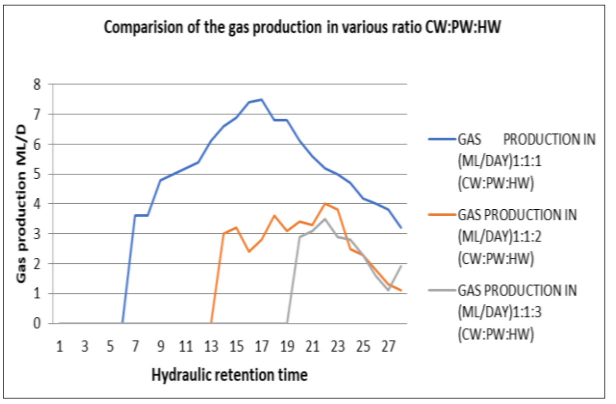

Fig 2 Operating days(Hydraulic retention time) VS gas production in ml/day (CD:PW:HW)

Gas output from the CD : PW: HW

Gas production ratio 1:1:1 begins on the 6th day of digestion and on the 16th and 17th day of activity the maximum production is observed. Gas production begins from 13th day for the ratio 1:1:2 and maximum production is observed on 22nd day. Similarly, gas output for the 1:1:3 ratio begins at 19th day and maximum production is observed in 22nd day [11-13].

Table 1 Nutrient analysis of the waste (CD:PW:HW)

Contents	1:1:1	1:1:2	1:1:3
Total solids	14.7	28.9	23.5
Moisture	87.3%	72.9%	78.6%
pH	4.52	5.35	5.5
C/N	25/1	42/1	49/1
Nutrients	N - 1.42	N - 1.26	N - 1.36
	P - .141	P - 0.087	P - .124
	K - 4.39	K - 3.338	K - 3.61

Table 2 Nutrient analysis of the liquid bio fertilizers (CD:PW:HW)

Contents	1:1:1	1:1:2	1:1:3
pH	5.5	4.9	5.8
Electrical conductivity	6.89µs	6.31µs	6.17µs
Calcium hardness	12.87mg/l	9.68 mg/l	8.12mg/l
Magnesium hardness	0.68mg/l	0.68mg/l	.43 mg/l
Nutrients	N - 1.32	N - 0.98	N - 0.98
	P - 0.081	P - .074	P - 0.025
	K - 3.32	K - 2.54	K - 2.64

Table 3 Nutrient analysis of the vermicompost (CD:PW:HW)

Contents	1:1:1	1:1:2	1:1:3	Standard values of vermicompost
pH	6.9	6.5	6.2	6.5 to 7.5
Electrical conductivity	3.2 µs	3.2µs	2.9µs	Not more than 4
Moisture	12%	15%	13%	15 to 25 %
Odour	odourless	odourless	Odourless	Odourless
Total organic carbon	9.8%	10.2%	11.14%	18% minimum
Nutrients	N – 1.52%	N – 1.89%	N – 1.74%	N – 1% min
	P – 0.98%	P – 0.92%	P – 0.93%	P – 0.8% min
	K – 1.15%	K – 1.11%	K – 1.14%	K – 0.8% min

CONCLUSION

The principal conclusions of this study revealed that horticultural waste is energy-rich and highly degradable feedstock capable of producing high yields of methane, but its content may vary the yield of methane in anaerobic digestion due to the imbalance of nutrients and other non-biodegradable matter in fruit waste. The anaerobic digestion of cow dung and poultry waste with horticultural waste generates high gas compared to cow dung and horticultural waste. The stability of the process of anaerobic digestion highly depends on the temperature which is affected by temperature variation. Horticultural waste co-digestion with cow dung reduces the digestion time and increases gas yield. Co-digestion provides the nutrient-rich digester environment and increases the process's stability. The addition of cow dung and horticultural waste to poultry waste increases the rate of biogas production and reduces the digestion time. Vermicompost obtained from the vermicomposting process is a good biofertilizer which is rich in nutrients. Liquid bio fertilizer with good nutritional value may be used as a fertilizer, too.

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