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START-UP PERFORMANCE OF ANAEROBIC FILTER (AF) REACTOR TREATING POULTRY SLAUGHTER HOUSE WASTEWATER

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ABSTRACT

A study was performed on anaerobic filter reactor to identify the startup time and optimum HRT required for treatment of poultry slaughter house wastewater. Initially, the reactor was loaded at an OLR of 0.77 gCOD/L/day and HRT of 36 h. Loading rates were increased by reducing HRT to 24, 16, 12, 10 and 8 h, which corresponds to the OLR of 1.15, 1.74, 2.27, 2.88, 3.43 gCOD/L/day. At an optimum HRT of 12 h, AF reactor shows TCOD and SCOD removal efficiencies of 69.5% and 77% respectively. Lower COD removal efficiency of 66% was observed when the HRT was reduced beyond 12 h. The SS removal efficiency was 76 %. Finally the reactor took 144 days for complete start-up. The granule size of 1-2 mm and settling velocities of granules of 0.5 to 0.83 m/min were observed in the reactor.

INTRODUCTION

Wastewater from food processing industries such as poultry has high total suspended solids (TSS) and biochemical oxygen demand (BOD), which may be harmful if disposed off without treatment into the environment (Welch & Lindell 1992). High-rate reactor represents an attractive alternative for wastewater treatment at the poultry slaughter house facilities (Masse & Masse 2000), since it contains high concentration of biodegradable organics (i.e., fats and proteins), sufficient alkalinity, adequate phosphorus, nitrogen and micronutrients for bacterial growth. Recovery of methane can also be made.

Anaerobic filters were first introduced by Young & McCarty (1969) and have grown to represent an advanced technology that has been used effectively for treating a variety of industrial wastewaters (Young 1991, Hudson et al. 1978, Kobayashi et al. 1983). AF has the better advantages compared to other reactor systems due to the availability of large biomass and consistent performance at higher loading rates (Jawed & Tare 2000).

Start-up is often considered to be the most unstable and difficult phase in anaerobic digestion. In high rate anaerobic reactors, finding optimum HRT is highly significant in order to avoid biomass washout. Surface roughness of media is considered as one of the important parameters in start-up of reactor since attachment of microorganisms on the smooth surface media is very difficult at early stages. Keeping these points in view, present study aims at evaluating the start-up time and optimum HRT required for the treatment of poultry slaughter house wastewater using anaerobic filter reactor. Besides these, the biomass properties like granulation period and settling velocities were also studied.

MATERIALS AND METHODS

Bench scale AF reactor made of polyvinyl chloride (PVC) was used in the present study. The reactor had an internal diameter of 10 cm and total height of 82 cm resulting in total volume of 6.4 L and working volume of 5.4 L with a gas head space of 1 L. The volume of packing media was 4 L. The packing media was pleated PVC rings with dimensions of length, internal and external diameter of 1.5, 1.1 and 1.3 cm respectively, and porosity ~ 98% and surface area 267 m^2/m^3. The effluent pipe was connected to a water seal arrangement to prevent escape of the gas through the effluent. The configuration and the system layout are shown in Fig. 1. Five sampling ports were installed along the length of each reactor at 11 cm intervals, starting from a height of 5 cm above the reactor bottom. Biogas produced from the reactor was collected by water displacement method using Mariotte bottle. The operating temperature of the reactors was in the mesophilic range (29-35°C).

Poultry slaughter house wastewater generated from a poultry food processing company located in Coimbatore District, Tamilnadu was used as substrate. The wastewater was collected after a fat separator to avoid the hindrance of fat in the anaerobic digestion process. The wastewater used as feed was maintained in a refrigerator at 4°C. It was maintained in a feed reservoir and mixing was performed manually at regular interval. The reactor was seeded anaerobically with a nongranular sludge obtained from wastewater treatment plant of the poultry slaughter house industry.

The influent and effluent flow rates, pH, and biogas production were monitored daily. Total COD (TCOD) and Soluble COD (SCOD) (for the soluble COD, the sample was filtered through a gas micro filter, 0.45 μm size), VFA and alkalinity in influent and effluent and biogas composition were measured at regular intervals. pH, COD, BOD, VFA, alkalinity, total Kjeldahl nitrogen (TKN),

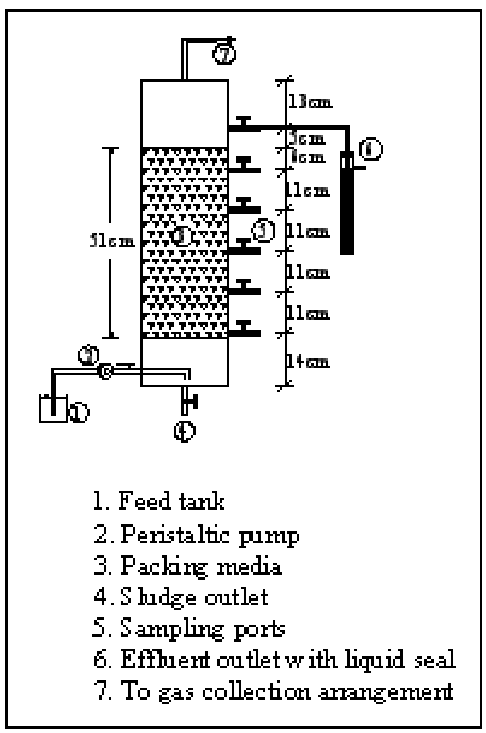

Fig. 1: Schematic arrangement of bench scale AF reactor.

ammonia, phosphates, TSS and VSS were analysed by standard methods (APHA 1989). Protein was measured by multiplying the difference between TKN and NH_4-N by 6.25 (AOAC 1984). The biogas composition was measured by a sachrometer.

Characteristics of poultry slaughter house wastewater: The Substrate used for the experiment was combined slaughter house process wastewater. Characteristics of the wastewater are summarized in Table 1. Feed total COD was maintained at approximately 1150 mg/L throughout the start-up period by dilution with tap water.

RESULTS AND DISCUSSION

Start-up of anaerobic filter reactor: The reactor was seeded with 2.5 L of sludge obtained from the wastewater treatment plant of poultry slaughter house and fed with wastewater at an OLR of 0.77 g COD/L/day. Seed sludge was comprised of 10.2 g/L of VSS with a low sludge loading rate of 0.11 g COD/g VSS/day. Ratio of VSS to TS was 0.55.

pH during the initial 10 days was varied from 6.5-7.0 in anaerobic filter as shown in Fig. 2. This was expected as the acid producing of the microbial consortium is always more rapid than that of methanogens, which ultimately increases the fatty acid accumulation. However, after initial drop, consistent pH level of 7.2-7.8 was maintained in the effluent indicating healthy environment. The variations of VFA and alkalinity are depicted in Fig. 3. The alkalinity was increased when loading rate was increased. During the steady state of each OLR, the VFA was less than 123 mg/L at all OLR values. Throughout the start-up period, VFA/Alkalinity ratio varied from 0.11 to 0.21. It has clearly shown that no instability occurred inside the reactor.

Effect of HRT on COD and SS removal efficiencies: The reactor was started with an OLR of 0.77 g COD/L/day and maintained in batch mode for 20 days until the production of gas, and another 14 days it was continued in the same loading in continuous mode to enhance the growth of microbes on the media.

Subsequently, the OLR was increased stepwise to 1.15, 1.74, 2.27, 2.88, and 3.43 g COD/L/day by reducing the HRT to 24, 16, 12, 10, 8 h respectively. Every change in OLR induced marked decrease in reactor efficiency which may be to the fact that sufficient acclimatization period is required for microorganisms in changing environmental conditions. The TCOD and SCOD removal efficiencies of 69.5% and 77% were achieved at a total OLR (OLR_T) of 2.27 g COD/L/day and soluble OLR (OLR_S) of 0.97 g COD/L/day respectively. Reduction in HRT less than 12 h showed decreased trend in COD removal efficiencies in terms of both TCOD and SCOD, and sludge washout was observed, which may be due to the short contact time between biomass and substrate. It led to reduction of entrapment capacity. Hence, the

Table 1: Characteristics of poultry slaughter house wastewater.

Characteristics	Values in mg/L except pH and Colour
pH	7- 7.6
Colour	Brownish grey
Total Solids	1400-3900
Total Suspended Solids	300-1900
Total Volatile Solids	800-1800
BOD_5	750-1890
Total COD	3000-4800
Soluble COD	1030-3000
VFA	250-540
Alkalinity	600-1340
Phosphates	16-32
Ammonia Nitrogen	16-165
TKN	109-325
Oil and Grease	800-1385
Protein	580-1000

Table 2: Operational parameters and treatment efficiencies of AF reactor during start-up.

Period	HRT	Applied loading rate		Removal efficiency (%)		Biogas	CH_4
		Total OLR	Soluble OLR				
(Days)	(hrs)	(g COD/l. d)		TCOD	SCOD	(L/d)	(%)
1-34	36	0.77	0.34	43	35	0.3	50
35-54	24	1.15	0.51	60	64	0.6	54
55-80	16	1.74	0.77	63	69	0.9	57
81-107	12	2.27	0.97	69	80	1.9	56
108-121	10	2.88	1.25	66	72	2.5	53
122-135	8	3.43	1.48	57	59	2.9	52
136-144	12	2.27	0.97	69.5	77	2.7	57

optimum HRT was found to be 12 h for AF reactor. Finally, the reactor took 144 days for complete start-up. The start-up summary is shown in Table 2.

During the start-up period of 1-107 days, the reactor showed the suspended solids (SS) removal efficiency of 40-78 % up to an OLR of 2.27g COD/L/day. Reduction in HRT from 12 to 10 h showed marked decrease of SS removal efficiency from 78 to 69% in the reactor. Further, reduction in HRT lowers the removal efficiency as low as to 54% in reactor (Fig. 4). Finally, reactor achieved SS removal efficiency of 76 % at an OLR of 2.74 g COD/L/day after retaining the optimum HRT of 12 h. This could be due to either long acclimatization time needed for the microorganisms and/or attachment of microorganisms and subsequent entrapment on the media.

Biogas production and methane content: The maximum gas collection of 2.7 L/d was observed at an OLR of 2.3 g COD/L/day. The observed methane content was 57%. Though the low methane content was observed in reactor, the removal efficiency observed was quite good. This indicates that the lower methanization capacity was prevailing inside the reactor. However, the efficiencies were comparatively as good as 43 to 69.5 %.

Formation of granules and settling velocities: In the AF, most of the biological activity and COD removal efficiency is due to the biomass in suspension (entrapped) rather than to the attached bio film (Young & Mc Carty 1969, Tilche & Vieira 1991). The granule formation was observed inside the reactor by drawing the sample along the port, which shows sizes of 1-2 mm. This has proven that the possibility of granules may be occurred in attached growth in between the interstices of the packing media. Increased soluble COD removal than total COD was observed throughout the study which was due to the fact that the small granules present between the packing media have a special effect of removing the soluble COD in higher range.

Scmidt & Ahring (1996) have reported the settling velocities as poor, satisfactory and good settling fraction with settling velocities ranges of 20m/h, 20 to 50 m/h and above 50 m/h, respectively. The settling velocity of the granule was varied from 0.5 to 0.65 m/min, which showed very low settling velocities. However, escaping of these granules can be prevented through the media due to the action of filtration.

CONCLUSIONS

The following conclusions can be drawn based on experimental results obtained.

- The anaerobic filter achieved the TCOD and SCOD removal efficiencies of 69.5 and 77 % at an OLR of 2.27 g COD/L/day at HRT of 12 h.

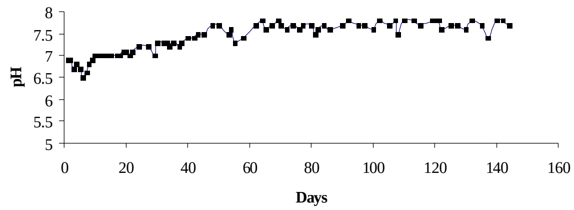

Fig. 2: pH variation during start-up of the reactor.

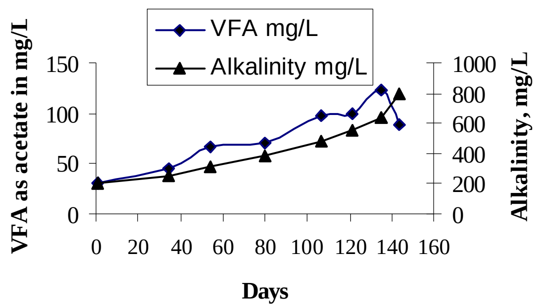

Fig.3: Variation of VFA and alkalinity at steady state during start-up

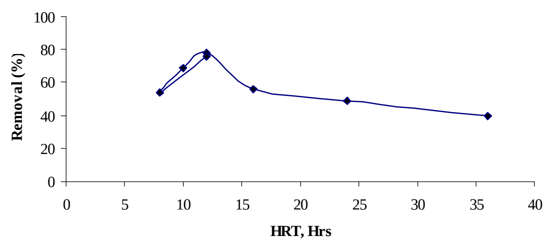

Fig. 4: SS removal efficiency at steady state.

- Reduction in HRT less than 12 h showed marked decreased in removal efficiency.
- Though the system was considered as attached growth, the granules of sizes 1-2 mm were observed.
- Settling velocities of granules varied from 0.5 to 0.63 m/min.
- AF reactor took 144 days for complete start-up.

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