



Anaerobic Digestion Process for the Treatment of High Brix Distillery Spent Wash

Govind P. Misale^{1*}, S.E. Neelgund², Vijendra Singh³ and S.V. Patil⁴

¹Associate Vice President (Ethanol), Renuka Sugars Limited, Belagavi, Karnataka, India

²Department of Biochemistry, Kuvempu University, Shimoga, Karnataka, India

³Executive Director, Shree Renuka Sugars Limited, Mumbai, Maharashtra, India

⁴Head Alcohol Technology, Vasant Dada Sugar Institute, Pune, Maharashtra, India

*Corresponding author: govind.misale@renukasugars.com

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Abstract

Distillery spent wash is the unwanted residual liquid waste generated during alcohol production and the pollution caused by it has become a critical environmental issue. Despite standards imposed on effluent quality, untreated or partially treated effluent very often finds access to watercourses. The distillery wastewater with its characteristic unpleasant odour poses a serious threat to the water quality in several regions around the globe. In this study, experiments were carried out to investigate the production of biogas from distillery spent wash by using an anaerobic digestion process with Continuous Stirred Tank Reactor (CSTR). The experiment was carried out to calculate the efficiency of the production of biogas. The digester was operated with feed of high Brix Spentwash. The digester shows stable performance with production of biogas.

Keywords: Anaerobic Digestion, Spent Wash, Alcohol Production.

Distillery spent wash refers to the effluent generated from alcohol distilleries. On an average, 8–15 L of effluent is generated for every litre of alcohol produced. The alcohol distilleries are extensively growing due to widespread industrial applications of alcohol such as in pharmaceuticals, food, perfumery, etc. It is also used as an alternate fuel. There are 319 distilleries in India alone, producing 3.25 billion litres of alcohol and generating 40.4 billion litres of wastewaters annually. As per the Ministry of Environment and Forests (MoEF), alcohol distilleries are listed at the top in the “Red Category” industries. Alcohol production in distilleries consists of four main steps viz. feed preparation, fermentation, distillation, and packaging. Ethanol can be prepared from various biomass materials but the potential for

their use as feedstock depends on the cost, availability, carbohydrate contents, and the ease by which they can be converted to alcohol. Nearly 61% of world’s ethanol production is from sugar crops. Most Indian distilleries exclusively use cane molasses as raw material for fermentation. Ethanol accumulates up to 8–10% in the fermented mash. The fermented mash is then distilled, fractionated and rectified after the removal of yeast (e.g., *Saccharomyces cerevisiae*) or bacterial (e.g., *Zymomonas mobilis*) sludge. The residue of the fermented mash which comes out as liquid waste is termed as spent wash. The main objective of this study was to treat the distillery spent wash using an anaerobic process for biogas production and to characterize the spent wash for various parameters such as COD, BOD, pH etc. To study the effect of

organic loading on the performance of anaerobic digestion process and to find the amount of biogas produced.

MATERIALS AND METHODOLOGY

Anaerobic digestion (stages)

Biogas production through anaerobic digestion is a biochemical process involving conversion of complex biological and organic wastes in sequential stages into Methane, the major energy fuel.

Stage 1: The hydrolytic bacteria primarily are involved in the breakdown of complex organic waste streams into simple sugars, fats & oils, and amino acids. This stage involves splitting of the complex organic biological molecules into simpler forms, the process is known as Hydrolysis or Liquefaction.

Stage 2: The Fermentative acidogenic bacteria convert the hydrolysed portion into organic acids.

Stage 3: The Fermentative acidogenic bacteria then convert the organic acids into hydrogen, acetate and carbon dioxide CO_2 .

Stage 4: Finally the methane producing bacteria, the methanogens, simultaneously produce biogas from the acetate, or from hydrogen & carbon dioxide.

Sources of Waste Water

Process Waste Streams: Spent wash from Analyser Column Fig. 1.

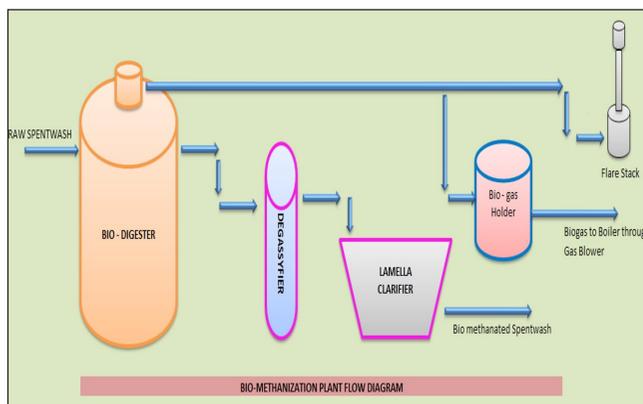


Fig. 1: Bio-Methanization Plant flow chart

Experimental Setup

Tank of capacity 15 M3 has been used as digester with working volume of 12.5 M3. The schematic diagram of the experimental setup for this study is shown in Fig. 2.

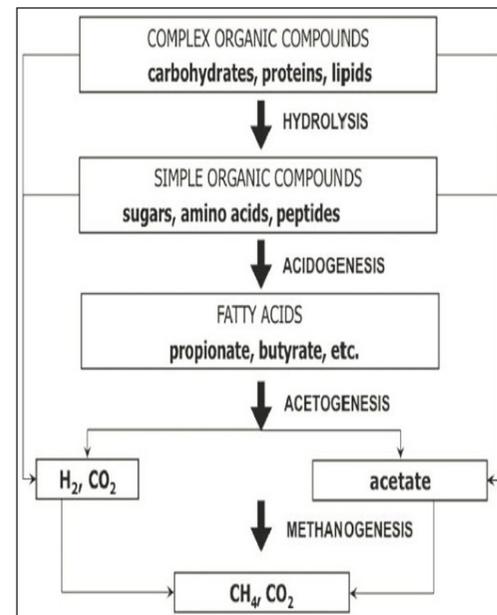


Fig. 2: Formation of Methane from Complex Organic compounds

The organic loading rate was calculated based upon the working volume of the digester.

General Characteristics of Distillery Effluent

The fresh Spentwash from the analyser bottom has been used. The key pollutants in this spent wash are organic compounds and solids. The BOD is 65000 mg/l and COD is 160000 mg/l and total suspended solids 1000 mg/l. The pH value in this case varies from 3.8 to 4.4. When waste water contains high concentration of organic matter, in absence of oxygen, sulphate acts as an electron acceptor to produce H_2S and odour.

Start-up of Reactor

During the start-up of reactor, the reactor was loaded with 150 litre of isolated anaerobic organism culture and 1000 litre of spent wash (6-7 Brix) with a COD concentration of 40000 mg/l, pH 7.0 & temp. 37 °C



was loaded along with micro nutrients of specified dosage. Later on daily reactor was feed with 800 litre Spentwash with increasing Brix. Once reactor gets level then feed maintained per day 250 lit. The reactor was loaded with continuously increasing brix and operated for a period of 30 days untill it attains stabilization. During this period pH is maintained from 7.2 to 7.6 and temperature is maintained from 37 to 39 °C. During various organic loading, effluent samples was collected for analysis of various parameters such as pH, BOD, COD, alkalinity etc.

RESULTS AND DISCUSSION

The anaerobic digestion is suitable particularly for distillery wastewater. The COD/N/P ratio for anaerobic digestion could be in the order of 800/5/1. The main parameters used for the characterisation of anaerobic digestion are: input and output concentrations of COD (kg COD or BOD/m³ of wastewater), organic loading rate (kg COD/m³ of digester/d), hydraulic retention time (day), gas productivity (m³ of biogas/m³ of digester/d), methane production (m³ biogas/kg COD removed) and COD (or BOD) removal efficiency (COD removed/COD applied). The organic load depends on the technology used and on the type of wastewater to be treated. The organic load obtained with suspended microorganism technologies is between 1 to 5 kg COD/m³/d. With UASB reactors, the load applied is between 5 kg to 15 kg COD/m³/d. For anaerobic filters it is between 5 kg to 20 kg COD/m³/d and generally between 15 kg to 30 kg COD/m³/d for the fluidised bed. The COD removal yields are generally high for distillery wastewater treatment. The values are generally between 80–98%. The biogas production is around 500 to 600 litres per kg of COD removed with 60–80% methane. The organic flow should be adjusted to the reaction capacity of the micro-organisms. If the reactor is overloaded, volatile fatty acids will accumulate, pH will fall down and we have a failure of the anaerobic reactor. Even with high depollution yields, anaerobic digestion treatment is generally not enough to release the effluent in natural environment. Therefore anaerobic digestion is generally followed by an aerobic

treatment. Anaerobic digestion of spent wash in a closed digester followed by its treatment under an activated sludge process, especially in an oxidation ditch to reduce costs, might be adopted as the most cost-effective system for the distilleries which are located away from sugar factories.

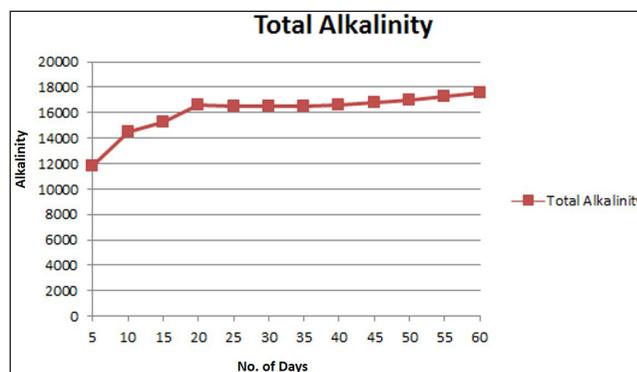


Fig. 3: Graph of Total Alkalinity

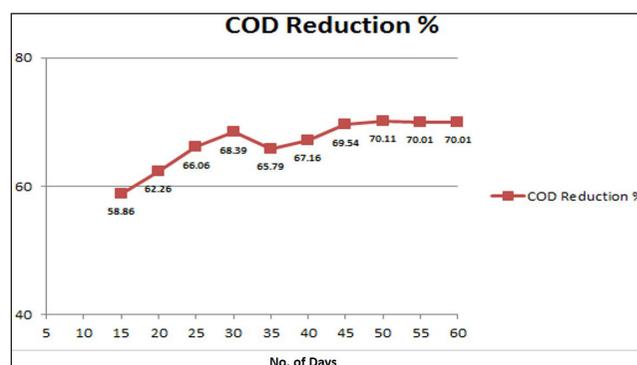


Fig. 4: Graph of percent COD reduction

The results of alkalinity, percentage (Fig. 3) of COD removal (Fig. 4) and Gas removal are shown in (Fig. 5). The reactor was started with 6^o Brix with COD 40000 mg/l. Daily feeding given with increasing brix. 30 days required to get stabilise the digester. During this alkalinity increased from 5700 mg/l to 15000 mg/l. Maximum COD reduction observed on 45th day. As time increased COD reduction increased & get stabilise & accordingly gas production also get stabilise. The reactor was started with an OLR of 0.5 kg COD/m³.d and operated for a period of 30 days till it attains stabilization. During this period the pH is maintained from 7.02-7.04. The alkalinity increased

from 1080-2980 mg/L & and COD reduced from 4200-3000 mg/L, refer Fig. 3. On 30th day the maximum COD removal efficiency obtained is 79.72 % & gas produced is 451mL. As the time increased, %COD removal increased & attained optimum value on 30th day. When the OLR was increased from 0.5 to 1.0 kg COD/m³.d (35-60th day) & operated for a period of 25days till it attains stabilization. Throughout the study period the pH is maintained from 7.10-7.03, the alkalinity increased from 810- 1945 mg/L & COD reduced from 5270-4248 mg/L, refer Fig. 4. On 60th day the maximum COD removal efficiency obtained is 71.29 % & gas produced is 815 mL. As the time increased, %COD removal increased & attained optimum value on 60th day. When the OLR was increased from 1.0 to 1.5 kg COD/m³.d (60-88th day) & operated for a period of 28days till the reactor stabilises.

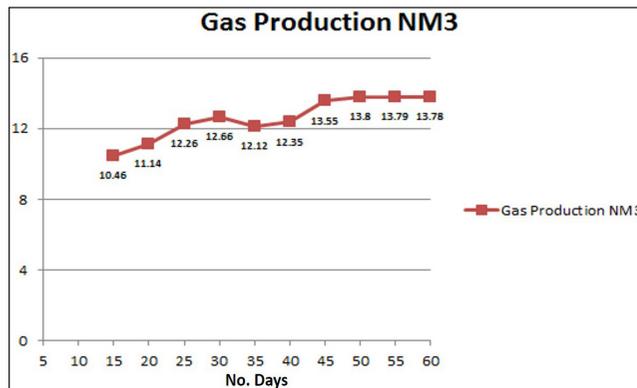


Fig. 5: Graph of Gas Production

Throughout the study period the pH is maintained from 7.02-7.08, the alkalinity increased from 690-1110 mg/L & COD reduced from 6370-5470 mg/L refer Fig. 5. On 88th day the maximum COD removal efficiency obtained is 63.04 % & gas produced is 1150 mL. As the time increased, %COD removal increased & attained optimum value on 88th day. Moreover, the treated effluent can be conveniently used for irrigation of cane fields or other crop lands, subsequently. Biogas generated from the distillery effluents, can be effectively utilized in production plant boilers thus saving about 50 to 60 percent fuel/steam. The treated effluent having almost all the

potash Low production of waste biological solids. Low nutrient requirements. Production of methane as an energy source to meet the steam requirement of distillery to the extent of 75-100%. Very high loading rates can be achieved. Active-anaerobic sludge can be preserved unfed for many months. Based on the experimental study it can be concluded that the spent wash is highly organic in nature having high value of COD (41,100 mg/L). The maximum COD removal efficiency is 79.72% achieved after 30th day (optimizing time) at an organic loading rate of 0.5 kg COD/ m³.d. The maximum biogas produced is 1150 mL after 88th day of the start of reactor at an OLR of 1.5 kg/m³.d. It was noticed that the percent COD removal was increased and attained optimum value on 88th day from the start up. As the OLR was increased from 0.5 to 1.5 kg COD/m³.d, the volume of gas produced increased form 5-451 mL, 451-815 mL and 812-1150 mL respectively, percent COD removal decreased from 71.62-79.72%, 64.39-71.29%, 56.95-63.04% and total alkalinity was decreased from 1080-2980 mg/L, 810- 1945 mg/L and 690-1110 mg/L respectively.

CONCLUSION

Anaerobic digestion is the most suitable option for the treatment of high strength organic effluents. The present study conclude reviewing the existing anaerobic technological status of treatment and disposal of distillery spentwash in our country. Application of anaerobic digestion to distillery effluents is a preferable primary treatment option. Conversion of COD into biogas through bi-methanation appears to be a reasonable solution. The different way of biogas utilisation is the production of steam, electricity, hot water (for small digester capacities) and co-generation. COD plays an important role in biogas production rate. COD reduction goes on increasing as the biogas production rate goes on increasing. The loading rates permissible in an anaerobic waste treatment process are primarily dictated by the sludge retention in an anaerobic reactor. The technologies are simple in construction and operation.



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