Performance Evaluation of Lab-Scale UASB Reactor for Treating Slaughterhouse Effluent

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Abstract: **Slaughter house waste stream is a highly biodegradable waste stream with BOD in the range of 1000 to 4000 mg/lit and COD from 2000 to 8000mg/lit. Slaughterhouse produces large amounts of different waste and wastewater, traditional way to make use of the waste such as application to agriculture land are not applicable because transport distances have become too long. Direct disposal into sewerage system without prior treatment is mostly not acceptable. Anaerobic process can contribute in an interesting way to improve waste treatment and energy. Up flow anaerobic sludge blanket reactor [UASBR] is a versatile, proven, high rate anaerobic reactor. The substance of the sludge blanket which is more dependent on the biodegradability and nutrients offers an edge for treating highly biodegradable waste stream such as slaughter house. The proposed study envisaged as on experimental work. A laboratory model on UASBR for an effective volume of 25 liters will be established for performing the experiments on slaughter house waste stream. The experiment was conducted for varying influent COD 2166, 3043, 4221, 5055, 6254 and 7226mg/l. The flow rates of the experiments are 9.6, 12.9, 21.6, 31.2 and 39.9 l/d respectively. The experimental work on UASBR model for treating slaughter waste stream is found to be successful with % COD removal from 81.48 % for the operating condition of OLR at 0.0474 kg COD/kg vss.Day and HRT at 2.60 days.**

Keyword: UASBR, COD, OLR, HRT, VSS and Biogas.

I. INTRODUCTION

India is facing severe problems of collection, treatment and disposal of effluents due to rapid industrialization. Two types of treatment can be done on effluents i.e. aerobic and anaerobic treatment, but in aerobic treatment external energy is required for aeration also there is excess sludge production in aerobic treatment. Anaerobic treatments are widely application for treating high strength waste water. It does not require external energy and itself produces the energy in the form of methane gas. UASBR is one of the anaerobic treatment converts the waste water organic pollutants into small amount of sludge and large amount of biogas as a source of energy (Hampannavar and Shivayogimath, 2010). Responsible parameters for the good performance of UASB are formation of compact granular sludge which ensures high specific methenogenic activities and superior settling characteristics (Jinye et al., 2008). UASB is applicable for treating variety of industrial wastewater i.e. Sugar industry waste water, dairy waste water, textile waste water, slaughterhouse waste water, food and potato processing waste water, brewery, distillery waste water and recent research indicate the feasibility of. UASB process in treatment of domestic effluents also.

A. Experimental Setup:

The experimental setup consists of an UASBR having 25 liters of effective volume. The features and process parameters are listed in Table - 1, the schematic of the experimental setup is presented in Figure - 1.

TABLE - 1: PROCESS PARAMETERS OF THE EXPERIMENTAL MODEL [UASBR-25 LIT]

Description	Measurements
Total volume of the reactor, lit	25
Total height of the reactor, mm	690
Effective height of the reactor, mm	600
Effective dia, mm	200
Dia of the reactor at top, mm	360
Dia of GLSS top and bottom, mm	72 & 170
Height of the GLSS, mm	90
Dia of Influent & Effluent pipe, mm	10
Width of the launder, mm	25
Peristaltic pump	pp - 30 model
Influent Flow Rate, liter/day	9.6, 12.9, 21.6, 31.2, and 39.9
Influent COD.mg/l	2166, 3043, 4221, 5055, 6254, 7226
Volumetric Loading Rate, KgCOD/m.day	0.83 to 11.56
Organic Loading Rate, Kg COD/kg VSS. Day	0.047 to 0.599

B. Experimental Methodology:

The operations of the experimental model were started with feed of domestic wastewater and of stabilized sludge from the wastewater treatment facilities of Annamalai University.

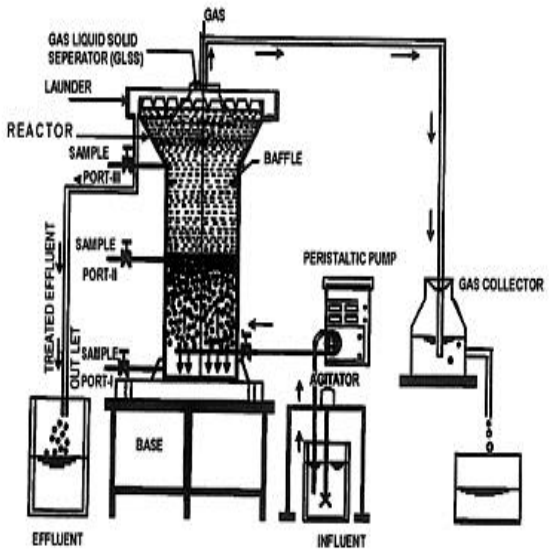

Fig - 1: Schematic of the Experimental Setup

The wastewater with a good amount of active microorganism was retained in the reactor in the batch mode for 35 days. The model was started for continuous operations after 35 days with domestic wastewater, whose average COD value is 610 mg/l. the wastewater is screened and the average COD value is maintained for 550-600 mg/1 and the system is evaluated for its treatment efficiency, in terms of % COD removal. The COD of influent and effluent were observed from 35th day. The observations are received for the percent COD removal for the continuous operation of the model. The COD removal is started with 30.00 % and it rise up to a maximum of 78.00 % and the process stabilization was observed after 65th day with the average COD removal at 75-78 %. The observations on model were started with COD removal efficiency as the treated effluent started comes out as clear, colorless liquid.

II. RESULT AND DISCUSSION

TABLE - 2: SLAUGHTER WASTEWATER SAMPLE ANALYSIS REPORT

S. No	Parameters	Sample
1.	pH	6.5
2.	Total suspended Solids, mg/I	3057
3.	Total Dissolved Solids, mg/1	4042
4.	Total Solids, mg/1	6571
5.	BOD_5@20°C,mg/l	2047
6.	COD, mg/I	5365
7.	Nitrogen, [as N] mg/1	101
8.	Phosphorus, [as P] mg/I	89

The real time wastewater was introduced in the reactor with an average organic loading rate(OLR) of 0.2107 Kg COD/m^3.day and in stages, mixed with domestic wastewater, at the rate of 20%, 40%, 60%, 80%, 100%. The process stabilization and acclimatization was get achieved with an average of 75.97 % COD Removal in 35 days.

The slaughter house effluent is considered for the experiment and introduced after the process stabilization. The chemical composition of the slaughter house effluent is presented in Table - 3.

TABLE - 3: CHEMICAL COMPOSITION OF SYNTHETIC SLAUGHTER WASTEWATER

Dry Fish Powder	Varied
NH4CI	Varied
$MgSO_4.7H_2O$	50mg/l
$FeCl_3.6H_2O$	3mg/I
$CaCl_2.H2O$	0.4 mg/1
KCL	60 mg/1
$(NH_4)2.PO_4$	Varied

The model was run under different Volumetric Loading Rates [VLR]. The varied influent COD are 2166, 3043, 4221, 5055, 6254, and 7226 mg/l. The varied HRT for the experiments are 2.60, 1.93, 1.15, 0.80, 0.68 days.

The COD removal efficiency is found to vary from 69.63 to 81.48 % with respect to varied OLR of 0.0474 to 0.599 kg COD/kg VSS. day and HRT of 0.68 to 2.60 days. The maximum % COD removal is found to be 81.48 % for the OLR of 0.0474 kg COD/kg VSS. day and HRT of 0.68 to 2.60 days. The biogas generation is found to vary from 0.22 to 0.32 m^3/kg COD removal with respect to varied OLR of 0.0474 to 0.599 kg COD/kg VSS. day and HRT of 0.68 to 2.60 days. The experimental work on UASBR model for treating slaughter waste stream is found to be successful with % COD removal from 81.48 % for the operating conditions of OLR at 0.0474 kg COD/kg VSS. day and HRT at 2.60 days.

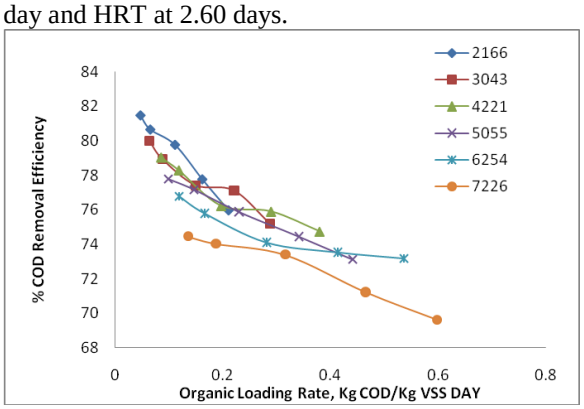

Fig. 2: Slaughter effluent: OLR Vs % COD removal

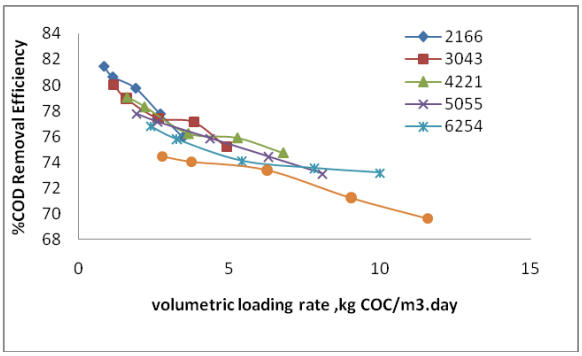

Fig 3: Slaughter effluent: VLR Vs % COD removal

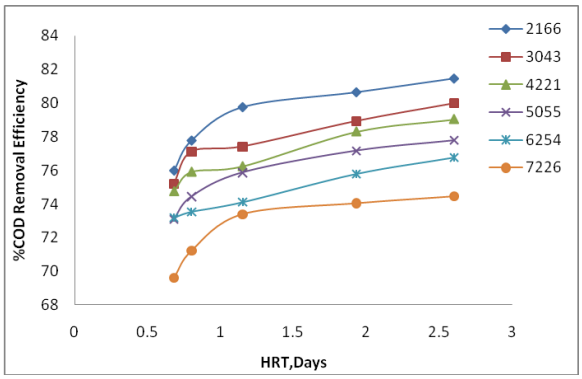

Fig 4: Slaughter effluent: HRT Vs % COD removal

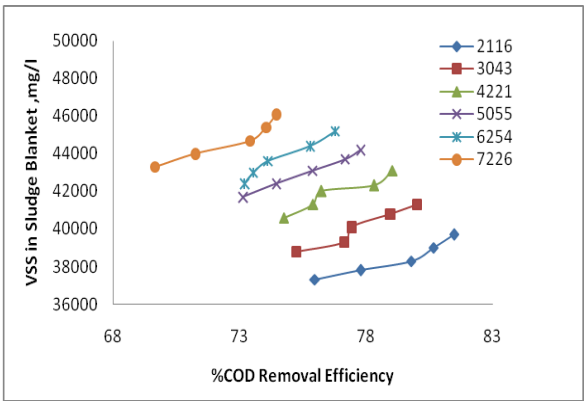

Fig 5: Slaughter effluent: % COD Removal Vs VSS

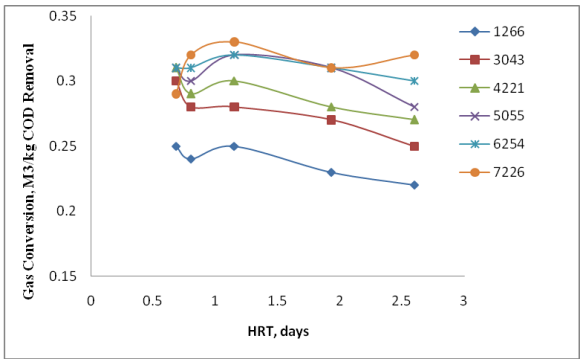

Fig 6: Slaughter effluent: HRT Vs Gas Conversion

The modified UASBR is found efficient treating slaughter house wastewater and the maximum of % COD removal found to be 81.48% for the OLR of 0.0474kg COD/kg VSS. day and HRT of 0.68 to 2.60 days. The biogas generation is found to vary from 0.22 to 0.32 m^3/kg COD removal with respect to varied OLR of 0.0474 to 0.599 kg COD/kg VSS. day and HRT of 0.68 to 2.60 days.

The synthetic slaughter house effluent was used to assess the system performance in the varying characteristics like COD [mg/l] and influent flow rate [lit/day]. The varying concentration of influent, COD applied over the model were 2166, 3043, 4221, 5055, 6254, and 7226mg/l.

The different flow rates of influents applied over the model were co-related with the specific volume of the reactor and it was found that in various flow rate conditions of the feed, the varied HRT for the experiments are 2.60, 1.93, 1.15, 0.80, 0.68 days.

The system performance curves of UASBR for treating Slaughter effluent are presented in Figure - 2 to 6.

The Figure - 2 is shown the treatment performance of the model as % COD removal under varying organic Loading Rates OLR, kg COD/kg VSS. day. The Figure - 2 depicted the performance for all the six different influent COD concentration.

The Figure - 3 is drawn for the performance evaluation model as % COD removal under varying Volumetric Loading Rates VLR, kg COD/m^3.day, for each influent concentration of COD.

The Figure - 4 is drawn on the performance of the model in terms of % COD removal under varying Hydraulic Retention Time HRT, days. The HRT is an important parameter of influence in enhancing the treatment efficiency. The Figure - 4 shows the % COD removal for all the influent COD flow regimes under different, specified hydraulic flow rates.

The Figure - 5 is drawn based on the concentration of VSS in the Sludge Blanket as concentration of active biomass. The influence of Sludge Blanket in the treatment process is well depicted in the Figure 4.4 as the influence lines of % COD removal verses the concentration VSS in the Sludge Blanket.

The Figure - 6 is drawn on the characteristic energy line of UASBR. The amount of gas generation per kg COD removed under varying HRT conditions were presented in the Figure - 6.

In the Slaughter Effluent treatment, COD removal the maximum efficiency of the UASBR was observed at 81.48 %. The maximum concentration of VSS in the Sludge Blanket of the model was observed at 46100 mg/l. The maximum gas conversion ratio was assessed at 0.32 m^3 of gas /kg of COD removal treatment.

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