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Enhanced Biogas Production Of A Revamped Fixed Film Anaerobic Digester On Raw Spent Wash- A Case Study

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Abstract: In the present scenario, the cost of conventional energies has increased at a rapid rate due to manifold increase in their consumption. Renewable sources of energy are our best option for sustainable and pollution free development. One of the chief renewable sources of energy is biogas. The biogas is produced as by product of anaerobic digestion of organic substrate. Raw Spent Wash (RSW) is generated as effluent from distilleries and is a high organic content wastewater with potential for tremendous quantity of biogas generation via anaerobic digestion. In the present study biogas generation from a revamped fixed media reactor was evaluated for biogas production using RSW as substrate. The revamped digester was able to achieve its designed performance and achieved an average COD reduction of 65%, with the average biogas production of 22343 m^3/d. The biogas production was 3535 m^3/day higher than design values, indicating the superiority of reactor system in treating the effluent. The present study found that media based reactor is highly efficient, reducing pollution loads from the effluent of the distillery and can additionally produce biogas in surplus quantities providing a double benefit of clean source of energy and financial savings to the industry.

Keywords: **Biogas, Raw Spent Wash, Fixed Film Anaerobic Digester, Distillery waste**

I. Introduction

Increased dependence on fossil fuels in growing economy has resulted in increasing fuel prices. These increasing fuel prices hamper the industries more as they consume them in bulk quantities. In distilleries furnace oil is the chief source of energy, used in boiler for production of steam which is subsequently used in distillation process (Rao, P. V, & Ponnapalli, C. (2016)). Another chief problem associated with use of conventional fuels in industries is its impact on environment. High fossil fuel consumption results in air pollution, filling the air environment with numerous air pollutants (STEVENSON, C. A. (1898)). Release of such pollutants is not only harmful to environment, but as it is in violation of pollution control norms of state and state government it can possibly result in large penalties for industry or even their closures.

The best case scenarios for industries are utilization of renewable sources of energy. It will provide the dual advantage of reducing pollution load and financial savings in terms of fossil fuel saved. The distilleries sections are of particular advantage in this regard as the effluent has marked potential for renewable energy production in from of biogas.

For alcohol production in distilleries, molasses is received from the sugar factories; this molasses is then put in fermentation tanks with yeast and water. Yeast is the main fermenting microorganisms and water is added for the dilution of molasses. The fermentation process is for time period of 30 hours, after which the fermented wash is send to distillation. The distillation process is steam based, which separate alcohol from the fermented wash. The residual matter after distillation is RSW. Distillery effluent known as raw spent wash (RSW) is highly organic in nature with volatile solids, this organic waste under anaerobic conditions and in presence of appropriate micro flora produces biogas, which is essentially composed of methane. The biogas is combustible gas and can be used for production of energy.

Using RSW for biogas production is highly lucrative option for distilleries as it acts as technology for treatment of effluent and biogas is produced as a byproduct, which is a clean energy source.

Numerous anaerobic digestion technologies are available for production of biogas, of them chief are:

1. Sludge Blanket Reactor
2. Fixed Film Reactor
3. Continuous Stirred Tank Reactor

Of the above main types, Fixed Film Reactor has several advantages as compared to others, especially they have much higher rate of gas production as compared to others and maintenance is very low (Mohana, S., Acharya, B. K., & Madamwar, D. (2009)). In the present study enhancement of Biogas and performance of revamped fixed film reactor provided by Lars Enviro Pvt. Ltd., (LESMAT) was evaluated on RSW.

II. Materials & Method

1. **Treatment Scheme & Brief Details about system:** Distillery effluent treatment plant (ETP) is located at Coimbatore, Tamilnadu, India. Process Flow Diagram is shown in **Figure 1.**

Equalization Tank (EQT): The equalization has provided to control fluctuations in RSW flow & characteristics in order to provide optimum conditions for subsequent treatment processes. The equalization basin adequately absorbs wastewater fluctuations caused by variation in plant production scheduling and to dampen the concentrated batches periodically dumped or spilled. Mixers are provided for proper mixing.

Plate Heat Exchanger & Cooling Tower (PHE & CT): RSW from the equalization tank pump into the buffer tank through PHE. Cooling Tower with PHE provided to reduce the inlet wastewater temperature to the desired level.

Buffer Tank (BT): In buffer tank the complex organics in the wastewater are subjected to hydrolysis etc. The hydrolyzed wastewater is then pumped from the buffer tank into the LESMAT for anaerobic treatment.

LESMAT (Lars Enviro Structured Media Anaerobic Reactor) is brand name of Fixed Film Anaerobic Digester: The existing tank used for the LESMAT. The additional strengthening required for shell, roof and bottom plates that done at site. The Tank inside fully sand blasted as per the specifications of the code and painted using chlorinated rubber paint by Lars Envior Pvt Ltd. The Tank outside also wire brush cleaned and painted with synthetic enamel paint. The reactor content is kept under constant re-circulation, used 4 no's of recirculation pumps. Each recirculation pump is connected to the newly designed suction network, placed next to the bottom of the reactor. All recirculation pumps pour their discharge into roof common feed tank. The distribution Network provided at the top of fixed film anaerbic digester.

It is mesophillic digester i.e. it operates best in a temperature range of 36 – 39^{o}C. The fixed film anaerbic digester is partially packed with structured media, made out of PVC materials. The entire media remain submerged in the reactor content. The bacteria grow and reside in the large surface area provided by the media. The bacteria developed on a media surface take upon organic content of wastewater to metabolize and produce biogas & biomass. Media provides a large surface area for immobilization of bacteria and their subsequent growth. It provides maximum substrate to micro organism contact by higher recirculation ratio. The reactor is provided with the following accessories to ensure efficient performance and safety of the reactor: Pressure breaker and Vacuum breaker, in case pressure go out of operating range. Flare stacks to flare the biogas generated in case it is not in used. Liquid flow meter for recording liquid flow. That has regularly calibrated with liquid displacement and bucket methods.

The biogas produced by anaerobic digestion inside the reactor is collected in the Gas dome. The Gas dome is placed at Reactor roof and is fitted with all essential safety equipment such as breather valve, flame arrestor etc. Biogas is then taken for further utilization and if not then it will be flared in flare stack. The treated effluent of fixed film anaerbic digester is collected from the reactor in treated water tank.

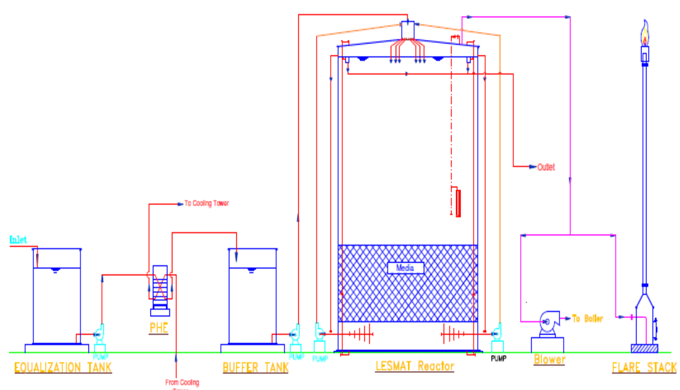

Figure 1: Process Flow Diagram

2. **Analysis and monitoring of the plant performance:** The raw spent wash, digested effluent and biogas samples has analysed by using 20th edition of standards methods for the examination of water and wastewater –(APHA/

AWWA/WEF) at the site. They have well equipped Laboratory. Laboratory equipments are calibrated by the external approved agency time to time.

III. Result And Discussion

Seeding Details

Seeding is one of the most crucial and vital stage for proper performance of anaerobic digester. It is the primary stage of commissioning after the respective hydraulic and pneumatic tests. The total duration for seeding was 28 days. The time period for seeding and operated full load are presented in **Figure 2**. The overflow was achieved within 21 days of starting the seeding. For seeding cow dung and pre acclimatized anaerobic sludge was used from already existing anaerobic digesters treating raw spent wash. A total of 42MT of cow dung was used along with 2904m^3 of seed culture from anaerobic digesters. For feeding of such seed 4495 m^3 of water was used. The overflow of the reactor was achieved within 21 days.

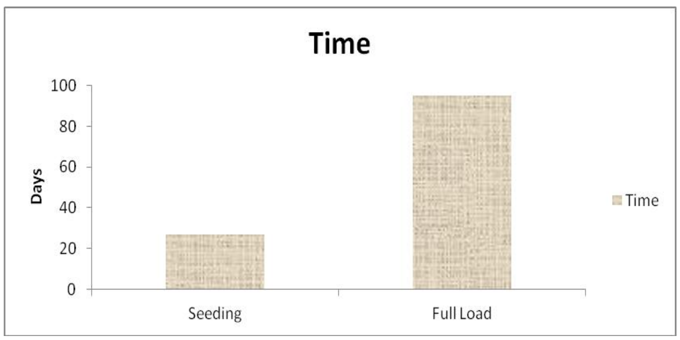

Figure 2: Seeding and full load time

To further enhance the development of seed, micro and macro nutrients was added. To maintain pH soda ash was used approximately 4560Kg, other nutrients requirements were Urea 950Kg, Di-ammonium phosphate 850Kg, 5.5Kg Ferric Chloride, Zinc chloride 0.49Kg. Nutrient dosing led to enhanced acclimatization and development of seed culture, which was indicated by biogas flare only after 18 days after the start of seeding. The reactor overflow was achieved after 21 days of the start of the seeding.

Performance Evaluation

After successful seeding, the digester was run at full load for a period of one month, to measure its performance. The average feed during this period was average of 463 m^3/day. The feeding trend is shown in Figure 3. The minimum and maximum feed for the period was 405 and 518 m^3/day. The feeding average inlet COD was 57602 Kg/day with minimum at 47142 Kg/day and maximum at 66553 Kg/day of which average of 36214 Kg/day of COD was removed. The trends are presented in Figure 4. The average COD reduction was 65%, with maximum COD reduction resting at 70%. The COD reduction is presented in Figure 5.

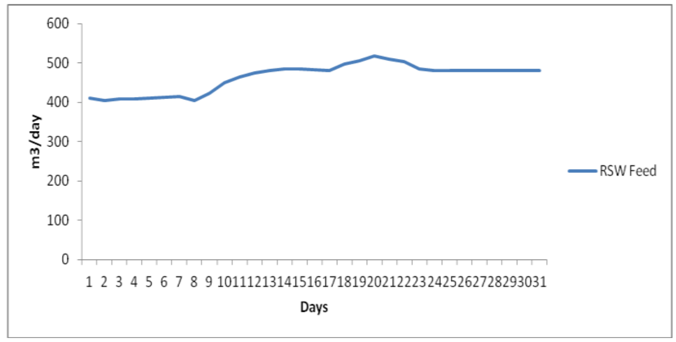

Figure 3: RSW feed

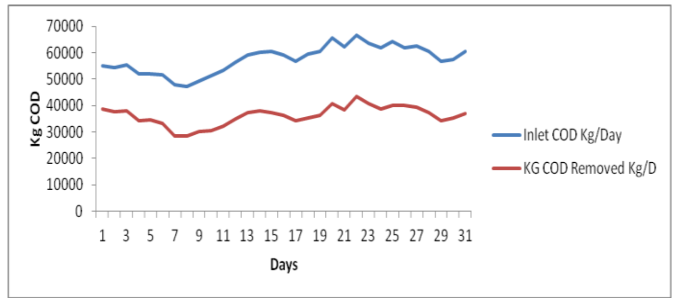

Figure 4: Inlet Kg COD and Kg COD removed

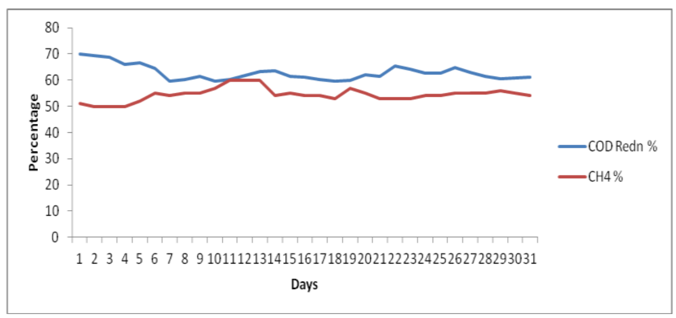

Figure 5: COD reduction and methane percentage

The biogas production as per flow meter was 23790 m^3/day which was substantially higher than average theoretical biogas yield of 18107m^3/day. The actual biogas yield was 31% higher than the estimated theoretical yield. Biogas yield is presented in Figure 6. The total biogas production during the entire performance evaluation of period was 0.66 m^3/Kg of COD reduced. The corresponding methane production was 0.36 m^3/Kg of COD reduced. The trends are presented in Figure 7. The total methane yield in terms of m^3/day was 13513 and is shown in Figure 8.

The main profit from the anaerobic digestion process is biogas produced and subsequent furnace oil saved. The furnace oil saved is presented in **Figure 9 and 10.** The average Furnace oil (FO) consumption without biogas was 16.3m^3/day. FO consumption with utilization of biogas was drastically reduced to a meager value of 3.2m^3/day. The total FO consumption was reduced by 80%. The total FO saved form per m^3 of biogas produced was 0.55L, parallel FO saved from per m^3 of methane was 1L.

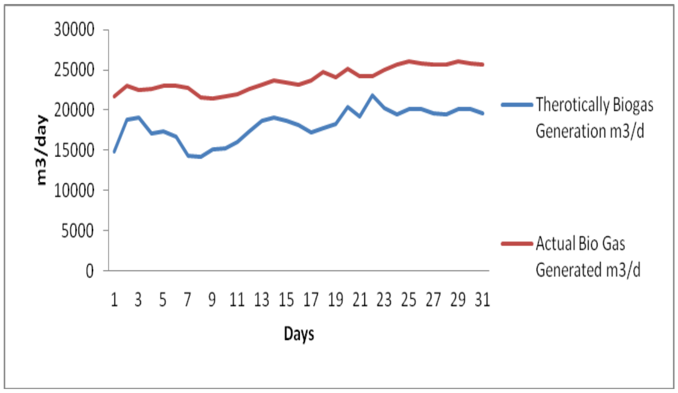

Figure 6: Theoretical and Actual Biogas Production in m3/day

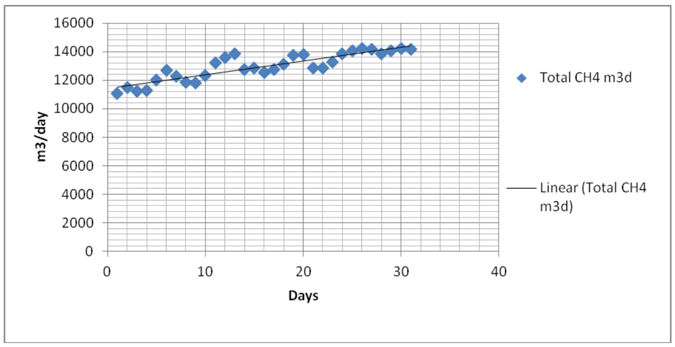

Figure 7: Total methane produced in m3/d

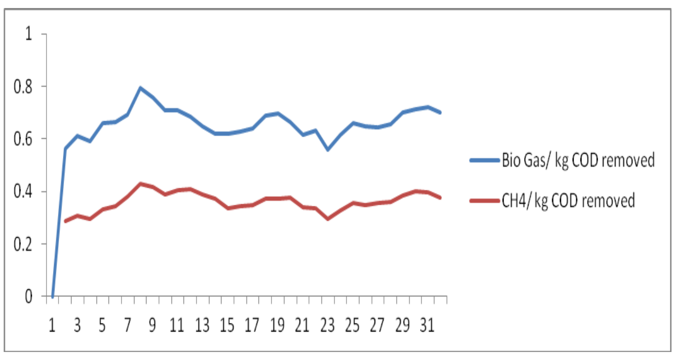

Figure 8: Biogas and Methane produced per Kg of COD reduced

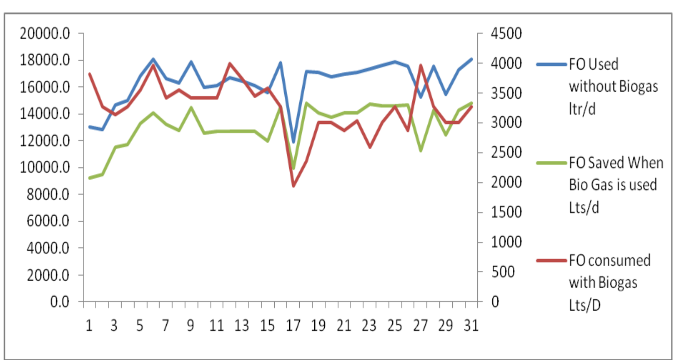

Figure 9: Furnace Oil consumed without biogas, with biogas and FO saved

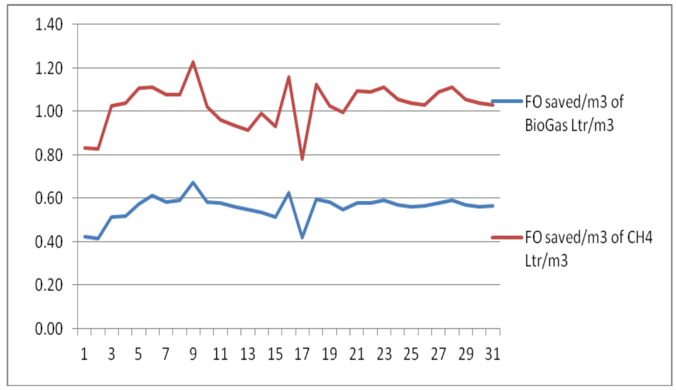

Figure 10: FO saved from per m3 of biogas and methane

IV. CONCLUSION

The study finds that anaerobic digestion is one of the most lucrative options for treatment of raw spent wash and parallel production of biogas as renewable source of energy. Findings of the present study indicate that, performance of revamped Fixed Film Anaerobic Digester is at par with new reactor and is a viable and lucrative alternative for treatment of raw spent wash.

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