UTILIZATION OF POULTRY MANURE IN BIOGAS PRODUCTION AS AN ALTERNATIVE TO LIQUIEFIED PETROLEUM GAS

[1]

Taha M. A. Razek [(1)]; Amin, N. A.[(2)]
and Ali, Eman, B. A.[(3)]

1) Dept. of Basic science, Institute of environmental studies and research, Ain, Shams University 2) Egyptian Petroleum Research Institute, petrochemicals 3) Petrogas Company

ABSTRACT

Egypt is facing a shortage of traditional fuels. Poultry farms consume a huge amount of liquefied petroleum gas (LPG) cylinders for heating purpose in winter, which affects the needs of the domestic sector. Poultry Manure is difficult to dispose and its accumulation causes spreading of harmful insects and pests which leading to the dissemination of various diseases that are transmitted to humans and animals and pose a threat to public health. While poultry wastes can be anaerobically fermented to produce biogas to make self-sufficiency of methane. Poultry manure (PM) contains high percentage of nitrogen though it must be co-digested with other substrates to adjust carbon nitrogen ratio to produce biogas with high quality and high percentage of methane. Poultry manure is co-digested with Banana Peels (BP). A simple setup was used to digest the mixed substrate PM /BP with different ratios. PM /BP mixtures at different ratios -5 mixtures- were digested. Mixtures are as follows BP and PM was mixed at ratios 1-3, 1-1, 3-1 respectively in addition to BP and PM only. Five digesters were used to carry out experiments. Biogas was collected and measured daily. The studied parameters were pH, C/N ratio, biogas yield, and methane content. The best co-substrates with the highest percentage of methane content and highest amount of biogas produced are 50% BP+50%PM.

Key word: Poultry manure, banana peels, biogas, methane, anaerobic fermentation

INTRODUCTION

Human population has grown rapidly in the latter half of the 21st century, from approximately 3 billion in 1960 to over 7 billion in 2015 (World Population Clock, 2015). As population rapidly increases, so does energy demand. Currently, approximately 81% of global energy demand is met with fossil fuels (REN21, 2015). Projections indicate that global energy demand will continue to increase annually with a rate of 2.2% approximately between 2015 and 2035 (IEA, 2010). Employing traditional fossil fuel-based energy solutions to meet this ever-growing demand will result in continued escalation of greenhouse gas (GHG) emissions and global warming.

In Egypt, the total energy consumption reaches to about 86 million tons of oil equivalent, fossil fuels represents 97% of total consumption (Ministry of petroleum, 2017). The country is facing a shortage of traditional fuels (petroleum products and petroleum gases), and the needs of citizens are imported from abroad which cost the country more than 180 billion pounds/year (Ministry of petroleum, 2017); this cost represents a very large load on the Egyptian economy, and is the reason for the deteriorating of current Economic situation.

LPG is one of the most important petroleum products produced by the petroleum sector to support the local market needs (Residential and Commercial sector). LPG is considered a strategic commodity affecting the national economy and the security aspects of the country, due to the increased domestic consumption of LPG, which rose up to 4.2 million tons per year

(Ministry of petroleum report, 2016). Egypt imports 55% of LPG consumption.

At the same time, poultry farms consume a lot of liquefied petroleum gas (LPG) cylinders for heating purpose. The consumer buys LPG cylinder at a cost of 30 LE per cylinder while it costs 115 LE per cylinder. It can be concluded that every cylinder is subsidized with LE 85 (Ministry of petroleum, 2017). The consumption of LPG in poultry farm is reaching to 50-150 cylinder/day in winter, which affects the needs of the domestic sector.

Poultry Manure causes a serious environmental problem where its piling up pollutes soil, ground water, surface water and air (caused by the emission of methane gas, ammonia and carbon dioxide), harmful insects and pests increased due to the problem of waste accumulation, leading to the spread of various diseases that are transmitted to humans and animals and pose a threat to public health (Manyi-Loh *et al*., 2013).

Anaerobic fermentation was used worldwide to get benefit from biodegradable organic waste to obtain biogas. Biogas is a flammable gas made of a mixture of gases produced by methanogenic bacteria while acting upon biodegradable materials in an anaerobic condition. Biogas is mainly composed of 50 to 70 percent methane (CH_4), 30 to 40 percent carbon dioxide (CO_2) and traces such as H_2S, N_2, NH_3 and CO (Abubakar, B. and Ismail, N. 2012). Biogas is about 20 percent lighter than air and has an ignition temperature in the range of 650° to 750° C. It is an odorless after burning and colorless gas that burns with clear blue flame similar to that of LPG. The calorific value of biogas is about 6 kWh/m^3 (20 mega joules) - this corresponds to about half a liter of diesel oil. Methane has 20 times more greenhouse gas potential than carbon dioxide, so the capture and burning of methane significantly reduces the greenhouse gas effect (Abubakar, B. and Ismail, N. 2012).

In Arab countries, the applying of biogas plants started in 1970s in Egypt, Morocco, Sudan and Algeria while it began in 1980s in other Asian Arab countries as Iraq, Jordan and Yemen (Chedid and Chaaban, 2003). In Western Europe there is political pressure for developing renewable energy. Therefore, farmers seek developing units for the production of energy using animal dung to produce biogas and earn money with it (Linke, Bernd, *et al*,2015).

Many previous researches used chicken manure in improved biogas production and poultry manure was used to produce biogas in many countries worldwide (Owamah *et al*., 2014), for example in Japan biogas production from chicken dung (Niu *et al*., 2013).

In India many studies are carried out on comparative biogas yield from different animal manures and the studies observed that poultry dropping showed higher gas yield (Khoiyangbam *et al*., 2011).

In Turkey biogas production from digestion of two different types of manure sources from chicken and cattle is applied at a biogas plant (Gomez and Ozturk, 2013). In Africa there are many studies, which the results suggest that chicken droppings can be used for biogas production and as biofertilzer (Adeoti *et al*., 2001). The production of biogas and methane is done from the starch-rich and sugary material which found in poultry manure and is determined at laboratory scale using the simple digesters (Dai *et al*., 2015).

The aim of this study is using poultry manure as a source of biogas in poultry farms to reduce consumption of LPG in heating purpose in winter, to protect environment from poultry manure piling in dumpsites which resulting air pollution with ammonia and methane.

MATERIAL AND METHOD

Sample Collection and Preparation:

Banana peels and poultry manure were used as substrate for the generation of biogas. Fresh poultry manure (1Kg), banana peels (1Kg) were collected. The collected banana peels were cut into small pieces and allowed to dry under shade condition for three days and ground (Gomez and Ozturk, 2013).

Feedstock Composition:

Five experiments were carried out; each of them used different feed stocks. Experiment 1 used only banana fruit (BP), experiment 5 used only poultry manure (PM), while the three experiments used BP and PM as follows

Exp. 2, 3:1, exp. 3 1:1, exp. 4 1:3 –ratio of BP is mentioned first. Water was added to each experiment at a percentage of 1:1. The pH of the digesters was between 6.87and 6.95. The amount of substrate and co-substrate in each digester is 100 gm.

The temperature was also maintained at about 38^{o} C by keeping the digester in the incubator (Knottier, 2003) which represents mesophilic condition.

xperimental set up (Digester configuration):

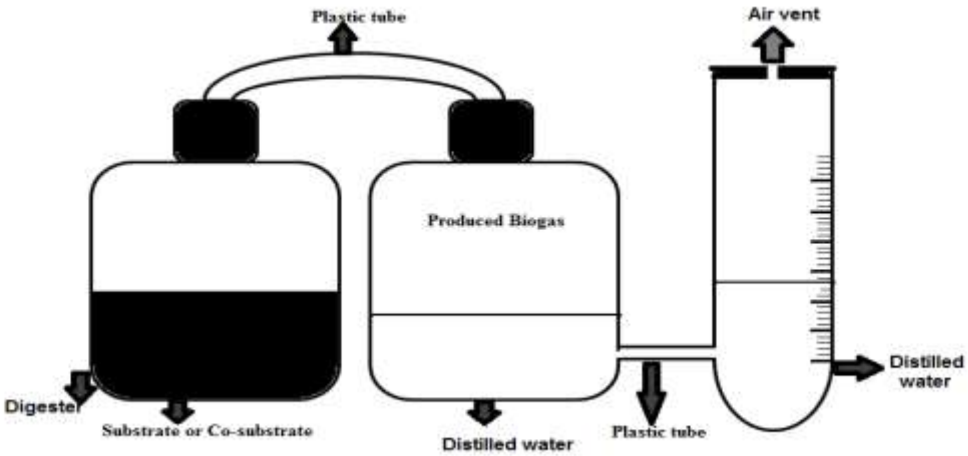

Figure 1 Digester configuration:

Anaerobic digesters were generally constructed in bench-scale experiments where biogas is produced out of the degradation of organic matter in 2L digester with appropriate working volume. The three plastic bottles were arranged in such a way that the first bottle contained substrate, the middle contained distilled water and the last was for collecting the distilled water that was expelled out from the second container.

All the three containers were interconnected with a plastic tube having a diameter of 1 cm. The tube connecting the first bottle to the second was fitted just above the slurry in the first bottle to help gas collection. First bottle to the second bottle that contained a distilled water to displace a volume of the brine solution equivalent to the volume of biogas produced. The lids of all digester were sealed tightly using super glue in order to prevent the entry of oxygen and loss of biogas.

Determination of pH:

The initial pH of each sample was measured directly by using digital pH meter by pH meter (yahne instrument, Shanghai, China) before and after AD (HANNA HI 8314).

Measuring Carbon: Nitrogen (C/N) ratio:

The C: N ratio of feed stocks employed here was determined by quantifying total carbon and total nitrogen within the substrates. Total carbon and total nitrogen were measured utilizing a LECO analyzer. Samples are combusted at 3000°C in an oxygen atmosphere to produce carbon dioxide and nitrogen gas. A non-dispersive infrared detection cell is used to determine the portion of CO_2 present in the sample. A thermal conductivity cell determines the concentration of nitrogen gas. Utilizing the concentrations of CO_2 and N_2 within the sample, total carbon and total nitrogen can be calculated (APHA, 2005).

Measuring the amount of produced biogas:

The amount of gas produced was measured by water displacement method using distilled water (Yetilmezsoy and Sakar, 2008). The daily gas production was recorded for different experiments until the gas production ceases.

Measuring percentage of methane content:

High percentage of methane content indicates high quality of biogas. Gas composition was measured from gas sample by Clarus 580 Perkin Elmer gas chromatograph according to Affes *et al*. (2013).

RESULTS AND DISCUSSIONS

1- pH

Table 1: Comparison of pH values between before and after Anaerobic Digestion (AD) of the various experiments of poultry manure and banana peels.

Experiment	pH	
	Initial	Final
E1(100%BP)	6.87±0.06	7.99±0.20
E2(75% BP+25%PM)	6.95±0.05	8.23±0.09
E3(50% BP+50%PM)	6.94±0.04	8.45±0.24
E4(25% BP+75%PM)	6.93±0.06	8.22±0.25
E5(100%PM)	6.88+0.07	8.81+0.13

The pH of experiments increase after digestion .There was no significant difference between experiments in pH before AD. The pH of 100% BP slurry and 100% PM before AD were 6.87±0.06 and 6.88+0.07, respectively. These values were slightly lower than the two substrates mixed, and this suggests that mixing the two substrates will raise the pH value toward optimum level recommended for anaerobic digestion in biogas production (Affes *et al.*, 2013).

Significant differences were observed between pH values of before and after AD in all mix ratios. Changes in pH may be brought by production of alkali compounds, such as ammonium ions during the degradation of organic compounds in the digester (Gerardi, 2003).

2- Carbon: Nitrogen (C/N) ratio

Table 2: Carbon: Nitrogen ratio in different experiments

Substrate	100%BP	75%BP +25%PM	50%BP +50%PM	25%BP +75%PM	100%PM
% C	11.1	15.3	22.5	25.2	34.4
% N	0.4	0.64	0.9	2.1	3.3
C : N	28 : 1	26.3:1	25:1	12 : 1	9.6 : 1

By increasing carbon to nitrogen ratio the methane content in biogas increase and that improve the quality and efficiency of biogas. Carbon: nitrogen ratio in 100% banana peels is 28:1 which more than C: N ratio of 100% Poultry manure 9.6:1 these results in agreement with other studies percentage of carbon in 100% BP is 10.7% and carbon: nitrogen ratio is 28:1(Habtie Bassie,2016)**,** % carbon in 100% PM is 32.6% and carbon: nitrogen ratio is 10.4:1 (Farrow Cameron,2016).

Therefore, we make co-digestion of banana peels with poultry manure in different experiments to of adjust Carbon: Nitrogen ratio for obtaining maximum amount of methane in biogas. Mixing of banana peels with poultry manure decrease nitrogen percentage in poultry wastes and improve carbon: nitrogen ratio of the mixture. This suggests that mixing two substrates will raise the carbon percentage value toward optimum level recommended for maximum methane content in the biogas It is found that the best Carbon : Nitrogen is in experiment 3(E3) 50% Banana Peels +50%Poultry Manure .

Measuring the amount of produced biogas

Table 3: Average Daily and Cumulative Biogas Production of Substrates (ml)

Days	100%BP	75%BP +25%PM	50%BP +50%PM	25%BP +75%PM	100%PM
D1	6	35	41	49	20
D2	9	45	39	40	40
D3	13	48	40	42	32
D4	20	46	59	43	51
D5	47	39	56	50	54
D6	49	41	45	40	53
D7	46	36	55	51	38
D8	39	38	45	41	34
D9	40	33	35	56	23
D10	47	41	59	41	38
D11	22	51	60	37	32
D12	30	33	53	35	42
D13	28	30	50	30	39
D14	29	30	42	31	30
D15	30	31	29	37	27
D16	29	20	55	24	31
D17	30	40	56	30	30
D18	20	20	55	25	25
D19	12	10	35	25	12
D20	10	12	33	28	10
D21	9	10	25	12	9
D22	8	15	33	10	5
D23	9	16	23	15	0
D24	8	11	18	5	0
D25	5	6	3	0	0
D26	2	1	0	0	0
D27	0	0	0	0	0
Total	597	738	1044	797	675

From 50% BP+50% PM, 1044 ml of biogas was produced; this was 447 ml higher than 100%BP which produced 597ml of cumulative biogas. Thus could be concluded that the higher production of biogas from the mixtures could be due to a proper nutrient balance, increased buffering capacity, and decreased effect of toxic compounds resulting from mixing of the substrates (Fulford, 1988; Macias-Corral *et al*., 2008; Li *et al*., 2009; Tamirat, 2012).

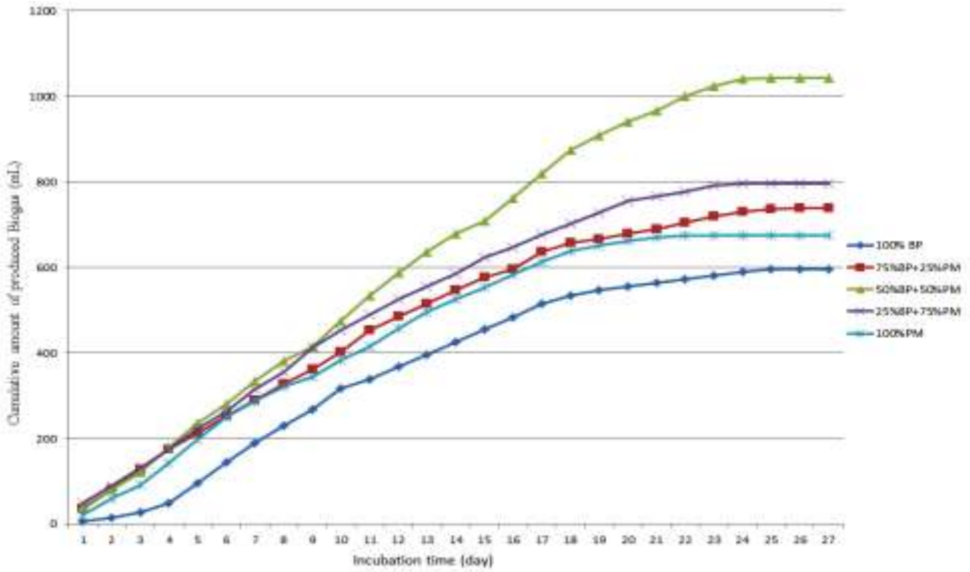

Figure 2: Cumulative amount of produced Biogas for different treatments

The benefits of co-digesting plant materials with animal manure were first reported by (Abouelenien, F., Nakashimada, 2009), by which it was found that manure could provide buffering capacity and a wide range of nutrients. Addition of plant materials with high carbon content could improve the C/N ratio of the feedstock, thereby decreasing the risk of ammonia inhibition to the digestion process. Therefore, this indicates that mixing substrates maximizes biogas production which supports this research.

In general, both banana fruit peels and poultry manure has potential for production of biogas and its remaining slurry could be used as fertilizer. As indicated in this work and by many researchers mixing substrates are important to obtain maximum yield of biogas.

The optimum mix ratio according to this measurement was found to be 50%BP + 50%PM for substrates.

Measuring the percentage of methane content:

Table 4: Methane content percentage in biogas produced from Poultry manure (PM), Banana peels (BP) and their mixtures.

Substrate	E1 (100%BP)	E2(75%BP +25%PM)	E3(50%BP +50%PM)	E4(25%BP +75%PM)	E5 (100%PM)
Methane Content %	59	58.2	57.9	54.2	51.7

100%BP produce biogas with 59% methane content these results in agreement with other studies 100%BP Produce biogas with 60% methane content (Zhang Zhengyun, Xu Rui, Duan Huanyun, Wang Qiuxia, Yang Bin, Han Jiahong, Yuan Yage and Wang Fuxian,2013).

The mixture which produces biogas with the maximum methane content is experiment 2 (75% Banana peels+ 25% poultry manure) but it gives small amount of biogas which is 738 ml , in experiment 3 (50% Banana peels+ 50% poultry manure) gives 1044 ml biogas with 57.9% methane content.

CONCLUSION

It is concluded that the best co-substrates is the experiment with the highest percentage of methane content and high amount of biogas produced are 50% BP+50% PM.

REFERENCES

Abouelenien, F., Nakashimada, Y., & Nishio, N. (2009). Dry mesophilic fermentation of chicken manure for production of methane by repeated batch culture. Journal of bioscience and bioengineering, 107(3), 293-295.

Abubakar, B. S. U. I., & Ismail, N. (2012). Anaerobic digestion of cow dung for biogas production. ARPN journal of engineering and applied sciences, 7(2), 169-172.

Akinbami, J. F., Ilori, M. O., Oyebisi, T. O., Akinwumi, I. O., & Adeoti, O. (2001). Biogas energy use in Nigeria: current status, future prospects and policy implications. Renewable and Sustainable Energy Reviews, 5(1), 97-112.

American Public Health Association. "APHA. 2005." Standard Methods for the Examination of Water and Wastewater. 21st ed. American Public Health Association, Washington DC, 1220p.

at\sqrt \\mathrm using the ATLAS detector at the LHC." The European Physical Journal C 73.8 (2013): 2518.

Chedid, R., & Chaaban, F. (2003). Renewable-energy developments in Arab countries: a regional perspective. Applied Energy, 74(1-2), 211-220.

Farrow, C. (2015). Anaerobic Digestion of Poultry Manure: Implementation of Ammonia Control to Optimize Biogas Yield.

Gerardi, M. H. (2003). Settleability problems and loss of solids in the activated sludge process. John Wiley & Sons.

Hills, D. J., & Roberts, D. W. (1981). Anaerobic digestion of dairy manure and field crop residues. Agricultural Wastes, 3(3), 179-189.

IEA, OPEC. "OECD, and World Bank. 2010." Analysis of the Scope of Energy Subsidies and Suggestions for the G-20 Initiative : 26-27.

Khoiyangbam, R. S., Gupta, N., & Kumar, S. (2011). Biogas Technology: towards sustainable development. The Energy and Resources Institute (TERI).

Linke, B., Rodríguez-Abalde, Á., Jost, C., & Krieg, A. (2015). Performance of a novel two-phase continuously fed leach bed reactor for demand-based biogas production from maize silage. Bioresource technology, 177, 34-40.

Manyi-Loh, C. E., Mamphweli, S. N., Meyer, E. L., Okoh, A. I., Makaka, G., & Simon, M. (2013). Microbial anaerobic digestion (bio-digesters) as an approach to the decontamination of animal wastes in pollution control and the generation of renewable energy. International journal of environmental research and public health, 10(9), 4390-4417.

Owamah, H. I., Dahunsi, S. O., Oranusi, U. S., & Alfa, M. I. (2014). Fertilizer and sanitary quality of digestate biofertilizer from the co-digestion of food waste and human excreta. Waste management, 34(4), 747-752.

Phillips, D. (2003). The truth of ecology: Nature, culture, and literature in America. Oxford University Press on Demand.

Pitk, P., Kaparaju, P., Palatsi, J., Affes, R., & Vilu, R. (2013). Co-digestion of sewage sludge and sterilized solid slaughterhouse waste: methane production efficiency and process limitations. Bioresource technology, 134, 227-232.

Reimer, P. J., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Ramsey, C. B. & Grootes, P. M. (2013). IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon, 55(4), 1869-1887.

Ren, P. S. (2015) "Renewables 2015 global status report." REN21 Secretariat: Paris, France .

Ward, A. J., Hobbs, P. J., Holliman, P. J., & Jones, D. L. (2008). Optimisation of the anaerobic digestion of agricultural resources. Bioresource technology, 99(17), 7928-7940.

Wang, B., Dai, G., Deng, S., Huang, J., Wang, Y., & Yu, G. (2015). Linking the environmental loads to the fate of PPCPs in Beijing: Considering both the treated and untreated wastewater sources. Environmental pollution, 202, 153-159.

Yetilmezsoy, K., & Sakar, S. (2008). Development of empirical models for performance evaluation of UASB reactors treating poultry manure wastewater under different operational conditions. Journal of Hazardous materials, 153(1-2), 532-543.

الاستفادة من فضلات الدواجن في إنتاج الغاز الحيوي كبديل للبوتاجاز [١]

طه عبد العظيم محمد عبد الرازق[١]– نبيل عبد المنعم أمين[٢]– إيمان بدير عبد الباسط علي[٣]
١) قسم العلوم الاساسية، معهد الدراسات والبحوث البيئية، جامعة عين شمس ٢) معهد بحوث البترول المصري، قسم البتروكيماويات ٣) شركة بتروجاس

المستخلص

تواجه مصر نقصا فى الوقود الاحفوري وتستهلك مزارع الدواجن كمية كبيرة من اسطوانات الغاز المسال (البوتاجاز) فى أغراض التدفئة فى فصل الشتاء مما يؤثر على احتياجات القطاع المحلى. على صعيد اخر تعد فضلات الدواجن مشكلة كبيرة فى حد ذاتها حيث يصعب التخلص منها وتتراكم بكميات كبيرة ويسبب ذلك انتشار الحشرات الضارة والآفات التى تؤدي إلى نقل الأمراض المختلفة إلى البشر والحيوانات حيث تشكل تهديدا للصحة العامة، فى حين أن مخلفات الدواجن يمكن تخميرها لاهوائيا لإنتاج الغاز الحيوي لتحقيق الاكتفاء الذاتى من الميثان الذي من الممكن استخدامه كوقود للتدفئة بالمزارع . تحتوي فضلات الدواجن على نسبة عالية من النيتروجين ولذلك فلابد من خلط مواد عضوية اخري فى عملية التخمر اللاهوائى وذلك لرفع نسبة الكربون بالنسبة للنيتروجين لانتاج غاز البيوجاز بجودة عالية ونسبة كبيرة من الميثان. تتم عملية التخمير بعد خلط فضلات الدواجن مع قشر الموز بخمسة نسب مختلفة وهى ٣–١،١–١،١–٣، بالاضافة الى قشر الموز فقط و فضلات الدواجن فقط . تم عمل ٥ مخمرات لاجراء التجربة وقياس كمية غاز البيوجاز المنتج يوميا وكانت المعاملات محل الدراسة هى درجة الحموضة (pH) ، نسبة الكربون والنيتروجين، كمية البيوجاز المنتجة ونسبة الميثان فى البيوجاز المنتج . يعد خليط ٥٠% قشر موز+٥٠% فضلات دواجن هو الافضل حيث تم الحصول على اكبر كمية من غاز البيوجاز و نسبة كبيرة من الميثان .

الكلمة مفتاحية: فضلات الدواجن، قشور الموز، الغاز الحيوي، الميثان، التخمر اللاهوائي.