COMPARISON OF UASB AND EGSB REACTOR PERFORMANCE ON THE ANAEROBIC DIGESTION OF REAL TIME TANNERY WASTEWATER

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Abstract: In the present study, an upflow anaerobic sludge blanket (UASB) and Expanded granular sludge blanket (EGSB) reactors were operated with Real time tannery wastewater under five different hydraulic retention times (HRT) viz., 5.21, 2.6, 1.74, 1.3 and 1.04 days. The performance of both systems were compared in terms of COD removal efficiency, chromium removal, biogas production. During the operation of the reactor with different OLRs ranging 1.658 – 8.14 kg COD/m^3 .d and 1.612- 7.9 kg COD/m^3 .d and various HRTs, the maximum COD removal efficiency of 81.1 % and 83.52 % were obtained in the UASB and EGSB reactor respectively. The maximum biogas production obtained in EGSB reactor. The maximum Chromium concentration reduction was found in EGSB than UASB reactor. SEM studies revealed that there was no significant morphological changes in the sludge granules. While treating tannery wastewater , EGSB reactor showed a better performance than UASB reactor.

Keywords: UASB, EGSB, Real Tannery Effluent, COD Reduction, Chromium, Biogas Production, SEM.

1.Introduction

Tannery effluent is one of the hazardous pollutants from industry. Wastewater generated from tannery industry is highly complex, concentrated, and toxic in nature. Tannery wastewater can cause significant pollution unless treated prior to discharge. These pollutants are expressed in terms of Chemical oxygen demand (COD), Biochemical oxygen demand (BOD_5), total suspended solids (TSS), and total Kjeldahl nitrogen (TKN), as well as sulfur, phosphorus, and chromium compounds. These substances are frequently toxic and persistent, and affect both human health and the environment. Many researcher reviewed that the tannery wastewater treatment methods include biological treatment (aerobic and anaerobic treatment), physico-chemical treatment, ion exchange, membrane filtration, and electrochemical systems.

From the Anaerobic treatment used, the treatment of concentrated industrial wastewater as well as domestic wastewater **(McCarty and Smith, 1986).** The upflow anaerobic sludge blanket (UASB) reactor has been widely used for the treatment of industrial wastewaters. This system has proved to be highly effective for medium and high strength wastewaters within a wide range of HRT (3–48 h) **(Seghezzo et al., 1998).** It is one of the most extended systems for the biological treatment of phenolic wastewaters **(Veeresh et al., 2005).** The expanded granular sludge bed (EGSB) reactor is a modification of the traditional UASB reactor. The main objectives of the present work is to compare the UASB and EGSB reactor performance on the anaerobic digestion of real time tannery wastewater.

2.Materials and methods

2.1 Experimental Setup

The experimental model of UASB (Upflow Anaerobic Sludge Blanket**)** Reactor and EGSB (Expanded Granular Sludge Blanket**)** Reactor was fabricated to conduct the experiment for Real Time of tannery industry to evaluate the treatment efficiency under varying experimental conditions. The Reactor model was made up of acrylic material. The size of the UASB (Upflow Anaerobic Sludge Blanket**)** Reactor and EGSB (Expanded Granular Sludge Blanket**)** Reactor having working volume of 25 liters. The baffles allowed to the wastewater flow through the sludge bed from the bottom to up. The physical feature of the experimental set-up is shown in **Table 1.** Sampling ports were used for drain the anaerobic sludge and liquid samples. A variable speed Peristaltic Pump (PP EX-30) was used to control the flow rate.

Table 1. Physical features and process parameters of experimental model

Description	Measurement of UASBR	Measurement of EGSBR
Total volume, (lit)	25	25
Total height, (cm)	161	127
Effective height (cm)	141	110
Effective diameter, (cm)	15	15
Diameter of the reactor at top, (cm)	15	24
Diameter of GLSS top and bottom, (cm)	4 and 12	4 and 24
Total height of the GLSS (cm)	9	20
Diameter of influent & Effluent pipe, (cm)	1	1
Peristaltic pump	PP – 30 Model	PP – 30 Model

2.2 Support Material

Moving Bed Bio Reactor (MBBR) was selected as packing media because of its low density, high porosity, vast surface area, easy availability and low cost. The MBBR media can retain more biomass on surfaces rather than plain surfaces. The Physical features of Moving Bed Bio Reactor (MBBR) Media shown in **Table 2**.

Table 2. Moving Bed Bio Reactor (MBBR) Media

Specification	MBBR Media
Media	Moving Bed Bio Reactor
Shape	Cylindrical with External Fins
Material	Polypropylene
Size Dia. Mm	22
Surface Area m^2/m^3	400
Void Ratio %	98
Specific Gravity g/cc	0.94

2.3 Analytical methods

During the reactor operation, pH, biogas Production and COD were monitored daily, whereas VFA and VSS were analyzed weekly. All determinations were performed according to standard methods **(APHA 2005).** COD was quantified by open reflux method, Chromium was analysed by using AAS and biogas production was measured by water displacement method.

2.4 SEM Analysis

The morphology of anaerobic granules fixed and cut according to previously reported method **(Alphenaar et al., 1994)** was analyzed by SEM using a JEOL JSM-6610LV Joel India Pvt. Ltd.Japan.

3. Results and Discussion

The performance of UASB and EGSB reactors were tabulated in **Table. 3** and **Table. 4**.

3.1 COD Removal

The performance of UASB and EGSB reactors compared with the COD removal efficiency, With different HRTs (Hydraulic Retention Time) 5.21, 2.6, 1.74, 1.3 and 1.04, Maximum COD removal of 81.1 % and 83.52 % for UASB and EGSB respectively, as Shown in **Figure 1**. **Lefebvre *et al.*, 2006** achieved 78% COD removal at an organic loading rate (OLR) of 0.5 kg COD/m^3/d, at hydraulic retention time (HRT) of 5 days, while they studied anaerobic digestion of tannery soak liquor using an up-flow anaerobic sludge blanket (UASB). **Wen *et al.*, (1999)** achieved 97% of COD removal at an hydraulic retention time (HRT) of 8 to 12 h, when they investigated an anaerobic hybrid reactor coupled with a membrane filtration for treating domestic wastewater. Various OLRs (Organic Loading Rates) of reactors operation attained maximum COD removal efficiency attained in EGSB reactor compared with UASB reactor, as shown in **Figure 2**. **Yoneyama *et al.*, (2006)** attained COD removal up to 75.9% with OLR of 11.7 kg/(m^3/d) while using a UASB reactor to treat the liquid streams of heat treated cow manure .

Table 3. Performance of UASB Reactor in COD Concentration

Influent COD mg/L	pH		HRT Days	OLR kgCOD/ m^3.day	Chromium mg/lit		Effluent COD mg/L	% COD Removal	Gas Conversion m^3/kg COD Removal
	Influent	Effluent			Influent	Effluent			
8640	6.2	6.5	5.21	1.658	18.4	3.49	1640	81.1	0.26
8520	6.1	6.8	2.6	3.271	18.15	3.83	1800	78.87	0.27
8480	6.3	6.6	1.74	4.884	18.06	4.6	2160	74.52	0.28
8520	6	6.9	1.3	6.543	18.15	5.28	2480	70.89	0.28
8480	5.9	6.4	1.04	8.14	18.06	5.71	2680	68.39	0.29

Table 4. Performance of EGSB Reactor in COD Concentration

Influent COD mg/L	pH		HRT Days	OLR kg COD/m^3.day	Chromium mg/lit		Effluent COD mg/L	% COD Removal	Gas Conversion m^3/kg COD Removal
	Influent	Effluent			Influent	Effluent			
8400	6	6.5	5.21	1.612	17.89	3.66	1720	83.52	0.26
8240	6.2	6.8	2.6	3.164	17.55	3.58	1680	79.61	0.28
8320	6.1	6.3	1.74	4.792	17.72	4.94	2320	75.11	0.29
8360	5.8	6.2	1.3	6.42	17.81	6.81	3200	72.11	0.29
8280	5.9	6.4	1.04	7.948	17.64	5.11	2400	68.51	0.31

3.2 Chromium Removal

During the operation of reactors, the chromium initial concentration was 17.55- 18.4 mg/lit as shown in the figure 3. The Maximum chromium reduction was achieved 3.4 mg/lit for UASB which is less than 3.58 mg/lit in EGSB as shown in **Figure 3**. The maximum removal compared to UASB and EGSB reactors with different OLRs.

3.3 Biogas Production

The biogas production is more in EGSB than UASB are 0.31 m^3/kg and 0.26 m^3/kg, as shown in **Figure 4. Song *et al.*, (2003)**This indicates that substrate destruction is a direct function of biogas generation was constantly at a rate of 0.27 m3 CH4/kg COD.

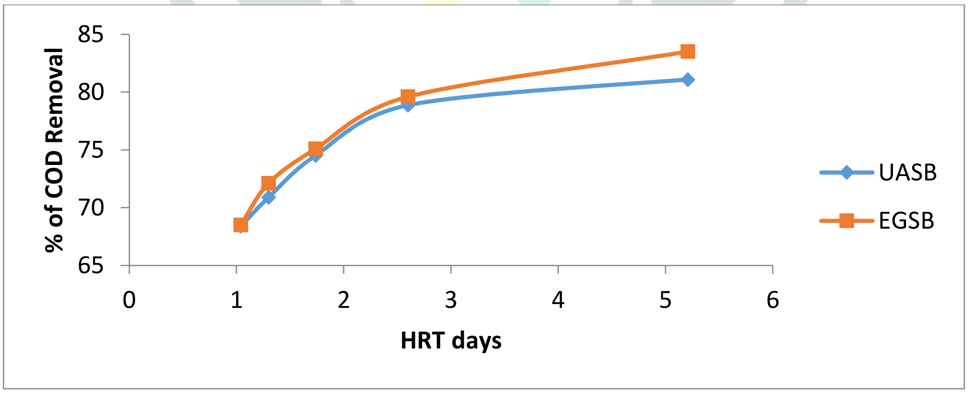

Figure 1. HRT Vs COD Removal

The COD removal efficiency with HRTs are illustrated in **Figure. 1,** and the COD removal percentage of EGSB and UASB were 83.5 % and 81.1 % respectively. Similarly the maximum COD removal is 78.32 % corresponding to the influent COD concentration of 4548.10 rng/l at a HRT of 24 hours. The above maximum COD removal is comparable to the reported values by various investigator for the treatment of starch-basxi waste streams by UASB reactors **Amachhatve and Amtya (2000); Karthikeyan and Sabatathinam (2002).**

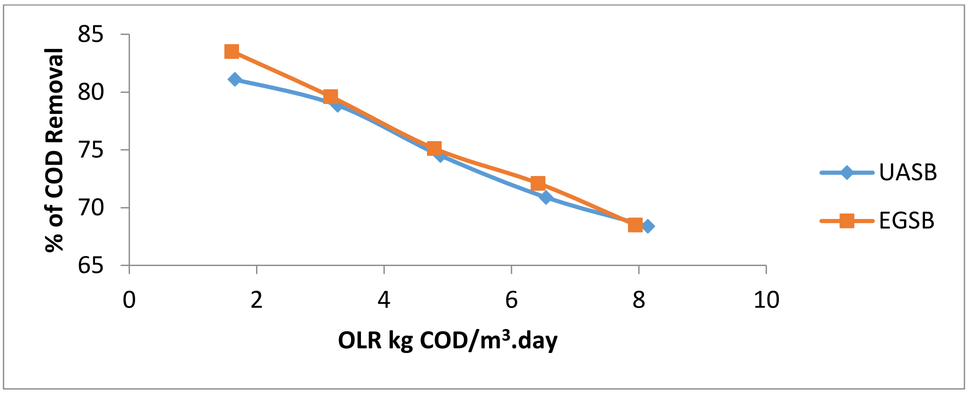

Figure 2. OLR Vs COD Removal

The COD removal efficiency of UASB and EGSB in OLRs range of an increase in the OLR (81.1 % at 1.658 kg COD/m3/day and 83.52 % at 1.612 kg COD/m3/day). The linear relationship between organic load and COD removal rate is also evident from **Figure. 2**. Similarly the COD removal rates increased from 0.12 to 2.15 kg COD/m3/day with an increase in COD load from 0.16 to 3.0 kg COD/m3/day, obtained by a decrease of HRTs from 16 days to 1 day, with varying influent COD concentrations. Thus, the COD removal rates appear to depend on mass loading rates if there is sufficient contact time between the waste and biomass retained in the reactor **Song et al., (2003**).

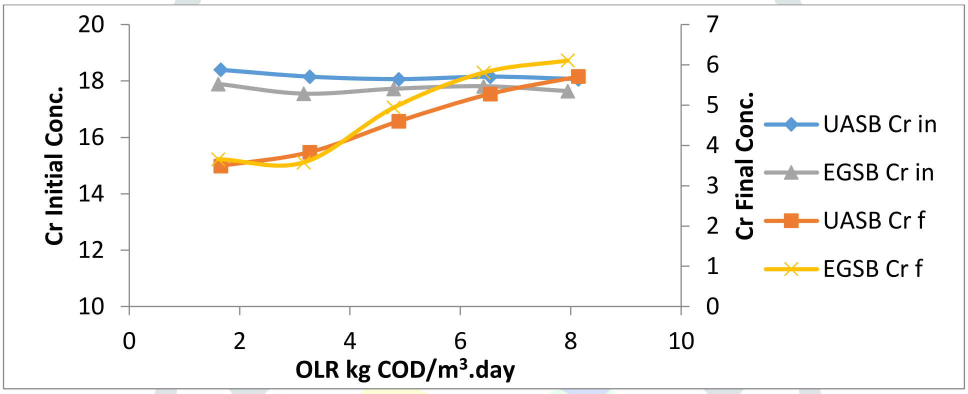

Figure 3. OLR Vs Chromium Removal

Figure. 3, illustrates the chromium removal with respect to organic loading rate for UASB and EGSB. The Maximum chromium reduction was achieved 3.4 mg/lit for UASB which is less than 3.58 mg/lit in EGSB

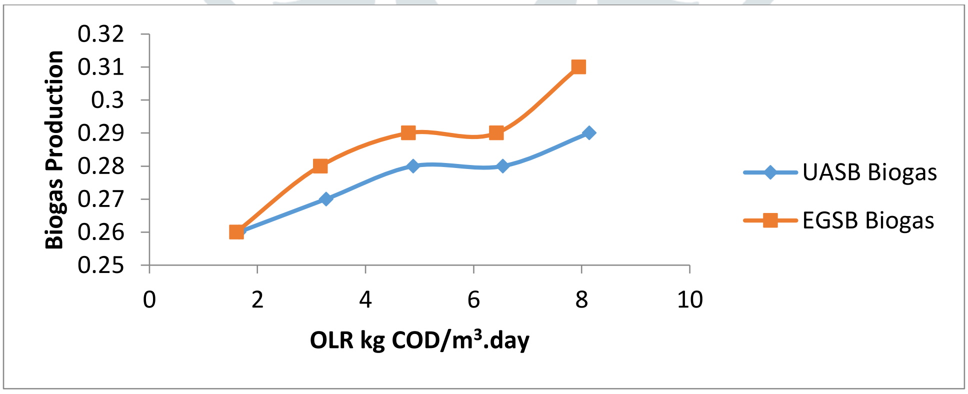

Figure 4. OLR Vs Biogas Production

Figure. 4 shows the quantities of biogas generated within UASB and EGSB during the different HRTs through the reactors. For EGSB, the quantities of biogas generated 0.26 to 0.31 kg m^3/kg COD Removal and for UASB 0.26 to 0.29 kg m^3/kg COD Removal are less than the EGSB reactor.

3.4 SEM Analysis

Microorganisms play vital role in degradation of organic pollutants in the reactors. Their population and distribution vary under different experimental conditions of the reactors **(Sallis and Uyanik, 2003).** In our study, the UASBR and EGSBR start-up, the sludge and the anaerobic sludge in the compartments were taken for SEM examination under different magnifications.

Scanning Electron Microscopic (SEM) studies reveal granular structure and cellular morphology of microbial species in the UASB **(Abbasi and Abbasi, 2012)**. **Fig 5** shows the mean size of sludge granules ranging with less than 5 microns. Granules were predominantly elliptical with substantial cavities and cracks on the surface which serve as an escape route for produced biogas **(Fig 5)**. Methanosaeta-like cells, Methanosarcina-like cells, rods and cocci colonies are evident by morphological structures of microorganisms in the micrographs of UASB **(Del Nery *et al.*, 2008; Lu *et al.*, 2016; Subramanyam and Mishra, 2013). Figure 6** shows the magnification of 5000 X.

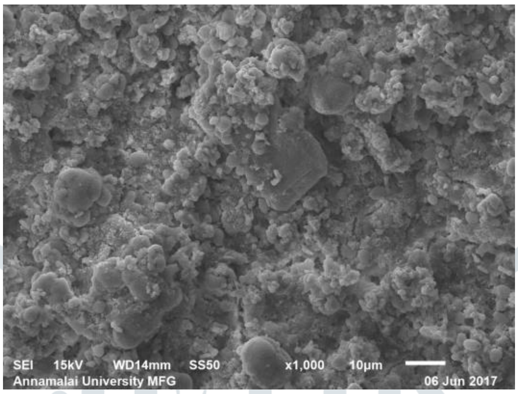

Figure 5 SEM image of anaerobic sludge granular Real time tannery wastewater a magnification of 1000 X

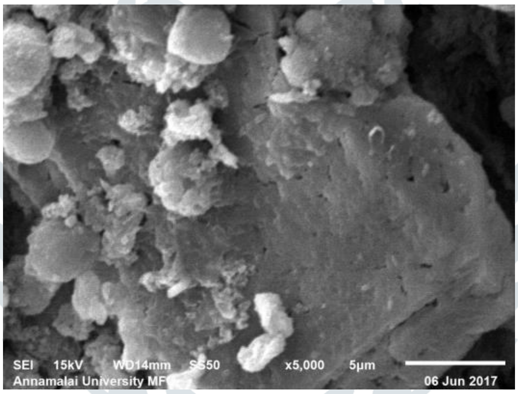

Figure 6 SEM image of anaerobic sludge granular Real time tannery wastewater a magnification of 5000 X

The granules in our work resembled brushy balloon with some flagella- like filaments outgrowing from the surface **(Figure. 7).** This observation is particularly similar to the previously report of **(Sekiguchi *et al.*, 2001).** Besides, a more close-up of granules revealed the distribution of microorganisms in the sludge's **(Figure. 7).** The granules mostly comprised of rod-shaped archaebacterial **(Figure. 7)** cells closely associated with or entrapped within sludge matrix, forming compact and intact micro-structures. In addition to rod-shaped archaebacterial, cocci-shaped archaea also prevailed on the surface or interior of granules **(Figure. 7 and Figure 8);** and the granules are less rigid with a lot of micro-pores observed between microorganisms, possibly caused by the emission of biogas.

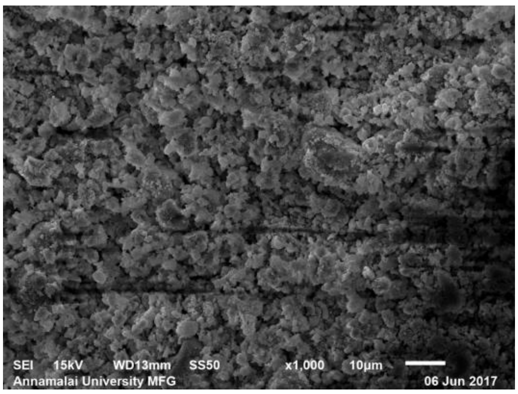

Figure. 7 SEM image of anaerobic sludge granular Real time tannery wastewater a magnification of 1000 X

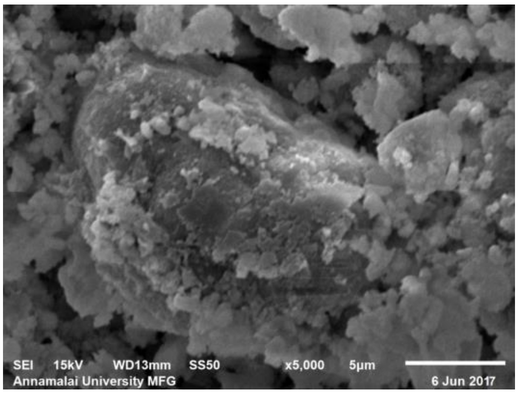

Figure. 8 SEM image of anaerobic sludge granular Real time tannery wastewater a magnification of 5000 X

4. Conclusion

Anaerobic processes are feasible for the treatment of diluted wastewaters since satisfactory treatment performance can be obtained with UASB and EGSB reactors. The maximum COD removal efficiency, Biogas production was attained in the EGSB than UASB reactors. The chromium concentration can be sucessfully degraded with anaerobic granular sludge in both UASB and EGSB reactors. The treatment of real time tannery wastewater EGSB reactor showed a better performance than the UASB reactor.

5. References

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