IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 18, Issue 1 Ser. III (Jan. – Feb. 2021), PP 57-62
www.iosrjournals.org

Treatment of Grain Based Distillery Spent Wash in Anaerobic Fixed Bed Digester (AFBD)

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Abstract:
Distilleries are one of the most polluting industries generating large volume of wastewater having a serious environmental concern. The aim of this work is to study the treatment of grain based distillery spent wash by a downflow digester. The digester was fabricated and packed with polyvinyl chloride pipe pieces and it was air tight sealed to maintain anaerobic conditions. The start up period, stability and performance of this digester were assessed at influent temperature 32^0C. Parameters such as pH and biogas were analysed daily, COD and BOD were analysed at selected HRT. The digester showed maximum COD and BOD removal efficiency of 84.19% and 86.37% at Organic loading rate (OLR) of 13.33 kgCOD/m^3.d. Start up period required by the digester was 48 days. Maximum biogas production was observed 2.355 L/d at 1 day HRT. BOD and COD removal increased as the HRT decreased from 6 to 3 days. A decline removal was noticed after HRT reduced from 3 to 1 day. Thus AFBD digester can be used for treating distillery wastewater and for producing biogas. This approach could be used to develop a cost-effective, eco-friendly biotechnology package for the bioremediation of spent wash before its disposal.
Key Word*: Grain based distillery wastewater, downflow digester, anaerobic digestion, biogas*

Date of Submission: 29-01-2021 Date of Acceptance: 14-02-2021

I. Introduction

In India, agro based industry is the 2^{nd} largest producer of alcohol (preferably ethanol). Of the total world demand of ethanol nearly 61% is produced from sugarcane molasses and beet. Which is not available throughout the year. Therefore other alternatives such as rice, wheat, corn, maize, jowar etc. are also considered for ethanol production. These crops are readily available in India, and hence, could be used for production of ethanol. After fermentation distillation is carried out to separate alcohol from feremntaed wash to concentrate it to 95%. After separation of alcohol, the remaining part is the effluent of the process, i.e. spent wash. Grain based spent wash contains high COD (56,000–80,000 mg/L) and BOD (25000–40,000 mg/L). The highCOD and BOD of the distillery spentwash are due to the presence of a number of organic compounds.If untreated spent wash disposed into water it creates serious effects on environment such as it adversely effect on aquatic life, decreasing in the light penetration capacity in water bodies. Therefore, the removal of BOD and COD from the grain based spentwash immense importance from the environmental point of view. Furthermore, regulatory agencies in India have notified discharge water quality standards for release into surface water (BOD < 30 mg/L, COD < 100 mg/L) and sewer (BOD < 100 mg/L, COD < 300 mg/L), therefore, effective treatment method is needed to reduce pollution load of these spentwash. Various treatment methods reported to treat spentwash includes coagulation, thermolysis, adsorption and electrochemical treatment, electrocoagulation treatment. Among all these treatment methods, anaerobic digestion is a better method due to its several advantages such as, e.g., the possibility of maintaining optimal environmental conditions for the acid- and methane-forming organisms, attenuation of imbalances between organic acid production and consumption, stable performance and a high methane content in the biogas produced in this process. In this background the present work aims to study the effect of pH, organic loading rate (OLR) and dilution factor for the removal of COD and BOD.

II. Material And Methods

Spent wash collection and its characterisation:

The distillery spent wash used in the present study was obtained from Anand Distillery Pvt., Ltd. Amravati, Maharashtra, India. Characteristics of raw spent wash is given in Table 1. To maintain characteristics of spentwash, the sample was stored at 4^0C in a deep freezer.

Table 1: Characteristics of Raw Spent Wash

Sr. No.	Properties	Concentration (mg/l)
01	Biochemical Oxygen Demand	25,000 – 40,000
02	Chemical Oxygen Demand	56,000 – 80,000
03	Total Solids	42,000 – 67,000
05	Volatile Solids	25,000 – 37,000
06	pH	4.5-5.0
07	Colour	Whitish Yellow

Experimental Setup:

A laboratory scale anaerobic fixed bed digester (AFBD) was fabricated by using PVC pipe 82 cm high. Internal diameter of the digester was 125 mm (5inch). Thermo-Polypropylene Compounds (TPPC) or Thermo-polyethylene Compounds (TPEC) type material was used as filter media. Inlet and outlet for the wastewater were provided at from top and bottom of the digester column respectively. Biogas evolved was collected by water displacement method. Effluent tap was fixed at the bottom of the digester to withdraw sludge. The digester was supported by iron frame; the schematic representation of this experimental setup is shown in Fig. 1. Pipe fittings were completely sealed to avoid air entry and to ensure anaerobic conditions in the digester.

Methodology:

The total volume of digester was 10 litres and its working volume was 8 litres. For start up operation, the influent OLR was held initially at 7.5 kg of COD/m^3/d for first 32 days and flow rate of 1 L/d. The OLR was then increased by additional input flow rate upto 48 days as 15 kg of COD/m^3/d. The OLR was calculated on the basis of the active volume. Total start up period was 48 days. After successful completion of start up period, two different influent COD, 60 kg/m^3 and 40 kg/m^3 conditions were adopted for further analysis at different OLR, HRT and pH. Analysis was carried out carried out for different pH such as 5, 6, 7, 7.5 and 8. This pH was maintained by using HCL and NaOH.

Figure. 1. Digester Setup

III. Results and Discussions

Start up Period:

TPPC or TPEC was an interesting filler material when compared to others like perlite, cork, polyethylene or polypropylene (R. Sowmeyan, 2008 and Garcia-Calderon et al., 1998). In total 48 days of start up operation, in the first 24 days COD and BOD removed upto 58.07% and 56.92% but biogas generation was negligible. The start-up period was divided into two parts. From day 1 to 32, input OLR had to be kept as 7.5 kg COD/m^3.d. Fromday 33, the digester had recovered an excellent COD removal efficiency. OLR increased from 7.5 to 15 kg of COD/m^3.d over the remaining days of operation. During this period the COD and BOD removal reached 69.47% and 71.91%. But after third week biogas was slightly generated. From 37 to 48 days steady-state performance was marked by near constant effluent BOD values and COD values with less than 5% fluctuation.

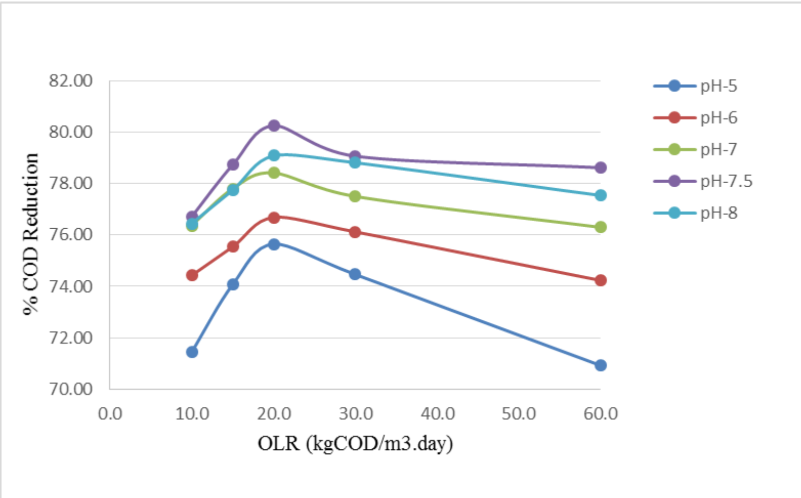
Effect of OLR

Effect of OLR on anaerobic digestion was analysed for influent COD of 60 kg/m^3 and 40 kg/m^3 . When influent COD was 60 kg/m^3, effect of organic loading rate was studied by varying the HRT as 6, 4, 3, 2 and 1day and increasing the organic loading rate from 10 kg COD/ m^3.d to 15, 20, 30 and 60 kg COD/ m^3.d.The digester fed with different organic loading rates and it was tested for COD and BOD removal efficiency for each OLR & HRT. The COD removal efficiency varied between 75.65% and 80.25% and BOD removal efficiency varied between 76.65% and 80.40% when the OLR increased from 10 to 60 kgCOD/ m^3.d. The COD and BOD removal at varied OLRs are depicted in Graph 1 and 2.

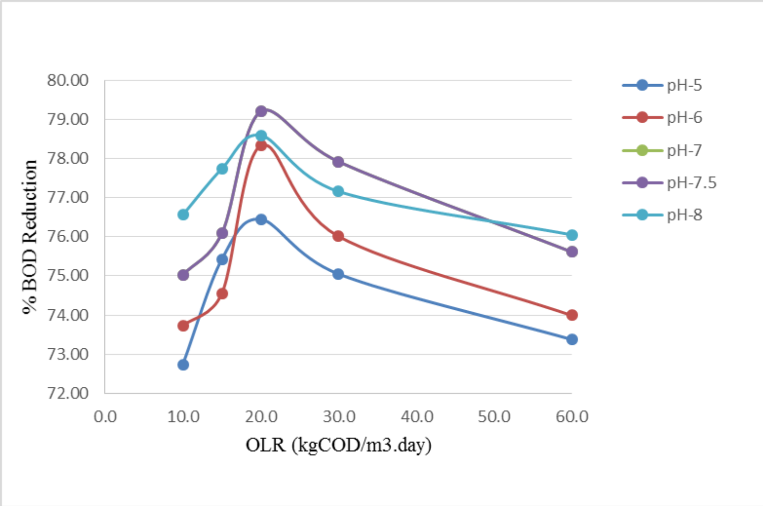
In the second stage, effect of dilution was checked and influent COD was taken as 40 kg/m^3 and organic loading rate increased from 6.67 kg COD/ m^3.d to 10, 13.33, 20 and 40 kg COD/ m^3.d.The COD removal efficiency varied between 77.31% and 84.19% and BOD removal efficiency varied between 79.27% and 86.37%. The COD and BOD removal at varied OLRs are depicted in Graph 3 and 4. Decrease in influent COD resulted in an increase in COD removal efficiency but variations in the total COD removal were significant.

Effect of pH

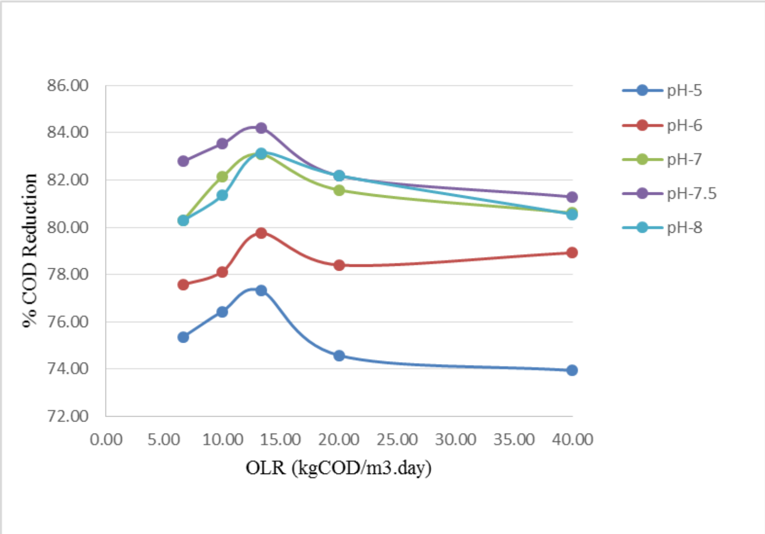
pH plays an important role in anaerobic digestion. Throughout the experiment, pH values at different HRTs remained reasonably stable in the range of 6.72–7.72 within the digester. When influent COD was 60 kg/m^3 COD and BOD removal efficiency 80.25% and 80.40% was obtained at influent 7.5 pH. Also at same pH when influent COD was 40 kg/m^3, COD and BOD removal efficiency was obtained 84.19% and 86.37%. The decreased and increased in pH as compared to 7.5, COD and BOD removal efficiency get decreased. Optimum pH was obtained as 7.5.



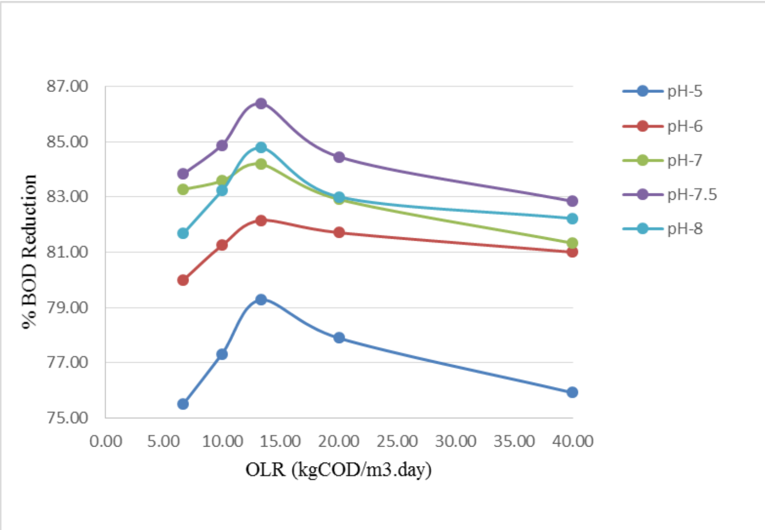
Graph 1: Effect of OLR on COD Reduction at Different pH for Influent COD 60 kg/m^3



Graph 2: Effect of OLR on BOD Reduction at Different pH for Influent COD 60 kg/m^3



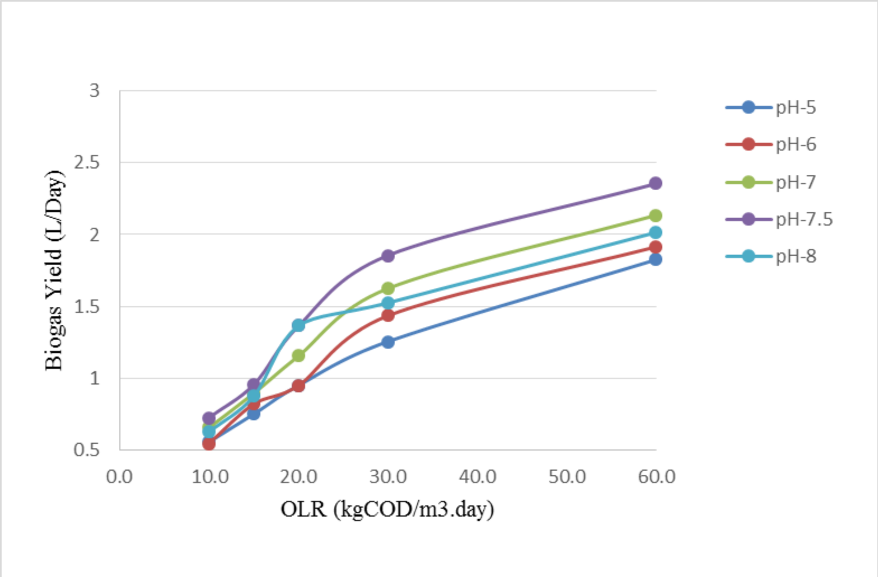
Graph 3: Effect of OLR on COD Reduction at Different pH for Influent COD 40 kg/m^3



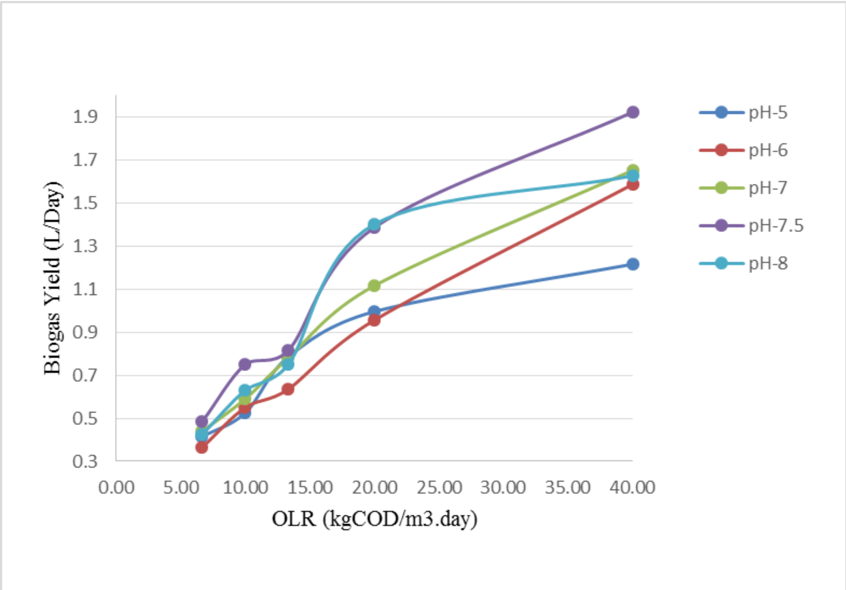
Graph 4: Effect of OLR on BOD Reduction at Different pH for Influent COD 40 kg/m^3

Biogas Generation

Strength of the wastewater plays an important role in biogas production. The biogas production rate during the study period for different influent COD is shown in Graph 5 and 6. For influent COD was 60 kg/m^3, initially the production of biogas was less in the range of 0.525 L/d. This was because initially the biomass required some time for acclimatization. As the time proceeded the gas production rate increased to around 2.355 L/d. For influent COD 40 kg/m^3, biogas was produced in the range of 0.355 L/d to 1.920 L/d. from graph it is stated that maximum biogas was produced at influent pH 7.5. the maximum values was obtained at 1 day HRT.



Graph 5: Biogas Production at Different pH for Influent COD 60 kg/m^3



Graph 6: Biogas Production at Different pH for Influent COD 40 kg/m^3

IV. Conclusion

Conclusions drawn from the present study are as follows:

1. Anaerobic digestion process for treatment of grain-based distillery resulted as an effective treatment method to reduce COD and BOD.
2. For COD influent 60 kg/m^3, 40 kg/m^3 maximum COD and BOD reduction efficiency was obtained at influent pH 7.5.
3. The COD and BOD reduction efficiency was found to increase with the dilution of spent wash.
4. Optimum HRT and pH were found for downflow digester as 3 days.
5. Optimum OLR for 60 kg/m^3 and40 kg/m^3 was found to be 20 kgCOD/m^3.d and 13.33 kgCOD/m^3.d.

6. Maximum biogas for influent COD 60 kg/m^3 and 40 kg/m^3 was produced 2.355 and 1.920 L/d.

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Prof. Yogesh S. Khandekar, et. al. "Treatment of Grain Based Distillery Spent Wash in Anaerobic Fixed Bed Digester (AFBD)." *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 18(1), 2021, pp. 57-62.