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Horticulture Waste Management by Biomethanation and Vermiculture Technology and Analysis of Its Liquid Bio-Fertilizer

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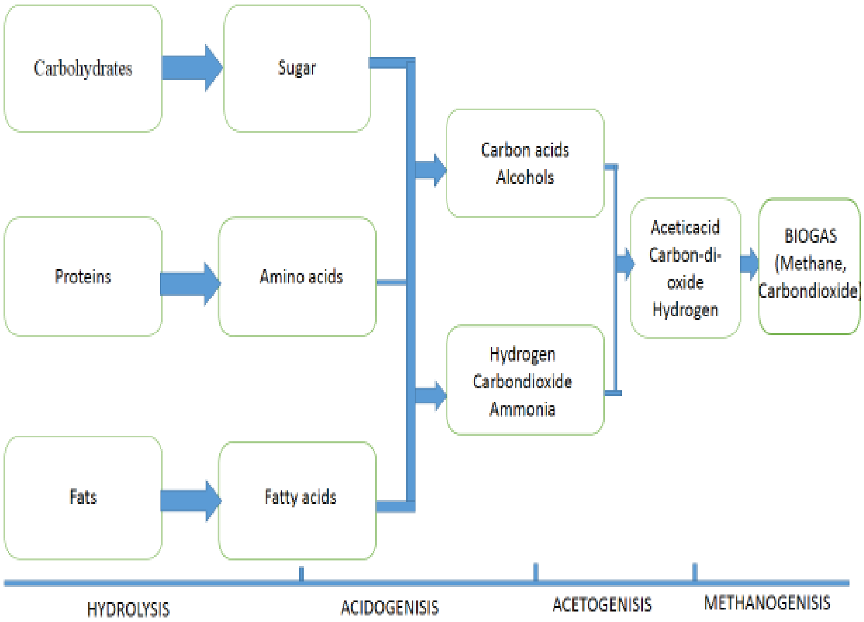
ABSTRACT:
Biomethanation, by means of which 'biogas' is obtained is a renewable, efficient and the good substituent of fossil fuels which are depleting very fast. In this paper we determine the optimal production of Biogas from different mixing ratios of Horticultural waste (HW), Cow dung (CD), and Poultry waste (PW) by the use of gravel filter and also the analysis of wash water and vermincomposting is also been done. The mixing ratios of horticultural waste and cow dung are (HW, CD) 1:1, 1:2, 1:3. The results showed that the co-digestion significantly influenced the biogas production and methane yield. The maximum biogas production is seen to be in the ratio 1:1. Similarly, the mixing ratios of Horticultural waste, cow dung and poultry waste are also been set up so as to analyses the enhancement in the production of biogas. The higher biogas yields were obtained from the ratio 1:1:1 (CD, PW, and HW). Gravel filter has been used and through that, wash water coming out from different ratios of wastes has been collected and analyzed and then vermin composting of the decomposed waste using earthworms is been performed and after that analysis of that vermincompost has also been done.

KEYWORDS: Anaerobic digestion (AD), Horticultural waste (HW), Cow dung (CD), Poultry waste (PW).

1. INTRODUCTION:

As population is increasing day by day, one of the biggest problems faced by today's population is energy crises. As we know that more the population more will be the energy utilization and due to this non-renewable energy sources will exhaust one day. So, there must be the use of renewable energy sources to meet the demand. There is various kind of renewable energy sources through which electricity can be generated and demand can be met. Biogas is one of the important energy sources which can be renewed again and again. It is obtained through AD being a source of renewable gas. It has been adopted as one of the best alternatives for conventional fuels in the past two decades. Horticultural waste management comes under solid waste management. Solid waste management is also known as garbage management. Solid waste management is of various types such as organic waste, toxic waste, hospital wastes and recyclable wastes. Horticulture waste is the branch of agriculture that deals with the art, science, technology, and business of vegetable garden plant growing. It includes the cultivation of medicinal plant, fruits, vegetables, nuts, seeds, herbs, sprouts, mushrooms, algae, flowers and non-food crops such as grass, trees and plants. It also includes plant conservation, landscape restoration, landscape and garden design, construction, and maintenance, and arboriculture. Inside agriculture, horticulture contrasts with extensive field farming as well as animal husbandry. Anaerobic digestion is the conversion of waste to energy and biological process that produces biogas by bacteria under no-oxygen conditions. Biogas is a colorless, flammable gas produced from variety of substrates such as animal manures, fruit wastes, vegetable wastes, plat wastes, flowers, leaves energy crops etc. It gives mainly methane gas, carbon-di-oxide and traces of some other gases such as nitrogen, hydrogen sulphide, ammonia, water vapour etc. Anaerobic digestion is a multi-step biological process in which the organic carbon is converted into carbon-di-oxide and methane. It consists of mainly four steps hydrolysis, acidogenesis, acetogenesis and methanogenesis.



Hydrolysis is a process where anaerobic bacteria breakdown complex organic molecules such as proteins, lignin, lipids cellulose into soluble monomers such as amino acids, fatty acids and sugar. The process which came after hydrolysis is known as acetogenisis or fermentation.The monosaccharides and amino acids formed by the hydrolysis process are converted into simpler products such as Volatile fatty acids (VFA), sugars, amino acids and fatty acids to hydrogen, acetate, and carbon dioxide. Acetogenesis is the conversion of certain fermentation products such as VFAs with more than two carbon atoms, alcohols and aromatic fatty acids into acetate and hydrogen by obligate hydrogen producing bacteria. Methanogenisis is the formation of methane by microbes known as methanogens. It is the final step in the process of biomethanation. Methanogenisis in microbes is a form of anaerobic respiration. Methanogens do not require oxygen to respire in fact oxygen inhibits the growth of methanogens. Acetate and hydrogen are converted to methane and carbon dioxide.
Secondly, analysis of wash water coming out from gravel filter is collected and stored in bottles and then analysis of that water has been done.
Thirdly, Vermicomposting is been done using earthworms *'Eisinia foetidia'* and analysis of that vermicompost is been done.

2. LITERATURE BASED ON HORTICULTURE WASTE:

Horticultural waste management comes under solid waste management. Solid waste management is also known as garbage management. Solid waste management is of various types such as organic waste, toxic waste, hospital wastes and recyclable wastes. Horticulturists apply their knowledge, skills, and technologies used to grow intensively produced plants for human food and non-food uses and for personal or social needs. Their work involves plant propagation and cultivation with the aim of improving plant growth, yields, quality, nutritional value, and resistance to insects, diseases, and environmental stresses.
There are various types of method use for the management of wastes such as landfills, incineration or combustion, pyrolysis, recycling or recovering, composting, briquetting, and vermicomposting. The most suitable, economical and environment friendly method is vermicomposting and in this paper the whole process of vermicomposting using earthworms and analysis of vermicompost has also been discussed.

The process by means of which organic matter in wastes is converted into methane gas and manure by microbes in the absence of air through a process known as anaerobic digestion Bio-methanation is the anaerobic digestion of biodegradable organic waste in an enclosed space under controlled conditions of temperature, moisture, pH, etc. thereby generating methane and carbon dioxide only.

Operational parameters for biomethanation

1. Temperature
2. pH
3. Hydraulic Retention Time
4. Nutrient
5. Reactor design

2.1 TEMPERATURE:

There are basically three optimized range of temperature namely thermophilic 50-60 degree Celsius, mesophilic 32-35 degree Celsius andpyschophilic is upto 20 degree Celsius.Any smallvariation in temperature of digesrer affects the biological activity of anaerobic bacteria thus reducing and affecting the production of biogas.For preventing the negative effect on biogas production constant temperature is important. Most of the methogenic micro-organisms are mesophilic and is very sensitive of thermal temperature. Microbe's growth rate increases at thermophilic temperature. Increase in temperature also increases ammonia toxicity.Some options to increase the heating within the reactors in rural areas are passive solar heating,underground digester and combination of both can be used.Digesters with black coating adsorb heat and help digester's to maintain the temperature.

2.2 PH:

Biomethanation is most effective in pH range from 6.5-8.5pH should be in the desired range as it directly affects the growth of microbes. The optimal pH of methanogenesis is around pH 7.0,the optimum pH of hydrolysis and acidogenesis had been reported as between 5.5 – 6.5.The variation in pH makes biomethanation process work effectively in two stage process, one hydrolysis/acid genesis and another is acetogenesis/methanogenesis separately. If pH is below 6.5,it is toxic to methanogenic activity. So, it is very important to maintain the range of pH for efficient gas production. pH can be maintain using calcium hydroxide.

2.3 HYDRAULIC RETENTION TIME:

Most of the anaerobic systems are designed to retain the waste for a fixed number of days. Number of days the material stays in the digester is termed as Hydraulic Retention Time. In tropical countries like India, HRT varies from 25 to 50 days and depend on the weather conditions of the particular country.

2.4 NUTRIENTS:

The major nutrient required by bacteria in digester are carbon, hydrogen oxygen nitrogen, phosphorus, potassium out of these nitrogen (N), phosphorus (p) potassium(k) are always in short supply and therefore to maintain proper balance of nutrient extra raw material rich n phosphorus(night soil) and nitrogen (urea) should be added along with cow dung to obtain the maximum production of biogas. Methane forming bacteria have particular growth requirements. It has been demonstrated that specific metals such as nickel, cobalt, molybdenum and iron are necessary for optimal growth and methane production

2.5 REACTOR DESIGNING:

Various kinds of digesters are used for anaerobic process such as one-stage or two-stage digester, wet or dry digesters, batch process or continuous process digesters, high rate digesters or digesters with combination of different approaches. Variation in the production of gas can be seen with time, and several units must be operated simultaneously to maintain the constant supply of gas.

3. RESEARCH METHODOLOGY:

MATERIALS AND METHODS

3.1 COLLECTION OF HORTICULTURAL WASTE:

Horticultural waste was collected from different sources in and around Jabalpur and all these wastes is grinded and converted into slurry form having 5-7 mm size for feeding into the digesters.

3.2 PREPARATION OF DIGESTION SLURRY:

Horticultural wastes were 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, were diluted with distilled water so as to maintain the pH, and mixed properly to obtain homogeneous conditions. All wastes are crushed and grinded properly into small particle sizes with the help of grinder. According to the respective ratios the prepared slurry were fed indigesters for 28 days hydraulic retention time (HRT) to determine the effect of mixture ratio. All these mixtures in different ratios were fed into 10 liters of digesters, inside which use of gravel filter is been used so as to collect the wash water coming out of it. The volume of produced gas was measured by water displacement method.

3.3 DATA COLLECTION:

In this study the amount and volume of biogas produced was measured by water displacement method .Data were collected on daily basis in the Energy laboratory till the generation of gas.

3.4 OBSERVATIONS:

Six observations were done feeding the digesters with different mixing ratios of HW: CD and HW: CD: PW. When the digesters were feed they were left for anaerobic digestion process and the gas was started togenerate. The HRT time was of 28 days. The gas which was produced was allowed to flow through the gas pipe and get accumulated in the gas collector above water surface, which expels same volume of water from the water chamber and then flow through the water pipe to the water collector. Volume of gas is directly measured by measuring the volume of the expelled water in the water collector.It has been analysed that the maximum production were seen in the ratio 1: 1 then in 1: 2 and lastly in 1: 3.Similarly, in the ratio of CD: PW: HW the maximum production were seen in the ratio 1:1:1, then in 1:1:2 and lastly in 1:1:3.

After the production of gas, decomposed horticultural waste (CD: HW and CD: PW: HW) was analysed and its composed and nutrient values has been analyzed.

Vermicomposting of the same decomposed horticultural waste has been done using earthworms *'Eisiniafoetidia'*.Whole process has been done in an earthen pots, wastes and earthworms are putted inside it and water has been sprinkled to it. During the whole process it has been observed that earthworms only survive in the ratio 1: 1 because its pH is good enough for the survival of earthworms. The process takes about 10-15 days and finally vermicompost is obtained. Analysis of the vermicompost has been done.

4. RESULTS & ANALYSIS:

4.1 GAS PRODUCTIONRESULTS:

4.1.1 GAS PRODUCTION FROM THE RATIO (CD: HW)

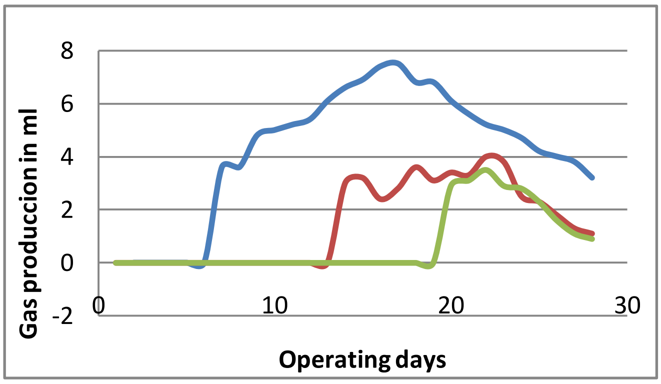


Fig 4.1.1 Operating days VS gas production in ml/day (CD: HW)

The amount of water displaced is equal to the gas produce in ml. The gas production for 1:1 start from 9th day of digestion and maximum production is observed 15th and 16th day. After 25th day of operation, production of gas decreases due to drop in temperature. The gas production for 1:2 starts from 12th dayand maximum production is observed on 17th and 18thday. Similarly, for the ratio 1:3 gas productions starts from 18th day and maximum production of gas is observed on 23rd and 24thday.

4.1.2 Gas production from the ratio CD: PW: HW

The gas production of ratio 1:1:1 starts from 7th day of digestion and maximum production observed on 16th and 17thday of operation. The production of gas for the ratio 1:1:2 starts from 14th day and maximum production is observed on 22ndday. Similarly, production of gas for the ratio 1:1:3 starts from 22nd day and maximum production is observed in 22nd day.

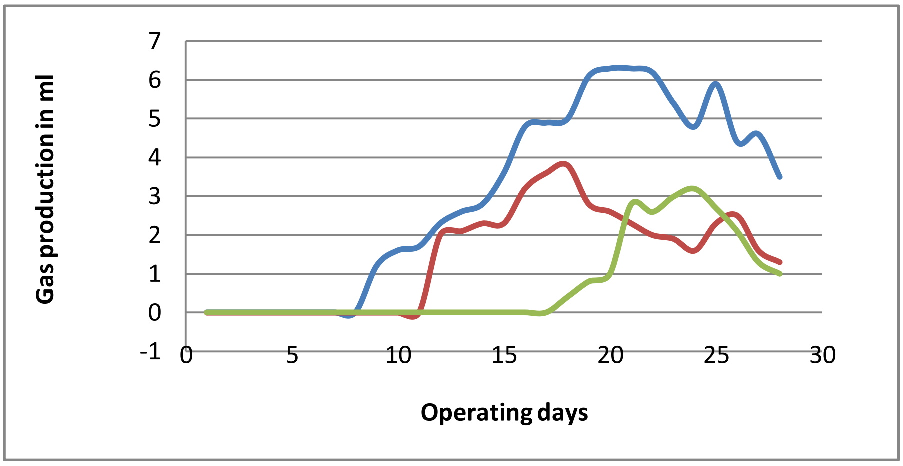


Fig 4.1.2 Operating days VS gas production in ml/day (CD:PW:HW)

4.2 COMPOSITIONAL ANALYSIS OF THE WASTES:

S.No	Characteristic of Waste	1:1	1:2	1:3
I	Total Solid	14.7	28.9	23.5
II	Moisture	87.3	72.9	78.6
III	Ph	4.52	5.35	5.5
IV	C/N	25/1	42/1	49/1
V	Nutrients	N-1.42 P-0.141 K-4.39	N-1.26 P-0.087 K-3.38	N-1.36 P-0.124 K-3.61

Fig 4.2.1 Comparative analysis of wastes CD: HW

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Fig 4.2.2 Comparative analysis of wastes CD: HW

4.3 ANALYSIS OF LIQUID BIOFERTILIZERS:

4.3.1 COMPARITIVE ANALYSIS OF LIQUID BIOFERTILIZER (CD: HW):

S.no.	Characteristic of bio fertilizer	1:1	1:2	1:3
I	Ph	5.84	5.26	6.13
II	Electrical conductivity	7.17 ms	6.67ms	6.27ms
III	Calcium hardness	10.26 mg/L	8.57mg/L	8.25mg/L
IV	Magnesium Hardness	0.6mg/L	0.5mg/L	6.9mg/L
V	Nutrients	N-0.44 P-0.138 K-1.89	N-00.30 P-0.099 K-1.35	N-0.44 P-0.057 K-2.30

4.3.2 COMPARITIVE ANALYSIS OF LIQUIDBIOFERTILIZER (CD:PW:HW)

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4.4 ANALYSIS OF VERMICOMPOST AFTER DIGESTION:

S. No.	Characteristic of Vermi-Compost	1:1:1	Standard values
I	pH	6.9	Between 6.5-7.5
II	Electrical Conductivity	3.2	Not more than 4
III	Moisture	12%	15% - 25%
IV	Odour	Odourless	Odourless
V	Total Organic Carbon	9.8%	18%(Minimum)
VI	Nutrients	N-1.52% P-0.98% K-0.75%	N-1% (min.) P-0.8% (min.) K-0.8% (min.)

Fig 4.4.1 Analysis of vermicompost of CD: HW

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I	pH	6.9	Between 6.5-7.5
II	Electrical Conductivity	3.2	Not more than 4
III	Moisture	12%	15% - 25%
IV	Odour	Odourless	Odourless
V	Total Organic Carbon	9.8%	18%(Minimum)
VI	Nutrients	N-1.52% P-0.98% K-0.75%	N-1% (min.) P-0.8% (min.) K-0.8% (min.)

Fig 4.4.2 Analysis of vermicompost of CD: PW: HW

CONCLUSION:

The main conclusions reached in this study are following:-

1. The horticultural waste is energy rich and highly degradable feedstock that can produce high methane yield but its content may vary the methane yield in anaerobic digestion due to imbalance of nutrient and other non bio degradable matter present in fruit waste.
2. The anaerobic digestion of horticultural waste with cow dung and poultry waste generates high gas compare to horticultural waste with cow dung.
3. The stability of the anaerobic digestion process highly depends upon the temperature it is affected by variation of temperature.
4. The co digestion of horticultural waste with cow dung reduces the digestion time and increases the gas yield. The co digestion provides the nutrient rich environment in digester and increases the stability of the process.
5. The addition of poultry waste with cow dung and horticultural waste increases the rate of production of biogas and reduces the digestion time.
6. Vermicompost obtained from the process of vermicomposting is rich in nutrient ans is a good fertilizer.
7. The liquid bio fertilizer having good nutritive value can also be used as a fertilizer.

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