Journal of Bioremediation & Biodegradation

Research Article Open Acces

Effect of Different Pre-Treatment Options for Maximizing the Renewable Energy (Biocng®) In Pome

Jyothi Hadli*

Sustainability (R and D) at KIS GROUP, Bangalore Urban, Karnataka, India

ABSTRACT

KIS GROUP provides solutions for Sustainable Treatment of Palm Oil mill effluent (POME) to renewable energy (BioCNG®) is important for all mills in Malaysia, Indonesia, Thailand and all other Palm oil producing countries. This sustainable treatment will reduce the GHG's emission and produce renewable energy, which will replace the part of fossil fuels in the mills, estates and plantation and also producing good organic fertilizer after anaerobic digested sludge. They are many technologies are available for capturing methane from POME to Produce higher Bioenergy. Pre-Treatment is playing a vital role to produce more biogas/renewable energy continuously by providing conditioned parameters before the anaerobic process. Three process were discussed here, first is conditioning of POME using cooling pond/Direct cooling tower where part of organic compounds was reduced, second is conditioning of POME through Equalization and Passing through the Heat Exchanger for reduction of Temperature and third process is with Hydrodynamic cavitation additional with second process to increase more biogas. As per the study, found that there was increased biogas generation of 13% and 25% in second and third process respectively.

Keywords: Renewable energy, Palm Oil, Anaerobic digestion, Sludge management, and Biogas management

Introduction

Palm oil is one of the two most important vegetable oils in the world's oil and fats market. The extraction and purification processes generate waste known as palm oil mill effluent (POME). The environmental impact of POME is huge contaminating ground water, affecting the animal life and emanating methane emissions contributing to GHGs [1]. The need for treatment measure is to reduce these impacts before discharge, which is very crucial and need of the hour. Moreover, along with reducing the BOD, COD, TSS the system can generate biogas which can be used for various applications as electricity generation or BioCNG® which can be used for mills, plantations and estates. Therefore, this paper reviews the treatment scheme for POME, which has already been implemented by KIS GROUP in palm oil mills for the treating of POME. The process involves pretreatment, anaerobic digestion, sludge management, and biogas management. This paper mainly deals on the biogas production based on the different pretreatment scheme, along with anaerobic digestion. The parameters are taken over a period of six months to understand the quantity of biogas generation and the cost analysis of having a pretreatment system before the AD [2]. Moreover, the effective treatment of POME yields useful products such as methane, fertilizers and Animal feeds.

Material and Methods

The study involves mills of capacity 60 TPH generating POME. The FFB to POME ratio is 0.6.

Palm oil mill effluent

The processing of oil palm (Elaeis gunineensis) into Crude Palm Oil (CPO) can generate very large quantities of liquid waste or POME (Palm Oil Mill Effluent). Effluent water is defined as water discharged from industry, which contains soluble materials that are injurious to the environment. Such soluble materials may be gases such as CH4, S02, NH3, halogens or soluble liquids or solids, which contain ions of either organic or inorganic origin and with their concentration above the threshold value [3]. Since these compounds are harmful to the environment, it becomes necessary that effluents water should be treated or purified before discharged into the environment.

Characteristics of the POME generated

POME treatment plant with KIS GROUP ZPHB® reactor is designed to treat raw influent having following characteristics. Table 1 shows the Inlet POME Parameters.

Sr. NO	PARAMETERS	UNIT	VALUES
1	Mill Capacity	TPH	60
2	Mill Operating	Hours	20
3	FFB Processing	Tones/Day	1,200
4	FFB to POME Ratio	-	0.6

***Corresponding author:** Hadli J, Director-Sustainability (R and D) at KIS GROUP, Bangalore Urban, Karnataka, India, E-mail: drjyothi@kisgroup.net

Received date: February 10, 2021; **Accepted date:** February 24, 2021; **Published date:** March 03, 2021

5	POME Generation	m3/day	720
6	COD (maximum for design)	mg/l	80,000
7	BOD	mg/l	35,000
8	TSS	mg/l	30,000
9	pH	-	3.5-4.5
10	O and G	mg/l	6,000
11	Temperature	0C	<80

Table 1: Shows the Inlet POME Parameters.

Treatment scheme

The study is based on the effect of 3 types of pre-treatment before the anaerobic digestor for the biogas generation.

Type 1-Directly taking the POME from the cooling pond/direct Cooling Tower/lagoon to the digestor

Type 2-Pre-treatment includes Equalization tank and Heat Exchanger with Cooling tower Type 3-Pretreatment of Equalization tank, buffer tank and cooling tower combined with Hydrodynamic cavitation

After the pretreatment, the POME is fed into the anaerobic digester, which is similar in all the three cases above. The digestate is handled through sludge management and Biogas is monitored through biogas management, which is same in all the three pre-treatment schemes [4].

Type 1: Directly taking the pome from the cooling pond to the digester.

The raw POME from the mill fat pit is transferred to the Cooling Pond which is constructed with volume of 2100 m3 where the temperature of the POME is reduced from 80°C to 40°C by natural cooling effect. The cooled POME is fed into the anaerobic digester/ lagoon system for further degradation process. In Cooling pond there

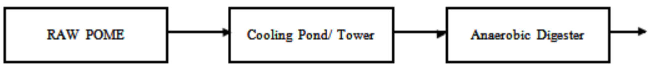

Figure 1: Directly taking the pome from the cooling pond to the digester.

Type 2: Pre-treatment included equalisation tank, buffer tank and heat exchanger with cooling tower

The raw POME from the mill fat pit is transferred to the Equalization Tank for equalization and homogenization, then POME pass through the Heat Exchanger where POME and Cooled water is heat transfer is taking place. There is no loss of organic compounds during this process and controlled/Conditioned POME is fed into the anaerobic digester for further process (Figure 2).

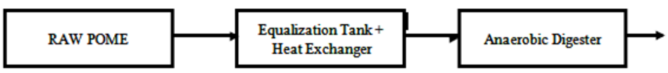

Figure 2: Pre-treatment included equalisation tank, buffer tank and heat exchanger with cooling tower

Type 3: Pretreatment of equalisation tank, heat exchanger combined with hydrodynamic cavitation process

The raw POME from the mill fat pit is transferred to the Equalization Tank for equalization and homogenization, then POME pass through the Heat Exchanger, where POME and Cooled water is heat transfer is taking place. There is no loss of organic compounds during this process and controlled/Conditioned POME is fed into the buffer tank where Hydrodynamic cavitation has been introduced this will breaking up the organic material making it more amenable for digestion in the digester, in turn resulting in more biogas (Figure 3).

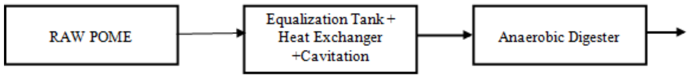

Figure 3: Pretreatment of equalisation tank, heat exchanger combined with hydrodynamic cavitation process

Several pre-treatment methods of organic wastes prior to anaerobic digestion have been reported, these include mechanical, thermal, chemical, biological and hybrid (combination of more than one method) methods. Each of these methods is targeted towards enhancing the solubilization and dis-integration of organic components of the waste which in effect lead to improvement in anaerobic digestion process. Here we selected Hydrodynamic cavitation methods.

Cavitation is a phenomenon of formation, growth and collapse of micro bubbles within a liquid. Tremendous amount of energy is dissipated when the micro bubbles collapse. It harnesses this energy for breaking up the organic material making it more amenable for digestion in the digester. It uses rotational flow to generate cavitation. Technology that can boost Biogas production from POME Solutions by 10-20% [5].

Above experiments/trial were conducted in existing POME to Biogas Power Plant Projects in Indonesia. Existing units like Cooling Pond, EQT, Heat Exchanger, Buffer Tank and Anaerobic digester (ZPHB® Reactor), below is the Equipment/units details (Table 2).

Sr. NO	PARAMETERS	UNIT	VALUES
1	Cooling Pond	M3	2100
2	Equalization Tank	M3	300
3	Plate Type exchanger	M3/hr	30
4	Cooling Tower water circulation	M3/hr	250
5	Cooling Tower Capacity	TR	300
6	Buffer Tank	M3	200
7	ZPHB® Reactor	M3	8400

Table 2: Shows the existing Facilities of units / equipment's for conducting the trial.

Measurement of flow and parameters

Waste water analysis – Existing Laboratory was used to analyze the pH, Temp, TSS, BOD, COD and O and G. Flow measurement – Existing Electromagnetic flow meter and ultrasonic flow meter were used to measure the liquid flow and Gas Flow reading and Portable biogas analyzer was used to measure the composition of biogas.

Results and Discussion

The POME from palm oil mill refinery is a brown liquid with a temperature of 70°C -90°C, acidic condition (pH 3.8-4.5), and the concentration of organic particles is quite high, COD and BOD are also high. It has to be cooled using lagoons or other pretreatment methods to be able to feed to the reactor. The major parameters as COD, BOD, TSS were analyzed and the flow for each day was averaged to month (Figure 4) (Table 3-12).

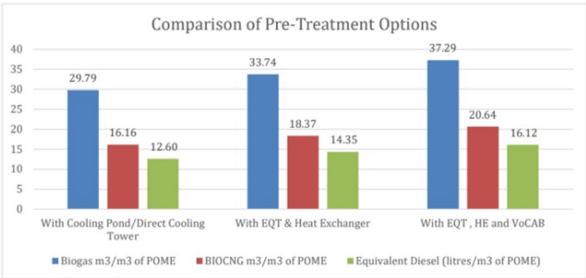

Figure 4: Shows the comparison between pre treatment options

Raw Parameters						
		POME Flow	Mill Outlet			
Sr. No	Month	m³/ month	pH	Temp 0 C	BOD	COD
					ppm	ppm
1	Jul'18	14,320	3.95	83	33,050	76,300
2	Aug'18	13,860	4.11	79	34,000	77,300
3	Sep'18	14,386	4.12	76	32,833	75,800
4	Oct'18	14,285	4.23	78	35,000	73,500
5	Nov'18	14,568	3.98	80	34,727	75,500
6	Dec'18	14,983	3.86	79	33,385	72,600
	Average:	14,400	4	79	33,833	75,167

Table 3: Outlet characteristic of POME and Biogas generation using cooling pond/lagoons as pretreatment.

Cooling Pond Outlet						
		POME Flow	**Outlet**			
Sr. No	**Month**	**m³/month**	**pH**	**Temp 0 C**	**BOD**	**COD**
					ppm	**ppm**
1	Jul'18	14,320	4.12	41	29,738	70,132
2	Aug'18	13,860	4.28	42	30,385	70,755
3	Sep'18	14,386	4.18	43	29,146	69,954
4	Oct'18	14,285	4.16	41	31,254	68,085
5	Nov'18	14,568	3.99	41	31,500	69,687
6	Dec'18	14,983	4.08	41	29,785	67,106
	Average:	14,400	4.14	42	30,301	69,287

Table 4: Outlet characteristic of POME and Biogas generation using cooling pond/lagoons as pretreatment.

ZPHB Digester Performance							
Sr. No	**Month**	**CH_4%**	**Biogas Generation (m³/m)**	**Potential BioCNG® Generation (m³/m)**	**Biogas (m³)/ m³of POME**	**Potential BioCNG® (m³)/ m³ of POME**	**Equivalent Diesel (liters/ m³ of POME)**
1	Jul'18	60	4,26,823	31,300	30	16	13
2	Aug'18	61	4,16,782	30,564	30	17	13
3	Sep'18	60	4,27,702	31,365	30	16	13
4	Oct'18	59	4,33,353	31,779	30	16	13
5	Nov'18	60	4,31,460	31,640	30	16	12
6	Dec'18	61	4,37,316	32,070	29	16	13
Average:		60	4,28,906	31,453	29.79	16.13	12.6

Table 5: Outlet characteristic of POME and Biogas generation using cooling pond/lagoons as pretreatment

Sr. No	Month	Raw Parameters				
		POME Flow	Mill Outlet			
		m^3/month	pH	Temp 0 C	BOD ppm	COD ppm
1	Jan'19	14,198	4.08	78	34,667	79,800
2	Feb '19	14,230	4.15	75	33,500	77,500
3	Mar'19	14,059	3.98	75	34,182	72,500
4	Apr '19	13,986	4.24	76	33,769	73,200
5	May '19	13,995	4.16	75	33,273	72,600
6	Jun'19	14,056	3.86	79	33,364	73,800
	Average:	14,087	4.1	76	33,792	74,900

Table 7: Outlet characteristics of POME and Biogas generation using heat Exchanger with Cooling Tower as the pretreatment.

ZPHB® Digester Performance							
Sr. No	Month	CH4%	Biogas Generation (m^3/m)	Potential BioCNG® Generation (m^3/m)	Biogas (m^3)/ m^3 of POME	Potential BioCNG® (m^3)/m^3 of POME	Equivalent Diesel (liters/ m^3 of POME)
1	Jan'19	61	5,10,417	37,431	35.95	20	15
2	Feb '19	60	4,96,823	36,434	34.91	19	15
3	Mar'19	59	4,59,185	33,674	32.66	17	14
4	Apr '19	60	4,61,211	33,822	32.98	18	14
5	May '19	61	4,57,725	33,566	32.71	18	14
6	Jun'19	62	4,67,318	34,270	33.25	19	14
	Average	61	4,75,446	34,866	33.74	18.37	14.35

Table 8: Outlet characteristics of POME and Biogas generation using heat Exchanger with Cooling Tower as the pretreatment.

Sr. No	Month	Raw Parameters				
		POME Flow	Mill Outlet			
		m^3/month	pH	Temp°C	BOD ppm	CODppm
1	Jul'19	13,860	4.08	77	33,769	72,600
2	Aug'19	14,052	4.15	78	33,500	72,800
3	Sep'19	13,985	3.98	76	33,182	73,200
4	Oct'19	13,457	4.24	72	33,667	79,800
5	Nov'19	14,698	4.16	77	33,273	77,500
6	Dec'19	14,685	3.86	75	33,667	72,500
	Average:	14,123	4.1	76	33,510	74,733

Table 9: Outlet characteristics of POME and Biogas generation using pretreatment as heat Exchange with Cooling Tower and Hydrodynamic Cavitation.

Heat Exchanger/Cooling Tower outlet						
		POME Flow	Outlet			
Sr. No	Month	m^3/month	pH	Temp°	BOD ppm	COD ppm
1	Jul'19	13,86	4.05	38	33,769	72,600
2	Aug'19	14,05	4.16	37	33,500	72,800
3	Sep'19	13,98	3.99	38	33,182	73,200
4	Oct'19	13,45	4.21	37	33,667	79,800
5	Nov'19	14,69	4.28	39	33,273	77,500
6	Dec'19	14,68	4.12	38	33,667	72,500
Average:		14,12	4.14	38	33,510	74,733

Table 10: Outlet characteristics of POME and Biogas generation using pretreatment as heat Exchange with Cooling Tower and Hydrodynamic Cavitation.

ZPHB® Digester Performance with Hydrodynamic Cavitation							
Sr. No	Month	CH_4%	Biogas-Gene-ra-tion(m^3/m)	Potential BioCNG® Genera-tion(m^3/m)	Biogas(m^3)/m^3 of POME	Potential BioCNG® (m^3)/m^3 of POME	Equivalent Diesel (liters/ $m^3$of POME)
3	Sep'19	61	5,29,012	38,794	37.83	21	16
4	Oct'19	61	5,20,775	38,190	38.7	21	17
5	Nov'19	61	5,31,702	38,992	36.18	20	16
6	Dec'19	62	5,37,627	39,426	36.61	20	16
Average		62	5,26,278	38,594	37.29	20.64	16.12

Table 11: Outlet characteristics of POME and Biogas generation using pretreatment as heat Exchange with Cooling Tower and Hydrodynamic Cavitation.

Sr. No	Parameters	Units	Raw POME	Anaerobic digested Sludge
1	pH	-	4.5	7.4
2	Carbon	%	36	38
3	Nitrogen	%	2.7	4.68
4	Phosphorous	%	1.01	1.25
5	Potassium	%	2.5	5.2
6	Magnesium	%	1.2	1.4
7	Calcium	%	1.56	2.55

Table 12: Comparison of fertilizer details in raw POME & Anaerobic digester Sludge.

BOD and COD reductions

The BOD and COD levels before the anaerobic digester were lower in cooling ponds as compared to the pretreatment with cooling tower and with EQT+ Heat Exchanger/Cooling Tower and EQT+Heat exchanger/cooling tower with VoCAB process. This is mainly because the BOD and COD levels were degraded in the cooling pond.

Biogas generation and BioCNG® generation

Moreover, there is direct link between COD levels and biogas generation were in the Biogas generation was higher in pretreatment with cooling tower and mechanical mixing because of the higher COD levels before the Anaerobic digester and also because of breakdown of the particles into smaller units thus enhancing bio-degradation in Anaerobic digester thus enhancing the biogas generation. It is inferred from the table that there is an increase of 13% biogas generation as compared to the cooling pond/lagoons and pretreatment with cooling tower. As compared to cooling tower the biogas generation is 25% higher in pretreatment with a combination of cooling tower and mechanical cavitation which leads to higher BioCNG® generation to replace the fossil fuels in the mills/Estates/Plantation [6,7].

Organic fertilizer

The digested POME to land has been proven beneficial with a 10%-20% increased FFB yield due to organic fertilizer present in the effluent than raw POME. Table 12 shows the nutrients valve between raw POME and digested POME sludge.

Conclusion

Sustainable POME treatment is useful for all the palm oils mills where in the POME can be treated to produce biogas, which in turn can be used to produce BioCNG®. The Produced BioCNG® is used to replace the fossil fuel of the mill, estates, and plantation. Thus saving the fuel cost. Moreover, the by-product of the ZPHB® biodigester mainly the organic fertilizer is used for plantations thus replacing the inorganic fertilizers as Urea or DAP. Thus, it is a circular economy of giving back the organic fertilizers to the soil.

References

1. Hosseini SE, Bagheri G, Khaleghi M, Abdul Wahid M (2015) Combustion of biogas released from palm oil mill effluent and the effects of hydrogen enrichment on the characteristics of the biogas flame. J Combustion. 612341
2. Aziz MM, Kassim KA, ElSergany M, Anuar S, Jorat ME, et al (2020) Recent advances on palm oil mill effluent (POME) pretreatment and anaerobic reactor for sustainable biogas production. Renewable and Sustainable Energy Reviews 119:109603.
3. Shakib N, Rashid M (2019) Biogas production optimization from POME by Using anaerobic digestion process. J App Sci Process Engineering 6(2):369-377.
4. Foong SZ, Chong MF, Ng DK (2020) Strategies to promote biogas generation and utilisation from palm oil mill effluent. Process Integration and Optimization for Sustainability.1-7.
5. Yacob S, Hassan MA, Shirai Y, Wakisaka M, Subash S (2006) Baseline study of methane emission from anaerobic ponds of palm oil mill effluent treatment. Science of the total environment. 366(1):187-196.
6. Hosseini SE, Wahid MA, Abuelnuor AA (2013) Biogas flameless combustion: A review. InApplied Mechanics and Materials 388: 273-279.
7. Miltner M, Makaruk A, Harasek M (2017) Review on available biogas upgrading technologies and innovations towards advanced solutions. J Cleaner Production 161:1329-1337.

ISSN: 2155-6199