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Treatment of Tannery Wastewater in an EGSB (Expanded Granular Sludge Blanket) Reactor

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ABSTRACT:

The treatment of tannery wastewater was studied in an expanded granular sludge blanket (EGSB) reactor. EGSB reactor has an innovative way to minimal sludge production and also energy utilization. A small number of drawbacks are in the Conventional approaches for treating tannery waste streams due to the complication of the chemical composition. The relevance of Expanded Granular Sludge Blanket (EGSB) reactor towards the purification of the same portrayed to exist a promising alternative, for the reason that the hybrid nature and a spacious range of influent adaptabilities. The experimental process incorporates fluidization to enlarge the flux and permits incomplete conservatory of the granular sludge bed. The present study evaluated the performance of the EGSB reactor, a laboratory model of 25 litres for treating the tannery wastewater. The prototype model was tested against its treatment efficiency in terms of COD reduction and biogas production. The experiment was conducted for varying influent COD concentrations of 6456, 6952, 7512, 7968 and 8320 mg/L with the flow rates of 4.8, 9.6, 14.4, 19.2 and 24 L/d respectively. The experimental working model of EGSB reactor for treating the tannery wastewater was proven to be successful in terms of COD removal with an optimum COD removal percentage of 85.52 % and 0.27 m^3/kg COD biogas production in the operating conditions 1.512 kg COD/m^3.d of OLR at 5.21 days of HRT.

KEYWORDS: EGSB Reactor, Tannery wastewater, HRT, OLR, COD Removal and Biogas production.

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INTRODUCTION

The tanning procedure is a transformation of raw animal hides into leather. It includes various chemical and mechanical process to eliminate the enduring meat, fat and hair from the hides, to deeply clean the hide and to develop its characteristic and its efficiency properties. Despite the existence of fewer noxious waste treatments, chromium, tanning remains the most employed technique because of the higher quality of the leather obtained. Tannery wastewater rise important environmental impacts because of their complex composition and huge concentrations of various organic and inorganic chemicals reflected in particular by high standards of Chemical Oxygen Demand (COD)[1,2] and chromium concentration over 5 g/L [3]. Although new tanneries use recent equipment with the most advantageous modification of the chromium quantity, straight chromium bath tanning processes still use chromium salts in glut.

Tanneries use large amounts of water for leather manufacture, employing poisonous substances, such as chrome and sulphide, and discharge the wastewater with high levels of infectivity. The large amount of water spending is due to the treatment of hiding in various aqueous steps of the process with discontinuous discharges, making this an industrial activity which generates a huge amount of wastewater which, in turn, require significant speculation and working costs for their treatment, to satisfy the emission standards necessary by environmental legislation[4].The modern review summarizes the chemical and biological treatment technologies for tannery effluents treatment and a number of methods have been attempted and used for the efficiencies[5,6].

The term anaerobic indicates that the process takes place in an oxygen-free environment. The procedure of anaerobic incorporation is across the world, separated into four phases which are named, according to the main response mechanism which was the hydrolysis, acidogenesis, acetogenesis and finally, methanogenesis. Each individual phase is carried out by a precise group of micro-organisms which has syntrophic relations with the others, but "operates" under different environmental conditions[7]. Anaerobic process is a very attractive elucidation for the treatment of high strength wastewater, due to low sludge production and energy consumption; nevertheless, a small number of drawbacks are in the Conventional approaches for treating tannery waste streams due to the complication of the chemical composition[8].

The Biobed EGSB system is able to conquer shortcomings of the UASB reactor in the chemical industry[9]. The mainly conspicuous aspect is the increase of biomass in a granular structure, parallel to the UASB granules and no transporter matter is used. The procedure is particularly appropriate to treat waste streams that contain compounds that are poisonous in high concentrations and that only can be besmirched in low concentrations. It is feasible to function the reactor, as an ultra-high loaded anaerobic reactor (30 kg COD/m^3.d) for applications in other sectors of the industry (e.g. Yeast, Brewery, corn ethanol production, sugar etc.,), Franklin (2001)[10] reported that UASB is most predominant processes built in plant worldwide before 1997. As increasingly gaining popularity, 50% of the plants built during 1997-2000 are based on EGSB type's process. It is apparent that the traditional UASB system is slowly being replaced by EGSB type systems.

An expanded granular sludge bed (EGSB) reactor is a modification of the upflow anaerobic sludge blanket digestion (UASB) conceptually for anaerobic wastewater treatment Field (2002). The design load for EGSB systems is something like double that of the UASB process, which results in a competitive advantage over lower loaded systems. The distinguishing characteristic is that a quicker rate of upward-flow velocity is premeditated for the wastewater passing through the sludge bed. The improved flow velocity is either accomplished by utilizing tall reactors, or by incorporating an effluent recycle. This is due to the effectiveness and competitiveness recompense of the EGSB system. The increased instability permits partial conservatory (fluidization) of the granular sludge bed, improving wastewater-sludge contact as well as enhancing the separation of the tiny inactive suspended particle from the sludge bed. These concepts will provide a higher effective at higher loading rates, are appropriate for extreme environmental conditions (e.g. High and low temperatures) and to inhibitory compounds. Anaerobic treatment of the brewery and chemical wastewater with a new type of anaerobic reactor, the Biobed EGSB reactor was apparently very efficient[9]. The main objective of this study was to understand the effectiveness of the EGSB reactor towards the treatment of the tannery industry complex wastewater and the start-up, performance of the EGSB reactor operating at different HRT and OLR, and the COD removal efficiency and biogas generation in different OLR.

MATERIALS AND METHODS

The core or nuclei of the present research is to estimate the performance of the EGSB reactor for treating tannery effluent. The percentage of COD removal and biogas conversion are the primary parameters, which were observed in operating the model for two varying operating conditions, viz., Influent COD, mg/L and Influent flow rate, m^3/d. The laboratory model of EGSB reactor was constructed based on the empirical design approach for 25-litre capacity. The experiment is started through domestic wastewater followed by tannery respectively. The experiment maintained by daily observation of a COD (influent & effluent), VSS and gas collection rate.

Experimental Setup

A laboratory scale model of EGSB reactor is used 5 mm thick acrylic pipe with an effective volume of 25 L and overall volume 28 L, 150 mm internal diameter and effective height of 1100 mm was fabricated Figure (1). The reactor was provided with an inlet at the bottom and gas outlet at the top, as the outlet for the treated waste streams at the similar point of a gas-liquid-solid separator (GLSS) was provided. Baffle arrangement was also made to direct the gas bubbles into the separator to confine the evolved gas. As per the guiding principle are given by Lettinga & Hulshoff Pol (1991)[11], three phase separator was also provided with 3 sampling ports at a detachment of 300 mm c/c along the reactor. A check valve was fixed at the bottom for sludge withdrawal. Miclins peristaltic pump of model PP 30 was used to maintain the flow rate and upward velocity of the feed.

Dimensional Details

The physical dimensions of the reactor model were assessed using an empirical approach for a successful reactor volume of 25 litres with an overall volume of 28 L. The design approach is done on the basis of HRT, influent flow rate, upward velocity, influent COD and OLRs. The physical proportions and progression parameters of the experimental working model of EGSB reactor are presented in Table 1. Whereas, Figure 1 shows the schematic view of the Experimental Set-up.

Table (1) EGSB Reactor – Experimental Model – Dimension details

Description	Measurements
The total volume of the reactor, (lit)	25
Total height of the reactor, (mm)	127
Effective height of the reactor, (mm)	110
Effective dia. (mm)	15
Dia. of the reactor at top, (mm)	24
Dia. of GLSS top and bottom, (mm)	4 & 24
Total height of the GLSS, (mm)	20
Dia of Influent & Effluent pipe, (mm)	1
Peristaltic pump	PP – 30 Model

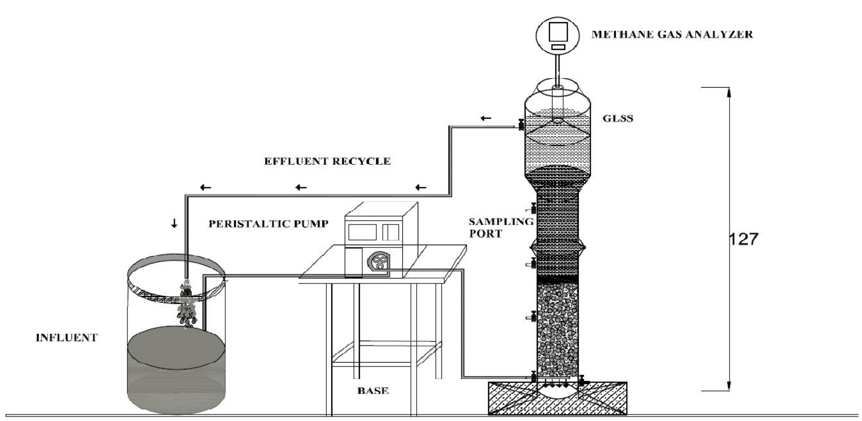

Figure (1) Schematic diagram of Experimental Setup

Characteristics of Tannery wastewater

The real-time wastewater collected from nearby Tannery Industry TALCO VANITEC CETP which is placed at Vaniyambadi in Vellore District, Tamilnadu. The subsequent experimental parameters such as pH, COD, BOD5, TSS and TDS were analysed in the laboratory as per APHA (1998)[12] standard methods for the examination of water and wastewater. The sample was analysed for specific parameters and obtainable in Table.2.

Table (2) Sample analysis report for tannery wastewater

SI.NO.	Parameters	Unit	Tannery wastewater
1.	pH		7.9
2.	BOD	mg/L	2240
3.	COD,	mg/L	6440
4.	TSS	mg/L	2566
5.	TDS	mg/L	20418

Analytical procedure

During the operation of the EGSB reactor pH, gas Production and COD were monitored daily, whereas VFA and VSS were analyzed weekly. All determinations were performed accordingly to standard methods (APHA 1998)[12]. COD was quantified by open reflux method and biogas production by water displacement method.

Start-up Operations of the model and process stabilization

The operation of the experimental model was in progress to feed domestic wastewater and stabilized sludge from the wastewater treatment amenities at Annamalai University. The model was in progress for continuous operations after 35 days with domestic wastewater, with an average COD value of 636 mg/l. The wastewater is screened and the average value is maintained for 550-650 mg/l and the system is evaluated for its treatment efficiency, in terms of % COD removal.

The COD influent and effluent were observed from 35th day and observations were received for the % COD removal for the unremitting method of the model. The COD removal starts with 37.90 % and it rises up to an utmost of 77.70 %, the stabilization method was observed after 65th day with an average COD removal rate of 77 - 80 %. The observation of the model was in progress with COD removal effectiveness as the treated effluent started comes out as clear, colourless liquid. The model for regular experimentation, tannery effluent was started from 94th day, from the actual date of reactor commissioning with domestic wastewater. The observation of the model was started with

COD removal efficiency as the treated effluent started comes out as obvious, colourless liquid and the biggest generation were observed for a utmost of 0.21 m^3/kg COD removed. There are two operating conditions for which the experiment was run and observations were made.

Operating Parameters

Influent COD: The model was operated with five different average COD of tannery wastewater range viz., 6515, 7027, 7571, 8104 and 8514 mg/L.

Flow rate: Tannery wastewater was fed into the reactor with five different flow rates ranges viz., 4.80, 9.60, 14.40, 19.20 and 24.00 L/d.

Organic loading rate: Tannery wastewater was fed into the reactor with five different OLR ranges viz., 1.612, 3.164, 4.712, 6.42 and 7.948 kg COD/m^3.d.

Hydraulic Retention time: The efficient volume of the reactor and flow rate are interpreted for the dissimilar flow retention time. The influent HRT of 5.21, 2.60, 1.74, 1.30 and 1.04 days; that are essentially corresponding to the flow rates of 4.80, 9.60, 14.40, 19.20 and 24.00 L/d respectively.

RESULTS AND DISCUSSION

The performance of the EGSB reactor model was evaluated in terms of COD removal efficiency and Biogas production. The model was run for different combinations of influent COD and flow rate. Under each condition of operations, the subsequent parameters of the method were observed, Influent COD, Effluent COD, Concentration of solids in the Sludge Blanket Zone, m^3 of gas per Kg. COD removal.

The influent COD was co-related to the flow rate and successful reactor volume for the evaluation of Organic Loading Rate kg COD/m^3.d[13]. The performance study for the tannery effluent was studied with the continuing experiments with a model run under continuous mode. The experiments were carried out by unreliable influent COD accretion at five different HRT's viz., 5.21, 2.60, 1.74, 1.30 and 1.04. The initial OLR for the HRT of 5.21 days was 1.512 kg COD/m^3.d. It was increased in a gradual manner to 7.948 kg COD/m^3.d, over the periods of 188 days[14].

EGSB reactor treating industrial waste seems to be an attractive choice for the exclusion of organic content and does not prove to be so effective in colour removal, hence it is suggested for the advanced aerobic process as post-treatment of high strength tannery wastewater. EGSB reactor is more versatile and effective in offering anaerobic treatment of high COD industrial waste streams. It is observed that tannery effluent can be treated for COD removal up to 85.52% from operating at 1.512 kg COD/m^3.d of OLR. The efficiency achieved in terms of COD removal in the present study has a concord with the finest removal values experiential[15]. Tannery wastewater was fed into the reactor with five different OLR ranges 1.512 to 7.948 kg COD/m^3.d.

An experiment was done by (Tiwari, 2005)[16] with implementing a low OLR of 1.5 kg COD/m^3.d has indicated flourishing granulation procedure with no degeneration in granule structure. The performance observed for tannery effluent is better only at influent COD and overall performance only below the influent COD of 8000 mg/L. The biogas generation rate increased from 0.21 to 0.27 m^3/kg COD, removed from the waste streams which further strengthen the view of EGSB reactor as fully fledged effluent treatment plant for treating biodegradable industrial waste streams. This indicates that substrate destruction is a direct function of biogas generation was constantly at a rate of 0.27 m^3 CH_4/kg COD[17]. The maximum upward velocity of the flow isobserved as 0.031 m/h.

The acclimatization process reaches in the reactor was observed in the tannery wastewater only at an utmost of 40 to 50 days. At a meticulous HRT, as the OLR increases with the percentage COD removal and also increase up to the influent COD from 6000 to 8000 mg/L beyond which the percentage COD removal decreased with increasing OLR. The maximum gas generation of 0.27 m^3/kg COD was recorded for a varying HRT. The decrease in a gas generation may be attributed to the occurrence of inhibiting substances such as tannin in the wastewater. The inhibitory role played by tannin and other such substances has been reported by some of the workers (Vijayaraghavan and Murthy 1996)[18]. The graphical representations to assess the system performance for the different working situation were drawn, using the observed ideals of the experiment.

The system performance curves of the EGSB reactor for treating tannery effluent are presented in Figure 2 to 5. The percentage COD removal efficiency in the medium of OLR 1.512 to 7.833 kg COD/m^3.d are illustrated in figure. 2, and the treatment performance of the model as % COD removal under unreliable OLR, kg COD/m^3.d. The performance for all the five different influent COD concentration was represented in figure 2. It is manifest from the results that the COD removal rate increased gradually up to an OLR of 1.512 kg COD/m^3.d for HRT of 5.21 days and 7.833 kg COD/m^3 .d for HRT of 1.04 days.figure. 2. OLR Vs % COD removal efficiency at variant HRT is illustrated in figure. 2.

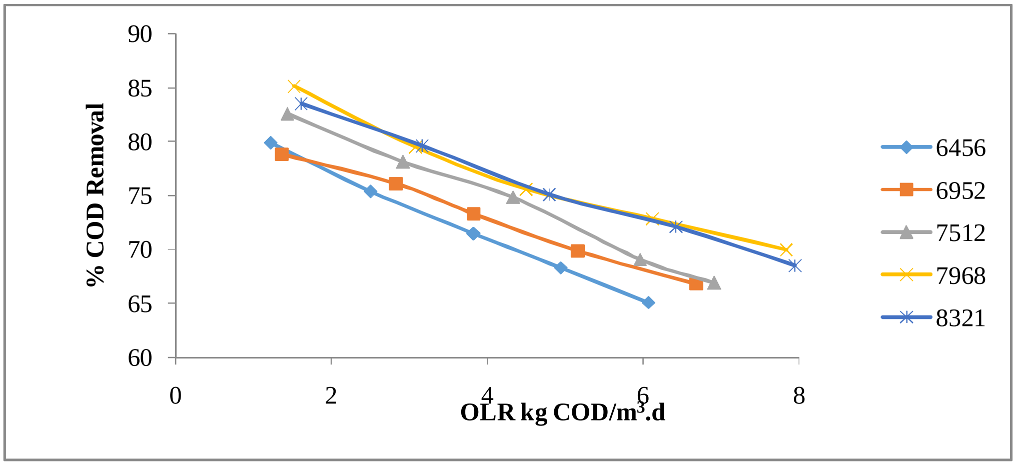

Figure. 2 OLR Vs % COD removal

It is manifest from the figure 3 that the VSS removal rate decreased gradually for varying HRT. The performance estimate model as HRT under varying VSS, mg/l, for each influent concentration of COD is mentioned in figure 3.

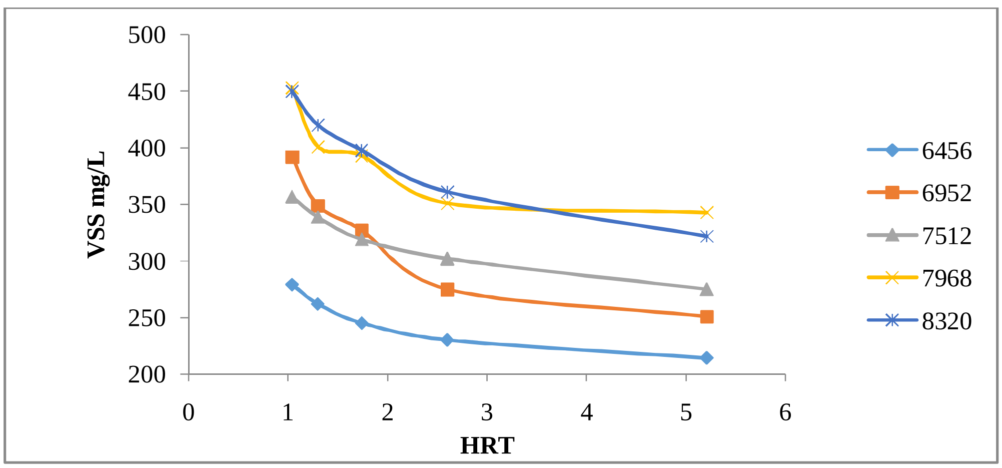

Figure. 3 % HRT Vs VSS

The maximum values for COD removal at HRT of 85%. Increase in OLR beyond this level caused a gradual decrease in the COD removal rate at variant HRTs[19]. The performance of the model in terms of % COD removal under varying Hydraulic Retention Time HRT, days is drawn in figure 4. The HRT is a significant parameter of influence in enhancing the treatment efficiency, the % COD removal for all the influent COD, flow regimes under different, specified hydraulic flow rates shows in figure 4.

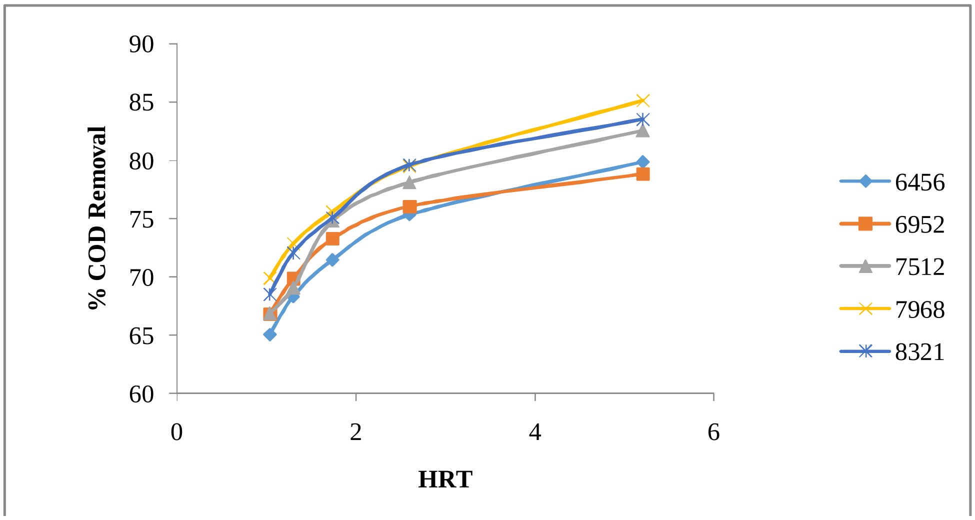

Figure .4 HRT Vs % COD removal

The biogas production in different HRT was shown in figure 5. The amount of biogas generated m^3/kg COD removed under varying HRT conditions were presented in figure 5.

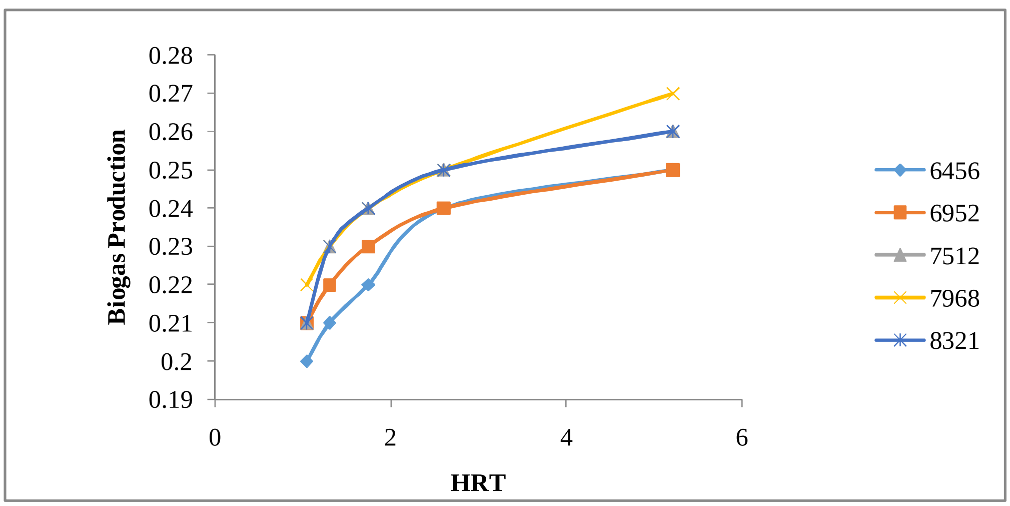

Figure. 5 HRT Vs Biogas Productio

CONCLUSION

The experimental results of the laboratory model of EGSB reactor establish that the COD removal effectiveness of EGSB reactor was 85.52 % in operating OLR 7.948 kg COD/m^3.d at different HRT. The biogas generation rate was 0.27 m^3/kg COD. The interpretation observations for process parameters and validation of outcome exposed that Expanded Granular Sludge Bed reactor is a viable technical option to remove COD up to 85.52% while treating industrial wastewater of the tannery. The response of the model shows that the major concentration of the substrate is degraded at the bottom part of the reactor where the major concentrations of biomass present. Better riddance of COD occurred in the meeting between the substrate and microorganisms only at the lowest upward velocity.

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