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Technical Feasibility of Anaerobic Bio-Treatment Mechanism for Safe Disposal of High Strength Tannery Wastewater Utilizing UASB Reactor

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ABSTRACT- *Treatment of tannery effluent is generally carried out by physical, chemical, biological or the Combination of these methods. Tannery effluent is highly complex, characterized by high content of organic and inorganic chromium, suspended solids and dissolved solids, with COD range from 6500 to 8500 mg/L. Up-flow Anaerobic Sludge Blanket Reactor [UASBR] is a versatile anaerobic reactor. Substances of the sludge blanket are more dependent on the biodegradability, and the nutrients offer an edge for treating biodegradable waste stream such as tannery. The present study evaluated the performance of UASB, a laboratory model of 25 liters for treating the tannery effluent. The prototype model was tested against its treatment efficiency in terms of COD reduction. The experiment was conducted for varying influent COD concentration of 6555, 7027, 7571, 8104 and 8545 mg/L with the flow rates of 4.8, 9.6, 14.4, 19.2 and 24 L/day respectively. The experimental work on UASBR model for treating the tannery waste stream was proved successful at COD removal of 77 % for the operating conditions of OLR of 0.09 kg COD /day and HRT of 5.2 h.*

Keywords: *Anaerobic Treatment, UASBR, Tannery Effluent, COD Removal*

1. INTRODUCTION

Tanning and processing of leather started a long back, but not in commercial scale. During this period of non-commercialization, tanning activities were performed on a smaller scale to satisfy the limited demands of leather goods. With the growth of population, the increasing requirement of leather and its products led to the establishment of large commercial tanneries (Soyalsan and Karaguzel, 2007). The major inputs are water and chemicals in each sectional operation starting from soaking, liming, fleshing, deliming, pickling, vegetable chromium tanning, etc. Approximately 30-40 liter of water is used for processing one kilogram of raw hide/skin into finished leather, and the effluent with high total dissolved solid, COD and BOD is discharged from each sectional operation such as wastewater flashings and waste trimmings. Techniques for treating the effluent from tanneries include source segregation and pretreatment for removal / recovery of chromium; grease traps, skimmers or oil water separators for separation of floatable solids; filtration for separation of filterable solids; flow and load equalization; sedimentation for suspended solids reduction using clarifiers; biological treatment, typically aerobic treatment, for reduction of BOD; biological nutrient removal in nitrogen and phosphorus; dewatering and disposal of residuals in nominated harmful waste landfills. Anaerobic digestion of organic materials has been known for decades for reducing the biochemical oxygen demand and simultaneously recovering chemically bound energy as a combustible gas, mainly consisting of methane and carbon dioxide. Municipal and industrial wastewaters containing high organic loads can be treated through anaerobic biological treatment by means of utilizing UASB Reactor (Ahring et al., 1988). The up flow movement of influent and raising gas bubbles will keep the biomass in a very active and suspended state, interestingly. The granular sludge blanket will immobilize the biomass in the reactor so as to envisage a long, characteristic cell retention time, which will enhance the stability and treatment efficiency of the process (Campos, 1992). Lopez Fiuza et al., (2003) used UASB Reactor for anaerobic treatment of natural tannin extracts at different concentrations of 100, 200, 400, 800 and 1,000 mg/L, along with 5 mg/L of glucose as a co-substrate. The reactor was operated for the period of 210 days and achieved the COD removal efficiency of greater than 85% . Zhongbai and Xiaoxing Li (2008) evaluated methanogenic treatment of tannery wastewater anaerobic treatmentYanfang et al.,(2010) evaluated the treatment of high-density tannery effluent by UASB process. The results demonstrated that the laboratory scale UASB reactor could be started up successfully within 50 days when using anaerobic sludge as seeds under mesospheric conditions. The COD removal rate became higher with the increase of influent COD, which reached 91.6% with influent COD of 5575 mg/L. Mahmoud et al. (2011) studied biological tannery wastewater treatment using two stage UASB reactors. Martensson et al. (1983) investigated the effects of cycle and fill period length on the performance of a Single Sequencing Batch Reactor in the Treatment of Composite Tannery Wastewater. In addition, the effect of the period of filling time on the chemical oxygen demand (COD) removal efficiency was studied. Kouzeli et al. (1988) observed chromium accumulation in submerged aquatic plant treated with tannery effluent. Tamilchelvan et al. (2013) evaluated anaerobic digestion treatment of tannery wastewater using UASBR. The treatment process of fresh leather hides gives harmful wastewater. Ding Shao-lan et al.,(2012) investigated the removal of ammonia nitrogen from tannery wastewater by natural and synthetic zeolite. Parthiban et al. (2012) studied treatment of chrome tannery wastewater by biological process. Usually, the biological treatment process doesn't provide satisfactory results in the case of direct application due to the adverse effects of toxic chromium, sulfide, chloride, etc. and hence, pre-treatment and dilution should be given to the raw effluent prior to the bio treatment. The present study assessed technical feasibility of using UASB reactor for high strength tannery wastewater treatment.

2. MATERIALS AND METHODS

The UASB reactor can be briefly described as a system, in which substrate passes first through an experimented sludge bed containing a high concentration of biomass. Sludge bed performs the majority of the substrate removal. Then the remaining portion of the substrate passes through a less dense biomass, called the sludge blanket. Above the sludge blanket, the reactor has three phase separator which separates the solid particles from the liquid and gas (Lettinga et al., 1980).

2.1 Start-Up Process of Reactor and Stabilization

The operation of the experimental model was started with the feeding of domestic wastewater and stabilized sludge from the nearby wastewater treatment facility. The prototype was operated with screened domestic wastewater continuously. After 6 weeks of operation, a considerable amount of microbial population was retained as the blanket. The influent and effluent COD was observed continuously and the COD removal efficiency of the reactor has gradually increased and standardized at one stage (Fig. 1).

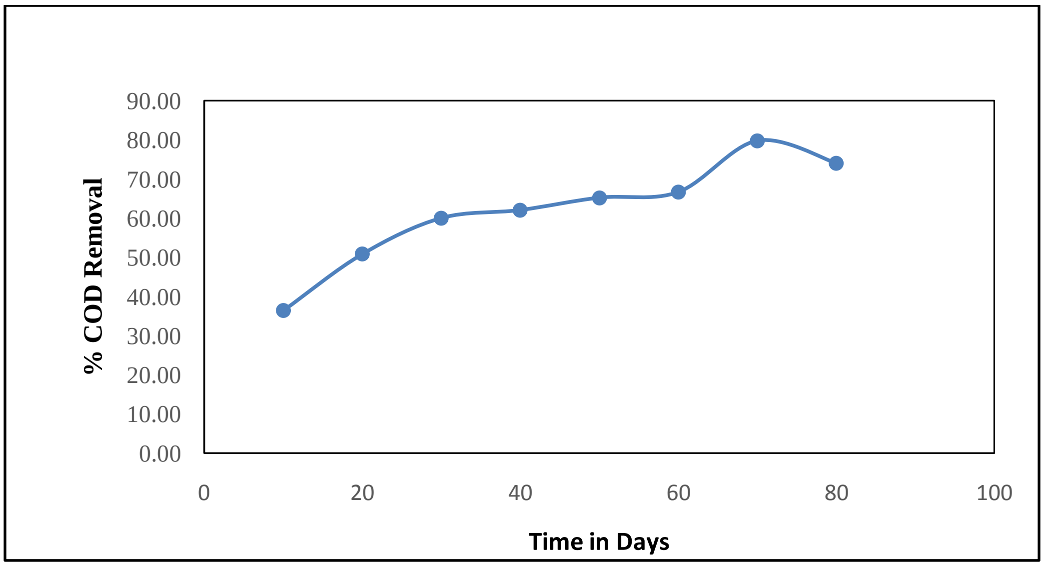

Fig.1 Start-up and process stabilization

2.2 Sample Collection and Characterization

The real time wastewater collected from nearby Tannery Industry (VANITEC) which is located at Vaniyambadi in Vellore District, Tamilnadu. The following experimental parameters such as pH, COD, BOD5, TS, TSS, TDS, Nitrogen, Phosphorus were analyzed in the laboratory as per APHA (1988) standards methods for the examination of water and wastewater.

2.3 Experimental Setup of UASB Reactor in Laboratory

The process essentially contains raw feed storage tank, peristaltic pump and UASB reactor and a gas measurement assembly. The various measurements of the fabricated UASB reactor are tabulated in Table 1 and the reactor was provided with the inlet, outlet arrangement and six sampling parts as shown in Fig. 2 and the overview of the lab scale prototype is shown in Fig. 3.

Table 1: Design features of laboratory model of UASB Reactor

Description	Measurement
Total value of the reactor, (lit)	25
Total height of the reactor, (mm)	161
Effective height of the reactor, (mm)	141
Effective diameter, (mm)	15
Diameter of the reactor at top, (mm)	15
Diameter of GLSS top and bottom, (mm)	4 and 12
Total height of the GLSS (mm)	9
Diameter of influent & Effluent pipe, (mm)	1
Peristaltic pump	PP – 30 Model

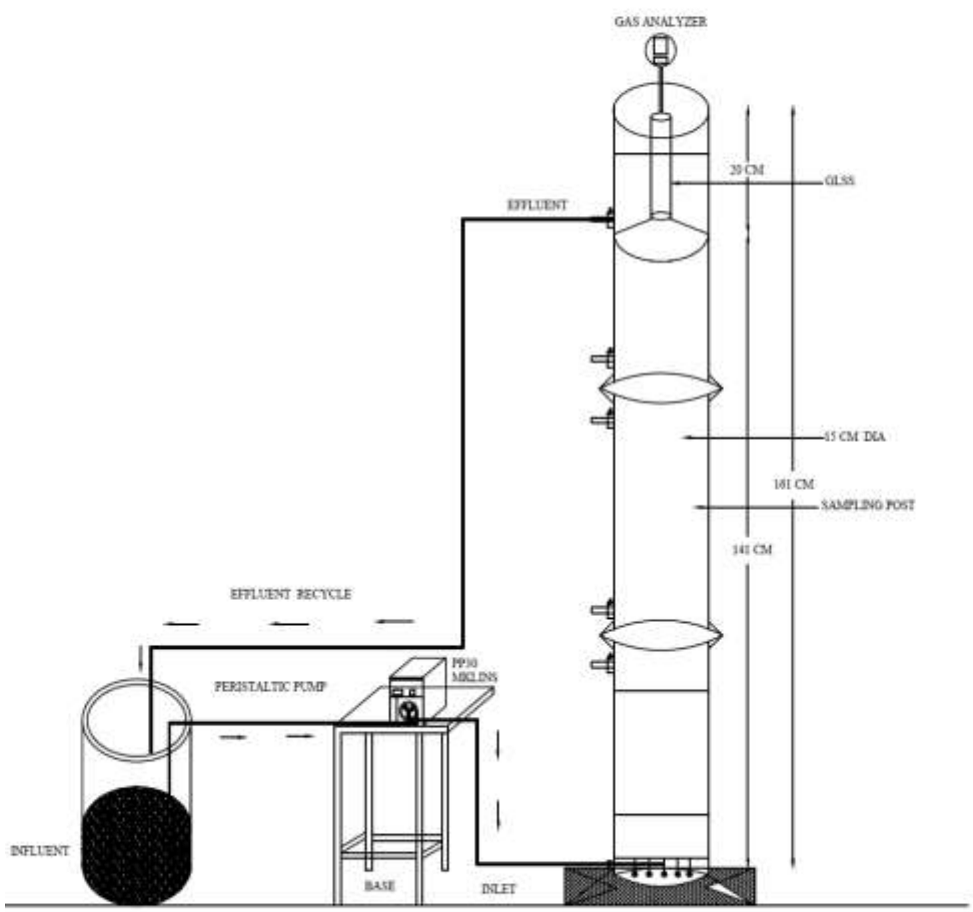

Fig. 2 Experimental setup of Laboratory UASBR Model

Fig. 3 Prototype UASBR model

2.4 Operating parameters

In the present study, UASB reactor of 25 liter capacity was monitored in order to evaluate its performance in terms of BOD/COD and TSS removal. The study was conducted for the period of 2-months from February 2017 to March 2017. BOD/COD, TSS in the raw wastewater and influent and effluent in the reactor were also analysed in order to assess the performance of the UASB reactor. Composite samples were centrifuged at 5000 RPM for 10 min in a centrifuge (Remi, India). Both centrifuged and un-centrifuged samples were analyzed for BOD, and COD using the closed reflex method as described in Standard Methods (APHA, 1989).

3. RESULTS AND DISCUSSION

The performance of the UASBR model was studied in terms of its COD removal efficiency. The model was run for various combinations of influent COD and flow rate. The influent COD co-related with the flow rate and effective reactor volume for the valuation of Organic Loading Rate (kg COD applied/ Kg VSS in the Sludge Blanket Zone/ day) and Volumetric Loading Rate (Kg COD applied/ effective volume of the reactor/day). The performance study for the Tannery waste stream was studied with the continued experiments with the model run under continuous mode.

3.1 Performance of the UASBR Model

The UASBR model, through a completely mixed reactor by virtue of its granular sludge blanket, is essentially immobilizing the microbial culture to envisage very high mean cell residence time. The rising gas bubbles from the sludge blanket that offered much-required mixing and solids concentration was observed as high as 57,800 mg/L in the sludge blanket zone. The model was essentially brought to steady-state conditions of treatment using domestic wastewater after continuous operation of the model for two months. The feed effluent was drawn from the tannery industry for process acclimatization and steady state conditions of the model operation. The steady state condition the model during the experiment using synthetic effluent, was achieved over operation of two weeks. The experiment was run for specific conditions of operations and observations were made, with the model continuously operated for the specified time.

3.2 Performance of Prototype Model for Treating Tannery Effluent

The synthetic tannery effluent is used for the evaluation of system performance for varying characteristics (as COD, mg/L) and influent flow rate (L/day). The varying influent COD applied over the model ranged from 6555 to 8545 mg/L and the varying influent flow rate applied over the model for each concentration of influent COD ranged from 4.8 to 24 L/day. The different flow rates of influent stream applied over the model were correlated with the specific volume of the reactor. It was found that in both the flow rate conditions of the feed, the hydraulic retention time (HRT) were 5.21 and 1.04 days respectively. The observed values and interpreted process parameters OLR, VLR and HRT are tabulated for each condition of the model operation in Table 2. An internal transmission was observed due to the formation of gases under anaerobic microenvironment which accelerated the generation of biological granules, but the effects were considerably scanty and hence it was not taken into the account while evaluating the reactor performance (Hulshoff Pol et al., 1983).

Table 2: Optimum performance of the reactor with maximum removal efficiency

Influent COD	Flow Rate	HRT	VLR	OLR	VSS	Effluent COD	%COD Removal	Gas conversion
8640	0.0048	5.21	1.66	0.096	310	1772	79.50	0.27
8545	0.0096	2.60	3.28	0.192	346	1867	78.16	0.26
8480	0.0144	1.74	4.88	0.296	390	2236	73.64	0.25
8548	0.0192	1.30	6.58	0.410	414	2099	75.45	0.24
8515	0.024	1.04	8.17	0.512	448	3784	65.27	0.23

The system performance curves of UASBR for treating tannery effluent are presented in the fig. 4-7. The treatment performance of the model as the percentage of COD removal under varying Organic Loading Rates is shown in the fig. 4, whereas the performance evaluation of the model as % COD removal under varying Volumetric Loading Rates, for each influent concentration of COD is depicted in the fig. 5. The performance of the model in terms of % COD removal under varying Hydraulic Retention Time isshown in the figs. 6. The fig. 7 reveals concentration of VSS in the Sludge Blanket as the concentration of active biomass with % of COD Removal. The treatment of tannery effluent with the help UASBR yields an optimum COD removal efficiency of 79.5% (Leta et al., 2004) with the maximum concentration of VSS in the Sludge Blanket of the model as 57800 mg/L (Ganesh et al., 2006). The efficiency achieved in terms of COD removal in the present study is in agreement with the optimal removal values observed by Hayadar et al. (2007).

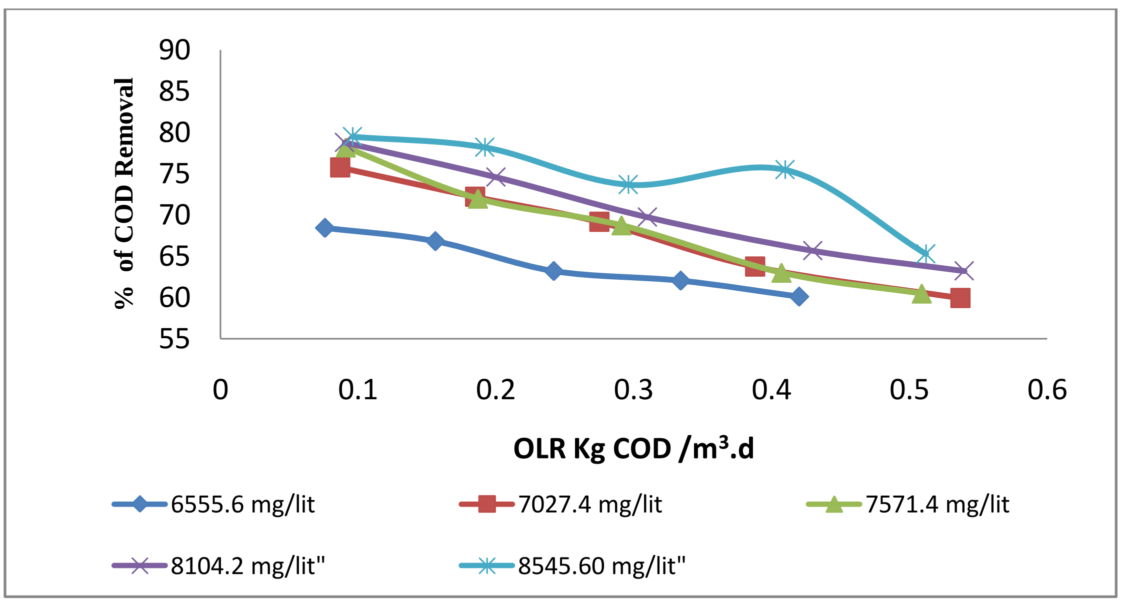

Fig.4 OLR Vs percentage of COD removal

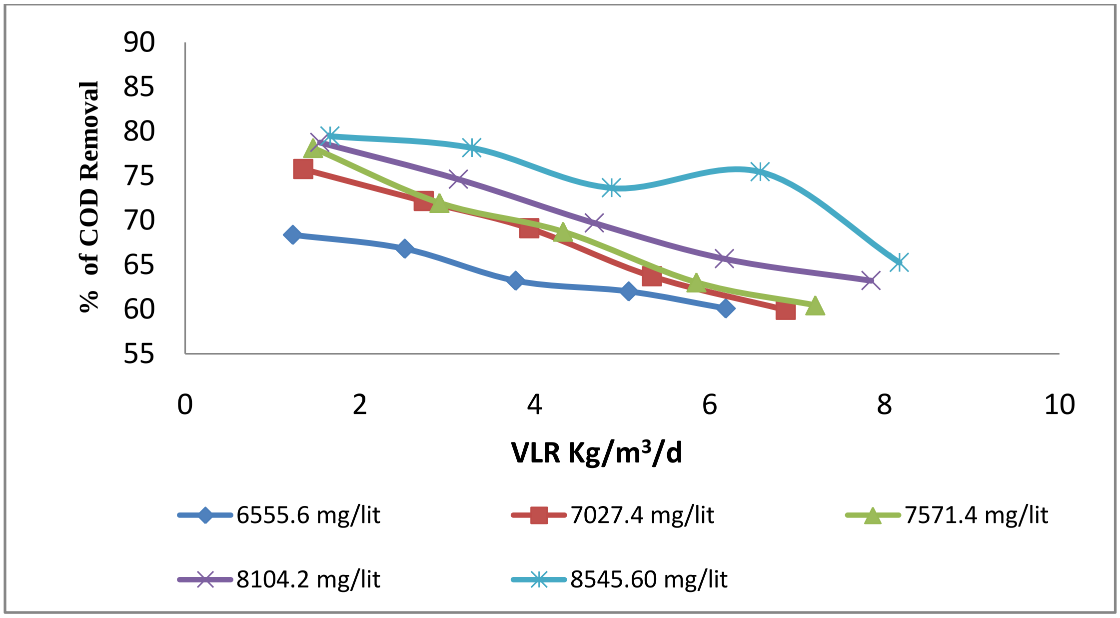

Fig.5 VLR Vs percentage of COD removal

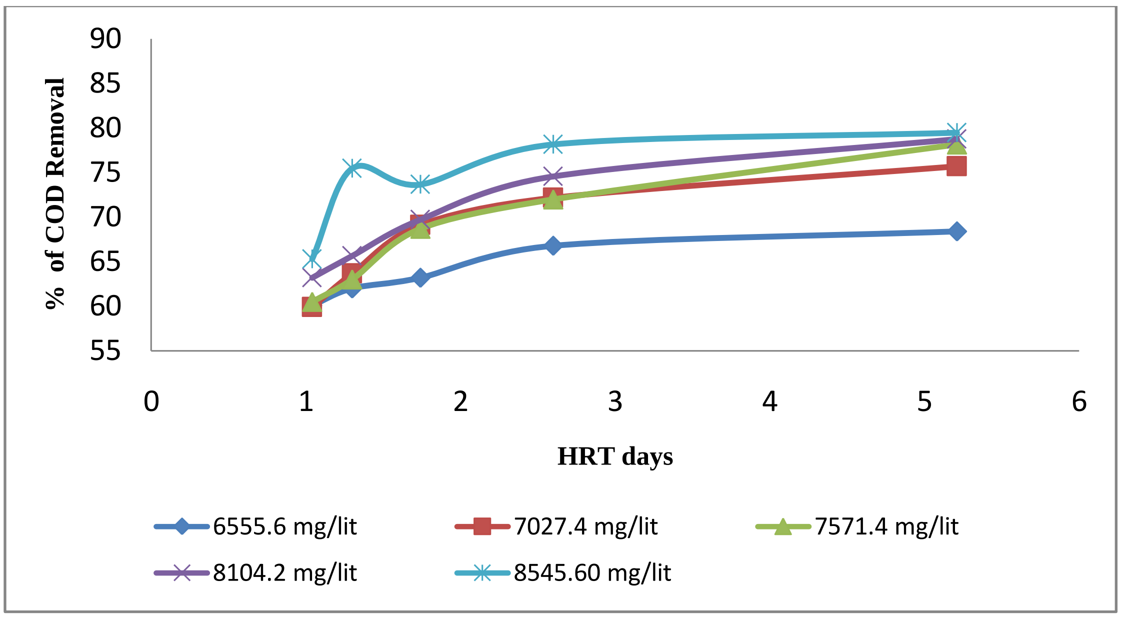

Fig.6 HRT Vs percentage of COD removal

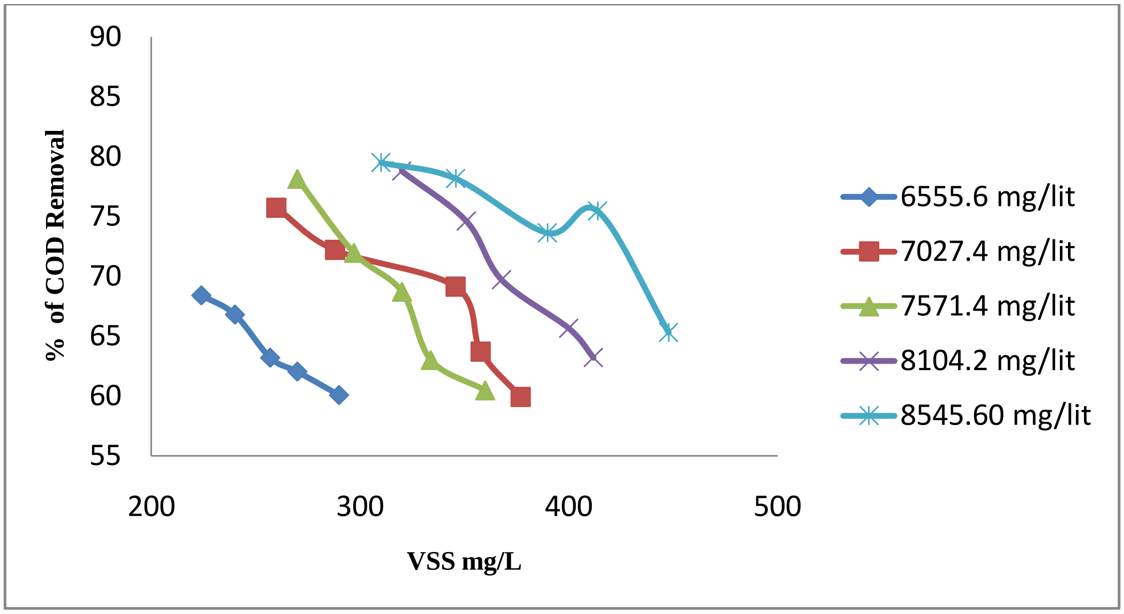

Fig.7 HRT Vs percentage of COD removal

4. CONCLUSION

The experimental results of the laboratory model concludes that Up-flow anaerobic sludge blanket reactor (UASBR) is more versatile and effective in offering anaerobic treatment of high COD waste stream and is able to remove COD up to 79% while treating tannery wastewater stream. The accumulation of sludge was observed for successive tannery waste stream only at the maximum of 35 to 45 days and hence the granule formation was accelerated. At a particular HRT, as the VLR increased the percentage of COD removal also increased up to the influent COD of 4000 mg/L, beyond which the % COD removal showed a negative proportionality. The HRT also varied inversely with % COD removal, when HRT decreased from 5.21 to 1.04 days; VLR increased and reduced the corresponding % COD removal .

5. REFRENCES

[1] Ahring BK, Westermann P (1988) Toxicity of Heavy Metals to Thermophilic Anaerobic Digestion, in Biotreatment Systems Wise D. L. (ed.), *CRC Press, Inc*, Florida USA.

[2] APHA, AWWA, WPCF, (1989) Standard Methods for the Examination of Water and Wastewater, 17th edition, *American Public Health Association, American Water Works Association and Water Pollution Control Federation*, Washington, D.C., USA.

[3] Central Pollution Control Board (1996) Performance Evaluation of Operational Projects (U.P.) on Common Effluent Treatment Plants, (*CPCB*) Central Pollution Control Board, New Delhi.

[4] Campos CMM, Anderson GK (1992) The effect of the liquid upflow velocity and the substrate concentration of the startup and steady state periods of lab scale UASB reactor., Vol. 25 (7), PP. 41 – 50.

[5] Ding SI, Li Ling, Zhang AT (2012) Study on the Ammonia and Nitrogen Removal from tannery wastewater by natural and synthetic zeolite, *College of Resource and Environment, Shaanxi University of Science and Technology*, 710021.

[6] Ganesh R, Balaji G, Ramanujam RA (2006) Biodegradation of tannery wastewater using sequencing batch reactor—respirometric assessment. *Bioresource Technology*, Vol. 97, pp. 1815 - 1821.

[7] Hayadar S, Aziz JA, Ahmad MS (2007) Biological Treatment of Tannery Watewater Using Activated Sludge Process. *Pak.J.Engg. Applies Sci.* Vol.1, pp. 61 - 66.

[8] Hulshoff Pol LW, Lettinga G, Velzeboer GTM, De Zeeuw WJ (1983) Granulation in UASB reactors. *Wat. Sci. Technol.*, Vol.15, pp. 291 - 304.

[9] Kouzeli KA, Kartsonas N, Priftis A (1988) Assessment of the Toxicity of Heavy Metals to the Anaerobic Digestion of Sewage Sludge, *Environmental Technology Letters*, Vol. 9, pp. 261.

[10] Leta S, Assefa F, Gumaelius L, Dalhammar G, (2004) Biological nitrogen and organic matter removal from tannery wastewater in pilot plant operations in Ethiopia. *Applied microbiology and biotechnology,*Vol. 66, pp. 333-339.

[11] Letlinga G, Pol HL (1991) UASB process design treatment of waste water treatment, *water science & technology*, Vol. 24, pp. 87 – 107.

[12] Lopez FJ, Omil F, Mendez R (2003), anaerobic treatment of natural tannin extracts in UASB reactors, *Water Science and Technology*, Vol. 48, pp. 157 - 163.

[13] Mahmoud A, Sheikh El, Hazem IS, Joseph RF, Mohmoud RAG (2011) Biological tannery wastewater treatment using two stage UASB reactors. *Desalination*, Vol. 276, pp. 253-259.

[14] Martensson L, Frostell B (1983) Anaerobic Wastewater Treatment in Carrier Assisted Sludge Bed Reactor, *Water Science and Technology,* Vol. 15, p 233.

[15] Parthiban R, Latha PS, Ravindranath E (2012) Multilayer perceptron modeling for UASB Reactor treating tannery effluent. *International Journal of Environmental Science,* Vol. 2, pp. 1504-1511.

[16] Soyalsan I, Karaguzel R (2007), Investigation of water pollution in the yalvac basic into egirdir lake. *Turkey Environmental Geology,* Vol –55, pp. 1263 – 1268.

[17] Tamilselvan P, Mohan S (2013) Anaerobic digestion treatment of tannery Waste Water *International. Conference Current Trend Engineering and Technology, ICCTET, IEEE-* 32107.

[18] Unnao Tanneries Pollution Control Company Limited (1998). *Chrome Recovery in Tanneries Description of Process & Cost Economics*, Unnao Tanneries Pollution Control Company Limited, Unnao.

[19] Yanfang NIU, Xingyuan MA, Rui Wang, Conzheng YU (2010) Treatment of highdensity tannery effluent by UASB process, *College oj Resource & Environment, Shaanxi University of Science and Technology,* 712081.

[20] Zhongbai Gao, Xiaoxing Li (2008) The Methanogenic Treatment of Tannery Wastewater, *China Leather & Footwear Industry Research Institute (CLFI), Vol.13,* pp.1-8.

