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Prospective of energy reclamation and electricity production from butchery wastes in Malaysia

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ABSTRACT

Energy reclamation and electricity production from butchery wastes has been studied for countering both energy wants and ecological contamination issues. Anaerobic degradation was performed in a 9 L reactor for 29 days at amesophilic state. The biogas amount was determined regularly after 24 hours intermission. Biogas and methane production was considered to find the equivalent electricity amount. Daily mean and cumulative biogas production of 0.00201 m^3 /kg VS and 0.022 m^3 /kg VS were achieved with 64% methane content. These results suggested that 1041 MWh and 1665 MWh of power may be produced from gas with lower and higher exchange efficiency. This work suggested that waste-to-energy technique if properly applied will be a feasible resolution to energy needs in Malaysia.

Key words : *Butchery waste; Biogas, Energy, Electricity*

Introduction

Energy need in Malaysia has driven focus to the necessity of research for alternate resources of power to counterpart the remnant gasoline (Abdelsalam *et al*., 2019). This need was significantly enhanced for the increasing rate of mechanization, populace, and urbanization (Adam *et al*., 2019). Accessibility of continuous power supply for farming and manufacturing is a key need for infrastructural growth (AR Syukor, 2015). Intake of power is an indicator of the rate of improvement of any country as it subsidizese normously to the financial development (Islam Siddique *et al*., 2020). Recently, power intake in Malaysia has been increased (Fig. 1). In addition, dependency on gasoline as the key resource of energy was indicated to be a reason for the universal climate amendment and ecological pollutions (Khalid *et al*., 2019). In the villages of Malaysia, the availability of gasoline posts a huge encounter for cost involvement (Krishnan *et al*., 2017). Consequently, a substitute for the power resource has become essential (Nasrullah, 2014). Green technologies efficiently utilize ordinary materials that can be restocked (Siddique, 2016). In recent times, enhanced flesh demand has increased the amount of butchery-houses in Malaysia (Md Nurul Islam Siddique, 2019). These activities have increased the number of butchery wastes. These wastes have become a huge threat to effective ecological conservation (Md Siddique, 2018). The degradation of the butchery wastes can lead to the depletion in air quality and contamination of numerous infectious microorganisms (Md. Nurul Islam Siddique, and Sakinah, 2014a). According to the study of (Md. Nurul Islam Siddique and Sakinah, 2014b) Malaysia produces about 85.85 kg/day of animal wastes. One kg of animal wastes is capable of generating 0.029 m^3 of gas/ day (Md. Nurul Islam Siddique and Zularisam, 2014). In general, a butchery house produces approximately 3881 kg of butchery waste per day (Md. Nurul Islam Siddique, 2012). Numerous works reported that a lot of wastes wereproduced from butchery houses in Malaysia per day and the hostile consequence of this activity on the human community (Md. Nurul Islam Siddique, 2012). Hence, research to utilize these waste into bio-energy by an anaerobic process is necessary (Mimi Sakinah Lakhveer Singh, 2012). The produced gas by this process has a CH_4 content of 60-69% that makes itself a significant gasoline resource (MNI Siddique, 2013). MNI Siddique, (2018) reported that crop residues produce 0.4-0.57 m^3 gas from the anaerobic process. (MNI Siddique, M Munaim, AW Zularisam, 2013b) studied that papaya residues produce 0.19 m^3 biogas per month cumulatively. Likewise, co-digestion of cattle manure and lemon makes 0.15 m^3 of biogas from the anaerobic system after a month was reported by (MNI Siddique, MSA Munaim, AW Zularisam, 2013). Several other researchers have investigated anaerobic digestion anaerobic mesophilic state digestion has been studied and established to be a promising process by many scientists (MNI Siddique *et al*., 2013a). Huge amounts of butchery wastes being generated by butchery-houses regularly along with related contaminations (MNI SIddique, 2014). Hence, power emergencies in developing states and the lack of data about the application of butchery waste into biogas generation have been highlighted in the present work. The generation of biogas using butchery wastes can be a solution to the waste dumping issues and the energy demand in Malaysia (NI Siddique, 2012). The aim of the present work was to evaluate the feasibility of butchery wastes for energy retrieval and power production that may contribute to the national grid. The proposed electricity production was assessed on the basis of gas generated daily and the number of the animal slaughtered in Malaysia daily.

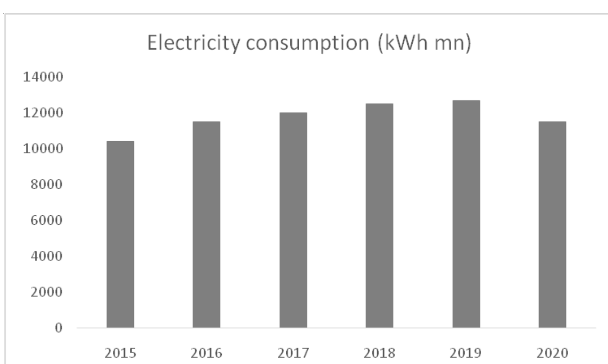

Fig. 1. Energy consumption trend in Malaysia (2015–2020)

Materials

Substrates and seeding

Butchery waste utilized for this work was taken from a butchery house in Terengganu, Malaysia. The sludge of the substrate was acquired by blending it with distilled water in a proportion of 3:1:2. The inoculum was taken from the sludge. The crisp rumen of suitable microbes necessary for the anaerobic process was supplemented to the inoculum. The Properties of substrates and inoculum have been listed in Table 2.

Characterization

Before the anaerobic process, wastewater should be sufficiently characterized (Siddique (2012). Therefore, substrates were analyzed to identify their characteristics. The characteristics of the substrates were determined at the wastewater processing Lab of University Malaysia Terengganu following the standards of APHA, (2015).

Reactor operation

Two sets of 12 liters digester were employed in this work. Both of the digesters were kept sealed with a feeding tank, sample retraction drainage, and a mixing propeller. Approximately 70% of the reactor was fed with sludge and the rest was kept blank for biogas development. The reactor was run for 29 days at a mesophilic state by the batch operation. The produced biogas out of the anaerobic system was monitored regularly using water displacement techniques. Nexis GC-2030 Gas-liquid Chromatograph was used to analyze the biogas. Sulfur Chemiluminescence Detector (10 ft. × 1/8 in.) was used at 130 ^{o}C and helium was the carrier gas.

Potential of the generated biogas

The cooking potential of the generated biogas by the butchery wastewater was assessed according to the process of Odekanle *et al.,* (2020).

Power potential of generated biogas

The power potential of the produced biogas was determined depending on the amount of animal slaughtered per day in Malaysia, biogas production per day, and methane content.

According to the equation of (Odekanle *et al.*, 2020), the power potential of the produced biogas can be calculated by the equation below:

$e_{biogas} = E_{biogas} \times \eta$ (1)

Where, E_{biogas} refers to the unconverted raw energy in the biogas, e_{biogas} refers to the total power which may be produced from biogas and η refers to the overall conversion efficiency.

Results and Discussion

Characterization of butchery wastewater before and after the anaerobic process is shown in Table 1. Post anaerobic moisture percentage of the substrate was greater than that of the pre-digested substrate. In addition, it was accountable for the contrary case of the ash percentage. The total carbon of post digestion time was greater than the pre-digestion time. It ensures a gradual enhancement into the energy resource available for microbes for improved bio-digestibility of the wastewater (Siddique *et al.*, 2015a). Nevertheless, uninterrupted consumption of nitrogen for protein demand results in a decrease of total nitrogen for microbial actions (Siddique *et al.*, 2017). This was established in the enhancement of carbon to nitrogen proportion. Earlier works suggested that the carbon to nitrogen proportion of the present work was efficient for the biogas production (Siddique *et al.*, 2016). Biogas production was started on the seventh day and continued till the fifteenth day and then decreased gradually (Table 2). The initial four days were difficult to adopt with the hydrolysis state of the wastewater. The activity of lignin in the added rumen content that declines the degradation process can be responsible for this (Siddique *et al.*, 2014). In addition, after three days, the pH of the substrate dropped from 6.38 to 6.29 (Table 3). Methanogens do not run smoothly during the hydrolysis state of the anaerobic system (Siddique *et al.*, 2015b). Under this condition, methanogens cannot break down the organic acids. As a result, the accumulation of acids takes place in the system and pH drops. Nevertheless, the rate of acid conversion was significantly enhanced with the increase of the methanogenesis. Moreover, at the starting phase of gas generation, the pH steadily increased and stayed steady at 7. It sustained as the wastewater exhibited a gradual enhancement in pH. Thus, biogas production improved gradually and became a maximum after thirteen days (0.003 m^3 kg VS at a pH of 7.2). At the end of nineteen days development of methanogenesis declined and daily biogas production decreased. It may be due to fact that biogas generations are proportional to the development of methanogens (Siddique and Wahid, 2018). Dailymean and cumulative biogas production of 0.00201 m^3/kg VS and 0.022 m^3/kg VS were attained. Trends of biogas generation from the present work are complying with the earlier works (Siddique *et al.*, 2015). Individual wastewater has individual periods of a maximum gas generation because of the different rates of digestibility. Biogas production of the present work is comparable to the study of (Zaied bin Khalid, 2019). The methane content of this research was observed to be 64%. This methane content was complying with the range of earlier works subjected to the substrates used in the experiment.

Table 1. Characterization of butchery wastewater before and after anaerobic process in percentage (%)

Parameters	Pre-digested	Post-digested
Ash	5.5	12
Total carbon	51	53
Crude fiber	2.3	1.3
Total Nitrogen	2.2	1.5
Crude protein	14.3	9.7
Moisture	75.2	85
C/N	22.5	30

Table 4 indicated that at the consumption rate of 0.00564 m^3/min; the water and the rice boiled at the average rates of 0.04 l/min and 0.00518 kg/min respectively. The outcomes of the combustibility of gas of the present work are in line with the earlier

Table 2. Properties of substrates and inoculum

Parameters	Butchery wastewater	Cattle manure	Inoculumn
pH	6.4 ± 0.2	6.3 ± 0.2	6.7 ± 0.12
Total solids (mg/l)	661 ± 5	633 ± 3	8.99 ± 0.10
volatile solid (mg/l)	535 ± 2.2	574 ± 2.2	9 ± 2.2
volatile solid and soluble oxygendem and (mg COD/l)	690 ± 3	1231 ± 90	161 ± 1.2

works (Odekanle *et al.*, 2020) studied that the cooking potential of biogas from the anaerobic digestion of cattle manure and grass were 0.07 /min and 0.0033 kg/min respectively with a combustibility rate of 0.0048 m^3/min, while co-digestion of the cocoa pod and poultry waste as reported by Picos-Benítez *et al.,* (2019) produced a cooking potential of 0.15 l/min and 0.005 m^3/min respectively, with combustibility rate of 0.0057 m^3/min. The minor difference may be accredited to the variety in the substrates utilized. It indicates that the biogas generated in the present work attained its efficient application as cooking fuel.

The electric energy obtained from the biogas can be used to run large turbines with an average conversion efficiency of 37%, and 26% for tiny generators (Zaied *et al.,* 2019). The assessment has been worked out considering the typical number of the animal slaughtered in Malaysia per day. If 26% conversion efficiency is considered, the projected electric energy which may be produced is 2,991.9 kWh, and if 37% conversion efficiency is considered, it is approximately 4257.66kWh (Equation 1). Therefore, 1092 MWh and 1554 MWh electric energy may be produced annually for running large and tiny generators respectively. According to the study of (Zaied *et al.,* 2020) approximately 227,501 tonnes of raw animal wastes were generating per day in Malaysia, therefore the possibility of power generation washuge. Earlier works reported that about 24 million and 39 million kWh of electric power may be produced from biogas with the efficiency of 25% and 40% respectively from agricultural wastes in Nigeria (Odekanle *et al.,* 2020). The greater amount of electricity production was predicted by the use of co-digestion while the present work uses butchery waste only. Consequently, a higher amount of feed substrates can produce higher biogas and electric power. Similarly, a huge amount of butchery wastes with different substrates can produce higher electric

Table 3. Daily and cumulative biogas yields at different temperatures and pH of the substrate with daily COD, TS and TVS at 30 (°C).

Retention time (days)	pH	COD (mg/l)	TS (mg/l)	TVS (mg/l)	Daily biogas yield (m^3)	Cumulative biogas yield (m^3)
1	6.38 ± 0.04	1900	750	600	-	-
3	6.29 ± 0.04	1730	735	585	-	-
5	6.9 ± 0.03	1500	670	500	-	-
7	7 ± 0.05	1400	630	460	0.0006	0.0009
9	7.1 ± 0.05	1200	580	410	0.0008	0.0025
11	7.1 ± 0.05	1090	560	385	0.002	0.0045
13	7.2 ± 0.03	960	530	550	0.003	0.009
15	7.3 ± 0.04	800	480	315	0.003	0.013
17	7.4 ± 0.03	760	450	290	0.003	0.018
19	7.4 ± 0.03	640	419	270	0.0027	0.03
21	7.4 ± 0.02	560	360	245	0.0025	0.031
23	7.5 ± 0.03	475	320	220	0.0016	0.03
25	7.5 ± 0.03	410	285	190	0.0006	0.04
27	7.6 ± 0.03	380	250	160	0	0.05
29	7.5 ± 0.03	330	195	115	0	0.04

Table 4. Determination of cooking potential of the gas produced

Runs	Volume of water (l)	Quantity of rice (kg)	Volume of gasconsumed (m^3)	Time taken (s)
1	0.4	0.006	0.0056	62
2	0.4	0.0049	0.0057	61
3	0.4	0.005	0.0056	61
4	0.4	0.0048	0.0056	61
5	0.4	0.0052	0.0057	61
Mean	0.4	0.00518	0.00564	61

energy and biogas.

Conclusion

The higher application of energy in Malaysia is leading to a great dependency on gasoline. Therefore, it creates problems like limited access to energy and waste management. If these issues are studied deeply and solved effectively may significantly develop socio-economic evolution in Malaysia. This work examined the feasibility of energy reclamation and electric power production from butchery wastewater to offer solution of both waste minimization issues and energy necessities. Results showed that gas generated from this study had a methane content of 64% that might be used as energy. Considering this gas composition, 1092 MWh and 1554 MWh per annum electric energy were produced with an efficiency of 25% and 40% respectively using only butchery wastewater. This suggests that the profusion of agro wastes may deliver a solution to the asking energy demand of Malaysia. Finally, it can be concluded that green technique, if properly discovered is a feasible solution to energy emergencies in Malaysia.

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