International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 11 (2015) pp. 30009-30018

http://www.ripublication.com

A Study on Treatment Efficiency of Tannery Wastewater Using Up Flow Anaerobic Sludge Blanket Reactor

***R. Elliss Yogesh, **Dr. V. Sekaran**
**Assistant Professor, Department of Civil Engineering, A.V.C. College of Engineering, Mannampandal, Mayiladuthurai, Tamilnadu, India – 609305*
***Dean, Pavai Engineering College, Namakkal, Tamilnadu, India – 637 018*
***Corresponding Author:** R.ELLISS YOGESH, **email:** ellissyogesh@gmail.com*

Abstract

Wastewaters from tanneries are high strength, having organic, inorganic and carcinogenic compounds like chromium. Treatment of such wastewater in efficient manner is important to meet disposal standards. It was found that the treatment of high strength wastewaters using anaerobic treatment methods is a logical alternative in recent years. Hence in this study, an attempt was made to treat the tannery wastewater using an anaerobic treatment method called up flow anaerobic sludge blanket reactor (UASBR). A laboratory scale UASBR model with an effective volume of 18.3 liters was used. After the initial startup and stabilization, the various working conditions were applied over the reactor model using synthetic tannery wastewater as substrate. The working conditions applied over the model were varying average influent COD's (5135, 5665, 6261, 6878 & 7566 mg/L) each at various flow rates (4.8, 9.6, 14.4, 19.2, 24 L/day) and at different hydraulic retention time (HRT) (5.21, 2.6, 1.74, 1.3 and 1.04 days). Also the various Organic Loading Rates (OLR) ranging from 0.072 to 0.728 kg COD/kg VSS day and volumetric loading rates (VLR) from 0.996 to 7.236 kg COD/m^3 day were applied and it was found successful of about 84% of COD removal for treating the tannery wastewater.

Keywords: Tannery, wastewater, UASBR, anaerobic treatment

Introduction

Water is ever more valuable for survival of living organisms and also for most industrial activities. The industries majorly involve in wet operations possessing chemicals, generate wastewater and cause several adverse effects. Tannery industrial processes are considered to be one of the most polluting industrial activities in the world [1]. In which, the animal hides and skin are converted into leather and related products by three sequential processes (beam–house, tan–yard and finishing). In beam

house operations, the removal of dirt and blood by washing is the first step after which the hides are then soaked in water for softening and removal of salts. Then the tanning of the hides is carried out in the tan – yard. Tanning is the transformation process of hides into leather using tanning agents (vegetable tannins or chrome). Chrome tanning is faster than vegetable tanning (less than a day for this part of the process). The tanning agent blocks carboxylic or amine groups and joins the proteinic colloid, thus increasing the cross linking of collagen fibers. Through this method, the leather is turned into a durable material [2]. And finally the finishing process involved for leather products.

Tannery requires water for all its processes and therefore it generates enormous volume of wastewater. For every kilogram of hides processed, 30 liters of effluent is generated and the total quantity of effluent discharged by Indian industries is about 50,000 m^3/day [3]. Tanneries are typically characterized as pollution intensive industrial complexes which generate widely varying, high strength wastewaters [4]. This is due to the addition of at least about 300 kg chemicals per ton of hides during the tanning process [5]. The nature of wastewater from tanneries is highly turbid, coloured and foul smelling. The major components of the effluent include sulfide, chromium, volatile organic compounds, large quantities of solid waste, suspended solids like animal hair and trimmings [6]. In which, Hexavalent chromium is highly toxic to living organisms even at low concentration causing carcinogenic effect [7]. Therefore the disposal of such high strength wastewater with untreated/partially treated will affect the living beings and its environment. Hence it is necessary to treat the wastewater in order to meet the disposal standards.

Treatment Method

The oxidation ditch, which was a more mature tannery effluent treatment, was no longer suitable for treating wastewater with heavy metals [8-10]. The treatment of heavy metal bearing wastewater using microorganism is one of the most active research fields in recent years [11] [12]. Some important characteristics of tannery wastewater include: high organic load, relatively high temperature and the possibility of degradation of recalcitrant and poorly biodegradable compounds such as tannins. These characteristics suggest that anaerobic digestion is a potential treatment alternative [13-16]. Biological transformation of biomass to methane has received increasing attention in recent years [17]. Anaerobic treatment converts the wastewater organic pollutants into small amount of sludge and large amount of energy as gas [18] is the interesting alternative choice compared to aerobic processes, as the sludge production and the energy consumption are both lower. The up flow anaerobic sludge blanket (UASB) reactor is by far the most widely used high rate anaerobic treatment system for variety of wastewater [19]. Hence the present study deals with the development of a laboratory scale model UASB reactor for the treatment of COD rich tannery effluent containing hexavalent chromium.

Materials

Wastewater collection and characterization

The wastewater used throughout this study was collected from a tannery located at Ranipettai in vellore district. The collection of samples was carried out using suitable containers by following the standard sampling procedures. Then it was preserved at a cool place until the experiments were carried out.

The characterization of the collected tannery wastewater was made by following the standard analytical procedures [20]. and it was found as: COD – 7450 mg/L; BOD – 2660 mg/L; TDS – 6120 mg/L; TSS – 2370 mg/L; pH – 7.9; N – 135 mg/L; P – 21 mg/L, and chromium 68 mg/L.

Laboratory scale UASBR model

A laboratory scale model of UASBR [figure.1] having total volume of 21 liters was fabricated using acrylic sheet of 5mm thickness with a total diameter of 210mm and total height of 750mm. The diameter of the reactor at the top is 420mm. A Gas liquid solid separator (GLSS) was provided with a diameter of 100mm at top and 180mm at bottom. The total height of GLSS is 120mm. The reactor was provided with an inlet at a height of 100mm from the bottom and a gas outlet at the top and another at a distance of 40mm from the top of the reactor as the outlet for the treated effluent, with 8mm diameter each. Three sampling ports were provided at a height of 140mm, 300mm and 500mm from the bottom of the reactor. The effective volume of reactor was known as 18.3 liters from its effective height and effective diameter; 520mm and 200mm respectively. Baffle arrangement was also made to guide the gas bubbles into the separator to capture the evolved gas. A check valve was fixed at the bottom for sludge withdrawal. Ravel Hiteks peristaltic pump of model RH-P120S was used to maintain the flow rate and upward velocity of the feed.

Experimental Procedure

The start-up period is considered as the period taken for stable operation to be achieved, when the measured parameters varied less than 10% after four reactor volume changes [21]. Initially the start up and process stabilization [figure.2] of the laboratory model UASB reactor was done with the fresh Cow Dung Slurry and domestic wastewater with help of a peristaltic pump (RH-P120S model) at ambient temperature range of 30-40°C. The performance and start-up of the model was evaluated by the COD removal efficiency. Stable operation was assumed when the COD removal efficiency did not vary more than 10%. It was found only after 70 days of the start up.

After stabilization, the reactor model was operated continuously at different working conditions with the synthetic tannery wastewater [table.1] as substrate. The working conditions applied over the model were varying average influent COD's (5135, 5665, 6261, 6878 & 7566 mg/L) each at various flow rates (4.8, 9.6, 14.4, 19.2, 24 L/day) with a resultant upward velocity in the reactor varying from 0.0064 to 0.031 m/hr and at different hydraulic retention time (HRT) (5.21, 2.6, 1.74, 1.3 and 1.04

days). Also the various Organic Loading Rates (OLR) ranging from 0.072 to 0.728 kg COD/kg VSS day and volumetric loading rates (VLR) from 0.996 to 7.236 kg COD/m^3 day were applied. The influent and treated wastewater COD, concentration of volatile solids in the sludge blanket zone and amount of gas per kg COD removal were observed for the treatment efficiency by using the standard analytical procedures.

Results and Discussion

The graphs were plotted from the observed readings for the various operating conditions. The figure.3 shows the COD removal efficiency of the reactor model under varying organic loading rates (OLR) ranging from 0.072 to 0.728 kg COD/kg VSS day. From this it was identified that the maximum % COD removal of 83.5% obtained at 0.076 kg COD/kg VSS day for the average influent COD 5665 mg/L. And also the maximum COD reduction under varying volumetric loading rates VLR, 0.996 to 7.236 kg COD/m^3 day was identified from the figure.4 at 1.087 kg COD/m^3 day. The HRT plays an important role in the treatment efficiency while using UASBR. Hence the % COD removal against varying HRT 5.21, 2.6, 1.74, 1.3 and 1.04 days was plotted. From the figure.5 the maximum was found at 5.21 days.

Since the biotransformation of biomass to gas is an important factor, the biogas generation was also considered. The bio gas generation was found to vary from 0.20 to 0.26 m^3/kg COD removal and the maximum concentration of VSS in the sludge blanket of the model was observed as 46920 mg/L.

From the results, the optimum condition for the maximum COD removal efficiency for each average influent COD was identified and tabulated [table.2]. And it was observed that the maximum COD removal efficiency of the UASBR is 83.5% in the tannery effluent treatment.

Conclusion

The startup of an UASB reactor had achieved within 70 days using domestic wastewater and cow dung slurry as seeding water. After that, the model was run at different working conditions with synthetic tannery wastewater as substrate. Finally it was found the maximum COD removal of about 84% in operating condition of OLR at 0.076 kg COD/kg VSS day; VLR at 1.087 kg COD/m^3 day and HRT at 5.21 days. The maximum gas conversion ratio was assessed at 0.26 m^3 of gas /kg of COD removal. Also the model was observed to retain a high concentration of biomass of 46920 mg/l as VSS in the sludge blanket zone. In order to increase the treatment efficiency, some post treatment methods are required.

References

[1] Mannucci, A., Munz, G., Mori, G., and Lubello, C., 2010, "Anaerobic treatment of vegetable tannery wastewaters: A review," Desalination, 264, pp. 1-8.

[2] Elsheikh, M.A., 2009, "Tannery wastewater pre-treatment," Water Sci. Technol., 60(2), pp. 433-440.

[3] Varsha, M., and APURBA, 2008, "Biological treatment of tannery wastewater for sulfide removal," D., Int. J. Chem. Sci., 6(2), pp. 472-486.

[4] Durai, G., and Rajasimman, M., 2011, "Biological treatment of tannery wastewater – A review," J. Envi. Sci. and Tech., pp. 1-13.

[5] Verhijen, L.A.H.M., Weirsema, D., Hwshoffpol, L.W., and Dewit, J., 1996, "Live stock and the environment: Finding a balance management of waste from animal product processing," International agriculture centre, Wageningen, The Netherlands.

[6] Thakur, I.S., 2006, "Environmental Biotechnology," I. K. International Pvt. Ltd., NewDelhi, pp. 398.

[7] Lee, C. K., Low, K. S., and Kek, K. L., 1995, "Removal of chromium from aqueous solution," Bioresource Technol., 54, pp. 183-189.

[8] Geng, T., 2004, "The new process of tannery wastewater treatment," Guizhou Environmental protection science and technology, 10(1), pp. 21-23.

[9] Xiudong Ma., 2003, "Treatment of tannery wastewater with biological oxidation process," J. shanxi chemical industry, 23(1), pp. 51-52.

[10] Bachman, A., Beard, V.L., and Mc-Carty, P.L., 1985, "Performance characteristics of the anaerobic baffled reactor," Water Res., 19(1), pp. 99-106.

[11] Zhou, P., Alfred, W.F.L., and Shirley, W., 1999, "Heavy metal removal from wastewater in fluidized bed reactor," Water Res., **33**(8), pp. 1918–1924.

[12] Drogui, P., Blais, J.F., and Mercier, G., 2005, "Hybrid process for heavy metal removal from wastewater sludge," Water Environment Research, 77(4), pp. 372–380.

[13] Vijayaraghavan, K., and Ramanujam, T.K., 1999, "Effect of chloride and condensable tannin in anaerobic degradation of tannery wastewaters," Bioprocess Engineering, 20, pp. 499–503.

[14] Tilche, A., and Vieira, S.M.M., 1991, "Discussion report on reactor design of anaerobic filters and sludge bed reactors," Water Science and Technology, 24, pp. 193–206.

[15] Omil, F., Mendez, D., Vidal, G., Mendez, R., and Lema, J.M., 1999, "Biodegradation of formaldehyde under anaerobic conditions," Enzyme and Microbial Technology, 24(5–6), pp. 353–363.

[16] Field, J.A., and Lettinga, G., 1987, "The methanogenic toxicity and anaerobic degradability of a hydrolysable tannin," Water Research, 20, pp. 367–374.

[17] Niu, Y., Ma, X., Wang, R., and Yu, C., 2009, "Treatment of high density tannery effluent by USAB process," pp. 1-6

[18] Ayati, B., and Ganjidoust., 2006, "Comparing the efficiency of UAFF and UASB with hybrid reactor in treating wood fiber wastewater," Iranian Journal of Environmental Health Science and Engineering, 3(1), pp. 3944.

[19] Van Haandel and G.Lettinga, 1994, "Anaerobic Sewage Treatment: A prac tical guide for regions with a hot climate." John Wiley and Sons, New Yor k.

[20] Operation manual – water quality analysis, 2003, "Hydrology project – Government of India and Government of The Netherlands," Volume 7.

[21] Westhuizen, V.D.A., and Pakkies, C., 1992, "Anaerobic treatment of a chemical distillery effluent using the ADU (Anaerobic Digestion – Ultrafiltration) process," Proc. 3rd Anaerobic Dig. Symp., Pietermaritzburg, pp. 181-189.

[22] Faouzi, M., Merzouki, M., and Benlemlih, M., 2013, "Contribution to optimize the biological treatment of synthetic tannery effluent by the sequencing batch reactor," J. Mater. Environ. Sci., 4, pp. 532-541.

Table 1: Chemical composition of synthetic Tanneries effluents (g/L) (Faouzi et.al., 2013)	
Glucose	3.64
$(NH_4)_2SO_4$	0.91
$MgSO_4,7H_2O$	0.025
$FeSO_4,7H_2O$	0.02
KH_2PO_4	0.088
K_2HPO_4	0.09
Na_2CO_3	0.066
$NaHCO_3$	0.105
$CaCl_2$	0.03
$KCrO_4$	1.86

Table 2: Optimum condition of each average influent COD for maximum % COD removal

Influent COD	Flow rate	HRT	VLR	OLR	VSS	Effluent COD	COD removal	Gas conversion
mg/l	m^3/day	Days	kg COD / m^3 day	kg COD / kg VSS day	mg/l	mg /l	%	m^3/kg COD
5135	0.0048	5.21	0.985	0.071	45650	916	82.2	0.25
5665	0.0048	5.21	1.087	0.076	46920	935	83.5	0.26
6260	0.0048	5.21	1.201	0.094	42300	1202	80.8	0.25
6880	0.0048	5.21	1.320	0.109	40160	1624	76.4	0.23
7565	0.0048	5.21	1.452	0.128	37520	1876	75.2	0.23

Figure 1: Up flow Anaerobic Sludge Blanket Reactor (UASBR) – A laboratory scale model

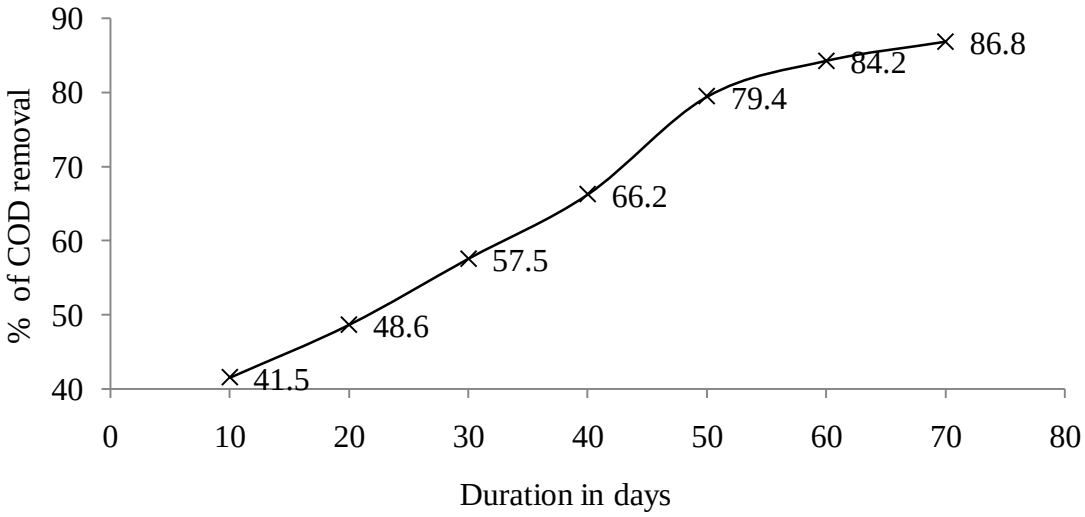

Figure 2: Startup and Process Stabilization

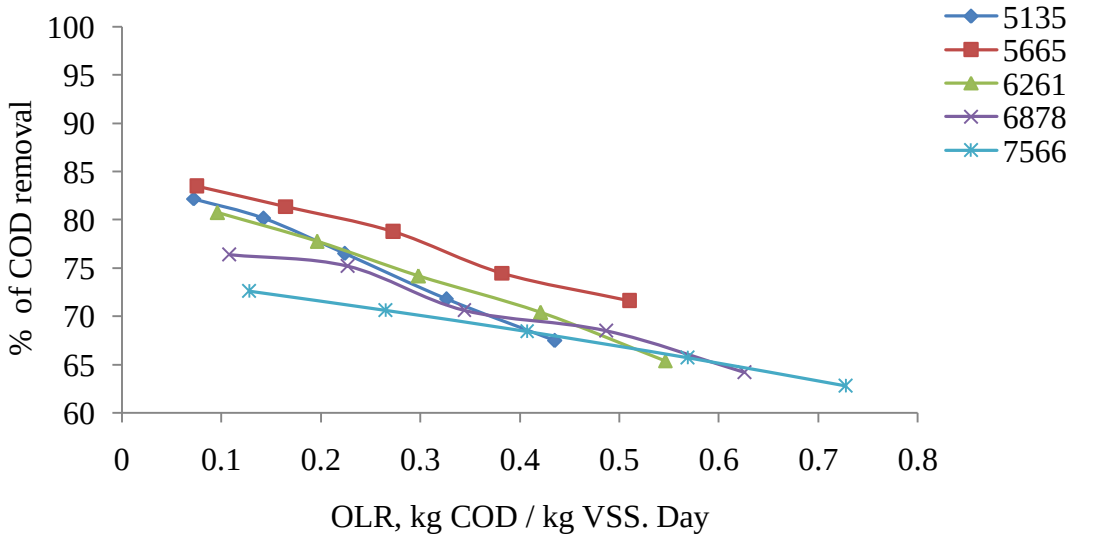

Figure 3: Organic Loading Rate (OLR) Vs COD removal percentage

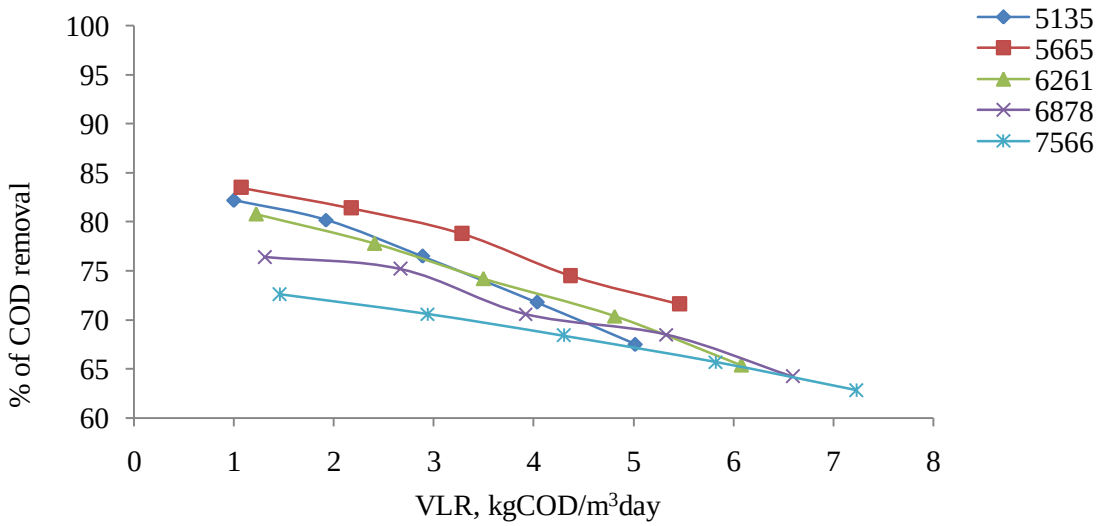

Figure 4: Volumetric Loading Rate (VLR) Vs COD removal percentage

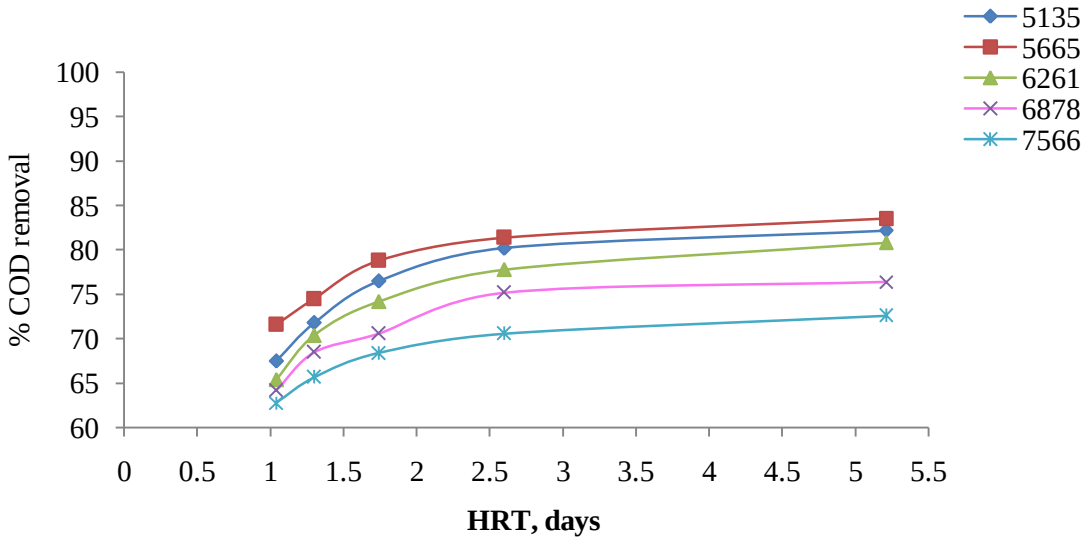

Figure 5: Hydraulic Retention Time (HRT) Vs COD removal percentage