Organic Load Performance Study For Anaerobic Treatment of Dairy Wastewater By UASB Reactor

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Abstract- *The present study is aimed at organic load performance for anaerobic treatment of dairy wastewater by UASB reactor. Anaerobic treatment of dairy wastewater by up flow anaerobic sludge blanket reactor operated on anaerobic sludge granules developed from digested cow dung slurry and earthworm cultured soil conducted under the mesophilic (22 – 40°C). A PVC pipe with a diameter of an 10cm and a total height of 121 cm and an effective height of 72 cm was used with a working volume of 6.2 L as a reactor. The COD concentration used in the present study ranges between 525 mg/L to 3250 mg/L. The digester efficiency of treating dairy wastewater at varying HRT of 5, 10, 20, 40 and 80 h with the corresponding OLR are 1.77, 1.68, 1.27, 0.85 and 0.57 kg COD/m³/day respectively. During this study, which lasted for 40 days when pH was maintained at 6.8 to 7.4.*

Keywords- Dairy wastewater, UASB, OLR, HRT, pH

I. INTRODUCTION

For over four decades, high-rate anaerobic digestion (AD) has been successfully applied for the treatment of industrial and municipal wastewater (van Lier *et al*. 2015a, b). AD processes not only remove complex organic pollutants from wastewater, but in doing so, also generate a methane based biogas as a renewable energy source. Success of these high-rate AD systems is underpinned by a highly settleable and active granular biomass, which can be retained in the system for up to months (Hulshoff Pol *et al*. 2004a, b). Each of these anaerobic granules contain the entire microbial community necessary to completely mineralize complex suspended organic material to methane. These granular- based reactor configurations, namely the upflow anaerobic sludge bed (UASB) and expanded granular sludge bed (EGSB), have been successful at a range of temperatures (Kim *et al*. 2002a, b).The EGSB often outperforming the UASB due to increased granule-wastewater contact (Kato *et al*. 1998a, b). Moreover, the hybrid expanded granular sludge bed anaerobic filter (EGSB-AF) incorporates a filter in the top of the reactor, trapping biomass which may otherwise be lost (Keating *et al*. 2018a, b).

Among these, dairy wastewater provides significant challenges and opportunities for AD. Not only is the dairy industry one of the largest sources of industrial wastewater in Europe – generating 2–10 times the volume of actual milk that is produced (Buntner *et al*. 2013a,b) – but the wastewater is generally energy-rich (thus having a high-methane potential), although not always containing easily biodegradable chemical constituents. Composition is highly variable, dependent upon the type of dairy product produced, but is generally characterized by high chemical oxygen demand (COD), consisting of carbohydrates, dairy proteins and dairy lipids, as well as nutrient components such as ammonia and phosphates (Sarkar *et al*. 2006a, b).

III. OBJECTIVES OF THE STUDY

Following are the salient objectives set for the present study:

- To study the organic load rate performance for anaerobic treatment of dairy wastewater by UASB reactor;
- To study the various operating characteristics during the start-up of the UASB reactors;
- To assess the various effluent parameters and gas yield for influent COD concentrations and at different flow rates, under continuous mode;
- To determine the organic parameters and to develop regression relationships of the UASB reactors based on the experimental results.

IV. MATERIALS AND METHODS

4.1 *Influent Composition*

The effluent was collected from a Sanchi dairy industry located at Ujjain (M.P.) the industry in India for the manufacture of dairy products especially as milk, cheese, curd, yogurt, ice cream. The effluent collected was stored at (22-40°C). The initial feed water characteristics were given in table1. In the present study OLR was decreased by keeping the starting flow rate fixed 970mL/h and decreasing the organics concentration in the dairy wastewater. The organic concentration in the dairy wastewater was adjusted to the desired level by diluting the feed water using distilled water.

4.2 *Inoculums used*

The reactor was inoculated with earthworm cultured soil, cow dung slurry. The characteristics of inoculums used were pH of 6.8, TS of 780 g/L, SS of 205 g/L, VSS of 178 g/L.

4.3 *Experimental Procedure*

The main objective to be achieved in the start-up of any high rate anaerobic UASB reactor is directly proportional to the concentration of the microbial inhabitants and the rate of beginning working depends on the type of inoculums and the type and strength of wastewater. An anaerobic sludge accumulation for the UASB reactor was developed by stabilizing the cow dung slurry and earthworm cultured soil.

The UASB reactor was hydraulically experimented with unnaturally prepared wastewater, before the addition of inoculums, after 30 days of bacteria growth; the inoculums were added to the reactor. The UASB reactor used like methanogenic reactor was seeded with 2.8 L of cow dung slurry and earthworm cultured soil giving a settled sludge bed height of 30.6 cm. the reactor was then allowed to stabilize for 24 hr at 22-40oC and DWW was then introduced into the lower part of the reactor.

In course of start-up, before feeding the DWW, unnaturally prepared reactor feed water was also added to provide phosphorous, nitrogen source and alkalinity buffering for anaerobic digestion. Compound NH4Cl, NaHCO3, gives the composition of nutrients, added to prepare synthesis DWW. The pH of influent and inoculums was adjusted to around 7.1 with an alkaline solution to optimize the environment for the highest granule growth, The feeding of influent was maintained at the loading rate of 1.77 Kg COD/m3/day until the reactor started producing gas. The reactors performances were assessed before and after required HRTs of 5, 10, 20, 40, 80hr.

4.4 *operational conditions during the study*

4.4.1 *Temperature:*

The experiments have been performed at a mesophilic (22-40^{o}C) range of temperature.

4.4.2 *PH:*

The PH of around 7.0 has been maintained in experiment work.

4.4.3 *Hydraulic Retention Time:*

To study the effect of HRT on the process performance, the reactors were operated at varying HRTs such as 5,10,20,40, and 80 hr.

Hydraulic retention time is the volume of the aeration tank divided by the influent flow rate:

HRT = Volume of aeration tank / Influent flow rate

Where using SI Units Volume is in (m3) and the Influent flow rate is in (m^3/h).

HRT is usually expressed in hours (or sometimes days).

4.4.4 *Organic Loading Rate:*

The OLRs corresponding to varying HRTs were kept at 1.77, 1.68, 1.27, 0.85, 0.57 Kg COD/m^3/day respectively.
OLR = Q (m^3/day)*10^3(L/m^3)*E*Si (mg/L)*10^{-6}(kg/mg)/ V (m^3)

Where, OLR = Organic Load Rate, Kg COD/m^3/day
Q = Flow rate, m^3/day
E = Efficiency, %
Si = Initial COD Concentration, mg/L
V = Volume, m^3

4.5 *UASB reactor design and operation*

Experimental setup

The schematic diagram of the UASB reactor is illustrated in fig.1. The laboratory scale the UASB reactor was fabricated using a PVC tube with an internal diameter of 10 cm and an overall height of 112 cm. the working volume of the reactor was 6.2 L. A gas headspace of height 12 cm was maintained above the effluent line.

A characteristic UASB reactor consists of three parts,

1. Sludge bed
2. Sludge blanket
3. Gas headspace

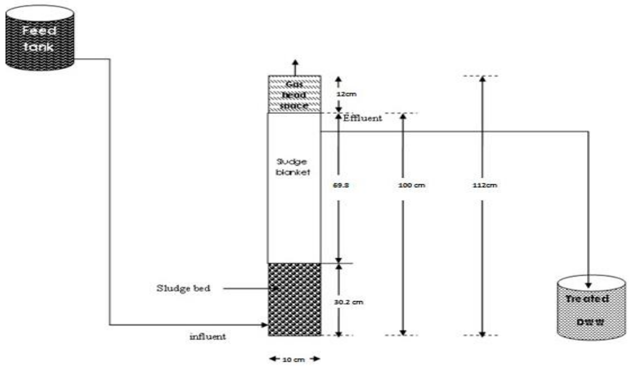

Fig.1: Diagram of UASB reactor

4.6 Chemical analysis

COD, BOD, pH, Total solids (TS), Suspended solids (SS) of the raw and treated wastewater were analyzed following American public health association standards (APHA, 2005). Shows the analysis result in table 1.

Table 1. Characteristics of dairy wastewater

Parameters	Unit	Dairy wastewater	
		Feed water	Anaerobically treated an OLR 1.77 Kg COD/m^3/day
PH	-	6.8	7.2
COD	mg/L	2908	2380
BOD	mg/L	1946	478
Total solids	mg/L	3525	1622
Suspended solids	mg/L	1209	383

V. RESULTS AND DISCUSSION

The primary OLR and HRT applied during the treatment phase were 1.77 Kg COD/m^3/day and 5 h. The OLR was decreased in a stepped manner 1.77 to 0.57 kg COD/m^3/day more than a period of 40 days. The reactors performances were assessed before and after required HRTs.

5.1 difference in pH and different OLRs

The experiment approved with the UASB reactor was various pH including 7.2, 6.8, 7.3, 7.4, 7.1. The maximum OLR 1.77 achieved a pH 7.2 and the minimum OLR 0.57 was achieved a 7.1. The pH of the treated wastewater was in the range of 6.8 - 7.4 at different OLRs.

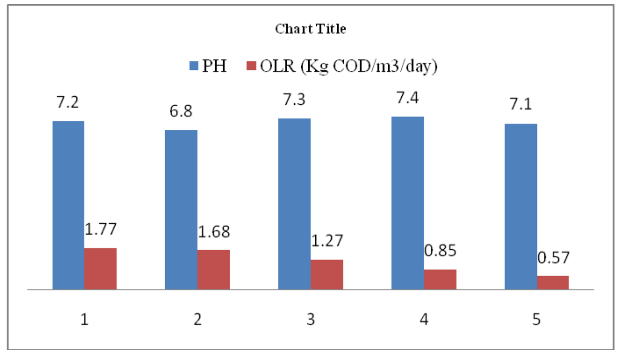

Fig.2 Variation in pH and different OLRs

5.2 difference in OLRs and different HRTs

Among the increase in HRTs from 5 h to 80 h the OLRs linearly decreases.

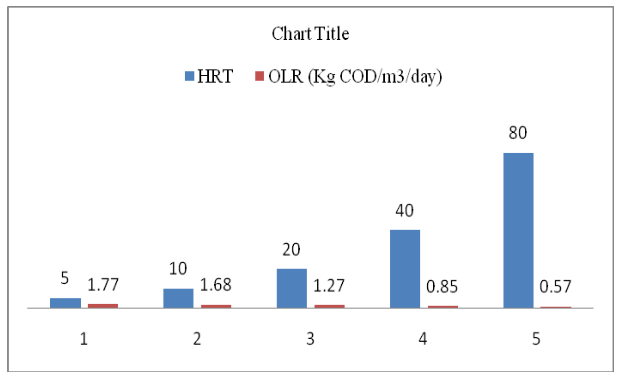

Fig. 3 Variation in OLRs and different HRTs

5.3 difference in OLRs and days of experiments

The maximum OLR 1.77 carried out days of experiments 1-2 in HRT 5h and working volume 6.2L. The OLRs linearly decrease 1.77 to 0.57 according to days of experiments 1-2 to 24-40.

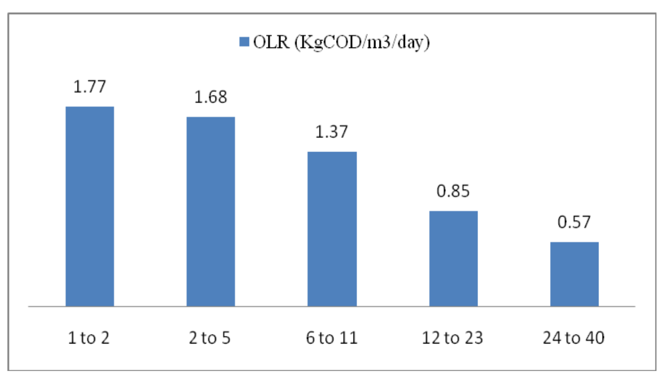

Fig.4 Variation in OLRs and days of experiments

Table 2. Characteristic values for the performance of UASB reactor during the different phases of experiments

Experiments (Days)	HRT (h)	Volume (L)	flow rate (L/day)	OLR (KgCOD/m^3/day)	pH
1-2	5	6.2	29.7	1.77	7.2
2-5	10	6.2	14.8	1.68	6.8
6-11	20	6.2	7.4	1.37	7.3
12-23	40	6.2	3.7	0.85	7.4
24-40	80	6.2	1.8	0.57	7.1

VI. SCOPE FOR FUTURE WORK

The experimental results obtained in this investigation show that the UASB reactor is efficiently practicable for treatment of DWW. Due to the nature of wastewater, it was favored to add light nutrients. The OLRs of the reactor has been gradually decreasing through the course of time. The COD concentration in the effluent of the anaerobic treatment step usually does not observe with standards for discharge into receiving water bodies. then, post-treatment is necessary. Several adequate post-treatment have to be useful for the entire removal of pollutants from the effluent. The arrangement of a UASB and AS (activated sludge) system would be a very promising option for the treatment of DWW. This joint system can satisfy standards required for the discharge of effluents into agricultural drains and receiving water bodies. It has also been exposed that reduction of alkalinity can lead to lower efficiency of the reactor.

Abbreviations:

UASB - Upflow Anaerobic Sludge Blanket
DWW - Dairy Waste Water
PVC - Poly Vinyl Chloride
AS - Activated Sludge
HRT - Hydraulic Retention Time, h
OLR - Organic Loading Rate, Kg COD/m^3/day
COD - Chemical Oxygen Demand, mg/L
h - hour

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