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Original Research Paper

Optimization of Conditions for Biohydrogen Production From Industrial Waste by Anaerobic Co-digestion

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ABSTRACT

Food processing wastewater contains biodegradable organic matter, and biogas and hydrogen content varies with the operational conditions of the anaerobic digester and may be useful control parameter. Up flow anaerobic sludge blanket reactor (UASB) was investigated for the treatment of low biodegradable composite chemical wastewater, which was complex in nature. In Phase-I, experiments were carried out in a laboratory scale batch reactor fed with sugar industrial wastewater with different concentrations. During batch mode operation the various characteristics of sugar industrial wastewater such as pH, TS, TDS, TVSS, $BOD_{5,20}$, etc. were studied. The variation among these characteristics with respect to days can be plotted to know the maximum growth of microorganisms in batch reactor. The batch process is mainly started for the acclimatization process (growing of microorganisms) and to find the steady state condition for the reactor which shows optimum conditions.

INTRODUCTION

Today, global energy requirements are heavily dependent on fossil fuels, natural gas and coal. The expected depletion of fossil fuels is inevitable and causing global warming effect, so there is a search for replacement of conventional energy sources. The hydrogen seems to be a promising and sustainable energy source because it is a renewable fuel which is odourless, tasteless and non-poisonous gas (Lee et al. 2011). Production of clean energy and utilization of waste materials make biological hydrogen production a novel and promising approach to meet the increasing energy needs as a substitute for fossil fuels (Show et al. 2011). Sequential fermentation was found to be preferable due to high H_2 yields and productivities (Atashi et al. 2010). The best conditions to remove the pollution loading is pH 7 and temperature range of 35 to 38°C (Arjun & Kargi 2011). The anaerobic treatment is considered one of the most efficient methods for treating several types of effluents (Habeeb et al. 2010). This study was conducted to investigate anaerobic treatability of sugar industrial wastewater by UASB reactor for the treatment of sugar effluent waste. Hence, there is ample scope to investigate the effluent under anaerobic condition and to study the effect of substrate on the acclimatization process.

MATERIALS AND METHODS

Selection of wastewater: The industrial wastewater used in this process was from sugar industry. The initial characteristics of the effluent are given in Table 3.

Batch mode operation: The experiments were carried out in batch operation process with two different types of batch operations.

i. Batch process with a working volume of 10 L.
ii. Batch process with working volume of 5 L.

The details of 10 L and 5 L batch process with their combination are given in Tables 1 and 2. The schematic of the UASB reactor is shown in Fig. 1.

RESULTS, DISCUSSION AND CONCLUSION

The various parameters analysed during batch mode operation are discussed below:

pH: pH is the principal operational control parameter in the anaerobic treatment of the wastewater. The variations of pH in the 10 L and 5 L reactors are presented in Figs. 2 and 3. The pH of 10 L and 5 L batch rectors varied from 4.5-6.0 and the pH was maintained between 5.5-5.8. The optimum pH condition of fermentative bacteria is between 5.0 and 6.0.

Total solids (TS): The TS monitored as a parameter from the steady state of the 10 L batch reactor shows that at the starting stage of the reactor it was 58000 mg/L and became 88000 mg/L after the 49th day in the effluent (Fig. 4). In the 5 L batch reactor, it increased from 25000 mg/L in the beginning to 72000 mg/L after the 49th day (Fig. 5).

Total dissolved solids (TDS): The total dissolved solids were also considered as monitoring parameter. In the 10 L batch

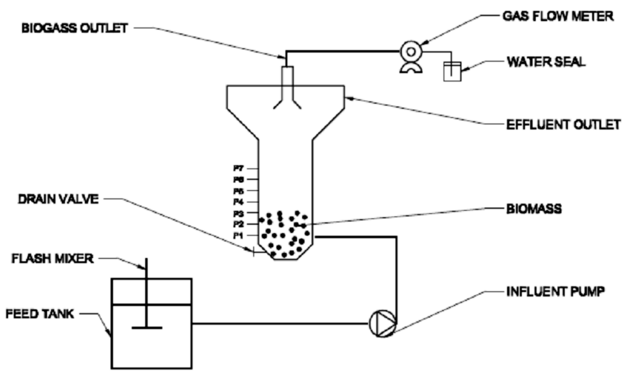

Fig. 1: Schematic representation of UASB reactor for biohydrogen production.

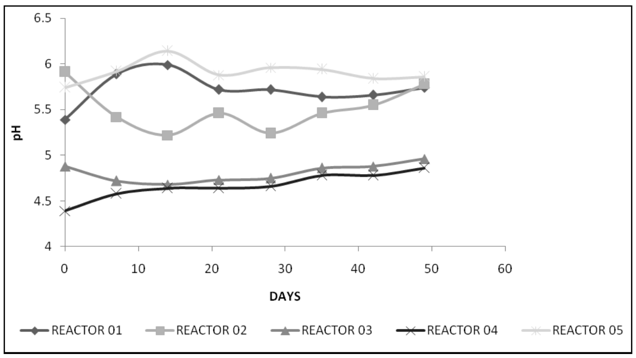

Fig. 2: Variation of pH during acclimatization of wastewater for 10 L batch reactor under batch mode operation.

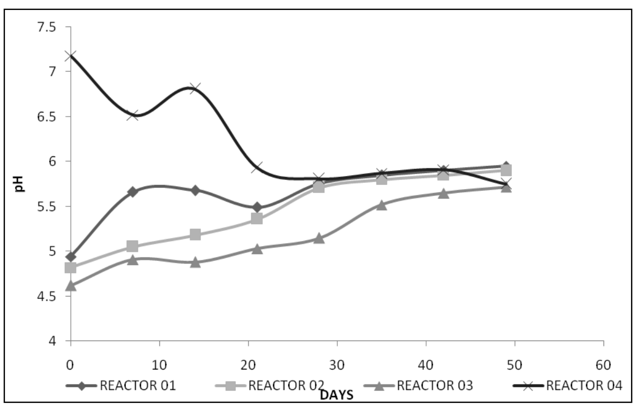

Fig. 3: Variation of pH during acclimatization of wastewater for 5 L batch reactor under batch mode operation.

reactor, initially the TDS in the effluent was 56000mg/L, which later increased to 81000mg/L after the 49th day (Fig. 6). In the 5 L batch reactor, the initial TDS of 22000 mg/L reached to 65000mg/L after the 49th day as shown in Fig. 7.

Total volatile suspended solids (TVSS): The TVSS for 10 L batch reactor were 1000 and 4000 mg/L at the start and on 15th day respectively as shown in Fig 8. The TVSS for 5 L batch reactor for the same period were 5000 and 9000 mg/L (Fig. 8).

Table 1: 10-L batch reactors (raw sugar effluent + cow dung).

S.No.	Reactor	Raw Sugar Effluent (E)	Cow Dung (C)
1	1	25 %	75 %
2	2	50 %	50 %
3	3	75 %	25 %
4	4	100 %	0 %
5	5	0 %	100 %

Table 2: 5-L batch reactors (raw sugar effluent + cow dung + pressmud).

S.No.	Reactor	Raw Sugar Effluent (E)	Cow Dung (C)	Pressmud (P)
1	1	20 %	20 %	60 %
2	2	40 %	20 %	40 %
3	3	60 %	20 %	20 %
4	4	0 %	0 %	100 %

The characteristics of each reactor were analysed for every 7 days.

Table 3: Characteristics of raw sugar effluent.

S.No.	Properties	Results
1	pH	4.38
2	Electrical conductivity (mS/cm)	1.461
3	Total solids (mg/L)	1,24,000
4	Total dissolved solids (mg/L)	1,18,000
5	Total suspended solids (mg/L)	6000
6	Total volatile solids (mg/L)	61000
7	Total volatile dissolved solids (mg/L)	49000
8	Total volatile suspended solids (mg/L)	12000

From the above, it can be concluded that at the end of the batch mode operation:

1. Acclimatization of the reactor has been observed at about 60 days and steady state has been attained at about 49 days for 10 L reactors. The reactor 1 (25%E : 75%C), reactor 2 (50%E : 50%C), and reactor 3 (75%E : 25%C) showed the optimum conditions. Of these, reactor 3 (75%E : 25%C) gives the best result amongst the five reactors considered.
2. Acclimatization of the reactor has been observed at about 60 days and steady state has been attained at about 49 days for 5 L reactors. The reactor 1 (20%E : 20%C : 60%P), reactor 2 (40%E : 20%C : 40%P), reactor 3 (60%E : 20%C : 20%P) showed the optimum condition. Of these, reactor 3 (60%E : 20%C : 20%P) gives the best result amongst the five reactors considered.

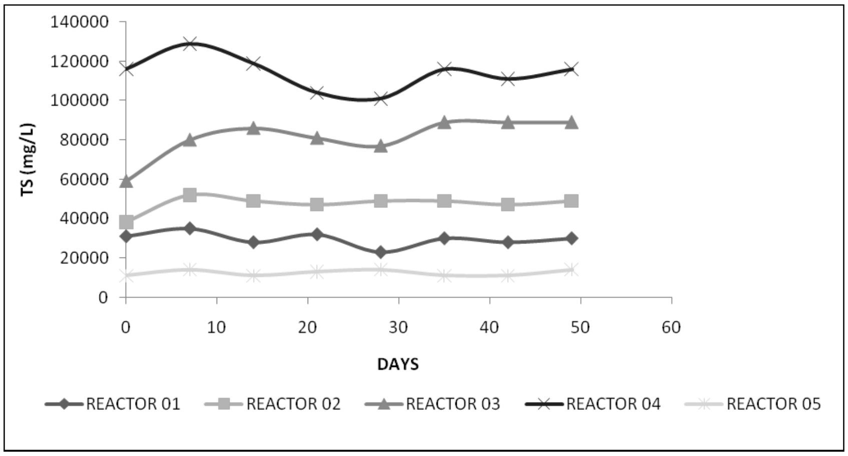

Fig. 4: Variation of Total Solids (TS) during acclimatization of wastewater for 10 L batch reactor under batch mode operation.

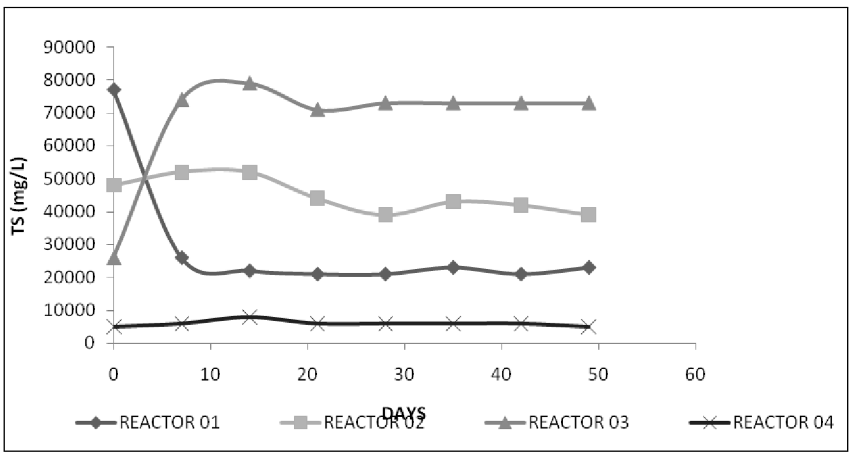

Fig. 5: Variation of Total Solids (TS) during acclimatization of wastewater for 5 L batch reactor under batch mode operation.

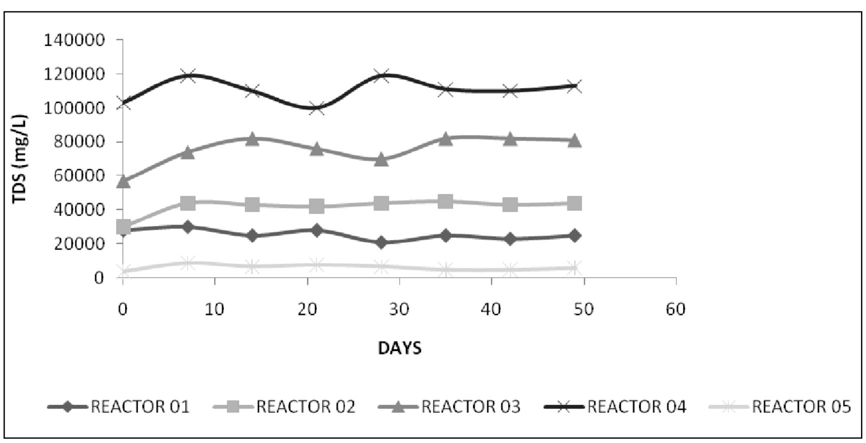

Fig. 6: Variation of Total Dissolved Solids (TDS) during acclimatization of wastewater for 10 L batch reactor under batch mode operation.

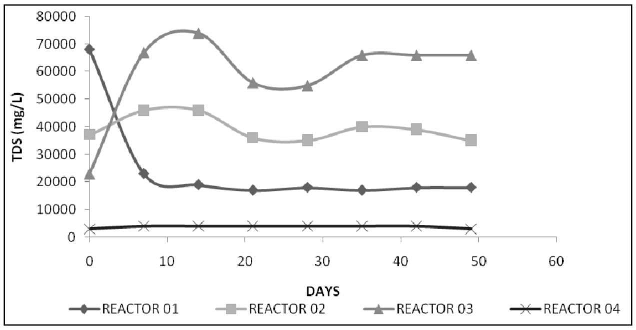

Fig. 7: Variation of Total Dissolved Solids (TDS) during acclimatization of wastewater for 5 L batch reactor under batch mode operation.

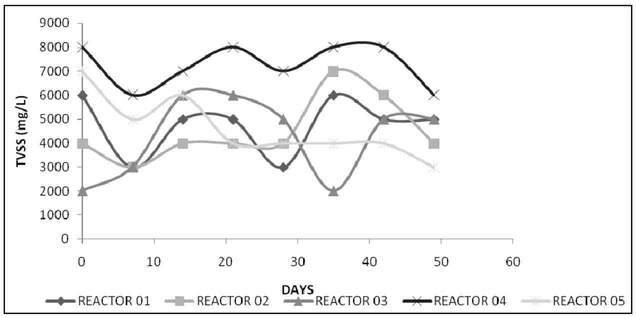

Fig. 8: Variation of Total Volatile Suspended Solids (TVSS) during acclimatization of wastewater for 10 L batch reactor under batch mode operation.

The next phase of work is concentrated on the production of biohydrogen with the combination of best optimum conditions obtained from the batch reactors.

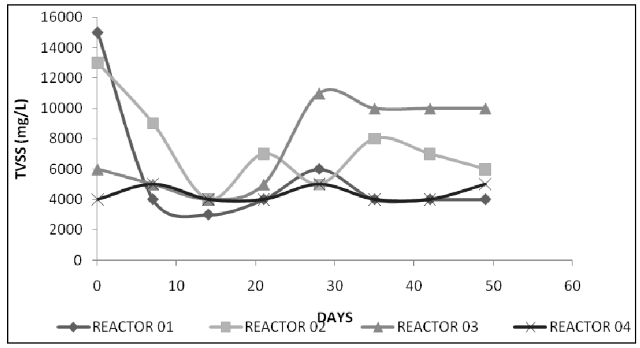

Fig. 9: Variation of Total Volatile Suspended Solids (TVSS) during acclimatization of wastewater for 5 L batch reactor under batch mode operation.

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