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RESEARCH ARTICLE OPEN ACCESS

Performance Of An Up-Flow Anaerobic Sludge Blanket Reactor In The Treatment Of Slaughter Wastewater

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ABSTRACT
The wastewater discharged by slaughterhouse is characterized mainly by high biochemical oxygen demand, high suspended solids, and a complex mixture of fats, proteins, and fibers requiring systematic treatment before disposal. This study was carried out to examine a lab-scale up-flow anaerobic sludge blanket reactor performance for the treatment of slaughter wastewater under varying operating conditions. (pH) 7.1-7.8, total suspended solids (TSS) 900-1500 mg/l, total dissolved solids (TDS) 1600-3000 mg/l, chemical oxygen demand (COD) 3000-5000 mg/l). The reactor was run at varying OLR (0.025) and HRT (7.00, 11.00, 15.00, 19.00, 23.00 hrs) at the temperature of (29-35°C). The maximum total chemical oxygen demand removal efficiency of 82.68% was achieved at an organic loading rate of 0.013 kg/COD/m^2/day and at a hydraulic retention time of 23 hrs. Mathematical modeling is an important preliminary step for implementing the wastewater treatment processes guiding systems. Hence the model of Stover Kincannon was considered in this work for evaluating biokinetics coefficients using the experimental data of this work.
KEYWORDS: Slaughter wastewater, UASB Reactor, COD, OLR, HRT, and Mathematical model

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I. INTRODUCTION

Slaughterhouse wastewaters are considered by the different European legislation as 'very contaminating' (Tritt & Schuchardt, 1992) due to their composition, characterized mainly by a complex mixture of fats, proteins, and fibers. Processing a chicken for human consumption requires 10 – 12 l of water so the overall water consumption in a poultry processing plant is considerable. Sixty percent of the water is converted into wastewater with pH between 6.1 and 7.1, a biological oxygen demand (BOD) between 4500 and 12,000mg/l and a large percentage of solids, mostly clotted blood (more than 40% in volume), with a high-fat content (Mercado, 1995). The rest of the wastewater is lost in the process through run-off.

Most of the slaughterhouses in TamilNadu effective collection of blood, separation of manure, or effluent treatment methods are not practiced and extremely complex effluents are discharged into land or water. Surface and groundwater pollution in addition to the odor, fly, and mosquito nuisances are posed by these practices. Most of this wastewater is treated physicochemical, requiring large quantities of chemicals and energy to dry the affluent and generating 20g of sludge per liter of water. The deposition of the sludge is difficult, thus limiting the use of this technique. A better option to reduce the generated biosolids might be anaerobic digestion using up-flow anaerobic sludge blanket reactors (UASB) (Speece, 1983; Young and Dahab, 1983; Young, 1991).

In the USAB process, anaerobic bacteria convert organic material into methane, carbon dioxide, and biomass while purifying the wastewater (Del Nery et al., 2001). USAB systems are known for their high volumetric treatment rates, good CH_4 productivity, and low sludge production, which makes the process economically and technologically attractive (Del Pozo et al., 2000).

As mentioned before, the objective of this study was to evaluate the performance up-flow anaerobic sludge blanket reactor in the treatment of slaughterhouse wastewater. The experiments carried out in the UASB reactor were designed to study the influence of organic loading rate (OLR) and hydraulic retention time (HRT) in the treatment of slaughterhouse wastewater.

II. RELATED WORK

A wide range of organic loading rates and Hydraulic retention times has been reported in the literature for UASB reactors, depending on the substrate used and the quality and quantity of the microbial community. In this study, the removal efficiency of COD for varying OLR (0.013, 0.023, 0.037 kg/COD/m^2/day) were studied. Initial

reduction with increased OLR was moderate, it tends to increase with a decrease in OLR.

The effect of varying HRT was investigated; removal efficiency was optimum at high retention time. The reason for the decrease in efficiency while reducing the HRT, despite increasing the turbulence in the reactor, is that the contact time of wastewater with sludge granules will be decreased, so less organic matters are utilized.

III. EXPERIMENTAL SET-UP

Bench-scale continuous up-flow Anaerobic Sludge Blanket (UASB) reactor made of fiberglass was used in this study. The reactor had an internal diameter of 11.5 cm and a total height of 98 cm resulting in a total volume of 10 l and a working volume of 5.4 l with a gas headspace of 1l. The reactors were fed with the substrate using a peristaltic pump (Model: PP-30, Miclins). The peristaltic pump can maintain a constant flow rate in the range of 2 ml/h to 10 l/h, available with timer and LED display for the flow rate of function and time. Five sampling ports were installed along the length of the reactor. Biogas produced from the reactor was collected by the water displacement method using the Mariotte bottle. The operating temperature of the reactors was in the mesophilic range (29-35°C). The experimental setup of a UASB reactor was shown below.

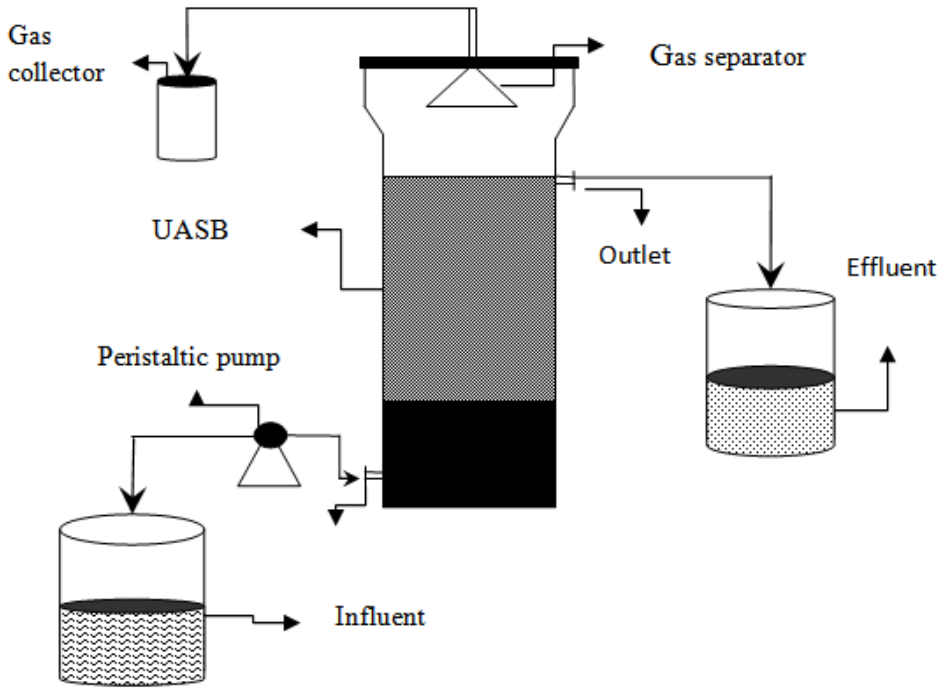


Fig.1 Experimental Setup of UASB System

INFLUENT WASTEWATER

For this study, the main source of wastewater was collected from a local slaughterhouse in the market in two different locations, Chidambaram, Cuddalore, and Tamilnadu. Wastewater consisted of effluent from a combination of several stages. It included blood from killing operations, wash waters from the stomach and intestines. The addition of nutrients was not deemed necessary since wastewater characteristics indicated an adequate concentration of essential proteins and trace elements. No dilution or recycling of feed was made in the beginning or at any of the phases of the study.

Chemical analyses such as pH, BOD, TSS, VSS, TDS, and COD for determination of wastewater quality parameters were conducted according to Standard Methods (APHA, 2005).

EXPERIMENTAL METHODOLOGY

For a startup, the bottom of the reactor was filled with anaerobic sludge taken from wastewater treatment facilities of Annamalai University and then fed continuously with screened domestic wastewater and allowed to stand for 15 days. Throughout the study, the reactor was operated at room temperature, 30±2°C.

After stabilization, synthetic wastewater was used for the experimental study to standardize

the experiment. The synthetic wastewater was prepared by using **Dry Fish Powder.**

The synthetic wastewater was fed into the reactor and it was studied for COD removal, as % COD removal efficiency under varied organic loading rates (OLR) and hydraulic retention time (HRT). The varied influent COD applied over system were 2121, 2789 and 3363 mg/l for varied HRT (7.00, 11.00, 15.00, 19.00, 23.00 hrs) and OLR (0.013, 0.023, 0.037 kg/COD/m^2/day). Under each operating condition, influent and effluent COD and amount of gas were observed using the Standard Method of Analysis.

The average values of the biochemical characteristics of the slaughter wastewater effluent are listed in **Table 1.**

Sl.no	Parameters	Concentration (mg/l)
1	pH	7.4
2	COD	3850
3	Total Solids	3072
4	Total Suspended Solids	979
5	Total Dissolved Solids	2093
6	Total Nitrogen	127
7	Sulphate Concentration	110

Table.1 Typical characteristic of slaughter wastewater

IV. RESULTS AND DISCUSSION

After the UASB reactor was stabilized, synthetic wastewater was prepared and used for experimental study. The experiment was conducted for evaluating the UASB system in terms of COD removal. The reactor ran continuously for 45 days.

The average influent COD prepared was 2121, 2789, and 3363 mg/l. Initially, COD removal efficiency was poor, after some period of reactor reached steady-state condition and removal efficiency was improved to 82.68%. The graphical representations to assess the reactor performance for different operating conditions were drawn, using observed values. The COD removal efficiency for varying OLR (0.013, 0.023, 0.037 kg/COD/m^2/day) was shown in **Fig 2**. And COD removal efficiency for varying HRT (7.00, 11.00, 15.00, 19.00, 23.00 hrs) was shown in **Fig 3.**

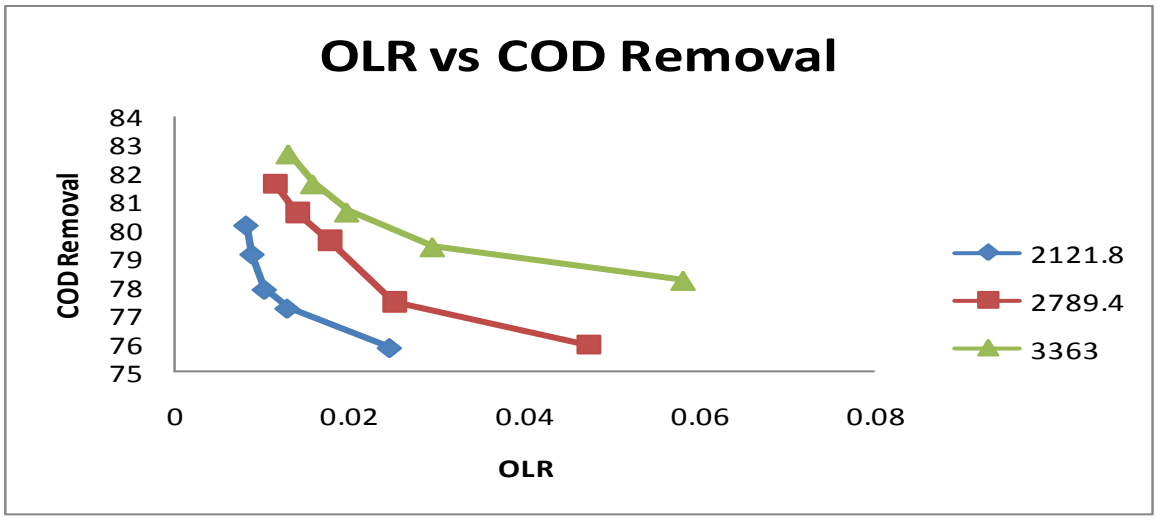


Fig.2 Average Influent COD mg/l Vs varying OLR kg/COD/m^2 day

It shows the treatment performance of the reactor as % removal under varying OLR, kg/COD/m^2/day. And it depicted the performance for all different influent COD concentration.

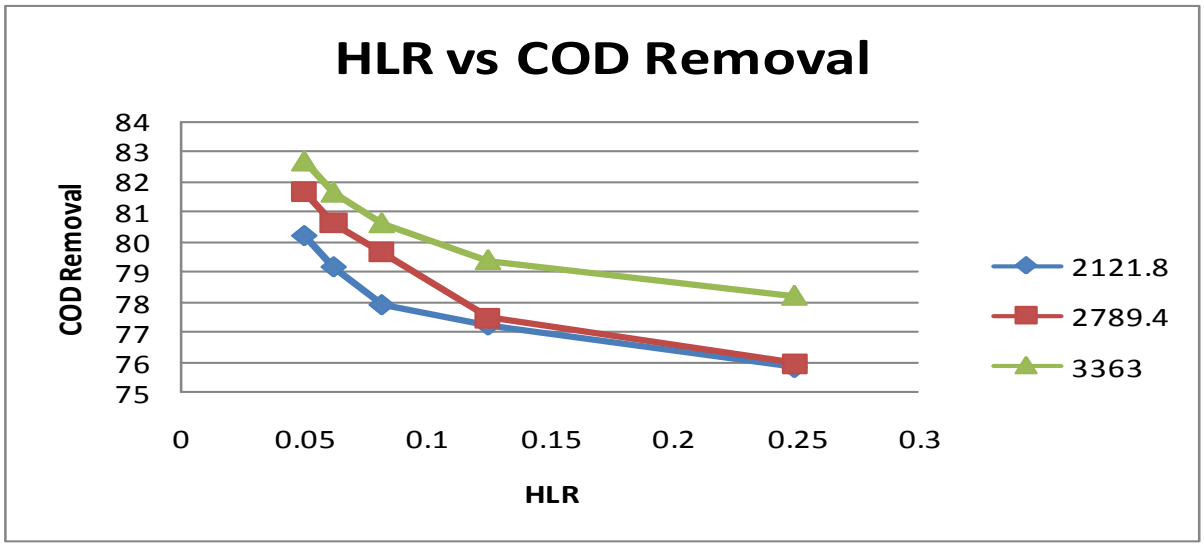


Fig.3 Average Influent COD mg/l Vs varying HLR hrs

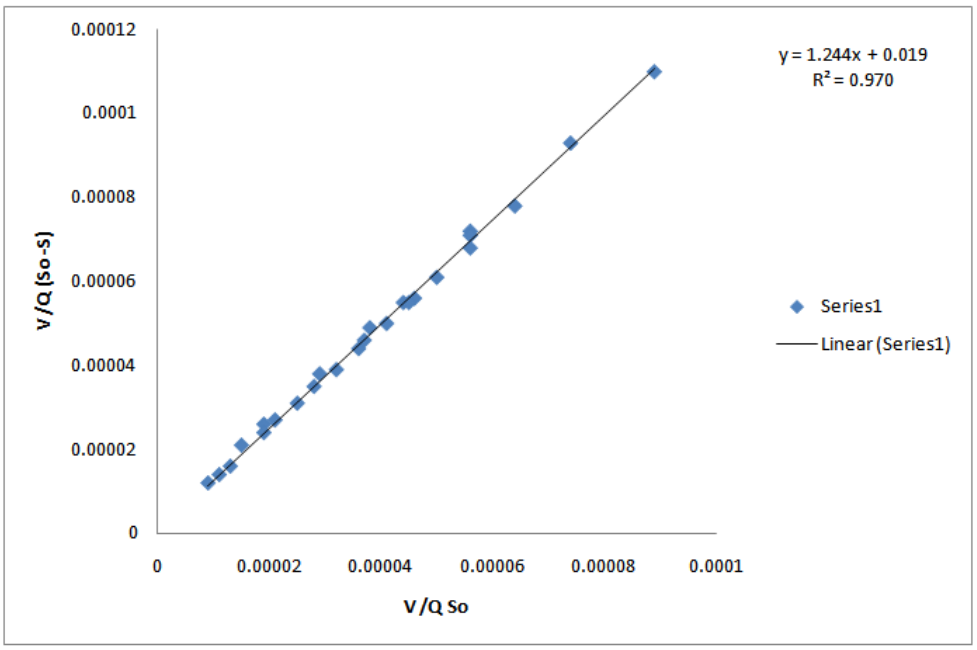
It was drawn on the performance of the reactor in terms of % COD removal under varying Hydraulic Loading Rates, hrs.

Mathematical model

Mathematical modeling is an important preliminary step for implementing the wastewater treatment processes guiding systems. Several mathematical models are used to describe the biokinetics of the UASBR system.

Hence the model Stover Kin cannon was considered in this work for evaluating biokinetics coefficients using the experimental data of this work.

Stover Kin cannon model



V. CONCLUSION

The UASBR is experimentally found to offer a maximum chemical oxygen demand removal efficiency of 82.68% was achieved at an organic loading rate (OLR) of 0.013 kg/COD/m^2/day and at a hydraulic retention time (HRT) of 23h. Hence, it can be concluded that UASBR is a credible alternative to reach the reusable standards for treating slaughter wastewater effluent streams.

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