International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 02 | Feb 2020 www.irjet.net p-ISSN: 2395-0072

Production and Analysis of Biogas from Municipal Solid Waste

Sushmita Patidar[a], Anjani Kumar Dwivedi[b]

[a] *M. Tech Research Scholar, Department of Chemical Engineering, Ujjain Engineering College Ujjain (M.P.).*
[b] *Professor, Head of the Department of Chemical Engineering, Ujjain Engineering College Ujjain (M.P.).*

---****---

ABSTRACT:- *Bio gas generation from fruit and vegetable waste requires anaerobic digestion. This work was carried out to create an organic processing facility for biogas production in an anaerobic condition which will be cost effective, eco-friendly and eliminate landfill waste problem. Additionally the left over slurry from the generator may be utilized as chemical free manure. The various parameters like time, temperature in ambient conditions, pH of the waste water was measured to find out their effect in methane formation reactions. The biogas plant capacity is 20 tons per day of fruits and vegetable wastes, which generates nearly 2400 m of Bio -CNG per day. Bio-CNG is that purified form of Biogas, where all the unwanted gases are removed and pure methane gas is 95%. The pH of inlet digester range is 5 – 6 and the outlet digester range is 6 – 7.66. The maximum biogas yield is 0.7527 m^3 under temperature in 35°C in anaerobic digeston.*

Keywords:- Biogas, methane, carbon dioxide, municipal solid waste, anaerobic digestion

1.INTRODUCTION

Municipal solid waste generation has become an increasing environmental and public health problem everywhere in the world, particularly in developing countries because of rapid urbanization and population growth [tadesse et al 2014]. A sustainable waste management systems has become an integral part of resources management. Several studies have shown that if the wastes aren`t properly managed, they will grow to such a level that will prevent human beings from carrying out their daily activities and have adverse effects on human life [jeniffer et al 2018]. In urban areas, especially within the rapid urbanizing cities of the developing world, problems and problems with Solid Waste Management (SWM) are of immediate importance.

Solid waste can be used for production of biogas. Biogas comprises of 55-75% methane , 25-45% carbon dioxide and 0-10% nitrogen. Anaerobic digestion may be a known process to treat organic wastes. Resources recycling and energy saving systems for processing organic solid waste in urban areas need to established. The anaerobic digestion is an attractive option for energy generation from the putrescible fraction of municipal solid waste also as for reducing the disposal problem. It has reduced environmental impact, especially with respect to the greenhouse effect and global warming [Ashik Ali et al 2016].

Anaerobic digestion has been considered to be a promising energy saving and recovery process for the treatment of organic waste. Anaerobic digestion also has been suggested as an alternate method of removing the high organic solid waste. This biological process generates a gas, generally known as biogas, primarily composed of methane and carbon dioxide. This process is very attractive because it yields biogas, a mixture of methane and CO_2 which can be used as renewable energy resources.

Anaerobic digestion technology has tremendous application with in the future for sustainability of both environment and agriculture because it represents a feasible and effective waste – stabilization method to convert the undilued solid bio waste into renewable energy with nutrient rich organic fertilizer. However, the application of this process is limitedly practiced especially in developing countries because of the lack of appropriate treatment system configuration and mainly due to the longer time required for the bio stabilization of waste. Any kind of reactor design and operational criteria selection to be operated is depends upon the feedstock characteristics, financial aspects etc. This paper deals with the experimental study carried out by means of industrial plant to generate biogas from the municipal solid waste.

The objective of this study was to obtain the optimal conditions for biogas production from anaerobic digestion of municipal solid waste using various inoculums from different sources like mud waste. The substrates were treated anaerobically for biogas production and pH , chemical oxygen demand were observed. The study of these parameters will help us to establish a biogas system with available substrate and utilize different types of available fruit and vegetable waste for biogas production.

2. MATERIAL AND METHODS

2.1 Biogas Plant

Raw biogas for the experiment of biogas production has been taken from the biogas plant of capacity 20 tons/day. The biogas plant is operated by bio-CNG plant at Choithram Mandi Indore (M.P.). Organic green waste is used as a feedstock for the biogas plant. Organic municipal solid waste were used as feed to the bio reactor. Fruit and vegetable waste was obtained from the Choithram Mandi Indore.

2.2 Experimental Setup

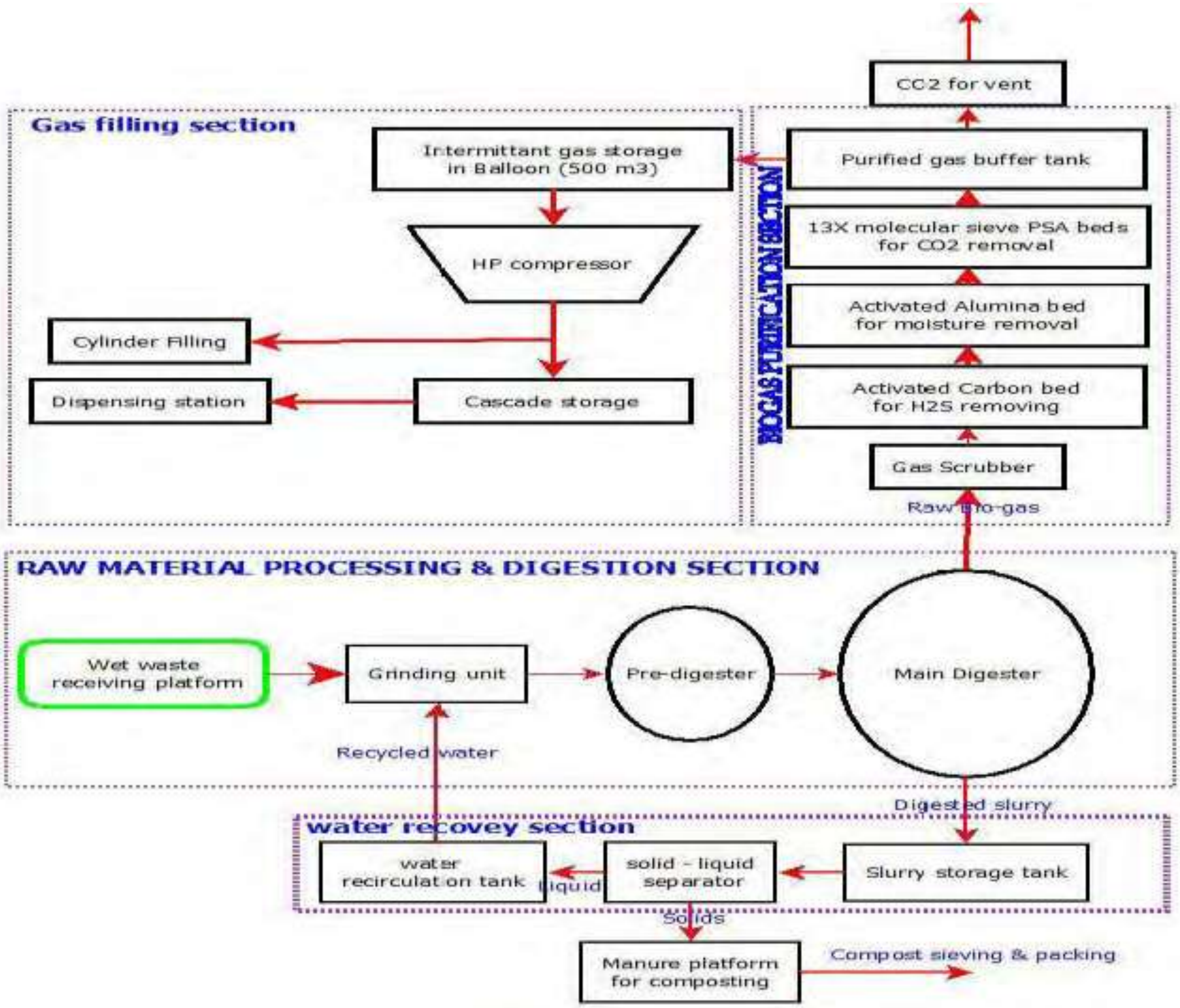

Figure 1 :- Process flow diagram of biomethanation plant [Source:- Choithram mandi, Indore]

Figure 2 :- Biomethanation plant of organic waste in anaerobic digestion [Source:- Choithram mandi, Indore]

Figure 1 show that the process flow diagram of biomethanation plant Indore and Figure 2 show that the biomethanation plant of organic waste in anaerobic digestion [Source:- Choithram mandi, Indore]. This is a biomethanation plant of 20 tons/day capacity in choithram mandi which is basically a whole sale fruit and vegetable market and generates a huge quantity of wet waste. The reactor were filled with fruit waste, vegetable waste and sludge waste used as a slurry in the reactor. Liquid sample were drawn from reactor periodically and analysed for pH and chemical oxygen demand. The pH were measured daily in inlet and outlet digester and it was maintained in the inlet digester range of 5-6 and outlet digester range of 7.5-7.66 using solution as which is the optimum range for methanogenes growth. The raw biogas is processed and purified from the unwanted gases like CO_2, H_2S and moisture up to a certain required level. Biogas up-gradation would mainly involve integration of suitable CO_2 – CH_4 separation facilities. The vacuum – pressure swing adsorption (VPSA) or medium pressure swing adsorption (MPSA) process, which is a subset of PSA, has high potential because here the adsorption step is carried out at near atmospheric pressure, at which the biogas is available, thus negating the high compression cost of PSA, the purification cost is substantially lower than the other technologies with this scale.

2.3 Analytical methods

The parameters analysed for the characterization of substrates were as follows: pH analysis , total solid (TS), Volatile solid (VS), Volatile fatty acid (VFA), Total Chemical oxygen demand.

1. pH analysis:- A glass electrode pH meter was used to monitor the pH of the sample.

2.Total solids (TS%) – It is the amount of solid present in the sample after the loss of water molecules present in it. In other words , is refers to the quantity of the material residue left in the crucible after evaporation of the sample and its subsequent drying in a laboratory oven at 105^{0}C for a period of one hour.
These were the procedures followed :

(1) A crucible was properly washed and dried in the laboratory oven at a temperature of 105^{0}C for one hour. The crucible was stored and cooled in a desiccators until needed.
(2) The crucible was weight before use.
(3) The laboratory oven was switch on and allowed to reach a temperature of 105^{0}C. This temperature was maintained throughout the experiment.
(4) The collected co-digested substrate sample was added to the crucible and diligently placed in the laboratory oven at a temperature of 105^{0}C. The substrate sample was dried to a constant mass for a period of 1 to 2 hours.
(5) The crucible plus substrate residue were allowed to cool during a desiccators to balance temperature. Desiccators are designed to supply an environment of standard dryness. The desiccators was properly lubricated with grease and this was to prevent moisture from entering the desiccators as the test glassware cools.

(6) The crucible plus substrate residue was weighed using electronic precision balance.
Equation was used to calculate the total solids

$$total\ solid = \frac{final - initial\ \times 10^6}{ml\ of\ sample}$$

3. Volatile solid (VS) ;–The volatile solid is the solid remaining after evaporation or filtration are dried , weighed , and ignited at 550^{0}C. The subsequent procedures were followed in determination of the volatile solid of the substrates used.

(1) The residue obtained from total solids determination was ignited at 550^{0}C for a duration of 30 minutes using a muffle furnace.
(2) The crucible and black mass of carbon were allowed to cool partially in air before it was transferred to the desiccators for complete cooling.
(3) The sample was weighed once temperature balance is reached.
Volatile solid was calculated using equation

$$mg\ volatile\ solids = \frac{(A - B) \times 1000}{sample\ volume\ , ml}$$

4. Chemical oxygen demand (COD):- The chemical oxygen demand method determines the quantity of oxygen required to oxidize the organic matter in a waste sample, under specific conditions of oxidizing agent, temperature and time.

(1) Distilled water :- Special precautions should be taken to insure that distilled water used in this test be low in organic matter.
(2) Standard $K_2Cr_2O_7$ solution (0.25N):- Dissolve 12.259 g $K_2Cr_2O_7$, primary standard grade, previously dried at 103°C for 2 hours, in distill water and dilute to 1000ml.
(3) Sulfuric acid reagent:- Conc. H_2SO_4 containing 23.5g silver sulfate per 4.09 kg bottle. With continuous stirring, the silver sulfate is also dissolved in about 30 minutes.
(4) Standard ferrous ammonium sulfate (0.25N): Dissolve 98.0g of $Fe(NH_4)_2(SO_4)_2 6H_2O$ in distill water. Add 20 ml of conc. H_2SO_4 (6.8) and cool and dilute to 1 liter. This solution must be standardized daily against standard potassium dichromate solution (6.2).
(5) Standardized: To approximately 200ml of distilled water add 25.0 ml of 0.25N $K_2Cr_2O_7$ (6.2) solution. Add 20ml of H_2SO_4 (6.8) and cool. Titrate with ferrous ammonium sulfate (6.4) using 3 drops of ferrion indicator (6.6). The color changes is sharp, going from blue – green to reddish – brown.

3. RESULTS AND DISCUSSION

The result and discussion pertaining to the biogas production from municipal solid waste. All the results of experiments were shown below with their analysis and detailed discussions and at the end conclusion of whole results was discussed followed by recommendation of future research was done.

Figure 3 show that the pH variation during anaerobic digestion process. In anaerobic system, the acetogenic bacteria convert organic matter to organic acids, possibly decreasing the pH, reducing the methane production rate and so the generally anaerobic digestion process unless the acids were quickly consumed by the methanogens. pH in the range of 6.8 to 7.66 should be maintained in the anaerobic digestion process, which is the optimum range for methanogens growth. The pH was observed during grinding slurry waste in inlet digester and the pH range is 5-6. The outlet digester pH are observed, when biogas generate. The pH is calculate at different–different time at 10 AM, 2 PM, 6PM. At 10 AM range is 7.54 to 7.64 and 2 PM range is 7.54 to 7.51 and 6 PM range is 7.61 to 7.57 .

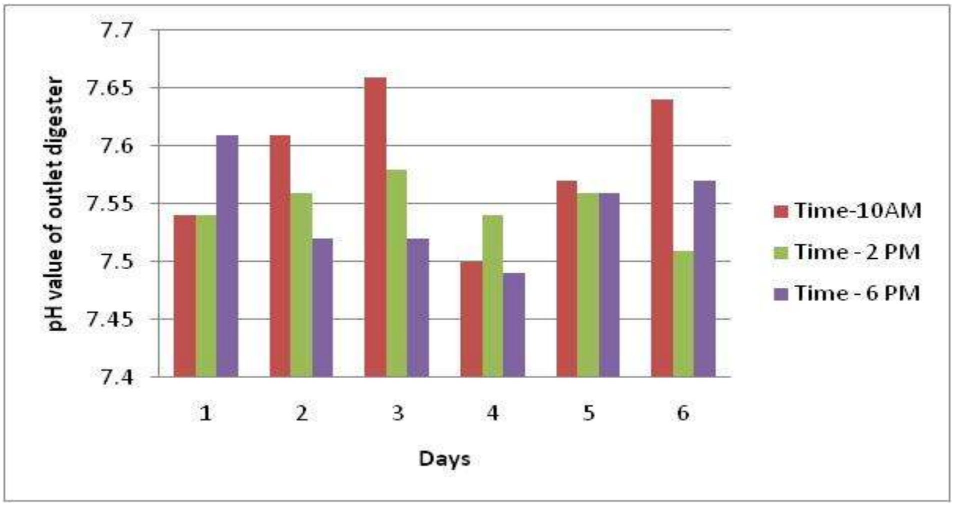

Figure 3 :- pH variation during anaerobic digestion process

Figure 4 show that the pH value in outlet digester in anaerobic digestion. In outlet digester pH was increased and observed daily in different – different time at 10 AM, 2 PM and 6 PM. The pH value is increase in 3 day at 10 AM is 7.66 and 2 PM is 7.58 and 6 PM is 7.52.

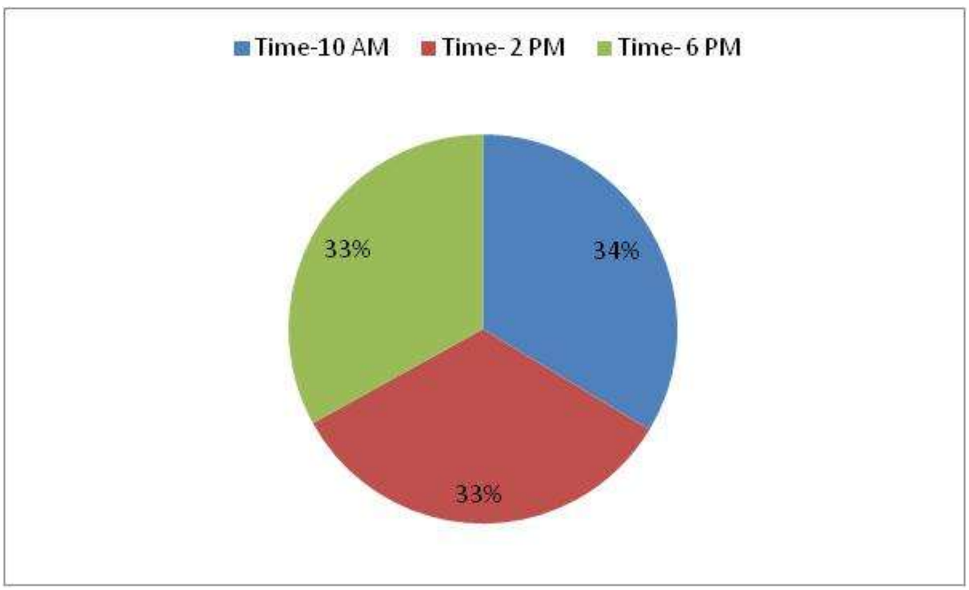

Figure 4 :- pH variation in outlet digester

Figure 5 shows that the daily biogas production in anaerobic digestion . Daily organic waste are feed in reactor. The biogas plant capacity is 20 tons/day of fruits and vegetable wastes. Daily biogas are generated. The temperature range is 35°C in biogas production. Fruit waste and vegetable waste are feed in digester as a slurry form. Daily biogas was produced 0.6930 m^3 (17.39 kg), 0.7316 m^3 (21.77 kg), 0.7523 m^3 (22.8 kg), 0.6863 m^3 (19.49 kg), 0.7312 m^3 (33.22 kg), 0.6584 m^3 (20.245 kg), 0.6953 m^3 (20.35 kg). Methane gas increased in 33.22 kg and decreased in 17.39 kg. Bio-CNG is that the purified form of Biogas, where all the unwanted gases are removed and pure methane gas is 95%.

Figure 5:- Daily biogas production (methane gas)

Figure 6 show that the chemical oxygen demand in anaerobic digestion process. Take 1 mL sample and mix distilled water 100 mL than 20 mL sample then add 10 mL potassium dichromate and 30 mL sulfuric acid. The chemical oxygen demand measure in inlet digester , the chemical oxygen demand is decrease in inlet digester is 17000mg/L, 15000 mg/L, 13000 mg/L, 12000 mg/L, 10000 mg/L. The chemical oxygen demand in outlet digester is 10000 mg/L, 10000 mg/L, 10000 mg/L, 10000 mg/L, 10000 mg/L.

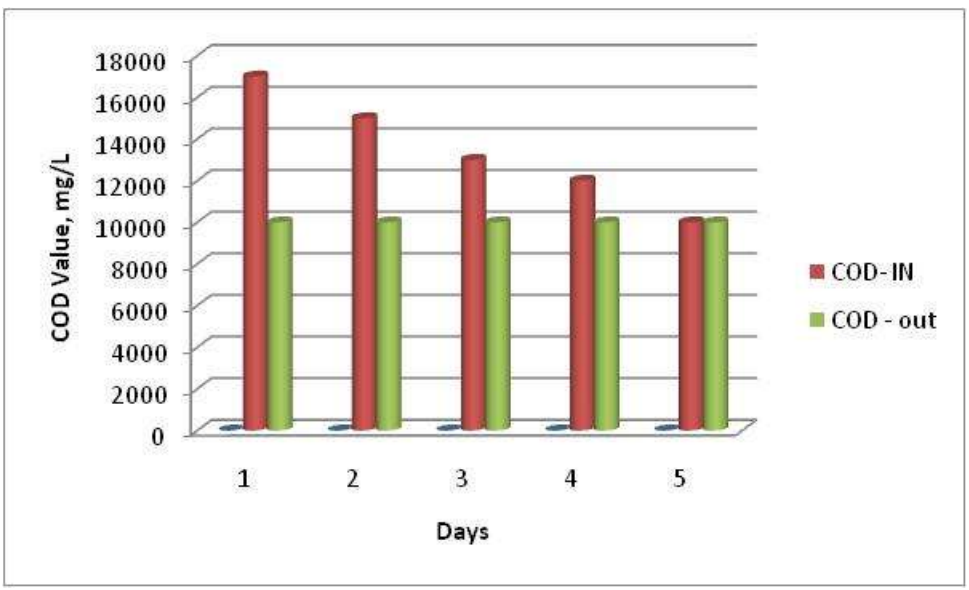

Figure 6:- Chemical oxygen demand in anaerobic digestion

Figure 7 show that the total solid in anaerobic digestion. Total solid is refer to the quantity of the waste material residue left in the crucible after evaporation of the sample and its subsequent drying in a laboratory oven at 105°C for a period of one hour. Take a 50 ml sample of both inlet and outlet digester in crucible and drying in a laboratory oven at 105°C for a one hour. Total solid of inlet digester is 35452 mg/L, 35292 mg/L, 35146 mg/L, 35000 mg/L, 33256 mg/L in anaerobic digestion, total solid of outlet digester is 18780 mg/L, 14156 mg/L, 7996 mg/L 5826 mg/L and 3598 mg/L in biogas production in anaerobic digestion.

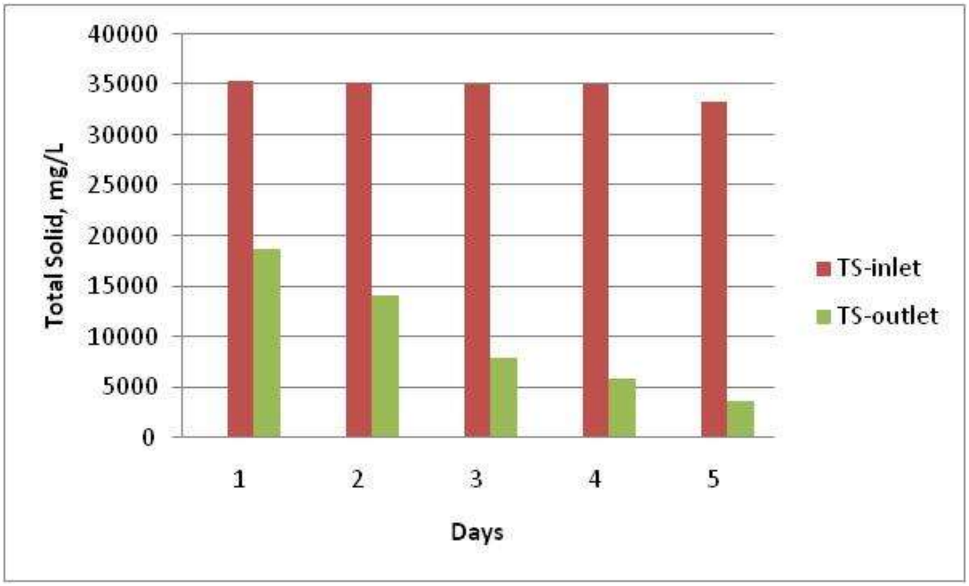

Figure 7:- Total solid in anaerobic digestion

4. CONCLUSION

The experimental work was devoted to optimize the bio gas production from municipal solid waste. In this paper show the various parameters of the municipal solid waste. Bio gas generation from fruit and vegetable waste requires anaerobic digestion. The bio gas composition was analysed in terms of CH_4 , H_2 *and* CO_2. The biogas plant capacity is 20 tons/day of fruit and vegetable wastes, which generates 2400 m^3 of BIO-CNG per day. The acid production ph of inlet digester range is 5 – 6 and outlet digester range is 6 – 7.66 at different - different time . BIO-CNG is that the purified from the biogas, where all the unwanted gas are removed. The maximum bio gas yield is 0.7527 m^3 and pure methane content is 95%. The total solid of inlet digester range is 35452 mg/L to 33256 mg/L and outlet digester range is 18780 mg/L to 3598 mg/L.

5. REFERENCES

1. Ali, J. Mohamed Ashik, S. Mohan, T. Velayutham, and S. Sankaran. "Comparative Study of Biogas Production from Municipal Solid Waste using Different Innoculum Concentration on Batch Anaerobic Digestion." *Asian Journal of Engineering and Technology (ISSN: 2321–2462)* 4, no. 04 (2016).
2. Al-Zuahiri, Firas, Domenico Pirozzi, Angelo Ausiello, Ciro Florio, Maria Turco, Luca Micoli, Gaetano Zuccaro, and Giuseppe Toscano. "Biogas production from solid state anaerobic digestion for municipal solid waste." *CHEMICAL ENGINEERING* 43 (2015).
3. Dasgupta, B. V., and M. K. Mondal. "Bio energy conversion of organic fraction of Varanasi's municipal solid waste." *Energy procedia* 14 (2012): 1931-1938.
4. Getahun, Tadesse, Mulat Gebrehiwot, Argaw Ambelu, Tom Van Gerven, and Bart Van der Bruggen. "The potential of biogas production from municipal solid waste in a tropical climate." *Environmental monitoring and assessment* 186, no. 7 (2014): 4637-4646.
5. Masih, Jeniffer Christeena, Shikha Mehta, Kamla Malik, Swati Sindhu, and Ramesh Chander Anand. "Enhancement of biogas production from cattle dung using additive." (2019).

6. Pavi, Suelen, Luis Eduardo Kramer, Luciana Paulo Gomes, and Luis Alcides Schiavo Miranda. "Biogas production from co-digestion of organic fraction of municipal solid waste and fruit and vegetable waste." *Bioresource technology* 228 (2017): 362-367.
7. Ranieri, Luigi, Giorgio Mossa, Roberta Pellegrino, and Salvatore Digiesi. "Energy recovery from the organic fraction of municipal solid waste: A real options-based facility assessment." *Sustainability* 10, no. 2 (2018): 368.
8. Ziauddin, Ziana, and P. Rajesh. "Production and analysis of biogas from kitchen waste." *İnternational research journal of engineering and technology* 2, no. 4 (2015): 622-632.

6. BIOGRAPHICS

Sushmita Patidar

Sushmita Patidar is M.tech Research Scholar, Department of Chemical Engineering, Gov Engineering College, Ujjain(M.P.)

Prof. Anjani Kumar Dwivedi

Dr. Anjani Kumar Dwivedi is Professor and Head of the Department of Chemical Engineering College, Ujjain(M.P.). He has more than 30 years experience of research and teaching in chemical engineering.