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Effect of Temperature and Nutrient on Anaerobic Digestion of Distillery Spent Wash

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Abstract:
The anaerobic digestion (AD) with downflow digester is an effective and novel approach to treat grain-based effluent of the distillery plant. This treatment was carried out in a 8 litres capacity digester for different parameters such as influent chemical oxygen demand (COD), temperature (mesophilic and thermophilic) and nutrient. When influent COD was 60 kg/m^3 and 40 kg/m^3, for mesophilic condition 32^{0}C temperature was found to be optimal. Maximum COD and biochemical oxygen demand (BOD) reduced upto 83.83% and 85.98% at 32^{0}C. The feeding of nutrient which enhanced COD and BOD removal efficiency of distillery spent wash. At nutrient concentration of 4 g/l, highest COD and BOD reduction were observed. Biogas were also analysed at different temperatures conditions and nutrient concentration. It was noted that biogas production was maximum for such optimal conditions.
Key Word*:Grain baseddistilleryspentwash, anaerobic digestion, temperature, nutrient*

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I. Introduction

Ethanol is one of the most important principal raw materials for production of various intermediate chemicals and medicines. In addition, many countries use pure ethanol and ethanol blended gasoline as motor fuel in automobiles. Ethanol is mainly produced from sugarcane molasses and sugar beet. Due to the increasing demand, rice, wheat, corn, etc. are also utilized for ethanol production. Rice is one of the major crops in Southeast Asia and some parts of South America. Ethanol is produced by fermentation of raw material in fermentation broth which contains 5–10 vol % ethanol. It is separated through distillation as top product and the liquor obtained as the bottom product is waste, called the spent wash (SW), which has a high chemical oxygen demand (COD, 10–120 kgm^{-3}) and biochemical oxygen demand (BOD, 3–40 kgm^{-3}) depending on the type of raw material. Due to the high organic content, the SW is first treated in an aerobic biodigester to produce methane gas where 50–70% COD and 60–80% BOD are removed. The effluent from the biodigester is called biodigester effluent (BDE) and still exhibits a high COD and BOD, 3–40 and 1–10 kgm^{-3}, respectively. Consequently, an effective treatment method is needed to reduce the pollution load of BDE. Various processes such as wet oxidation, thermolysis, coagulation, adsorption, and electrochemical degradation have been reported to treat BDE but all these processes have limitations. Anaerobic digestion is one of the best options for the treatment of BDE. This process has many advantages such as requirement of less external chemicals, i.e., coagulants, easier installation, lower secondary pollution, odor and color removal, and lower residence time.

II. Material And Methods

Characterization of effluent:

The distillery effluent used in this study was obtained from Anand Distillery Pvt. Ltd. Amravati, Maharashtra. To maintain constant characteristics of spent wash, the sample was stored at 4^{0}C in a deep freezer. The effluent was characterized for various parameters, namely COD, BOD, total solids, volatile solids, pH, colour etc., as per standard method of analysis. Furthermore, the COD, BOD and biogas of treated effluent was also analysed. The main characteristic of the original and treated effluent used for this study is given in Table 1.

Table 1: Characteristics of Raw Spent Wash

Sr. No.	Properties	Raw Spent Wash
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

All the values are in mg/l except pH values.

Digester Inoculation and Startup:

The lab-scale batch experimental setup used for the anaerobic digestion studies is shown in Figure 1. Anaerobic fixed bed downflow digester was made up of PVC pipe. It consisted of column with a total volume of 10 lit. (Working volume 8 lit., 0.82m in height). The gas outlet have been placed at the removable cap covering the top section. The gas outlet was connected to gas measurement assembly. The digester was filled with the solid carrier material upto 60% of its active volume. This material is a filter media mainly composed of Thermo polypropylene Compound (TPPC). The digester was fed with a distillery wastewater as per decided flow rate. Total start up period of the digester was 48 days. Initially for the startup period OLR was kept 7.5 kg of COD/m^3/d for first 32 days and then increased upto 15 kg of COD/m^3/d for the rest period. Biogas generation was started after 24 days. During this startup period COD and BOD reduced upto 69.47% and 71.91%.

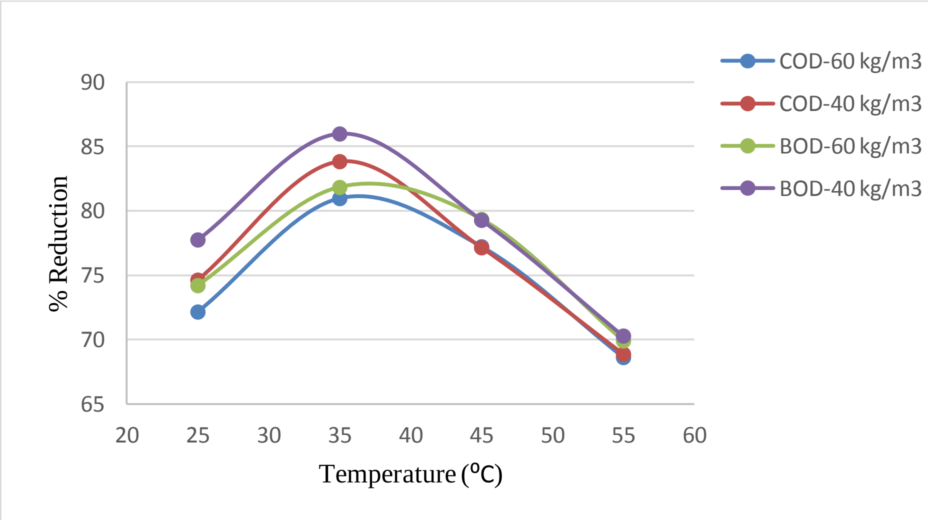
Figure.1: Set up of Fixed Bed Digester

III. Results and Discussions

Effect of Temperature:

Anaerobic decomposition of organics is accomplished through a series of biochemical reactions which is very dependent on temperature. Most take place at mesophilic condition. When the reactor temperature is below 30^{0}C the activity of methanogens is seriously reduced due to its generation times. Although high temperature seems to increase the pace of granulation, most bacteria will lose their activity if the temperature is too high. Experiments showed that if temperature is increased suddenly from 35^{0}C to 55^{0}C lower COD and BOD removal efficiency was observed. The pH in the digester was adjusted to 7.5 with NaOH during the total period of analysis. Graph 1 shows reduction efficiency of COD and BOD for different temperature ranges. For influent COD 60 kg/m^3, 3 day HRT and OLR 20 kg of COD/m^3/d maximum COD and BOD reduction 80.97% and 81.83% was observed at 35^{0}C. For the same HRT and temperature when influent COD was 40 kg/m^3, OLR

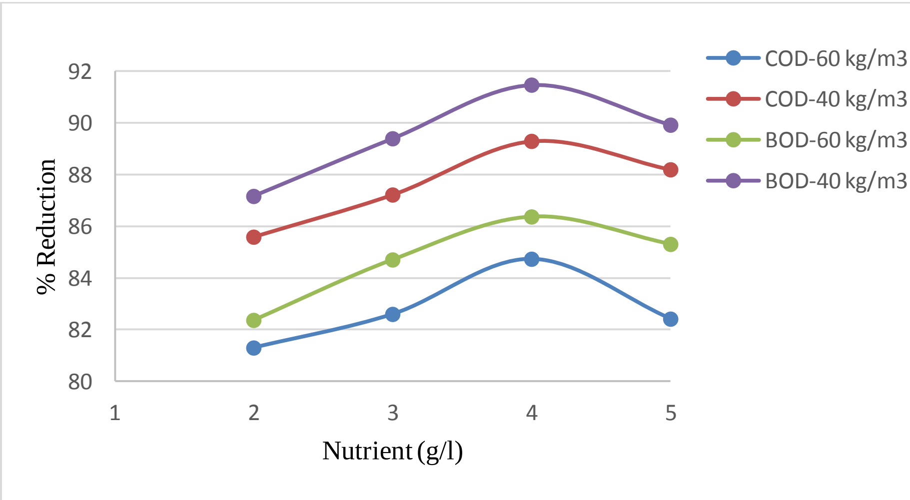
13.33 kg of COD/m^3/d COD and BOD reduced by 83.83% and 85.98%. Effect of temperature on effluent pH was also observed. At 35^{0}C, effluent pH was obtained in the range of 7.62-7.65, temperature below and above 35^{0}C pH values was obtained in the range of 7.12-6.75.



Graph 1: Effect of different mesophilic and thermophilictempearature ranges on COD and BOD reduction

Effect of Nutrient:

The effect of externally provided nutrient on anaerobic digestion was studied. Experimental investigation was carried out for two different COD influent 60 kg/m^3 and 40 kg/m^3. 3 day HRT was kept constant. When influent COD was 60 kg/m^3 and 40 kg/m^3 OLR was taken as 20 kg of COD/m^3/d, 13.33 kg of COD/m^3/d. COD and BOD reduction efficiency for glucose concentration 2, 3, 4 and 5g/l is shown in Graph 4. Maximum COD and BOD was reduced for influent COD of 40 kg/m^3 and glucose concentration 4 g/l, by 89.29% and 91.46%. This indicating that 4 g/l is the optimum concentration for anaerobic digestion.

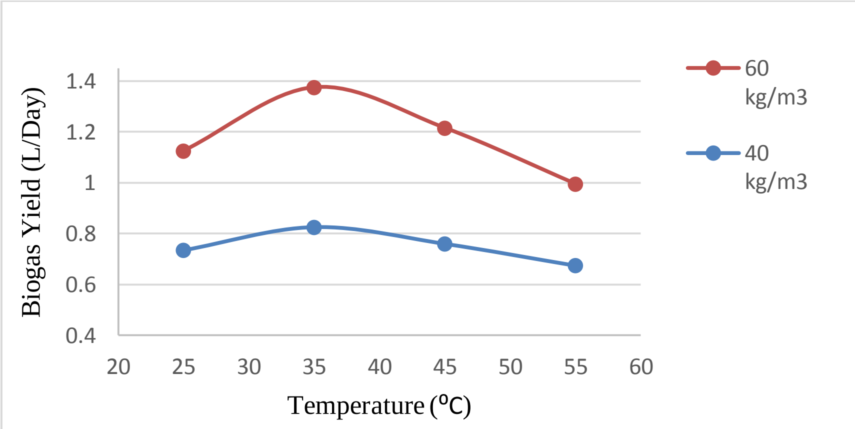


Graph 2: Effect of different concentration of Glucose on COD and BOD reduction

Effect of Temperature and Glucose on Biogas Yield:

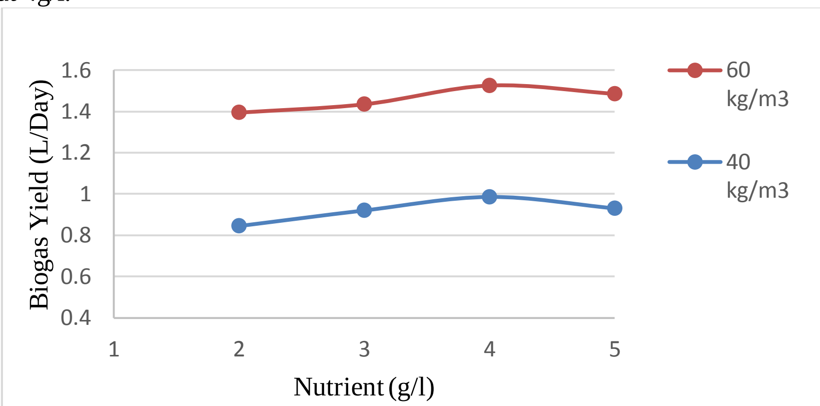
One important factor for the selection of anaerobic treatment is the possibility of energy recovery through biogas combustion. Biogas was generated as a by-product during the anaerobic treatment of grain based distillery industry wastewater. Biogas produced was measured by water displacement technique. Gopala Krishna et al. (2008) used water displacement method for the collection and estimation of biogas produced during the treatment of low strength wastewater in anaerobic baffled reactor (ABF) (Gopala Krishna et al. 2008). Graph 3 and 4 represents the biogas generated during the operating period. The amount of biogas generated in L/day for 60 kg/m^3 influent COD, 3 day HRT, OLR 20 kg of COD/m^3/d, temperature 25^{0}C, 35^{0}C, 45^{0}C, 55^{0}C is shown in Graph 3. The biogas generated for 25^{0}C, 35^{0}C, 45^{0}C, 55^{0}C was found to be 1.125, 1.375, 1.215 and 0.995 L/day respectively.

The amount of biogas generated in L/day for 40 kg/m^3 influent COD, 3 day HRT, OLR 13.33 kg of COD/m^3/d, temperature 25^{0}C, 35^{0}C, 45^{0}C, 55^{0}C is shown in Graph 3. The biogas generated for 25^{0}C, 35^{0}C, 45^{0}C, 55^{0}C was found to be 0.735, 0.825, 0.760 and 0.675 L/day respectively. It is indicating maximum amount of biogas generated at 35^{0}C.



Graph 3: Effect of different mesophilic and thermophilictempearature ranges on biogas yield

The amount of biogas generated in L/day for 60 kg/m^3 influent COD, 3 day HRT, OLR 20 kg of COD/m^3/d, glucose concentration 2, 3, 4 and 5g/l is shown in Graph 4. The biogas generated for 2, 3, 4 and 5g/l was found to be 1.395, 1.435, 1.525 and 1.485 L/day respectively. The amount of biogas generated in L/day for 40 kg/m^3 influent COD, 3 day HRT, OLR 13.33 kg of COD/m^3/d, biogas generated for 2, 3, 4 and 5g/l was found to be 0.845, 0.920, 0.985 and 0.930 L/day respectively. From the analysis indicating maximum amount of biogas generated at 4g/l.



Graph 4: Effect of different concentration of Glucose on biogas yield

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 35^{0}C temperature.
3. The COD and BOD reduction efficiency was found to increase with the dilution of spent wash.
4. Optimum glucose concentration was found for downflow digester as 4 g/l.

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