ZIBELINE INTERNATIONAL™ PUBLISHING

Engineering Heritage Journal (GWK)

DOI: http://doi.org/10.26480/gwk.02.2021.49.52

SSN: 2521-0904 (Print)
ISSN: 2521-0440 (Online)
CODEN: EHJNA9

RESEARCH ARTICLE

EFFECT OF TEMPERATURE ON BIOGAS PRODUCTION POTENTIAL OF BANANA PEELS CO DIGESTED WITH BIOGAS SLURRY IN ANAEROBIC BIOREACTOR

Atif Zahoor[a], Ch Arslan[a], Asma sattar[a], Muhammad Asad Tahir[b], Zia Ur Rahman Farooqi[c], Muhammad Shoaib[d], Muhammad Saqlain[e], Muhammad Safdar[e], Noman Ahmad[c]

[a]Department of Structures and Environmental Engineering, University of Agriculture Faisalabad (UAF)
[b]Inland Revenue, Federal Board of Revenue, Islamabad
[c]Institute of Soil & Environmental Sciences, UAF
[d]Department of Mechanical Engineering, CEME, National University of Sciences & Technology (NUST)
[e]Department of Irrigation and Drainage, UAF
[*]Corresponding Author E-mail: atifzahoor90@gmail.com

ARTICLE DETAILS

Article History:

Received 18 September 2021
Accepted 20 October 2021
Available online 02 November 2021

ABSTRACT

Due to increase in demand our conventional resources are insufficient to fulfill the world energy demand. Renewable techniques are extremely economical due to converting useless waste into energy. To achieve that purpose anaerobic digestion was performed on banana peels with co digested with biogas slurry. Input feedstock to anaerobic plant was banana peels which already passed through four pretreatments such as, glycerol, sodium hydroxide, calcium hydroxide and acetic acid at variable conditions. Glycerol treatment give most efficient results due to more removal of lignin up to 87%. Anaerobic digestion is completely environmental friendly with no carbon dioxide emission and due to benefits it can adopted more in future on industrial and domestic scale. 6 liter capacity tank was installed at 4 liter with 10% TS level to giving space at top for biogas production. Trails was performed at two temperature 37°C and 55°C but more biogas produced at 55 °C with retention time period of eighteen days. In slurry tank manually stirring was provided and produced gas was calculated through water displacement method. This study help to decrease city waste by installing anaerobic plants. In that way we can achieve sustainability and waste can also be controlled.

KEYWORDS

anaerobic digestion, biogas, slurry, anaerobic plant, glycerol treatment

1. INTRODUCTION

Municipal solid waste is a waste that is generated from service sector which includes industrial waste and waste produced by final demand (Tisserant et al., 2017). Municipal solid waste generated in Pakistan on daily basis and 60% of total shift to disposing point only and 12000 ton waste only generated from Karachi which having 52% organic fraction but generally municipal solid waste in Pakistan have 80 to 85% organic fraction waste (Sohoo et al., 2021).

Waste in cities increased due to gigantic urbanization and shifting of folks from different small cities to massive cities which are already overpopulated and having less amenities for own citizens (Hoornweg and Bhada-Tata, 2012). Europe producing a lot of biogas, in 2015 they installed 17,000 anaerobic digestion plant having a capacity of 8293 MW. 60% of biogas is used to attain heat and electricity (Laperrière *et al.*, 2017).

Pakistan is facing challenges to overcome the energy crisis. MSW producing in plentiful quantity due to development in Pakistan and all the requirement of energy attained by using best tactics to recycle waste and make them productive (Deressa *et al.*, 2015). Waste have many types and used for enormous purposes such as, Fruit, plants and many types of animal waste are most suitable examples of biodegradable waste (Van der Sloot *et al.*, 2017). Power consumption is increasing in 21st century and fossil fuel are depleting, which has led the researcher to build innovative and modern technological process for energy generation. The biogas has less hazardous emission like CO_2 in the environment (Mursec *et al.*, 2009).

Massive burden produce by fruit and vegetable waste in all over the world is increasing day by day and typical task for municipal administration to control leftover (Liu and Liao, 2019). Over the last 30 years the banana production increases 175% in a revolutionary way to 102 million tons up to 2010 (Housagul *et al.*, 2014). 116 million tonnes banana produced around the world and major contribution comes from India and other African countries (Mago *et al.*, 2021). Bananas are considered main fruit crop of Pakistan. Bananas are produced on 34,800 hectares yielding a production of 154,800 tonnes (Rehman *et al.*, 2018).

Pretreatment of peels before it mix in bioreactor for biogas generation and prior to anaerobic digestion sample stored at 4°C after cutting of peels. Main components are acid soluble lignin, hemicellulose, cellulose and acid insoluble lignin which resist against degradation (Pei *et al.*, 2014). Biogas slurry declined the need of fertilizer after applying one time and it contain enormous sort of micro nutrients along with macro nutrients that play vital part in the growth of plant (Kumar *et al.*, 2015).

2. LITERATURE REVIEW

According to Abraham *et al.*, (2020) World energy demand in current circumstances is approximately 542 (QBTU) quadrillion BTU and envisaged to rise around 50% up to 2050. Green energy tools are

Quick Response Code	Access this article online	
	Website: www.enggheritage.com	**DOI:** 10.26480/gwk.02.2021.49.52

Cite The Article: Atif Zahoor, Ch Arslan, Muhammad Asad Tahir, Zia Ur Rahman Farooqi, Muhammad Shoaib, Muhammad Saqlain, Muhammad Safdar, Noman Ahmad (2021). Effect of Temperature on Biogas Production Potential of Banana Peels Co Digested With Biogas Slurry in Anaerobic Bioreactor. *Engineering Heritage Journal, 5(2): 49-52.*

increasing rapidly and estimated the 85% of energy demand will be fulfil by renewable sources in 2050.

Safar *et al.*, (2019) states that Pakistan generating municipal solid waste about 45.420 million tons annually with generation of household waste house/day is between 1.9 to 4.29kg in large cities. 64% of organic and 36% of inorganic MSW produced by Pakistan. Normally organic waste is disposed in non-technical ways, it emit toxic and harmful gases to the environment on daily basis. Waste handled by landfill (40%), recycling (5.0%), composting (3.0%) and in both incineration and digestion is (0.0%). Additionally, dumping along road and in open land also done in small cities and village areas.

According to El-Din *et al.*, (2018) banana peels are unmatchable in characteristics as it contain many ingredients including complex Vitamin B along with fibers. It provides exceptional health impacts as well as ample pros for the environment. (Shah *et al.*, 2011) elaborated that in Pakistan the biggest problem is less awareness in our scholastic system about the renewable and green technologies due to little bit high initial cost of installation. Vogt and Nunes (2014) states waste handling is most quandary task for worker while in collection of waste, transportation of waste and especially in disposal of waste that may be landfill, composting, anaerobic digestion or any other strategy of recycling of waste.

Gumisiriza *et al.*, (2019) described that second biggest producer of the globe after India is Uganda as playing leading role in generation 9.77 million tonnes annually and in processing of banana is well. Banana wastes contain 80% volatile solids and moisture contents. Pretreatments are requisite to ameliorate the gas production.

Zheng *et al.*, (2014) elucidated that combing of hemicellulose, lignin and cellulose that form abundantly present lognocellulosic biomass exist in feedstock. It's good for biogas generation but due to physical and chemical properties it resists to biodegradation. Sodium hydroxide pretreatment increased biogas generation and in fact 80% lignin elimination led to 75% more biogas generation as compare to untreated material used in process. Laskri *et al.*, (2015) explained that degradation done in three phases, in first phase hydrolysis of substrate and pH decrease, in second phase pH increase and acetates form and in third phase methanogenic bacteria produce biogas from the product of acetogenic phase.

Gandhi *et al.*, (2019) explained that if pH exceeds from these limits of 6 to 8.5 than significant declination can be observed in the process of biogas production. Variation in temperature during process and presence of long chain fatty acids (LCFA) produce hazardous impact on biogas generation process. According to Viswanath *et al.*, (1992) 20 to 30 is most appropriate C/N ratio for generating maximum biogas from fruit waste. pH also drops during process and gradually rose. Pollution extenuates if the digester is functioned at high loading rate while drop in pH, intensification of total volatile fatty acids.

Palacios-Ponce *et al.*, (2017) expressed that 30% to 40% total load of world fruit consist of banana peels and consist of carbohydrates, proteins and fiber which had low cost and highly productive also help to resolve environmental issues.

3. METHODOLOGY

3.1 Apparatus

These apparatus were used such as, oven for the heating of pretreated peels samples, water bath used for continuous heating, temperature and pH meter, anaerobic reactor and pump placed inside the bath for hot water supply in reactor, 3% NaoH solution for biogas collection and temperature sensor placed at the top of reactor for temperature monitoring.

3.2 Experimental Design

Banana peels collected from five selected points of university of agriculture Faisalabad such as, two fruit shop of market, one fruit shop of eat and meat, one milk shake shop of computer science department and one from milk shake canteen of DVM. All the collected sample passed through these four pre-treatment with three replications of each treatment. After collection peels were cut down into different lengths alike 1 to 2 centimeter and 2 to 3 centimeter and stored at 4 ºC before different pretreatment applied. These following treatment was applied.

3.3 Treatment with Glycerol Treatment

Glycerol in pure or in waste form was mixed with banana peels for the purpose of enormous biogas production by applying this pretreatment technique.(Housagul *et al.*, 2014).

Glycerol with 65% purity level of glycerol and already ripened peels of banana which mixed together for 12 hours. After 12 hours sample was take out from glycerol concentration and which further sent for the test of lignin in Hi-Tech Lab, University of Agriculture, Faisalabad.

3.4 Treatment with Calcium Hydroxide

Calcium hydroxide mixed with banana peels to protract the degradability of peels in anaerobic plant. Thermal pretreatment performed at specific temperature range of 60 ºC to 90 ºC for 4 hours and it intensify biogas production up to 61%. Another thing was also found that banana peels itself can be used as a pretreatment agent such as calcium hydroxide. Declination in hemicellulose, cellulose and lignin increases the generation of biogas (Patowary and Baruah, 2018).

Banana peels mixed with calcium hydroxide at 90 ºC for 4 hours and then dipped peel sample were taken out for lignin test.

3.5 Treatment with Sodium Hydroxide

Treatment done with the help of 4% NaOH mixing with banana peels for 3 days at 48 ºC.(Pei *et al.*, 2014).

4% NaOH solution prepared with specific concentration of water and sodium hydroxide. Water bath used to monitored temperature of prepared dipped sample at 48 ºC for 72 hours. After termination of specific time limit sample was out from water bath which further sent for lignin test.

3.6 Treatment with Acetic Acid

Pretreatment of peels was done with mixing of 2% acetic acid for one hour at 100 ºC.(Saha *et al.*, 2016).

Banana peels dipped into prepared solution of 2% of acetic acid which prepared with 98 ml of H_20 with 2 ml acetic acid. Peels dipped for 60 minutes at 100 ºC in 2% of acetic acid solution.

3.7 Working Volume

Total capacity of reactor was 6 liter but installed at 4 liter to give proper space at the top of reactor for biogas production. Anaerobic reactor installed at 10% TS with retention time of 18 days.

3.8 Collection of Biogas

Biogas generated at the top of the reactor and as showed in above picture then it transfers to 3% NaoH flask solution where it push solution to next flask and it measured by glass cup in milliliters.

3.9 Other Gases

Last product was biogas with some other gases, but other gases was in small amount such as, Nitrogen, carbon di oxide and Hydrogen Sulphide etc. Produced methane was combustible, transferable and compressed gas which can be further used for numerous purposes.

3.10 Statistical Analysis

In statistical analysis complete random design (CRD) applied on the pretreatment of banana peels by several chemicals and find most effective treatment. Average of two trails at 37 ºC (mesophilic temperature) and two trails at 55 ºC (mesophilic temperature) were taken to show in two graphs instead of four graphs.

4. RESULTS

4.1 Pretreatment Analysis

Statistical analysis performed on obtained values of four pre-treated banana peels samples ADF (Acid detergent fibre), NDF (Neutral detergent

fibre), Cellulose, Hemicellulose and Lignin were determined. The most effective pre-treatment was found glycerol pre-treatment due to lowest value of lignin compared calcium hydroxide, sodium hydroxide and acetic acid. While low value of lignin help to decompose peels rapidly in digester.

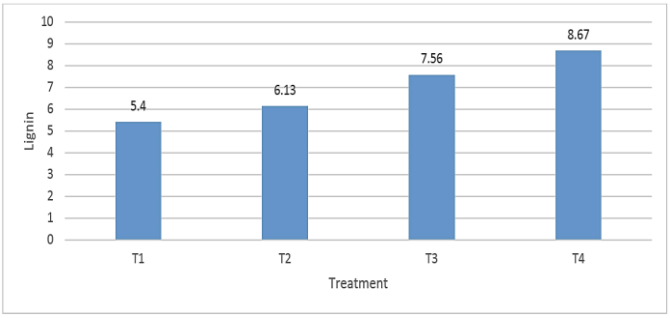

Figure 1: Graphical representation of Lignin

Lignin percentage were declined from 40, 38.5, 39 and 37 respectively to 5. 4, 6.13, 7.56 and 8.67 in all treatment from T1, T2, T3 and T4.

4.2 Trails

Rigid structure not help in degradation process alike complex form of cellulose, hemicellulose and lignin creates massive problems so, it turned down into simple or in less complex form by adopting pretreatment for easily degradation.

Total four trails performed with retention time period of 18 days in anaerobic bioreactor. Two trails performed at 37 °C (mesophilic temperature) and two trails performed at 55 °C (thermophilic temperature) and their average of mesophilic and thermophilic has been taken for better understanding.

4.3 Biogas Production at mesophilic Temperature

After four pretreatment of banana peels glycerol treated peels was selected for final mixing with biogas slurry for anaerobic digestion due to lower value of cellulose, hemicellulose and lignin values attained with glycerol treatment and make perfect environment for biogas and more degradation can easily performed as compare to other treatment which have higher value for cellulose, hemicellulose and lignin.

Table 1: Time and cumulative biogas generation rate (Avg of Mesophilic Trails)

Time (Days)	Cumulative Biogas Yield (ml)
0	0
1	200
2	396
3	789
4	1044
5	1498
6	2180
7	2390
8	2478
9	2484
10	2568
11	2580
12	2599
13	2604
14	2616
15	2619
16	2630
17	2647
18	2680

Biogas production in first 24 hours was equal to zero then it producing slowly toward more biogas production and after attaining a specific level it became constant. First two trails was done on 37 ºC at mesophilic temperature conditions. On eighteenth day retention time period production of accumulated biogas was 2680 ml observed.

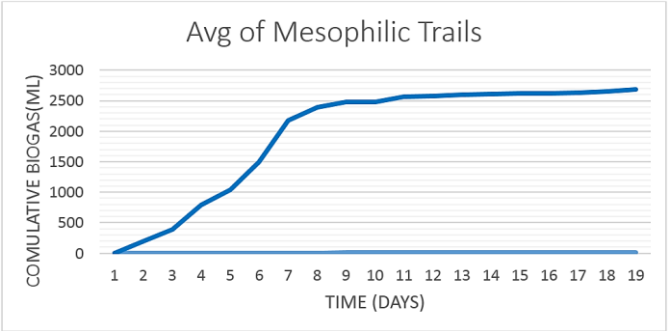

Figure 2: Time vs. cumulative Biogas yield rate

Graphical representation of mesophilic trail elucidated how biogas production rises at different stages and cumulative biogas production start approximately after 24 hours of the plant initiation. At sixth day maximum cumulative biogas was achieved while on the other hand very minute or low fluctuation was observed after tenth day in the production of biogas.

4.4 Biogas Production at thermophilic Temperature

Glycerol treated sample was mixed with biogas slurry at 55 ºC on thermophilic condition. Biogas production in first 24 hours was equal to zero then production of biogas was gradually increases and after attaining a specific level it became constant. On eighteenth day retention time period production of accumulated biogas was 3045ml observed.

Table 2: Time and cumulative biogas generation rate (Avg of Thermophilic Trails)

Time (Days)	Cumulative Biogas Yield (ml)
0	0
1	260
2	405
3	812
4	1233
5	1522
6	1631
7	2449
8	2490
9	2545
10	2683
11	2842
12	2913
13	2921
14	2934
15	2949
16	2945
17	2992
18	3045

Graphical representation of thermophilic trails shows how biogas production rises at different stages and cumulative biogas production start approximately after 24 hours of the plant initiation. At seventh day maximum cumulative biogas was achieved while on the other hand very minute or low fluctuation was observed twelve day hours in the production of biogas.

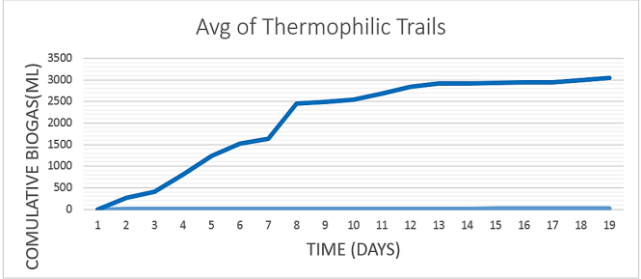

Figure 3: Time vs. cumulative Biogas yield rate

Treated sample was already favorable for degradation process due to best treatment sample was picked and other indispensable factor of high temperature of 55 ºC was provided by water bath to the tank that provide best combination for microbes to degrade feedstock in anaerobic tank and a lot of variation in graph was observed due to variation in temperature and more biogas produced with high temperature in the inner side of anaerobic digester during degradation process.

5. Conclusion

Renewable sources and strategies are most like and adopted by whole world due to benefits, cost effectiveness and sustainability as compared to fossil fuels. Initially four pretreatment were performed to increase efficiency of feedstock and also increased the production of biogas. In first treatment 65% purity level of glycerol was used, in second treatment calcium hydroxide used, in third treatment temperature 4% NaOH used and in fourth treatment 2% of acetic acid solution was used and mixed with banana peels. After all these treatment test was performed and glycerol treatment find out the best one which further mixed with biogas slurry that already stored at 4 ºC for anaerobic digestion.

Selected glycerol treated sample was mixed with biogas slurry having a retention time of eighteen days. First two trail was examined at mesophilic range and other two trail was performed at thermophilic range. Research elucidated that biogas production was 13.61% higher on thermophilic temperature as compared to mesophilic temperature. More temperature in inner tank help for speedily degradation of available feedstock and more biogas production attained. High temperature kill some microbes but moderate or mesophilic temperature produced less biogas. Produced biogas was calculated by water displacement method with 3 % NaOH solution.

Main objective of this study was to assess the biogas production potential from banana peels and pre-treatment impact on lignocellulosic properties of banana. This anaerobic technique assist to sort out the problem of city waste because city waste is different from village or town waste and in city a lot of fruit waste is generated and especially banana peels waste are produced in large amount. By using this strategy we can overcome the city waste by installing anaerobic plant which provide us biogas by taking waste.

References

Abraham, A., A.K. Mathew, H. Park, O. Choi, R. Sindhu, B. Parameswaran, A. Pandey, J.H. Park and B.I. Sang. 2020. Pretreatment Strategies for Enhanced Biogas Production from Lignocellulosic Biomass. Bioresour. Technol. 122725.

Deressa, L., S. Libsu, R. Chavan, D. Manaye and A. Dabassa. 2015. Production of Biogas from Fruit and Vegetable Wastes Mixed with Different Wastes. Environ Ecol Res. 3:65-71.

El-Din, G.A., A. Amer, G. Malsh and M. Hussein. 2018. Study on the Use of Banana Peels for Oil Spill Removal. Alex. Eng. J. 57:2061-2068.

Gandhi, P., S. Kumar, K. Paritosh, N. Pareek and V. Vivekanand. 2019. Hotel Generated Food Waste and its Biogas Potential: A Case Study of Jaipur City, India. Waste Biomass Valorization, 10:1459-1468.

Gumisiriza, R., J.F. Hawumba, A.S.P. Balyeidhusa, M. Okure and O. Hensel. 2019. Processing of East African Highland Green Bananas: Waste Generation and Characterization as a Potential Feedstock for Biogas Production in Uganda. Am. Sci. Res. J. Eng., Technol., Sci. 53:215-236.

Hoornweg, D. and P. Bhada-Tata. 2012. What a Waste: A Global Review of Solid Waste Management.

Housagul, S., U. Sirisukpoka, S. Boonyawanich and N. Pisutpaisal. 2014. Biomethane Production from Co-Digestion of Banana Peel and Waste Glycerol. Energy Procedia. 61:2219-2223.

Kumar, S., L.C. Malav, M.K. Malav and S.A. Khan. 2015. Biogas Slurry: Source of Nutrients for Eco-Friendly Agriculture. Int. J. 2:42-46.

Laperrière, W., B. Barry, M. Torrijos, B. Pechiné, N. Bernet and J. Steyer. 2017. Optimal Conditions for Flexible Methane Production in a Demand-Based Operation of Biogas Plants. Bioresour. Technol. 245:698-705.

Laskri, N., O. Hamdaoui and N. Nedjah. 2015. Experimental Factors Affecting the Production of Biogas During Anaerobic Digestion of Biodegradable Waste. Int J Environ Sci Te, 6:451.

Liu, W.-Y. and B. Liao. 2019. Anaerobic Co-Digestion of Vegetable and Fruit Market Waste in Lbr+ Cstr Two-Stage Process for Waste Reduction and Biogas Production. Appl. Biochem. Biotechnol. 188:185-193.

Mago, M., A. Yadav, R. Gupta and V. Garg. 2021. Management of Banana Crop Waste Biomass Using Vermicomposting Technology. Bioresour. Technol. 124742.

Mursec, B., P. Vindis, M. Janzekovic, M. Brus and F. Cus. 2009. Analysis of Different Substrates for Processing into Biogas. J. Achiev. 37:652-659.

Palacios-Ponce, S., A. Ilyina, R. Ramos-González, H.A. Ruiz, J.L. Martínez-Hernández, E.P. Segura-Ceniceros, M.A. Aguilar, O. Sánchez and C.N. Aguilar. 2017. Bioproducts Obtained from the Bioprocessing of the Banana Peel Waste: An Overview. In Applied Chemistry and Chemical Engineering, Apple Academic Press, 5:223-250.

Patowary, D. and D. Baruah. 2018. Effect of Combined Chemical and Thermal Pretreatments on Biogas Production from Lignocellulosic Biomasses. Ind Crops Prod. 124:735-746.

Pei, P., C. Zhang, J. Li, S. Chang, S. Li, J. Wang, M. Zhao, J. Li, M. Yu and X. Chen. 2014. Optimization of Naoh Pretreatment for Enhancement of Biogas Production of Banana Pseudo-Stem Fiber using Response Surface Methodology. Bioresources. 9:5073-5087.

Rehman, A., Z. Deyuan, I. Hussain, M.S. Iqbal, Y. Yang and L. Jingdong. 2018. Prediction of Major Agricultural Fruits Production in Pakistan by Using an Econometric Analysis and Machine Learning Technique. International Journal of Fruit Science. 18:445-461.

Safar, K.M., M.R. Bux, U.M. Aslam, B.K. Muhammad and M.S. Ahmed. 2019. Analysis of The Feasibility of Fruit and Vegetable Wastes for Methane Yield Using Different Substrate to Inoculum Ratios at Hyderabad, Sindh, Pakistan. J. Mater. Cycles Waste Manag. 21:365-374.

Shah, A.A., S. Qureshi, A. Bhutto and A. Shah. 2011. Sustainable Development Through Renewable Energy - The Fundamental Policy Dilemmas of Pakistan. Renew. Sust. Energ. Rev. 15:861-865.

Saha, S., M.B. Kurade, M.M. El-Dalatony, P.K. Chatterjee, D.S. Lee and B.H. Jeon. 2016. Improving Bioavailability of Fruit Wastes Using Organic Acid: An Exploratory Study of Biomass Pretreatment for Fermentation. Energy Convers. Manage. 127:256-264.

Sohoo, I., M. Ritzkowski, J. Heerenklage and K. Kuchta. 2021. Biochemical Methane Potential Assessment of Municipal Solid Waste Generated in Asian Cities: A Case Study of Karachi, Pakistan. Renewable and Sustainable Energy Reviews. 135:110175.

Tisserant, A., S. Pauliuk, S. Merciai, J. Schmidt, J. Fry, R. Wood and A. Tukker. 2017. Solid Waste and the Circular Economy: A Global Analysis of Waste Treatment and Waste Footprints. Journal of Industrial Ecology. 21:628-640.

Van der Sloot, H., D. Kosson and A. Van Zomeren. 2017. Leaching, Geochemical Modelling and Field Verification of a Municipal Solid Waste and a Predominantly Non-Degradable Waste Landfill. J. Waste Manag. 63:74-95.

Viswanath, P., S.S. Devi and K. Nand. 1992. Anaerobic Digestion of Fruit and Vegetable Processing Wastes for Biogas Production. Bioresour. Technol. 40:43-48.

Vogt, J. and K.R. Nunes. 2014. Recycling Behaviour in Healthcare: Waste Handling at Work. Ergonomics. 57:525-535.

Zheng, Y., J. Zhao, F. Xu and Y. Li. 2014. Pretreatment of Lignocellulosic Biomass for Enhanced Biogas Production. Prog. Energy Combust. Sci. 42:35-53.

Cite The Article: Atif Zahoor, Ch Arslan, Muhammad Asad Tahir, Zia Ur Rahman Farooqi, Muhammad Shoaib, Muhammad Saqlain, Muhammad Safdar, Noman Ahmad (2021). Effect of Temperature on Biogas Production Potential of Banana Peels Co Digested With Biogas Slurry in Anaerobic Bioreactor. *Engineering Heritage Journal, 5(2): 49-52*.