International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 1, November-December 2020 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

# Biogas Production from Decanter Cake of Palm Oil Mill from South India

**S J Malik[1], Aparna Saraf[2], Srinivas Kasulla[3]**

[1]Biogas Expert, Pune, Maharashtra, India
[2]Associate Professor, The Institute of Science, Mumbai, Maharashtra, India
[3]Waste to Energy Expert, Hyderabad, Telangana, India

## ABSTRACT

Palm Oil Mill Effluent (POME) is a liquid waste from palm oil factory that pollutes the environment but is very useful as a raw material for producing biogas. POME processing has advantages to meet environmental requirements and to produce commercialized products. Although there are already enough biogas systems installed in oil palm factories, there are handful of players in this sector who can design and install an optimal working plant on palm oil mill effluent. The design involves many parameters and quite complicated process. Apart from POME the palm oil mills also generate solid cake from their decanters which is also known as decanter muck or decanter cake. There are no biogas plants observed which were working on this decanter muck. The purpose of this study is to obtain an understanding about the biogas system utilizing solid decanter cake in Southern part of India. Various dilution rates were studied to understand the best possible feedstock to water ratio in terms of gas generation and better stability of the digester. These concentrations also showed difference in CH4 concentration as well and ranged between 70 – 79%. Since it was seen that the internal process before the decanter varies with every batch as well as with every palm oil mill and so does the feedstock characteristics which is the inlet of the digester varies. It was found that when one kilogram of feedstock when fed to the lab scale digester it showed 0.075 – 0.12 m3 of raw biogas with different methane percentages and at different temperature levels. It was found that 38 Deg C was optimum and the study was carried out at various retention times and 20 days was found to be the best to digest decanter muck.

***KEYWORD:** Palm Oil, POME, Decanter Muck, Digester, Biogas, Gas, CH4*

***How to cite this paper:*** S J Malik | Aparna Saraf | Srinivas Kasulla "Biogas Production from Decanter Cake of Palm Oil Mill from South India" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-1, December 2020, pp.1144-1147, URL: www.ijtsrd.com/papers/ijtsrd38147.pdf

**IJTSRD38147**



## INTRODUCTION

India is an agriculture dominated nation with one of the largest economies in the world. The potential to harness the biomass can prove to be a boon to India's growing energy desire. Biogas is nothing new to India and even Mahatma Gandhi emphasized on using biogas as an energy source. Mahatma Gandhi, in his vision for India, imagined a system of devolved, self-sufficient communities, sustaining their needs from the local environment, and organizing income generating ventures around co-operative structures. Several years on, and Mahatma Gandhi's vision of Swadeshi (self-sufficiency) for India, despite interpreted by some as a bucolic notion, is perhaps more urgent than ever. Diminishing forests and a burgeoning, mainly rural biomass-dependent population of billion necessitates a co-ordinate effort of rural India to supply itself with a dependable and sustained source of energy.

Indian government has formed an expert committee to look into suitable land for Palm Oil production in India. Vizianagaram district from Andhra Pradesh is one such district identified by the committee for the purpose. Apart from this there is an increasing demand for identifying it as a plantation crop for its further growth. Among the major benefits of Palm Oil is the fact that a single tree can be harvested for over 75 years. Indonesia and Malaysia are two countries which have almost dedicated themselves to the palm fruit due to favorable conditions, but growing conditions in India are no less favorable too. Additionally, in order to create self-sufficiency in edible oil, the plantation of Palm fruit further needs to be encouraged in the future. In order to bridge the widening gap between the production and demand, more extraction plants will also be needed.

Palm Oil mill plant generates large amount of solid wastes such as empty fruit bunch (EFB) (23%), mesocarpfiber (12%) and shell (5%) for every ton of fresh fruit bunches (FFBs) processed in the mills. Fresh fruit bunches is supplied to the oil mills as raw material. The oil extraction rate from palm oil biomass is about 10 - 12% with the majority 90% left as residues biomass. There are various forms of liquid and solid wastes from the mills. Around 60% of biomass residues from oil palm mills is a solid waste, while the rest is a liquid waste. Solid oil palm biomass residues are generated throughout the year include empty fruit bunches (EFB), palm press fibre (PPF), palm kernel cake (PKC), palm kernel shell (PKS), decanter cake (DC) in palm oil mills and liquid waste as palm oil mill effluent (POME). Liquid waste could be easily converted to value as products such as biogas. While, solid waste is not utilized, due to its composition are difficult to degrade by microorganisms. Palm oil biomass residues composed of hemicellulose, celluloses that could be used as substrate for methane production through anaerobic digestion. However, the composition of lignocellulosic biomass such as lignin content affects methane yield were limited to liquid anaerobic digestion. Palm oil biomass containing mainly fibrous matter, floats to the surface to form a scum layer and is difficult to break because of entrapped gases . So, palm oil biomass is unsuitable for feeding liquid phase anaerobic digesters and biogas production can be severely affected due to the floating and poor mixing of fibrous materials. The anaerobic digestion process can operate in both liquid and solid states in terms of total solid (TS) content. In general, the TS content of liquid anaerobic digestion systems ranges from 0.5 to 15%, while solid-state anaerobic digestion systems usually operate at TS contents of higher than 15%.

Solid state anaerobic digestion can address several problems encountered in liquid anaerobic digestion, such as floating and stratification of fibres, that make it well suited to handle lignocellulosic biomass. Compared to liquid anaerobic digestion, the major advantages of Solid state anaerobic digestion include the reduction in reactor volume, minimal agitation, fewer moving parts, and lower energy input for heating due to a smaller operating volume and as mentioned earlier there are many merits and demerits of this system. Furthermore, the problems encountered in liquid anaerobic digestion, such as floating and stratification of fibers and disposal of large amounts of liquid effluent, can be addressed in solid state anaerobic digestion. Furthermore, the finished dig estate could be a compost like material with about 20% TS content, making the waste disposal easier. Comparison of solid to liquid state anaerobic digestion of nice lignocellulosic feed stocks including switch grass, corn stover, wheat straw, yard waste, leaves, waste paper, maple, and pine for biogas production were evaluated no significant difference in methane yield between liquid anaerobic digestion and solid-state anaerobic digestion, except for some feed stocks which needs to be studied in depth. Therefore, this work aim to determine the methane potential from decanter cake with a combination of he solid state and the liquid state anaerobic digestion and ensured that the solids entering the digester were in the range of 19000 – 34000 mg/litre.

## Materials and Methods

Innoculum and Decanter cake biomass were used for the present study and these were collected from a palm oil mill plant. The decanter cake or muck showed a very different variations when collected from different mills. However to come to a common study purpose it was considered with the common total solid content mentioned in the Table No. 1 below. The decanter muck was oven dried at 95 Deg C for 48 hours in a convection oven. The oven dried sample were then grounded to pass through a 3 mm screen with a grinder and stored in a air tight containers for later use. The characteristics of the substrates and inoculum for the methods are shown in the Table No. 1 Prior to use, the inoculum was acclimated and degassed at 37 Deg C for 7 days to minimize the background methane production.

**Table No: 1 Characterization of Decanter Muck or Cake:**

| Sr. No. | Parameters Tested | Values with units |
|---|---|---|
| 1 | Total Solid | 1,90,000 – 2,10,000 mg/kg |
| 2 | TSS | 1,55,000 – 1,78,000 mg/kg |
| 3 | TVS | 1,45,000 – 1,55,000 mg/kg |
| 4 | TDS | 28,000 – 30,000 mg/kg |
| 5 | COD | 2,50,000 – 2,70,000 mg/kg |
| 6 | Percentage of Volatile Solids | 86 – 92 |
| 7 | Percentage of Moisture | 78 – 81 |
| 8 | pH | 4.3 – 5.1 |
| 9 | Oil and Grease | 60 – 70 mg/kg |

The experiments which were carried out showed a steady reduction of COD in the range of 70- 93%. Since the decanter muck/cake is not available for 365 days and this showed a difference in total solids, volatile solids, COD reduction rates and in the overall biogas generation data. However it was seen that when the COD reduction was above 70% the gas generation was ranged between 0.075 – 0.082$M^3$ and when the COD reduction was between 80 – 93% the biogas generation ranged between 0.095 – 0.120$M^3$, per kg of decanter muck/cake. We have studied the same with various different dilution rates to understand the digester design and the total solids fed to the digester. Table No. 2 shows the results of various dilution rates at the same time the Table No. 3 shows the results when the temperature was changed and increased

**Table No: 2**

| Sr. No. | Dilution Rates | pH | Temp | TS (mg/l) | TSS (mg/l) | TVS (mg/l) | TDS (mg/l) | COD (mg/l) | Acidity (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1:5 | 4.50 | 28 | 34200 | 29600 | 26900 | 5100 | 42400 | 165 |
| 2 | 1:6 | 4.65 | 28 | 31600 | 27000 | 23800 | 4600 | 37600 | 135 |
| 3 | 1:7 | 4.75 | 28 | 26600 | 22800 | 20200 | 4100 | 34800 | 125 |
| 4 | 1:8 | 5.05 | 28 | 23100 | 19900 | 16900 | 3400 | 31100 | 100 |
| 5 | 1:9 | 6.00 | 28 | 19000 | 16900 | 15100 | 3100 | 29600 | 85 |

**Table No: 3**

| Sr. No. | Dilution Rates | pH | Temp | TS (mg/l) | TSS (mg/l) | TVS (mg/l) | TDS (mg/l) | COD (mg/l) | Acidity (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1:5 | 4.50 | 38 | 34200 | 29600 | 26900 | 5100 | 42400 | 165 |
| 2 | 1:6 | 4.65 | 38 | 31600 | 27000 | 23800 | 4600 | 37600 | 135 |
| 3 | 1:7 | 4.75 | 38 | 26600 | 22800 | 20200 | 4100 | 34800 | 125 |
| 4 | 1:8 | 5.05 | 38 | 23100 | 19900 | 16900 | 3400 | 31100 | 100 |
| 5 | 1:9 | 6.00 | 38 | 19000 | 16900 | 15100 | 3100 | 29600 | 85 |

**Conclusion:**

For experimental purpose different dilution rates were studied along with two different temperatures. Different dilution rates were 1:5 – 1:9 where 1000 kgs of decanter muck/cake was diluted with water accordingly. For every 1000 kgs of decanter muck almost 5 litres of water was added in the first dilution experiment and similarly upto 9 litres of water was added for the experiments ahead. The COD for the first dilution with 1:5 was found to be 42400 mg/l with total volatile solid 26900 mg/lit. The above experiments at different temperatures showed different results. The COD reduction was ranging between 70-75% when digested at 26 deg C and when the same was digested at 38 Deg C the COD reduction was almost 93%. Similarly, the biogas generation showed two different ranges when digested at 26 Deg C and at 38 Deg C. At 26 Deg C the biogas generation ranged between 0.075 – 0.082 $M^3$ whereas at 38 Deg C the biogas generation showed a increase and it ranged between 0.095 – 0.120 $M^3$per kg of the raw material. The Biogas generation also changed with the change in the increase of hydraulic retention time, it was observed best to be at 20 and 21 days and after this the biogas generation started reducing.

**Remarks:**

There were almost no reference material found on the decanter cake or decanter muck to biogas generation. The total solid concentration of the decanter muck changed when checked from different palm oil mills and again it was different season wise as during availability the moisture content was more and during off season when the muck was not available the moisture content was almost reduced and the percentage of total solids to moisture levels almost reversed, for example when it was observed total solids during the season it was 20% and moisture levels were 80% and during off season the total solid concentration was almost 60-80% and the moisture levels ranged between 20-40%. Gas production was observed for 3 life cycles and it was found that at 20 days it was the highest considering the same TS levels feed to the digester at steady temperature levels. However, it was found that during 26 Deg C and 38 Deg C the methane percentage ranged between 70 – 79%. Agitation is a must when the digester is operated at a field levels as without agitation the TSS will be accumulated and start forming the dead pockets inside the digester. The start up of the digester before the experiment was explained in the materials and method section and it was found that the temperature also needs to be increased if one wants to generate more biogas as with more acidic conditions the gas production showed a decrease and it can also be concluded that for digesting decanter muck the project also needs a alkaline raw material or feed stock to avoid mono digestion issue. Since the feedstock needs to be stored for the off season due to non availability during this time and has to be silaged and stored in a proper and efficient way to use it throughout the year. Efficient ways to store the decanter muck for 365 days needs to be studied and experimented with various enzymes and cultures and further the same can be explored. Another way of digesting could be a solution where the available decanter muck can be digested along with the other feedstock in the ratio 7:3 during the availability that is during availability, for example if a 50 ton per day of biogas project is installed then 35 tons of decanter muck to be used and balance 15 tons of other feedstock needs to be added. In this way only little amount of decanter muck needs to be stored where during off season the other feedstock shall be 35 tons on daily basis and decanter muck shall be only 15 tons per day. pH and Temperature is the key to digest and get more biogas from decanter muck throughout the year.

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