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Hybrid EGSB Reactor for Treating Distillery Wastewater

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ABSTRACT: Anaerobic treatment offer great potentials for highly organic wastewater. The study was carried out under ambient conditions in the laboratory scale Hybrid EGSB reactor was designed with electrodes for electrolysis process, with an effective volume 18 L. In the start-up period, the granulation was carried out in batch reactors and the accelerated granulation was achieved on 21st day with addition of chitosan, aluminium, sulfate, methanol etc. The reactor was fed with the granular anaerobic sludge. The reactor is expected decrease hydrogen sulphide and increase methane production by virtue of electrolysis process. In this study I have achieved the COD removal of about 86.12% and 81.4 % in the Hybrid EGSB and EGSB reactors at an OLR of 38.4 kgCOD/m³ day, increasing feed concentration 2300 mg/l to 9600 mg/l, upflow velocity was maintained 4 m/h with methane generation of 4.05 L/L/D.

KEYWORDS: Hybrid EGSB reactor, Batch reactor, Methane production, Anaerobic degradation.

I. INTRODUCTION

In India there are approximately 319 sugar industries. Wastewater out flowing from distilleries known as spent wash leads to extensive soil and water pollution. Removal of waste and colour from distillery effluent is becoming more essential from environmental point of view [1].

In the list of 17 industries, distillery ranks as the topmost polluting industries identified by Ministry of Environment & Forests, Govt. of India. Distillery spent wash is causing the serious pollution problems in the country. Distilleries spent wash containing extremely high COD (Chemical oxygen demand), BOD (Biochemical oxygen demand), SS (Suspended solids), inorganic solids, colour and has low pH value [2].

Economical and eco-friendly distillery spent treatment is a great challenge to environmentalists. A biological method gives good results as compared to physical and chemical methods. Both anaerobic and aerobic systems are commonly used to treat the wastewaters from distillery industries. Aerobic treatment requires large amount of power for mixing and aeration as compared to anaerobic treatment processes. Therefore, several treatment systems were developed that depend on anaerobic digestion than aerobic [3].

This enormous achievement in the growth of anaerobic wastewater expertise can be recognized to the introduction of advanced bioreactors, i.e. UASB reactor and EGSB reactor and anaerobic fluidized bed [1]. The expanded granular sludge bed (EGSB) reactor is recent developed form of up flow anaerobic sludge blanket reactor (UASB), has recently experienced vast growth. Although UASB is still the principal technology in use, EGSB-type processes are now becoming more popular. Compared with conventional UASB reactors (0.5 to 2 m/h), the advantage of the EGSB system (> 4 m/h) helps in better contact between sludge and wastewater [4].

II. RELATED WORK

Moletta et al (2005), Showed the distillery and wastewater treatment by anaerobic digestion. With the organic loading between 5-15 kg COD / m³ d of digester a high up to 90-95% COD removal was observed. The biogas production was

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between 400-600 L / kg.COD removed with 60-70% of methane content. The addition soda helped the process to maintain the pH of 6.5-8.

Tartakovsky et al (2011)., The authors reviewed that methane yield from wastewater in the laboratory scale, electrodes were introduced in the anaerobic reactor for water hydrolysis and a voltage of 2.8-3.5 were applied which is resulted in the hydrogen and oxygen .The oxygen created micro aerobic condition which is resulted in hydrolysis of wastewater and reduced the release of hydrogen sulphide and hydrogen produced will improve the combustion properties and methane production by hydrogenotrophic methanogens. By installation of electrodes resulted much more production of methane by 10-25 %.

Khandegar et al (2012)., Distillery spentwash is used as a substrate ,aluminium and iron electrodes were used in batch mode operation. The parameters regularly noted and noticed that aluminium performed better than iron electrodes with COD removal efficiency of 81.3 % for Al-Al electrodes at current density 0.187 a-cm²

Karnchanawong and W.Phajee (2009)., Investigated the up-flow liquid velocity effect (ULV) on performance of EGSB system. At the ULV 4 to 16 m/h performed better to remove organic matter and also suggested that ULV 4 m/h as a suitable design criterion.

Sharma and Sharma (2001)., Reviewed the effect of nutrient supplement on anaerobic sludge growth and activity for treat distillery waste matter. In this methanogenic activity of the sludge was improved by adding up of phosphate and calcium to the spentwash effluent. The effluent seems to be sufficient in both these macro nutrients for anaerobic digestion. Micro nutrient (Ni, Fe and Co) boosted methanogenic activity of sludge.

III. METHODOLOGY

The reactor was operated in two stages, In the start- up period the granulation was carried out in batch process. The reactor was seeded with 2 litres of digested and screened sludge, septic tank sludge and cow dung in the ratio 1:1:1. Micronutrients and macro nutrients, methanol, chitosan and glucose as a food were added for the granulation process [5]. On 21st day sludge sample was taken out, granules of diameter 1.5 – 2.0 mm were found within the reactor. Regularly COD removal efficiencies carried out, pH were monitored.

Figure 1. After 21st day granulation sizes of 1.5-2.0 mm were observed. The granulated sludge loaded to the Hybrid EGSB reactor.



Figure 1.Granulation on 21st day

Figure 2. The laboratory scale EGSB and Hybrid EGSB was fabricated using acrylic pipe of 110 mm diameter and overall height of 1900 mm. Inlet was provided at the bottom of the reactor with opening of 18 mm, one outlet has been provided at the top as the gas outlet and other as the outlet for the treated wastewater (effluent).

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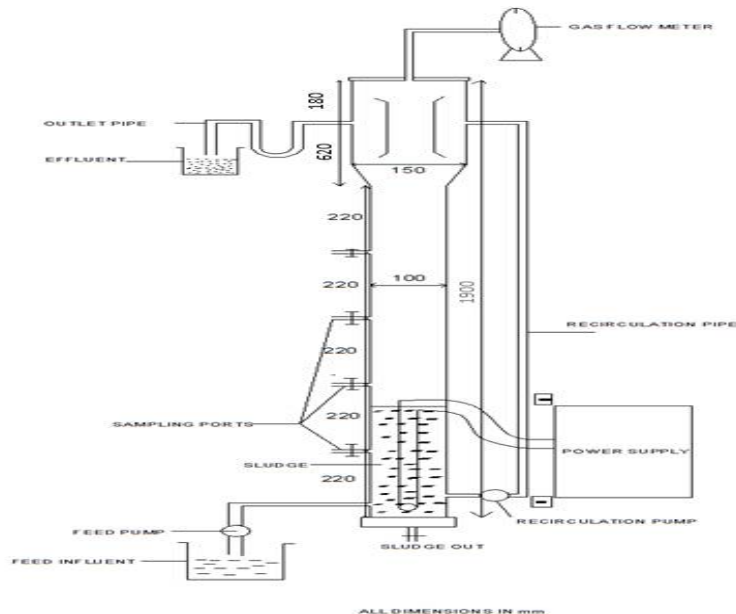


Figure 2. Hybrid EGSB reactor

The reactor consists of a Gas-liquid –solid separators (GLS) portion was provided at a distance of 350 mm from the top. To create electrolysis process in the reactor, zinc electrodes were installed with size of 10 cm x 6 cm. By increasing the OLR, we have increased the voltage, intern increases current density, thereby improving electrolysis process which liberates more amount of hydrogen. The liberated hydrogen combines with CO₂ by hydrogenotrophic methanogens converting into methane, which is very quick process [7]. During the process the voltage varied from 1.7 to 6.0 V, these electrodes were connected to the DC regulated power supply. The parameters like pH, VFA and alkalinity were monitored from different sampling ports. Micilns peristaltic pumps were used for feeding and recirculation of spentwash. The methane was measured by wet gas flow meter provided at top. Provision for sludge withdrawal was provided at the bottom of the reactor.

Table 1. Distillery spentwash characteristics were analysed and listed below. Then the distillery spentwash is diluted to concentration of 2300 mg/l initially by using tap water and loaded to reactor by operating peristaltic pump at desired rate.

Table1. Distillery spentwash characteristics

Parameter	Values
Colour	Dark brown
pH	4.2-4.5
COD	96400-105200 mg/l
BOD	46000-55000 mg/l
Total solids	86400-93600 mg/l
Chlorides	3850-4200 mg/l
Sulphate	3940-4340 mg/l
Nitrogen	3940-4350 mg/l
Phosphorous	780-1040 mg/l
Potassium	7900-8710 mg/l

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IV. RESULTS AND DISCUSSION

In the first stage, batch reactors were seeded with 2000 ml of crushed sludge and loaded with glucose as a food, the COD 1000 mg/L was maintained during batch process [8]. The batch process was maintained at pH value of 7. If its pH less than 7, sodium carbonate was added to maintain the pH value. Reactors performance and sludge characteristics such as granules, COD concentration of the effluent were monitored. Reactors were operated with addition of polymer (Chitosan)[9,10]. First granulated sludge of 9 L fed to the Hybrid EGSB reactor. During this study parameters such as pH, VFA, Alkalinity and methane production were recorded.

Figure 3. Shows the HRT and feed concentration, during operation 24 h HRT was maintained until 22nd day, later it was changed. Initially feed concentration was operated 2300 mg/l in both the reactor at 24 h, later it was varied to 4600 mg/l, 6900 mg/l and 9600 mg/l. Feed concentration was varied until optimum COD removal efficiency was achieved.

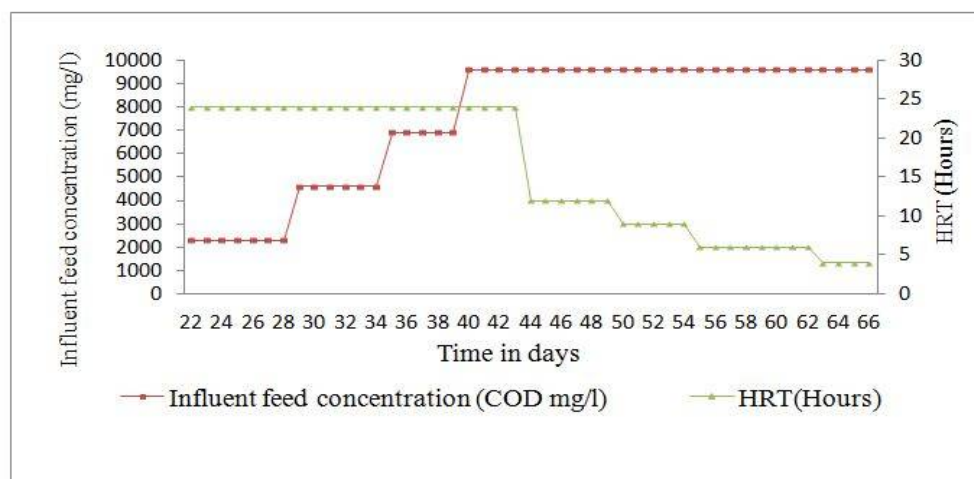


Figure 3. HRT vs Influent feed concentration

Figure 4. The pH is a very important factor controlling anaerobic digestion. The optimum growth of methane producing bacteria was noticed between the pH 6.6 to 7.6. The pH values below 6.0 and above 8.3 inhibit the methane producing bacteria, also inhibit the hydrolysis or acidogenesis phase. The pH 7 was maintained by adding sodium bicarbonate. During operation pH was maintained within the range (6.6-7.6) which showed the good performance of both reactors. The Figure 4 shows the variation in influent and effluent pH values.

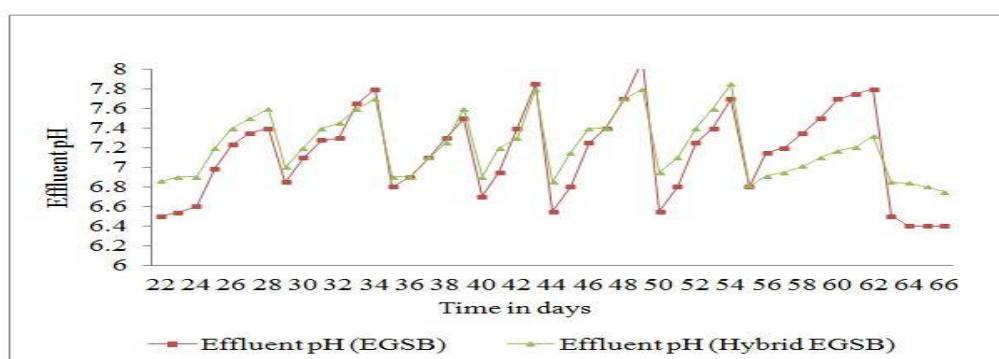


Figure 4. Effluent pH observed during operational periods

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Figure 5. It is well documented that higher the VFA/Alkalinity ratio inhibit methanosarcina. The VFA/Alkalinity ratio between the 0.1 to 0.3 shows good performance of the reactor. When the VFA to Alkalinity ratio is more than 0.4 activity of methanosarcina completely reduced. During the reactor operation the ratio was recorded between 0.1 to 0.32 in HEGSB reactor indicating the superior performance. In EGSB reactor the ratio was recorded between 0.13 to 0.38 and during failure of reactor the ratio was 0.55 in EGSB and 0.51 in HEGSB reactor. The Figure 5 shows VFA/Alkalinity ratio with OLR.

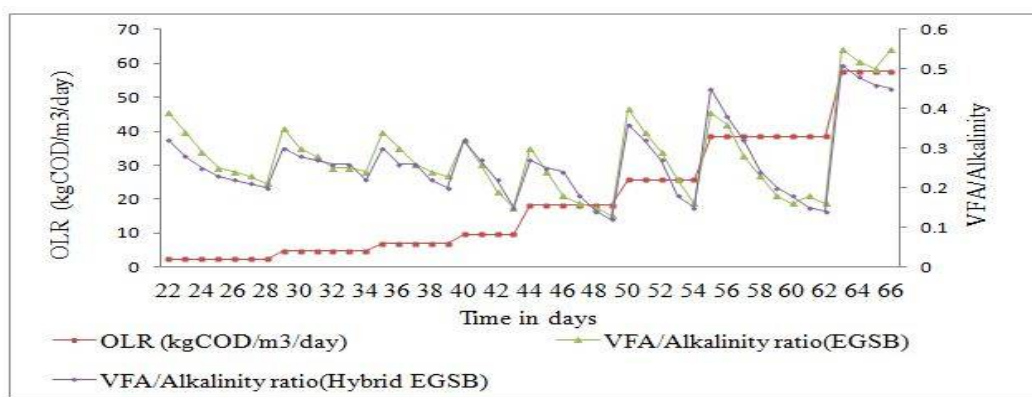


Figure 5. OLR V/s VFA to Alkalinity ratio

Figure 6. Shows the variation of Influent COD and Effluent COD during operation, the reactors were operated continuously for 66 days. The reactors were operated continuously for 66 days. The reactor was operated varying OLR 2.3, 4.6, 6.9, 9.6, 18.2, 25.6, 38.4 and 57.6 kg COD/m³/d by changing HRTs 12h, 9h, 6h, 4h. During the operation optimum COD removal efficiency recorded as 81.40 % for EGSB reactor and 86.12 % for Hybrid EGSB reactor.

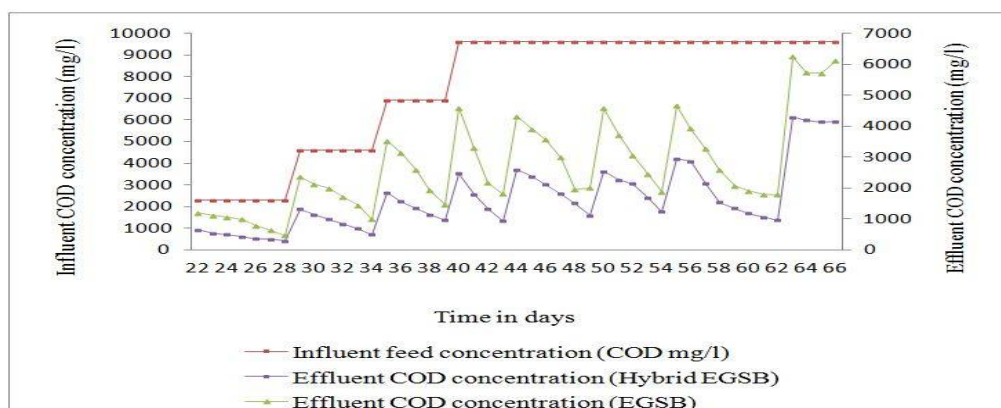


Figure 6. Influent COD concentration V/s Effluent COD concentration

Figure 7. Shows the comparison of both EGSB and Hybrid EGSB during operational periods, COD Removal efficiency is the major parameter to study the performance of a reactor. Two reactors (EGSB and Hybrid EGSB) were designed in order to compare the performance of the both under various conditions. COD removal efficiency in the beginning was

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48.04% in EGSB and 60.1% in Hybrid EGSB when the influent COD was maintained at 2300 mg/l. Later it was noticed that an increase up to 81.40% in EGSB reactor and 86.12% in Hybrid EGSB reactor. During operation, pH was maintained within the range (6.6-7.6) which resulted in the optimum COD removal efficiency. The Figure 7 shows the COD removal efficiency during operational period.

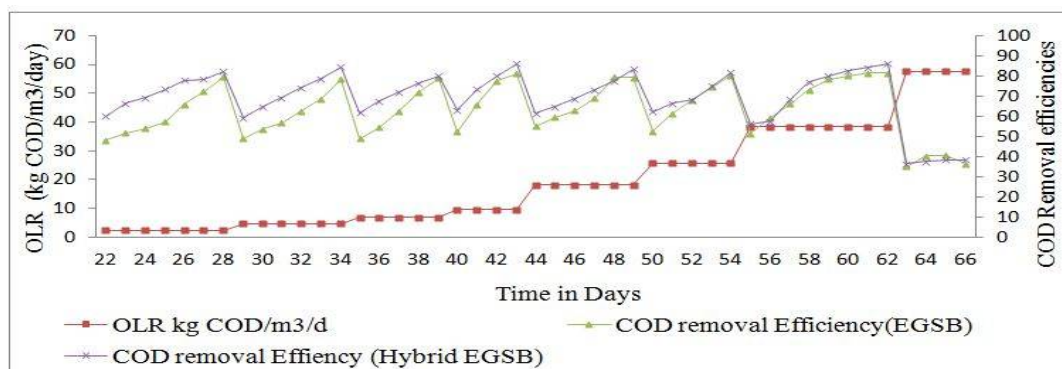


Figure 7. OLR V/s COD removal efficiencies

Figure 8. Illustrates the methane gas production in Hybrid EGSB reactor, At an OLR of 2.3 kg COD/m³/d EGSB showed methane production of 0.17 L/L/day (3.20 L/D). At an increased OLR of 38.4 kg COD/m³/day, it was 2.61 L/L/D (47.10 L/D), similarly Hybrid EGSB showed methane production of 4.05 L/L/D (73.0 L/D) at an OLR of 38.4 kg COD/m³/day. An increase in OLR had shown increased the methane production in both the reactors. Whereas, in Hybrid EGSB due to electrolysis process liberated hydrogen combined with CO₂ by producing more amount of methane gas that was amounted 1.54 (54% higher) times more than EGSB ,at 6 volts and 2 ampere current.

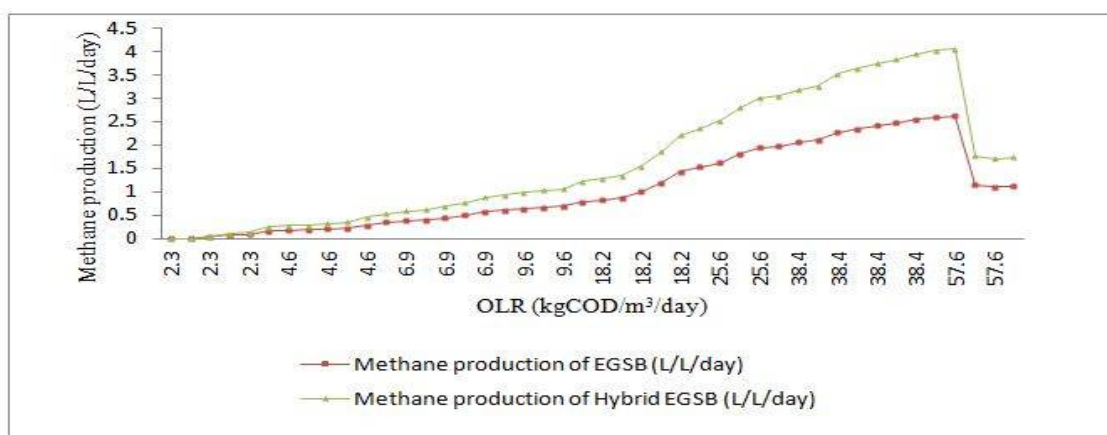


Figure 8. Methane production with OLR

V. CONCLUSION

The performance of two laboratory scale anaerobic reactors such as EGSB and Hybrid EGSB reactor were investigated and compared for treatment of the distillery wastewater.

1. Addition of natural polymer (Chitosan) has positive effect on the granular size.

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2. Granules size of 1.5-2.0 mm was achieved in short period of 21 days in batch reactors.
3. At 6 hours HRT, Hybrid EGSB showed optimum COD removal efficiency of 86.12%, the maximum methane production was noticed at the rate of 4.05 L/L/D of reactor volume, at the applied voltage of 6 volts and current of 2 ampere.
4. In Hybrid EGSB reactor methane production was observed to be 1.54 times that of EGSB reactor.

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