Evaluation of biogas production from manure of hybrid and local breed cows fed with different types of feeding practices

Md. Enamul Haque¹, Roman Ryndin², Heinz-Peter Mang², Humayun Kabir³, Mohummad Muklesur Rahman¹, A. K. M. Khasruzzaman¹, Mohammad Asir Uddin¹ and Md. Alimul Islam¹*

¹Department of Microbiology and Hygiene, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.
²Centre of Sustainable Environmental Sanitation, University of Science and Technology Beijing (USTB), China.
³Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

Accepted 22 January, 2021

ABSTRACT

This study aimed to evaluate the biogas production from the manure of hybrid and local breed cows fed with different types of feeding practices. The feedstock and digestive composition were measured to determine their effects on biogas production. The batches were prepared from manure of hybrid and local breed cows fed with roughages and mixed ration (roughages and concentrate) adding inoculum (I) and with a total weight of 200 g. Four experimental groups (T1, T2, T3 and T4) were set up using mixing ratios of CM: H2O: I (25: 25: 50). The digesters were set up at ambient temperature for 40 days of Hydraulic Retention Time (HRT) using a water displacement method to monitor biogas production in the prototype digesters. The biogas yield from the manure was found 250.90 Nml/g VS for T1, 176.50 Nml/g VS for T2, 208.25 Nml/g VS for T3 and 180.88 Nml/g VS for T4, respectively. The average CH4 and CO2 concentration (% vol.) in biogas were found 53% and 47% for T1, 55% and 45% for T2, 52% and 48% for T3, 53% and 47% for T4, respectively. The content of H2S was not found in this study. The study concluded that the overall biogas production was higher in the manure of hybrid cows fed with roughages. However, the biogas production was also higher in the manure of local breed cows fed with roughages than mixed ration. The results indicated that C, N, P, K and S values were relatively lower in this study.

Keywords: Biogas, CH4, hybrid and local breed cows, prototype digester, HRT.

INTRODUCTION

Bangladesh is a densely populated country with an estimated about 165 million population (Worldometer, 2021). The annual Gross Domestic Product (GDP) growth rate of Bangladesh is 8.2% (Trading Economics, 2020). About 75% of people in Bangladesh live in rural areas and use traditional stoves for cooking their three meals daily and other heating purposes. About 30% of rural people have access to national grid electricity where the quality of service is unreliable and electricity is 23%. Less than 10% of households have natural gas connections via national pipelines, but unfortunately, remote and rural areas have no natural gas access (Chakrabarty et al., 2013). Barnes et al. (2011) reported that 58% of the rural families in the country are officially "energy poor" (i.e., utilization of modern energy services per capita is very low), with the shortage of access to even necessary energy facilities. In Bangladesh, 70% of electricity is generated from natural gas (Halder et al., 2016). Bangladesh has a very insufficient energy reserve. To overcome the present situation, finding alternative sources of renewable energy is the only option. Biogas is one of the essential promising renewable energy resources for Bangladesh, mainly from animal manure and municipal waste (Uddin et al., 2018).
Anaerobic digestion (AD) is a biological process used for anaerobic digestion of organic matter like livestock manure and agriculture residues into clean, renewable energy and organic fertilizer. AD is a series of complex microbiological processes where diverse types of aerobic and anaerobic bacteria work in four different stages: hydrolysis, acidogenesis, acetogenesis and methanogenesis (Gonzalez-Fernandez et al., 2015). These bacteria are susceptible to environmental conditions, and it is essential to balance a range of factors to maximize the chances of achieving optimum design and efficient operation (Mao et al., 2015).

Biogas is typically composed of 50 to 70% methane (CH₄), 30 to 50% carbon dioxide (CO₂), and trace amounts of H₂S and other gases. Biogas is a clean, efficient, and renewable source of energy that offers a multi-purpose carrier of energy that can be used as a substitute for other fuels (like firewood and cattle dung) currently used in rural areas (Bond and Templeton, 2011).

Cow manure (CM) is one of the most common substrates for biogas production in the AD process. The CM contains enormous amounts of polysaccharides, lignocelluloses, proteins, and other biomaterials (Jingura and Kamusoko, 2017). Biogas production from manure can be increased through several mechanisms. If the manure fibers are decreased, the biogas yield in manure increases by 30% (Angelidaki and Ahring, 2000).

This study’s objective was evaluation of biogas production from the manure of hybrid and local breed cows fed with roughages and mixed ration (roughages and concentrate) adding manure (25%) and with with a total weight of 200 g. In the batch T1, (25%) manure collected from hybrid cow with manure collected from (25%) mixed ration (roughages) and concentrate) adding manure (25%) and (50%) and (100%). In the batch T2, (25%) manure collected from hybrid cow with manure collected from (25%) mixed ration (roughages and concentrate) adding manure (25%) and (50%) and (100%). However, in the batch T3, (25%) manure collected from local breed cow with manure collected from (25%) mixed ration (roughages and concentrate) adding manure (25%) and (50%) and (100%). Whereas in the batch T4, (25%) manure collected from local breed cow with manure collected from (25%) mixed ration (roughages and concentrate) adding manure (25%) and (50%) and (100%). (Table 1). The digesters were set up at ambient temperature for 40 days of HRT.

Collection and measurement of biogas

Biogas generated in the digesters was transported by a rubber hose pipe into graduated cylinders and displaced the graduated cylinders’ water. The volume of the headspace of the graduated cylinders represented the volume of biogas generated in the digester. The biogas was collected from the graduated cylinder using another hose pipe and a 100 ml gas-tight plastic syringe. When not in use, this tube was sealed with a clip.

Analytical methods

Total Solid (TS) and Volatile Solids (VS) were analyzed by using a muffle furnace (Model: JSMF-30T, JSR, China) according to standard methods of DROQ (2013). The feedstock and digested effluent pH were measured using an electronic pH meter (PHS-25, pH meter, Shanghai, China). The nitrogen was determined by the micro-Kjeldahl method as described in Pearson (1976) and carbon was determined by the Walkley-Black method (Walkley and Black 1934). The concentration of phosphorus and potassium was determined by Vanadomolybdo-Phosphoric yellow color method in the nitric acid and flame emission spectrophotometer methods described by Jackson (1962). The concentration of sulfur was determined by the Turbidimetric method, according to Hart (1961). The digested samples were centrifuged at 10,000 g for 10 minutes and assess the accumulation rate of Volatile fatty acids (VFA) according to Liebetrau et al. (2016). Total Volatile fatty acids of the samples’ liquid portion were determined by Kappus (1984) three-point-titration method. The temperature was recorded daily using Thermo Hygrometer (Model NO DO 2001, Conrad Electronic) and the digester temperature were also recorded using a portable...
Haque et al.               3

Figure 1. Experimental set up of lab-based prototype biogas digester by water displacement method with different parts.

Table 1. Mixing ratios of the substrate in hybrid and local breed CM with inoculum.

| Experimental batches | Mixing ratio (% wt.) | Weight (g) |
|----------------------|----------------------|------------|
| T1                   | CM (25%), H₂O (25%), I (50%) | 200        |
| T2                   | CM (25%), H₂O (25%), I (50%) | 200        |
| T3                   | CM (25%), H₂O (25%), I (50%) | 200        |
| T4                   | CM (25%), H₂O (25%), I (50%) | 200        |

CM - Cow manure; I – inoculum.

The composition of biogas (methane and carbon dioxide, % vol.) was analyzed using a portable biogas analyzer gas board-3200P. The H₂S gas was measured using Sulphide detector tubes (Hebixinxing, China, range = 100-1000 ppm) and portable gas dragger syringes. All the data obtained from the three replications of four treatment batches in this study were recorded in MS excel sheet (MS-2019) and determined the average value, cumulative average value and graphical analysis.

RESULTS AND DISCUSSION

Feedstock characteristics of hybrid and local breed CM

The pH value for manure of Hybrid Cow fed with Roughage (HCR), Hybrid Cow fed with Mixed ration (HCM), Local Cow fed with Roughage (LCR) and Local Cow fed with Mixed ration (LCM) was measured 7.3, 7.1, 7.0 and 7.0, respectively (Table 2). The pH value was indicated within the neutral range. Jingura and Kamusoko (2017) have reported that the optimal pH range for obtaining maximal biogas yield was 6.5 to 7.5. Weinfurtner (2011) also noted that the range for CM pH was 6.2 to 8.8.

The TS content was found 12% for HCR, 20% for HCM, 15% for LCR and 24% for LCM (Table 2). The TS values were found within the reported range 12-25% for CM described by Korres et al. (2013); FNR (2010) and Bioenergy (2013). However, the VS/TS content was 83% for HCR, 70% for HCM, 80% for LCR and 83% for LCM. The finding of this study was related to other studies. Vogeli et al. (2014) reported that the accepted range of VS/TS content was 70 to 90%. Korres et al. (2013) and Bioenergy (2013) also found that the VS content of TS was 70 to 80% for CM.

The C: N ratio for HCR, HCM, LCR and LCM was found 40:1, 41:1, 41:1 and 32:1, respectively (Table 2). The C: N ratio of HCR, HCM and LCR was relatively higher than reported in the previous studies. Korres et al. (2013) and FAO (2015) reported that the C: N ratio of feedstock was found 6:1–32:1. The optimal range of C: N ratio was 10:1 to 30:1, higher C: N could mean that all the carbon cannot entirely be converted and the maximum methane yield eventually not achieved (FNR, 2010). According to Braun (1982), C:N ratios were acceptable in the range from 10:1 to 45:1, which means all substrates are within the range and it might be expected lower biogas yield but higher methane composition. The
The TS content of manure from hybrid and local breed cows fed with roughages and mixed ration

| Parameters          | Hybrid cow fed with roughages (HCR) | Hybrid cow fed with mixed ration (HCM) | Local breed cow fed with roughages (LCR) | Local breed cow fed with mixed ration (LCM) |
|---------------------|-------------------------------------|----------------------------------------|----------------------------------------|------------------------------------------|
| pH                  | 7.3                                 | 7.1                                    | 7.0                                    | 7.0                                      |
| TS (% wt.)          | 12                                  | 20                                     | 15                                     | 24                                       |
| VS (% wt.)          | 10                                  | 14                                     | 12                                     | 20                                       |
| VS/TS (% wt.)       | 83                                  | 70                                     | 80                                     | 83                                       |
| C (% wt.)           | 37.5                                | 38.30                                  | 37.50                                  | 38.90                                    |
| N (% wt.)           | 0.94                                | 0.94                                   | 0.92                                   | 1.20                                     |
| C: N ratio          | 40:1                                | 41:1                                   | 41:1                                   | 32:1                                     |
| P (% wt.)           | 0.614                               | 1.860                                  | 0.588                                  | 0.790                                    |
| K (% wt.)           | 0.942                               | 0.933                                  | 0.686                                  | 0.713                                    |
| S (% wt.)           | 0.190                               | 0.174                                  | 0.171                                  | 0.194                                    |

TS - Total solid; VS - Volatile solid; C - Carbon; N - Nitrogen; P - Phosphorus; K - Potassium; S – Sulphur.

The pH values for all inoculated batches (T1, T2, T3 and T4) were measured ranging from 7.0 to 7.5 (Table 3). The pH values of all inoculated batches were laid within an acceptable range. This range of pH was ideal for methanogenic bacteria to produce a high amount of biogas. For optimal performance of microbes, the digester's pH should be kept in the range of 6.8 to 8.0 (Sreekrishnan et al., 2004). According to Liu et al. (2008) the most favorable pH range to attain maximal biogas yield in anaerobic digestion is 6.5 to 7.5.

The TS content of T1, T2, T3 and T4 batches were 7, 10, 8 and 10%, respectively (Table 3). The TS content was slightly lower than the previously reported value. Korres et al. (2013) have found that the TS content was 12 to 25% for CM. Moreover, the VS/TS content of T1, T2, T3 and T4 batches were 71, 60, 75 and 80%, respectively (Table 3). The VS/TS content was slightly lower in T2 batches than the previously reported value. Korres et al. (2013) and Bioenergy, (2013) have found the VS/TS values were 70 to 80% for CM.

For all inoculated batches, the C:N ratio was found within the acceptable range 32:1 to 40:1 (Table 3). According to Bischofberger et al. (2005), the acceptable range of C: N ratio was 10:1 to 45:1. The ideal range of C: N ratio was 10:1 to 30:1 for optimum and sustainable biogas production (FNR, 2010). The high content of carbon was present in the substrate that may lead to lower biogas yield.

All the batches were observed over a specified period of 40 days HRT. The batch experiment was conducted at a mesophilic temperature range between 27.3 to 31.7°C, with a median temperature of 29°C. Vogeli et al. (2014) have reported that methanogenic archaea were active at mesophilic conditions.

Comparison of biogas and methane yield of different experimental batches

The results of cumulative biogas and methane yield from the manure of hybrid and local breed cow fed with roughages and mixed ration during the experiment were expressed in Nml. The cumulative biogas from the manure was found 2509 Nml for T1, 2118 Nml for T2, 2499 Nml for T3 and 2894 Nml for T4, respectively (Figure 2). The biogas yield from the manure was found 250.90 Nml/g VS for T1, 176.50 Nml/g VS for T2, 208.25 Nml/g VS for T3 and 180.88 Nml/g VS for T4, respectively. The biogas yield was closely related to the previous study except in T1 batch experiment. Budiyono et al. (2010) found that the best performance for biogas production in the digester with 7.4 and 9.2% of TS i.e., give biogas yield 184.09 and 186.28 ml/g VS, respectively. The overall biogas yield was comparatively higher in T1 batch than the other three batches. The biogas yield was higher in T1 batch this might be due to the substrate contains adequate VS/TS and C: N ratio. Whereas, the cumulative methane yield was found 1330 Nml for T1, 1165 Nml for T2, 1400 Nml for T3 and 1523 Nml for T4, respectively (Figure 3). The values of
Table 3. Batch characteristics of hybrid and local breed CM.

| Experimental batches | pH  | TS (%) | VS (%) | VS/TS (%) | C (%) | N (%) | C: N |
|----------------------|-----|--------|--------|-----------|-------|-------|------|
| T1                   | 7.5 | 7      | 5      | 71        | 19.54 | 0.64  | 30:1 |
| T2                   | 7.0 | 10     | 6      | 60        | 19.62 | 0.48  | 40:1 |
| T3                   | 7.0 | 8      | 6      | 75        | 19.38 | 0.48  | 40:1 |
| T4                   | 7.0 | 10     | 8      | 80        | 20.34 | 0.59  | 35:1 |

TS - Total solid; VS - Volatile solid; C - Carbon; N - Nitrogen.

Figure 2. Cumulative biogas yield of different experimental batches.

Figure 3. Cumulative methane yield of different experimental batches.
Comparison in biogas production between T1 and T2 experimental batches

The biogas production was started on day 2 of both T1 and T2 experimental batches. The cumulative biogas was found 2509 Nml for T1 and 2118 Nml for T2 batch (Figure 4). The volume of biogas produced was higher in T1 treatment batch than T2. The highest volume of biogas produced in batch T1 was 178 Nml on day 9 and in batch T2 240 Nml on day 11. In general, the gas volume produced by group T1 from day 2 until day 40 was higher than that of group T2. Average gas production per day in treatment group T1 was also higher (62 Nml) compared to that of group T2 (52 Nml). The biogas production was higher in T1 batch this might be due to the substrate contains optimum C: N ratio.

Comparison in biogas production between T3 and T4 experimental batches

The biogas production was started on day 5 for T3 and day 3 for T4 experimental batches. The cumulative biogas was found 2499 Nml for T3 and 2894 Nml for T4 batch (Figure 5). The volume of biogas produced was higher in T4 batch than T3. The highest volume of biogas produced in batch T3 was 144 Nml on day 29 and in batch T4 186 Nml on day 14 and in general, the gas volume produced by group T4 from day 3 until day 40 was higher than that of group T3. Average gas production per day in treatment group T4 was also higher (72 Nml) compared to that of group T3 (62 Nml). The biogas production was higher in T4 batch this might be due to contains adequate amount of VS/TS content and C: N ratio in the substrate.

Figure 4. Biogas production between T1 and T2 experimental batches.

Figure 5. Biogas production between T3 and T4 experimental batches.
Biogas composition of different experimental batches

The average CH\textsubscript{4} and CO\textsubscript{2} concentration (% vol.) in biogas were found 53 and 47% for T1, 55 and 45% for T2, 52 and 48% for T3, 53 and 47% for T4, respectively. The content of H\textsubscript{2}S was not found in this study. However, the concentration of CH\textsubscript{4} and CO\textsubscript{2} in this study's biogas was closely agreed with other studies' findings. Haryanto et al. (2018) have conducted the experiment using a lab-scale self-designed anaerobic digester of 36-L capacity with the substrate of a mixture of fresh cow dung and water at a ratio of 1:1. They have reported that the concentration of CH\textsubscript{4} and CO\textsubscript{2} was 41.73 to 57.23% and 31.13 to 39.04%, respectively.

Digestive characteristics of hybrid and local breed CM

After 40 days of digestion, the substrate was analyzed once more for determining the composition. The digestive pH value of all batches was within a suitable range (6.7 to 7.2) for producing methanogenic microorganisms (Table 4). FNR (2010) reported that the favorable range of pH was found 6.5 to 8.0 for producing methanogenic microorganisms in the digester.

The C: N ratio of T1, T2, T3 and T4 batches were found 23:1, 24:1, 41:1 and 44:1 respectively (Table 4). According to Bischofsberger et al. (2005), the acceptable range of C: N ratio was 10:1 to 45:1. The C: N ratio adjustment for batches within time closer to the ideal range (10:1 to 30:1) than the batch characteristic might indicate that the carbon was utilized faster than N.

The C, N, P, K and S content of all batches were found ranging from 1.71 to 2.29%, 0.05 to 0.08%, 0.03 to 0.07%, 0.05 to 0.09% and 0.01%, respectively (Table 4). The results indicated that C, N, P, K and S values were relatively lower than other studies. Islam (2006) reported that the N, P, K and S content in CM slurry were 1.23 ± 0.05%, 0.03 ± 0.01% and 0.01%, respectively. The VFA concentration of all batches was found within an acceptable range from 56 to 131 mg/L (Table 4). Bioenergy (2013) reported that the ideal concentration of VFA was found below 1000 mg/L stable for biogas production.

| Experimental batches | pH   | C (% wt.) | N (% wt.) | C: N ratio | P (% wt.) | K (% wt.) | S (% wt.) | VFA (mg/L) |
|----------------------|------|-----------|-----------|------------|-----------|-----------|-----------|------------|
| T1                   | 6.8  | 1.71      | 0.08      | 23:1       | 0.03      | 0.09      | 0.01      | 65         |
| T2                   | 6.7  | 2.04      | 0.08      | 24:1       | 0.05      | 0.08      | 0.01      | 131        |
| T3                   | 7.2  | 2.10      | 0.05      | 41:1       | 0.04      | 0.05      | 0.01      | 67         |
| T4                   | 6.7  | 2.29      | 0.05      | 44:1       | 0.07      | 0.07      | 0.01      | 56         |

TS - Total solid; VS - Volatile solid; C - Carbon; N - Nitrogen; P - Phosphorus; K - Potassium; S - Sulphur; VFA - Volatile fatty acid.

CONCLUSION

The finding of this study concluded that the biogas yield was higher in the manure of hybrid fed with roughages than mixed rations. However, the biogas production was higher in local breed cows fed with mixed rations. The overall finding of this study found that the biogas yield was comparatively higher in the manure of hybrid cows fed with roughages compared to that of other three treatment groups. In this study, the nutrient (N, P, K and S) concentration was found low in the digestive of hybrid and local breed cows.

ACKNOWLEDGMENTS

The author would like to express their sincere thanks and gratitude to the World Bank-IDCOL, Bangladesh for financial support to conduct this research work (package No: S-32, Ref No.: IDCOL/REREDPII/S-32/2015/03). The author also extended their thanks and gratitude to the authority of the University of Science and Technology Bangladesh, China for providing technical support throughout conducting the research by supplying necessary instruments, chemicals, and equipment for the measurement and analysis of the different compositions of biogas in this study.

REFERENCES

Angelidaki I, Ahring BK, 2000. Methods for increasing the biogas potential from the recalcitrant organic matter contained in manure. Water Sci Technol, 41(3): 189–194.

Barnes DF, Khandker SR, Samad HA, 2011. Energy poverty in rural Bangladesh. Energy Policy, 39(2): 894-904.

Bioenergy IEA, 2013. The biogas handbook: Science, Production, and Applications. Cambridge: Woodhead Publishing Limited.

Bischofsberger W, Dichtl N, Rosenwinkel KH, Seyfried CF, Böhnke B, 2005. Anaerobic technology. 2nd Ed. Berlin Heidelberg, Springer-Verlag. ISBN 978-3-540-26593-1.

Bond T, Templeton MR, 2011. History and future of domestic biogas plants in the developing world. Energy Sustain Dev, 15(4): 347-54.

Braun R, 1982. Biogas - Methangarung organischer Abfallstoffe. 1st Ed. Springer, Vienna. ISBN 978-3-7951-8675-6.

Budiyono, Widiasa IN, Johari S, Sunarso, 2010. The Influence of Total Solid Contents on Biogas Yield from Cattle Manure Using Rumen
Fluid Inoculum. Science Publications, Energy Research Journal, 1: 6-11.

Chakrabarty S, Boksh FM, Chakraborty A. 2013. Economic viability of biogas and green self-employment opportunities. Renew Sustain Energy Rev, 28: 757-66.

Dros B, 2013. Process monitoring in biogas plants. IEA Bioenergy. ISBN 978-1-910154-03-8.
e.Gen Consultants Ltd., 2015. Biogas Generation and Demand Survey in Bangladesh. JICA.

Trading Economics, 2020. Bangladesh GDP Annual Growth Rate. https://trading.economics.com/bangladesh/gdp-growth-annual?user=analyst35099 (Accessed on January 15, 2021).

FAO, 2015. Farmer’s Compost Handbook: Experiences in Latin America. Santiago: Food and Agriculture Organization of the United Nation.

FNRR, 2010. Guide to Biogas from Production to Use. Gulzow: Fachagentur Nachwachsende Rohstoffe e.V.

Gonzalez-Fernandez C, Silave B, Molinuevo-Salces B, 2015. Anaerobic digestion of microalgal biomass: challenges, opportunities and research needs. Bioresour Technol, 198: 896-906.

Halder PK, Paul N, Joardder MU, Khan MZ, Sarker M, 2016. Feasibility analysis of implementing anaerobic digestion as a potential energy source in Bangladesh. Renew Sustain Energy Rev, 65:124-34.

Hart MGR, 1961. A turbidimetric method for determining elemental sulphur. Analyst, 86 (1024): 472-475.

Haryanto A, Triyono S, Wicaksono NH, 2018. Effect of hydraulic retention time on biogas production from cow dung in a semi continuous anaerobic digester. International J Renew Sustain Ener, 7(2): 93.

Islam MS, 2006. Use of bio-slurry as organic fertilizer in Bangladesh agriculture. Prepared for the presentation at the international workshop on the use of bio-slurry domestic biogas program, Sep 27, Bangkok, Thailand, pp: 3-16.

Jackson ML, 1962. Soil chemical analysis, constable and Co. Ltd. London, 497.

Jingura RM, Kamusoko R, 2017. Methods for determination of biomethane potential of feedstocks: a review. Biofuel Res J, 4(2): 573-586.

Kapp H, 1984. Sludge digestion with high solids content. Stuttgart Reports on urban water management. Oldenbourg Verlag, Munich 96, 200.

Korres N, OKiely P, Benzie JA, West JS, 2006. Bioenergy production by anaerobic digestion: using agricultural biomass and organic wastes. 1st Ed. Routledge, United Kingdom.

Liebetrau J, Pfeiffer D, Thran D, 2016. Collection of Methods for Biogas: Methods to determine parameters for analysis purposes and parameters that describe processes in the biogas sector. Biomass Energy Use, 7, DBFZ, Leipzig, Germany.

Liu CF, Yuan XZ, Zeng GM, Li WW, Li J, 2008. Prediction of methane yield at optimum pH for anaerobic digestion of organic fraction of municipal solid waste. Bioresour Technol, 99(4): 882-888.

Mao C, Feng Y, Wang X, Ren G, 2015. Review on research achievements of biogas from anaerobic digestion. Renew Sust Energ Rev, 45: 540-55.

Naher MS, Paul AK, 2017. Effect of integrated nutrient management on nutrient uptake and sustainable grain yield in transplanted aman rice. SAARC J Agric, 15(1): 43-53.

Pearson D, 1976. The Chemical Analysis of Foods, Longman Group Ltd.: Harlow, U.K.

Sreekrishnan TR, Kohli S, Rana V, 2004. Enhancement of biogas production from solid substrates using different techniques—a review. Bioresour Technol, 95(1):1-10.

Trading Economics, 2020. Bangladesh GDP Annual Growth Rate. https://trading.economics.com/bangladesh/gdp-growth-annual?user=analyst35099

Uddin MM, Faysal A, Rahian MR, Jahangir KM, 2018. Present Energy Scenario, Necessity and Future Prospect of Renewable Energy in Bangladesh. Am J Eng Res, 7, 45-51.

VDI 4630, 2006. Fermentation of organic materials-characterization of the substrate, sampling, collection of material data, fermentation tests, VDI Guideline 4630. Verein Deutscher Ingenieure, Dusseldorf.

Vogell Y, Lohri CR, Gallardo A, Diener S, Zurbrugg C, 2014. Anaerobic digestion of biowaste in developing countries. Practical information and case studies. Swiss Federal Information of Aquatic Science and Technology (Eawag), Dubendorf, Switzerland. ISBN-978-3-906484-58.7.

Walkley A, Black IA, 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci, 37: 29-38.

Weinfurter K, 2011. Matrix parameters and storage conditions of manure. Dessau-Roßlau: Federal Environment Agency (Umweltbundesamt). https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4054.pdf (Accessed on November 27, 2020).

Worldometer, 2021. https://www.worldometers.info/world-population/bangladesh-population/ (Accessed on January 15, 2021).

Citation: Haque E, Ryndin R, Mang H-P, Kabir H, Rahman MM, Khasruzzaman AKM, Uddin MA, Islam A, 2021. Evaluation of biogas production from manure of hybrid and local breed cows fed with different types of feeding practices. Net J Agric Sci, 9(1): 1-8.