STUDY ON MODELING FISH PROCESSING WASTEWATER ANAEROBIC TREATMENT

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Received Date: 2 July 2012

Abstract

A simple model anaerobic treatment treats fish processing wastewater as necessary for small and medium factories. For this reason, several techniques have been proposed. However, they have been expensive and hardly operational. A simple technique with low cost of treatment and operations was applied. In this study, the hydraulic retention times (HRTs), including 4, 6, 8, 12 and 24 hours with various loading rate of 1.0 to 6.0 kg COD/m^3/day, were examined. A biomass as VSS in the model was at 10 to 11g/l. On the basis of the result the optimal hydraulic retention times (HRTs) with a 4.0 kg COD/m^3/day organic loading rate was 6 hours with BOD_5 and COD removal efficiency of 92% and 90%, respectively. By the end of the optimal hydraulic retention times, the total methane production volume collected was 3.2 litters.

Keywords: Anaerobic Treatment, Fish Processing Wastewater Treatment

Introduction

During the past two decades, anaerobic wastewater treatment biotechnology was extensively advanced by the development of up-flow anaerobic sludge blankets (UASB), anaerobic baffled reactors (ABR), anaerobic fluidized beds (AFB), anaerobic filters (AF) as well as expanded granular sludge blankets (EGSB) [3], [7], [9], [10]. These give various advantages over aerobic processes. Less energy is required, less biological sludge is produced, fewer nutrients are used, and methane is generated as a potential energy source, with suitable environmental conditions. These anaerobic processes can be grouped into two categories according to the mechanism of biomass retention: *fix film reactor,* where the bacteria are attached to a carrier material (e.g AF, AFB), and *suspended growth reactor*, without any carrier material (UASB, EGSB). For the suspended growth process, granular sludge formation has received much attention recently [2], [6], [10]. However, the mechanisms that trigger granulation are yet poorly understood. The development of granular sludge is affected by wastewater characteristics and is often successful with wastewater containing high levels of carbohydrates and sugar.

Wastewater from seafood processing operation can have very high levels of dissolved and suspended organic materials. This results in high biological oxygen demand (BOD) and chemical oxygen demand (COD). Fats, oil and grease are also present in high amounts. Suspended solids and nutrients such as nitrogen and phosphate can often be found in high levels also. Seafood processing wastewater has been noted to sometimes contain a high concentration of sodium chloride from boat unloading, processing water and brine solutions.

The major types of waste found in seafood-processing wastewater are blood, offal products, viscera, fins, fish heads, shell, skins and fine meat particles. . The major process operations include product receiving, boat unloading, sorting and weighing, preparation (butchering, scaling, filleting, skinning, evisceration), inspection, and trimming. Organic material in the wastewater is produced in the majority of these processes. However, most of it originates from the butchering process, which generally produces organic materials such as blood and gut materials.

It has been established that a few fish processing wastewater treatment techniques such as biological treatment have many problems, such as the high cost of treatment for meeting discharge standards and the instability of the treatment system. The effective and economical wastewater treatment of fish processing has become an important issue for the beginning development of seafood industry.

In the case of relatively low strength wastewater such as fish processing, the hydraulic retention time and organic loading rate are the most important parameters for successful operation of an anaerobic reactor.

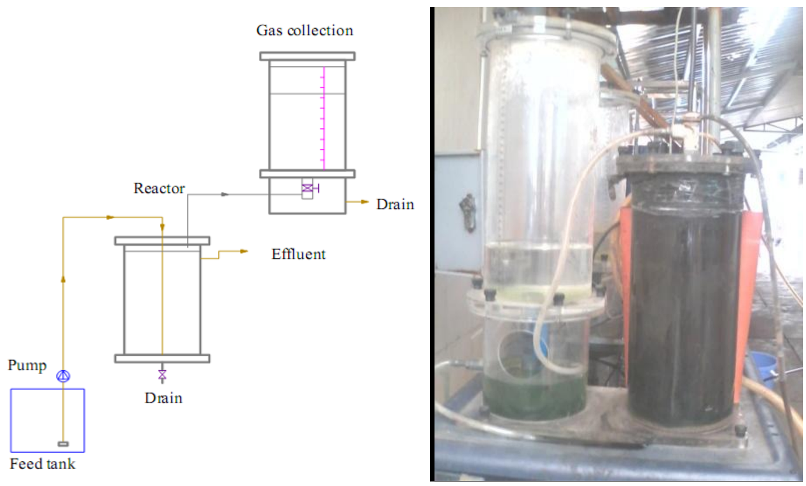
Methods

The Experimental Site

A pilot scale anaerobic reactor system was built in the laboratory department of Faculty of Environment, University of Technology, Ho Chi Minh City, Vietnam. Ho Chi Minh City has a tropical climate and two distinct seasons. During the rainy season, the average annual rainfall is about 1,800 millimetres (approximately 150 rainy days per year), from May to late November and the dry season begins from December to April. With an average humidity of 75%, temperatures range from 16^0C (61 °F) to 39 °C (102 °F) with an average temperature of 28 °C (82 °F).

Experimental Setup

The anaerobic reactor which was used in this study was made with a column with an inner diameter of 150mm, a total volume of 5 litters including reaction section of 4.8 litters and a gas zone of 0.2 litters. The wastewater was introduced into the bottom of the reactor though a tube with a diameter of about 3mm. The source of sludge was taken from the UASB of a factory of tapioca products in Chau Thanh district, Tay Ninh province, Vietnam. Sludge concentration in the reactor was 11.6g SS/L (10.2gVSS/L).



a) b)

Figure 1. Schematic diagram a) and Actual experimental set up b) of anaerobic reactor

The methane gas was collected with a tube to a column of 5 liter diameter. In this column, it took a 5 percent sodium hydroxide solution to absorption to absorb carbon dioxide (CO_2) and hydrogen sulfide (H_2S) gases. Influent and effluent samples were analyzed for pH, alkalinity, COD, BOD_5, suspended solid (SS) and VFAs on a daily basis. The volume of produced methane gas was measured at every loading rate.

Fish Processing Wastewater Influent

Fish processing wastewater which was taken at Ba Hat market, District 10, Ho Chi Minh City was diluted with tap water to intended concentration to serve an influent for this study. The characteristics of the wastewater included 1000 ± 50mg COD/l, 112 – 168 mg TN/l, 14 – 29 mg TP/l was 100 : (11.2 – 16.8): (1.4 – 2.9) which is similar to (200 – 500) : 5: 1 [16]. Sodium hydrogen bicarbonate ($NaHCO_3$) was used as buffer solution to adjust influent pH to about 7.

Analytical Techniques

COD, BOD_5, SS, VSS, VFAs, alkalinity, TN, TP: Filtered $COD_{effluent}$ and $BOD_{5effluent}$ (1.2µm) were measured by the closed reflux titrimetric method (SMEWW, 2005)[13] and 5 – day BOD test)[13], respectively. SS in effluent and VSS in sludge samples were measured by Total suspended solids dried at 103 – 105^0C and volatile solids ignited at 550^0C (SMEWW, 2005) [13], respectively.

VFAs were measured by distillation method (SMEWW, 2005) [13]. Alkalinity was measured by the titration method (SMEWW, 2005) [13]. Total Phosphorus (TP) was measured by the ascorbic acid method (SMEWW, 2005) [13]. Total nitrogen (TN) was measured by TCVN 6638 – 2000.

Gas was collected by a tube with a 5 liter column. Carbon dioxide (CO_2) and hydrogen sulfide (H_2S) were absorbed by a 5 percent sodium hydroxide solution. The volume of produced methane was the lost sodium hydroxide volume.

Table 1. Summary of Conditions Used During Operation of Anaerobic Reactor

Day	Parameter									
	OLR kg $COD/m^3/d$	**HRT** h	**COD_i** mg/l	**COD_e** mg/l	**BOD_{5i}** mg/l	**BOD_{5e}** mg/l	**VFAs** mg/l	**SS_e** mg/l	**pH_i**	**pH_e**
1	0.5	48	1093	115	-	-	-	-	7.32	7.68
2	0.5	48	1000	99.6	-	-	-	56	7.44	7.56
6	0.5	48	1000	92	-	-	-	56	7.08	7.21
7	0.5	48	1000	82	-	-	-	16	7.3	7.34
8	0.5	48	1000	75	-	-	-	40	7	7.12
10	0.5	48	1000	74.6	-	-	-	30	7.32	7.51
11	0.5	48	1000	75	-	-	-	30	7.32	7.52
13	0.5	48	1000	74.6	-	-	-	35	7.28	7.45
15	1.0	24	1080	160	-	-	-	170	7.10	7.32
19	1.0	24	980	148	-	-	-	-	7.42	7.47
20	1.0	24	980	125	-	-	-	-	-	-
23	1.0	24	1025	130	-	-	-	240	7.13	7.30

24	1.0	24	1025	88.3	-	-	56	68	6.90	7.31
25	1.0	24	1025	85.3	-	-	-	66	6.90	7.33
26	1.0	24	987	82.6	-	-	52	58	7.03	7.24
27	1.0	24	1000	84.5	824	62	52.5	62	7.2	7.37
29	2.0	12	1013	122	-	-	-	100	6.9	7.18
31	2.0	12	1000	90	-	-	54	68	7.18	7.22
32	2.0	12	-	-	-	-	-	-	6.87	7.19
34	2.0	12	1066	94	-	-	60	116	7.14	7.28
35	2.0	12	1066	94	-	-	50	118	7.14	7.35
39	2.0	12	1108	106	-	-	48.2	-	7.13	7.28
41	2.0	12	1080	102	794	58	-	80	6.9	7.13
43	3.0	8	1093	138	-	-	-	124	6.94	7.06
47	3.0	8	1093	104	-	-	62.4	266	6.88	7.15
48	3.0	8	1093	104	-	-	64	162	6.97	7.21
51	3.0	8	1080	102	-	-	56.5	360	7.11	7.27
53	3.0	8	1080	96	-	-	45.2	580	7.07	7.21
54	3.0	8	973	88	-	-	56.5	580	7.1	7.36
55	3.0	8	973	98	785	51	75.2	580	7	7.25
59	4.0	6	973	109	-	-	69.2	124	6.92	7.21
62	4.0	6	1100	130	-	-	72.4	-	6.94	7.42
65	4.0	6	1103	105	-	-	75	510	6.80	7.14
66	4.0	6	973	109	-	-	66	320	6.69	7.12
67	4.0	6	1013	92	-	-	53.6	210	6.85	7.20
68	4.0	6	1146	96	-	-	55	380	6.76	6.86
69	4.0	6	1146	126	768	64	53.6	210	6.90	7.12
73	6.0	4	1050	216	-	-	146.1	340	6.99	7.23
74	6.0	4	1050	206	-	-	146.1	670	6.8	7.21
76	6.0	4	1100	218	-	-	132	580	7.03	7.36
78	6.0	4	1100	185	-	-	142	620	6.98	7.31
81	6.0	4	1060	204	-	-	138	580	7.21	7.42
84	6.0	4	1038	230	720	158	152	650	7.06	7.28

Results

Reactor Start Up

The reactor was started up with an organic loading rate (OLR) 0.5 kg COD/m^3/d (HRT of 48h), considering the results of previous studies [4], [13], [20]. During the first 14 days of reaction operation, the COD removal efficiency was about 93%. The volume of methane produced was 218 cm^3. Suspended solid (SS) effluent was lower than 56 mg/l. Even SS was of 16 mg/l after eight days of the reaction operation.

Table 2. Average COD, BOD Removal Efficiency

OLR	HRT	parameter	
(kg COD/m^3/d)	(hour)	**COD (mg/l)**	**BOD (mg/l)**
0.5	48	91.5 ± 1.3	-
1.0	24	88.8 ± 3.1	92.5
2.0	12	90.4 ± 1.3	92.7
3.0	8	90.1 ± 1.3	93.5
4.0	6	89.7 ± 1.3	91.5
6.0	4	80.3 ± 1.8	78.1

Table 3. Average SS, VFAs, CH_4 Effluent

OLR	HRT	parameter		
(kg COD/m^3/d)	(hour)	**SS** (mg/l)	**VFAs** (mg/l)	**CH_4**(l/kg COD)
0.5	48	37.6 ± 14.6	-	7.3
1.0	24	110.7 ± 76.4	53.5 ± 2.2	9.7
2.0	12	96.4 ± 22.0	53.1 ± 5.2	8.6
3.0	8	378.8 ± 202.6	60 ± 10	8.2
4.0	6	292.3 ± 139.8	65.2 ± 9	13.3
6.0	4	573.3 ± 119.9	130 ± 34.3	15

Table 4. Calculated Biomass Loss from System with VSS: SS = 0.7 and Overall Yield = 0.08

HRT (h)	Q(l)	Parameter				
		Effluent biomass (mgVSS/l)	**COD removed (g/d)**	**Biomass produced (gVSS/d)**	**Biomass concentration (mgVSS/l)**	**Biomass loss (mgVSS/l)**
48	2.4	26.32	2.19	0.17	73.12	-46.8
24	4.8	77.49	4.32	0.34	72.00	5.49
12	9.6	67.48	9.08	0.72	75.68	-8.2
8	14.4	265.16	13.69	1.09	76.08	189.08