

Experimental Investigation of HUASB Reactor for Treatment Characteristics of Leather Effluent with Varying of Different Operating Parameters

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Abstract : The anaerobic treatment is considered one of the most efficient methods for treating several types of effluents. This is due to its scope for treating high rate of simply biodegradable matters in the various effluents. Several researches have been widely conducted in order to enhance the performance of the anaerobic process. The up flow anaerobic sludge blanket (UASB) technology was considered as the most popular method in which the highest rate of organic materials can be removed. Nonetheless, the long start up interval of UASB reactor requires more understanding of the biological process inside the reactor. A pilot scale study was set up to investigate the principle design parameters of up flow anaerobic sludge blanket (UASB) reactors for treating waste water of small communities in the tropical regions of India. A steel pipe with a diameter of 7cm and a height of 65cm was used as the reactor in which a digestion and a three phase separator element have a volume of 2.157×10^3 respectively. During this study, which lasted for 70 days, two distinct phases were carried out according to the ambient temperature. The temperature of the waste water entering the reactor was naturally ranged from 26°C to 30°C and no heat exchanger was used. The hydraulic retention time including 2, 3, 4, 5, 6, 7 & 8 hours with various loading rates of 56 to 197 mg of COD/lit/day were examined. On the basis of the results in optimal hydraulic retention time and organic loading rate BOD₅, COD and TSS was removed respectively.

Keywords : Anaerobic process, HUASB Reactor, Ambient temperature, Hydraulic retention time (HRT), Organic loading rate (OLR).

1. Introduction

The modified up flow anaerobic sludge bed (UASB) technique developed by industrial technology research institute (ITRI) has been applied to industrial waste water treatment. 25 full scale treatment plants and more than 50 modified UASB reactors have been installed for industrial waste water purification including food processing, brewery, distillery, pulp and paper textile, chemical and petro chemical industries. Anaerobic processes characterized by its low production of sludge, and its generation of energy comparing with the aerobic treatment. The development of use of anaerobic waste water treatment had been started in Netherlands, whereby the UASB system was firstly used on treatment of beverage industry, distilleries and fermentation industries, food and paper industries. Recently, the use of aerobic technology has been expanded, where it comprised the treatment of chemical and petrochemical industry effluents, and the UASB concept is also considered more than suitable for the domestic waste water treatment especially in warm climates in tropical countries. Tropical, over the last decades, up flow anaerobic sludge blanket (UASB) technology has been

commonly used, due to its all- round performance for high-low organic content waste water treatment. The operational parameters that are specially mentioned in literature have been controlled the process.

This indicates that the design is well suited and efficient. But proper attention should be given towards reduction of algal cell. In recent years there has been a growing interest in anaerobic treatment of sewage. Compared to aerobic growth, anaerobic fermentation produces much less biomass from the same amount of chemical oxygen demand removal by Tchobanoglous. [1]

The high rate reactor was widely used for the treatment of several types of waste water in up flow anaerobic sludge blanket reactors developed by Lettinga [2]. The up flow anaerobic hybrid reactors (UAHR) configuration has combined the advantages of both UASB and up flow anaerobic filters(UAF) while minimizing their limitations and the reactor is efficient in the treatment of dilute to high strength waste water at high organic loading rates and short HRT. Anaerobic digestion has been applied with different degrees of success to the treatment of liquid and solid wastes from the tannery waste

Agrawal et al. [3] can be observed a 78% decrease in the gas production rate when the temperature was reduced from 27°C to 10°C. The low gas production and 25% lower COD removal at 10°C than at 27°C, indicating suspended solids accumulation in the reactor.

Elmitwalli et al., [4] had at low temperatures; low hydrolysis rate and a decrease in the degradable organic matter fraction were found to cause the deterioration of the overall anaerobic reactor performance. YanfangNIU and Xingyuan MA et al. [5] had published experimental result as the maximum removal rate of COD is 91.6%, The macromolecule organic compounds are degraded into the small molecular organic acid by the acidate bacteria firstly, among which acetic acid is the most and then the small molecular organic acids are degraded into CH₄ and CO₂ by the methanogenus, realizing the transformation from waste to resource. Anna KWARCIAK-KOZŁOWSKA, Jolanta BOHDZIEWICZ [6] this study attempted to determine the influence of the HRT and OLR on the treatment of wastewater from the meat industry and biogas production. If this works given minimum efficiency of COD and BOD removal at the HRT of 6 days the daily biogas production decreased with an increase in the HRT. Gangesh Kumar and asaudhan et al [7] has focused on the design analysis indicates that the design of the sewage treatment plant is adequate and appropriate. According to the standard design considerations the design criteria has been found complying. The hydraulic loading rates have been found frequently going beyond the designed capacity.

Sunny Aiyuk and Philip Odonkor et al [8] UASB process for the direct treatment of domestic sewage was effective in producing effluents with somewhat low amounts of organic matter, but not sufficient for efficient recycling/reuse. There were serious limitations inherent within the system: inefficiency in removing nutrients, and difficulties in removing suspended solids, leading to rapid rise in sludge bed height and frequent sludge removal. The high rate of sludge production, due to the accumulation of SS, was certainly a disadvantage, as sludge handling in full-scale installations can be expensive.

In recent years there has been a growing interest in anaerobic treatment of waste water. Compared to aerobic growth, anaerobic fermentation produces much less bio mass from the same amount of COD removal. Up flow anaerobic sludge blanket UASB reactor is a popular anaerobic reactor for both high and low temperature. The UASB reactor is by far the most widely used high rate anaerobic system for anaerobic waste water treatment. In the case of relatively low strength waste water such as ternary waste, the hydraulic retention time rather than organic loading rate is the most important parameter determining the shape and the size of the UASB reactor. The several favorable characteristics of anaerobic processes, such as low cost, operational simplicity, low bio solid production and considerable biogas production, together with suitable environmental conditions are contributed to highlight anaerobic systems for the treatment of tannery waste in small communities of tropical regions. Although different types of anaerobic treatment system have been applied to a great variety of industrial wastes, so far the anaerobic treatment concept is rarely used for tannery waste. To compare the different anaerobic treatment systems, the UASB concept looks the most attractive option for tannery waste treatment. The present work evaluates an important design parameter for a UASB reactor that is hydraulic retention time (HRT). The performance of UASB reactor was assessed by applying various HRTs.

2. Material and Methods

2.1 Experimental Setup and Procedure

UASB REACTOR: Up flow anaerobic sludge blanket (UASB) technology, normally referred to as UASB reactor, is a form of anaerobic digester that is used in the treatment of wastewater. The UASB reactor is a methanogenic (methane-Producing) digester that evolved from the anaerobic digester. A similar but variant technology to UASB is the expanded granular sludge bed (EGSB) digester. A diagrammatic comparison of different anaerobic digesters can be found here.

Table 1. Construction details

S.No	Particulars	Specification
1	Material of construction	Steel
2	Inner diameter	6.5cm
3	Height	65cm
4	Packing material	Foam
5	Packing height	26cm

The main components of the HUASB are,

- ✚ Inlet and outlet distribution system
- ✚ Sampling port
- ✚ Packing media

UASB uses an anaerobic process whilst forming a blanket of granular sludge which suspends in the tank. Wastewater flows upwards through the blanket and is processed (degraded) by the anaerobic microorganisms. The upward flow combined with the settling action of gravity suspends the blanket with the aid of flocculants. The blanket design to reach maturity at around 3 months and Small sludge granules begin to form whose surface area is covered in aggregations of bacteria. In the absence of any support matrix, the flow conditions create a selective environment in which only those microorganisms, capable of attaching to each other, survive and proliferate. Eventually the aggregates form into dense compact biofilms referred to as “granules”. A picture of anaerobic sludge granules can be found here.

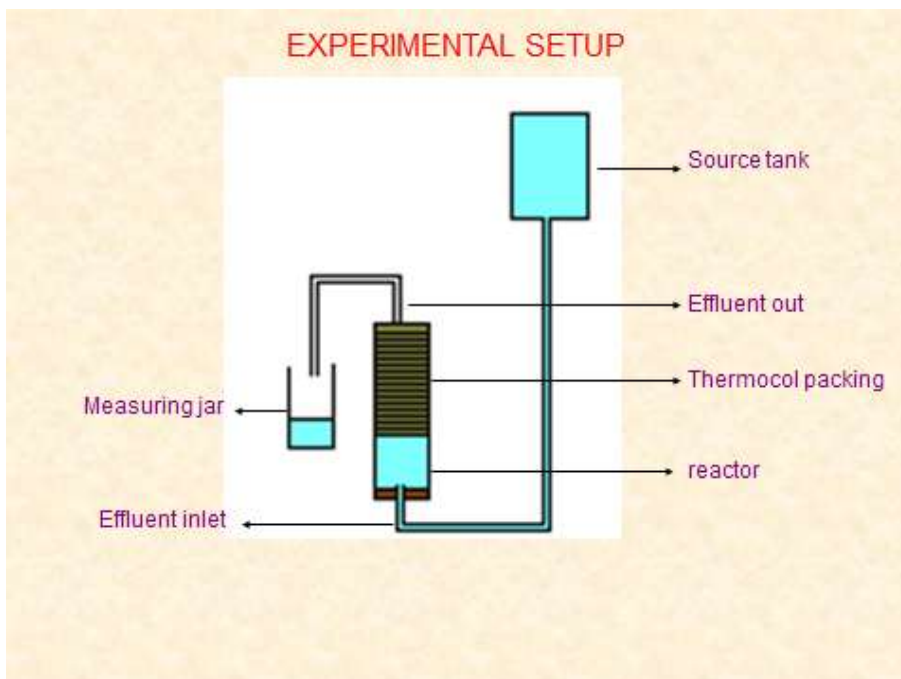


Fig 1: Experimental Setup of HUASB Reactor Design

2.2 Sludge

The sludge granules have many advantages over conventional sludge flocs are dense compact bio-film, High settle ability, High mechanical strength, Balanced microbial community, High methanogenic activity, Resistance to toxic shock, Biogas with a high concentration of methane is produced as a by-product, and this may be captured and used as an energy source, to generate electricity for export and to cover its own running power. The technology needs constant monitoring when put into use to ensure that the sludge is maintained, and not washed out (there by losing the effect). The heat produced as a by-product of electricity generation can be refused to heat the digestion tanks. The blanketing of the sludge enables a dual solid and hydraulic (liquid) retention time in the digesters. Solids requiring a high degree of digestion can remain in the reactors for periods up to 90 day. Sugars dissolved in the liquid waste stream can be converted into gas quickly in the liquid phase which can exit the system in less than a day.

2.3 Sampling and Analysis

The reactor is fixed and the set up was done as per the plan. This is followed by the loading of waste water for the formation of sludge blanket. The waste is prepared by mixing poultry waste and cow dung in equal proportions with water. The reactor is left undisturbed for the function of the sludge and growth of anaerobic microorganisms on the foam packing provided at the top portion of the reactor. After two months it is observed that the reactor is at the start up stage. Now the reactor can be loaded with tannery waste for treatment. Effluent from the tanning industry has been collected. The effluent was analyzed to found various parameters like COD, pH, turbidity, TDS and amount of chromium. The initial values were found to be as follows;

COD = 31105 mg/, Turbidity = 175.2, TDS = 11543 mg/l

Chromium = 2.25 mg/l and pH = 9.2

For experimental convenience the effluent is diluted with water. The samples after dilution, has the following values for different parameters. The COD value is found to be 448 mg/l. the amount of chromium found to as 0.23 mg/l. the dilution also helps to reduce the pH to a more favorable value 8.5. Then it would be difficult for the microorganisms to grow. The values of turbidity and TDS are found to be 1438 and 1752 respectively. The diluted effluent is then reached in the HUASB for different flow rates. The sample is analyzed at the end of each 7th day. The experiment is repeated for another flow rate of the effluent. This procedure is repeated for 10 different flow rates and the results are tabulated. Please use a 9-point Arial font, or other Roman font with serifs, as close as possible in appearance to Arial in which these guidelines have been set. The goal is to have a 9-point text, as you see here. Please use sans-serif or non-proportional fonts only for special purposes, such as distinguishing source code text. If Arial is not available, try the font named Computer Modern Roman. On a Macintosh, use the font named Times. Right margins should be justified, not ragged.

3. Results and Discussion

The experiment shows there is considerable reduction in the amount of chromium. The reactor also shows effective reduction in the values of COD, TDS, pH and turbidity. It is noted that the reactor is more effective at very low flow rates.

3.1 Potentials for Improvement

The tannery waste contains heavy metals and toxic metals in it. The treatment in the HUASB is showing considerable reduction. This is due to the bio sorption of these elements by the anaerobic microorganisms. By inoculating some other anaerobic microorganisms which can be brown in the HUASB reactor there is a great chance of reducing the amount of harmful metals like chromium, copper, calcium, zinc etc., this can be increased the quality of the treated tannery waste to further extent. For pages other than the first page, start at the top of the page, and continue in single-column format.

3.2 Measurement of TDS

The two principal methods of measuring total dissolved solids are gravimetry and conductivity. Gravimetric methods are the most accurate and involve evaporating the liquid solvent and measuring the mass

of residues left. This method is generally the best, although it is time-consuming. If inorganic salts comprise the great majority of TDS, gravimetric methods are appropriate. Electrical conductivity of water is directly related to the concentration of dissolved ionized solids in the water. Ions from the dissolved solids in water create the ability for that water to conduct an electrical, which can be measured using a conventional conductivity meter or TDS meter. When correlated with laboratory TDS measurements, conductivity provides an approximate value for the TDS concentration, usually to within ten-percent accuracy.

3.3 UASB Design

In general there are two ways to design an UASB

- ✚ If input COD: 5000-15000 mg/l or more the design method is based on Organic Loading Rate (OLR)
- ✚ If input COD is <5000 mg/l, the design method should be based on velocity.

3.4 Organic Loading Rate

In wastewater treatment, the rate of introduction organic compounds is defined as organic loading rate. The organic loading rate can be calculated as follows.

$$\text{Organic loading rate} = \frac{\text{Design flow} \times \text{COD/day}}{\text{Volume}}$$

When input COD <5000 mg/l using the method based on OLR is not effective in operation process because the granular sludge will be hardly formed.

$$\text{Hydraulic retention time} = \frac{\text{Volume of Reactor}}{\text{Influent flow rate}}$$

$$\text{Volume of UASB reactor } V = Q \times \text{HRT}$$

$$\text{Area of the UASB reactor } A = V/Q$$

Table 2. Experimental results

S.No	Flow rate (L/day)	HRT (day)	Up flow velocity (m/day)	OLR (mg COD/L.day)
1	1	2.157	0.301	242.93
2	0.9	2.397	0.271	218.637
3	0.8	2.696	0.241	194.344
4	0.7	3.081	0.211	170.051
5	0.6	3.595	0.181	145.758
6	0.5	4.314	0.151	121.465
7	0.4	5.392	0.12	97.172

The minimum flow rate is enhanced the higher microbial growth and reduced for Biological oxygen demand (BOD), Chemical oxygen demand (COD), Total dissolved solids (TDS), Turbidity, chromium and High rate of production of methane gas. The treatment efficiency of high up flow anaerobic sludge blanket reactor is dependent on the flow rate.

Table 3. Treatment efficiency of HUASB Reactor

S.No	Flow rate (L/day)	Removal Efficiency (%)			
		COD	Turbidity	TDS	Chromium
1	1				
2	0.9	79.96	90.19	69.98	62.5
3	0.8	74.61	88.82	69.06	60.94

4	0.7	72.9	86.27	67.16	57.81
5	0.6	70.22	85.49	64.8	56.25
6	0.5	67.55	83.92	62.25	50
7	0.4	64.31	80.58	60.22	45.31

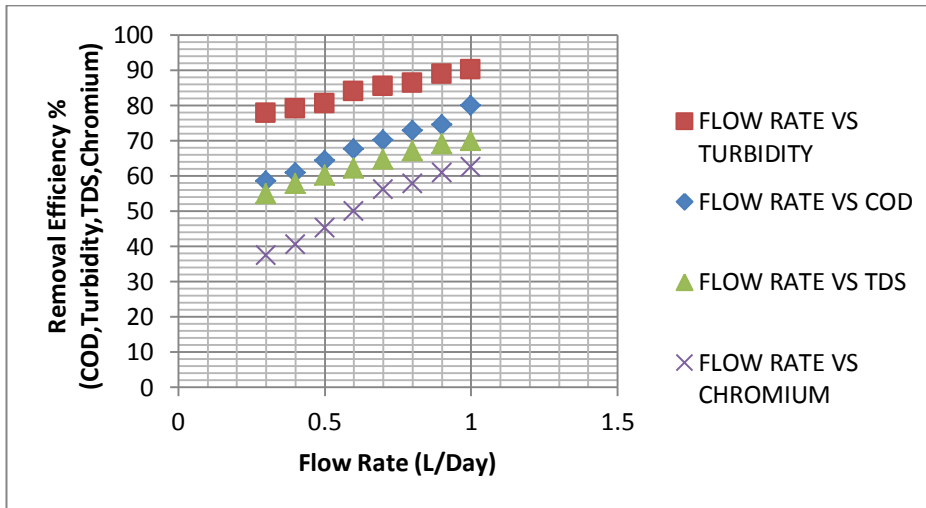


Fig 1: Experimental Setup of HUASB Reactor Design

4. Conclusion

In the high up flow anaerobic sludge blanket reactor was studied for different operating and design parameters are hydraulic retention time (HRT), organic loading rate (OLR) for treatment characteristics of leather effluent. Operating temperature, pH value of the effluent, volatile fatty acid content, inoculum – substrate ratio, microbial population, presence of ammonia are the important factors affecting the performance of the reactor. In this experimental results showed that the chromium removal, COD and turbidity depend on the OLR and HRT of the reactor. The reactor achieved maximum chromium reduction of 65.22% at an OLR of 50-60 mg COD/l day and maximum COD removal of 81.25% is obtained in the HUASB reactor at an OLR range of 50-60 mg COD/l day. It is observed that the minimum flow rate is enhanced for higher microbial growth and reduced for Biological oxygen demand (BOD), Chemical oxygen demand (COD), Total dissolved solids (TDS), Turbidity, chromium and High rate of production of methane gas. The treatment efficiency of high up flow anaerobic sludge blanket reactor is dependent on the flow rate. The study of contamination by the leather industries is done. It is observed that the untreated leather effluent have harmful effect on the environment. Operating temperature, pH value of the effluent, volatile fatty acid content, inoculum – substrate ratio, microbial population, presence of ammonia are the important factors affecting the performance of the reactor. Detailed survey suggested that the HUASB reactor is suitable to treat the leather effluent.

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