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THE EFFECT OF HYDRAULIC RETENTION TIME AND LOADING RATE ON THE REMOVAL OF POLLUTANTS FROM FISH PROCESSING WASTEWATER BY ANAEROBIC PROCESS

Dao Khanh Chau
Dong Nai Technology University, Nguyen Khuyen street, Trang Dai ward, Bien Hoa city, Vietnam
Email: daokhanhchau@dntu.edu.vn

Abstract

Anaerobic treatment model treats fish processing wastewater to be necessary for a small and medium factory that is very popular in Vietnam and other countries. Several techniques have been proposed. However, they are quite expensive and hardly operation, especially in remote areas. In this study, the hydraulic retention times (HRT) including 3, 5, and 7 hours with a various organic loading rate of 1.5 to 6.5 kg COD/m3/day were investigated. Biomass concentration as mix-liquor volatile suspended solid (MLVSS) in the model is at 6,000 to 9,000 mg/L. On the basis of the result the optimal HRT with a 4.0 kg COD/m3/day organic loading rate was 8 hours which BOD5, COD removal efficiency were 92.18, 87.36 percent respectively. By the end of the optimal hydraulic retention times, the total methane gas volume as a by-product was collected with 2.6 liters.

Keywords*:* Wastewater treatment, anaerobic process, organic loading rate.

1. INTRODUCTION

Global consumption of fish has doubled since 1973, and the developing world has been responsible for nearly all of this growth. The total per capita consumption of food fish in the developing world has increased from 7.3 kg/capita/year to 14.0 kg/capita/year from 1973 to 1997 while it has come down from 22.6 kg/capita/ year to 21.7 kg/capita/year from 1973 to 1997 in the case of the developed world. The projected per capita consumption of food fish in the year 2020 are estimated to be 16.2 kg/capita/year and 21.5 kg/capita/year for the developing world and developed world, respectively (Chowdhury, Viraraghavan et al. 2010).

Water consumption in a fish-processing industry and high-strength wastewater from such an industry are of great concern world-wide. Liquid effluent regulations are becoming more stringent day by day. The anaerobic treatment process can be considered as the core method of a resource preservation and environmental protection (EPRP) technology, and it, therefore, represents - combined with other proper methods - the advanced sustainable technology society urgently needs. Despite the persisting reluctant attitude of the established wastewater pollution control world, anaerobic treatment is assured of increased usage in the future, the more so because the potentials of the method are far bigger than expected a few years ago(G. Lettinga 1997). The big benefits of the anaerobic wastewater treatment concept compared to conventional aerobic methods should be known and will not be discussed here again. Accepting that the anaerobic treatment principle is a pre-treatment method, at the present state of knowledge, little if any serious drawbacks can be brought up against it any more. Previously mentioned drawbacks have vanished almost completely, like its presumed low stability.

The anaerobic treatment of wastewaters from the seafood-processing industry was studied in a 15 m3 industrial pilot-plant. These effluents have a high organic content (10–60 g COD/liter), with protein percentages between 25 and 70%, and a salinity similar to sea water: sodium (5–12 g/l), chloride (8–19 g/l) and sulphate (0·6–2·7 g/l). This high concentration of salts, together with the production of sulphide and ammonia due to sulphate reduction and protein breakdown, respectively, produces important inhibitory/toxic effects on non-adapted biomass. After an initial start-up procedure, where the acclimation of the biomass was the objective, 70–90% organic matter removal was achieved (Omil, Méndez et al. 1995).

The performance of one-step UASB reactors treating fish processing wastewater of different lipid levels was determined using artificially generated influent simulating that of the canning of sardines and tuna. The organic loading rates (OLR) and the hydraulic retention times (HRT) were 5–8 g COD.L−1. d−1 and 11–12 hours, respectively. In treating a wastewater that contains 3–4 g.L−1 total COD of which 5–9% was lipids, the COD removal and conversion to methane were ca.78% and 61%, respectively (A. Palenzuela-Rollon 2002).

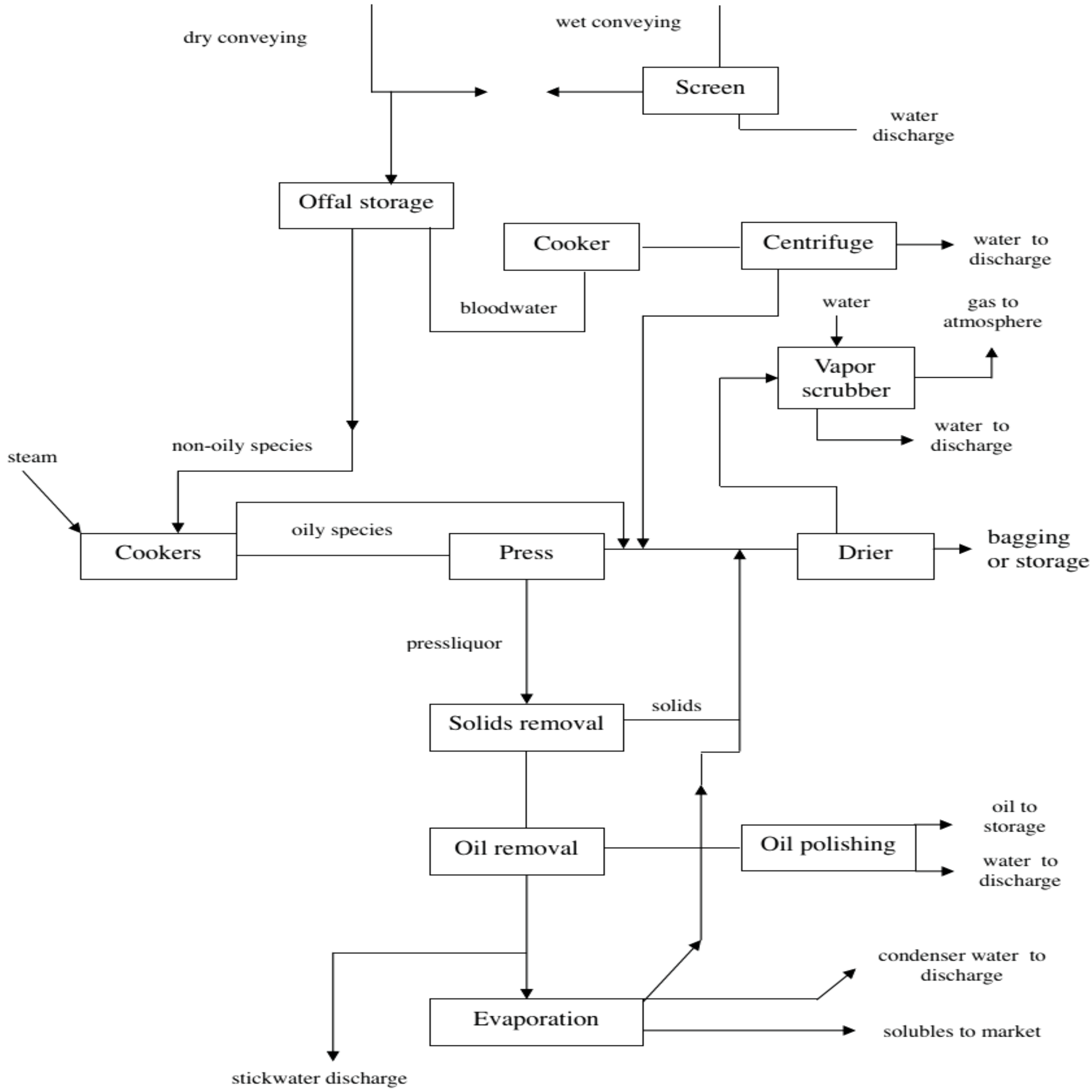

Fig. 1. Flow diagram for fish meal production (adapted from (Riddle 1973))

2. Experiments

2.1 Lab-scale model setup

The system was designed with a 7-litter anaerobic tank used in this study was made with a column of 120mm inner diameter, a total volume of 7 liters including reaction section of 6.5 liters and a gas zone of 0.5 liters. The wastewater was introduced at the bottom of the reactor through a tube of about 2mm. Sludge concentration in the reactor was 12.5gSS/L (11.3gVSS/L).

The methane gas was collected to a column of 5 liters' tank that was filled with sodium hydroxide solution (5 percent) to absorpt carbon dioxide (CO2) and hydrosulfite (H2S) gases. Influent and effluent samples were analyzed for pH, alkalinity, COD, BOD5, suspended solid (SS).

The system was started up in 30 days at 1.0 kg COD/m^3/d before analyzing all parameters.

2.2 Methods of analysis

COD, BOD5, SS, VSS, TN, TP was measured depending on Standard Method (1993), respectively. SS in effluent and VSS in sludge samples were measured by Total suspended solids dried at 103 – 1050C and volatile solids ignited at 5500C based on Standard Method (1993), respectively.

Table 1. The parameters of raw wastewater

Time (Days)	OLR (kgCOD/m³/d)	HRT (h)	COD_{in} (mg/l)	BOD_{in} (mg/l)	pH_{in}
1			1231	-	
3			1050	-	
5			1035	-	
7			1127	-	
8			1341	-	
9			1110	-	
12			1020	-	7.1±0.3
13	1.5	7	1224	832	
15			1080	-	
19			1350	-	
21			1180	-	
22			1425	926	
24			1025	-	
26			1025	-	
29			1100	-	
31			1099	-	
33			1054	-	
35			1032	-	
37			1157	-	
41			1389	931	
42	3.5	5	1279	-	7.2±0.5
44			1076	-	
47			1055	-	
51			1077	-	
53			1179	-	
55			1290	-	
57			1390	917	
60			1378	-	
62			1364	-	
63			979	-	
65			1188	-	
66			1056	-	
69			1349	-	
71			1382	903	
73			1017	-	
74			1051	-	
77	6.5	3	1093	-	6.9±0.2
80			1067	-	
81			1178	-	
83			1193	776	
85			966	-	
7			1328	-	
90			1084	-	

3. Results and Discussions

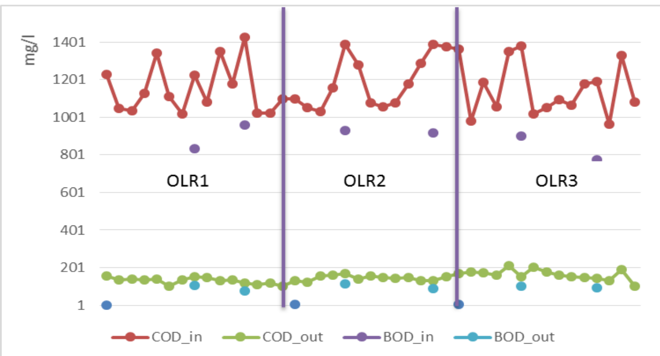

Fig .2. The changes in COD, BOD inlet, and outlet through 3 OLRs

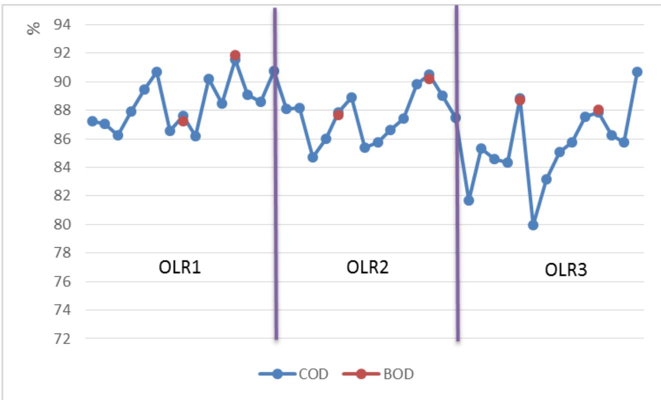

Fig .3. The changes in COD, BOD efficiency through 3 OLRs

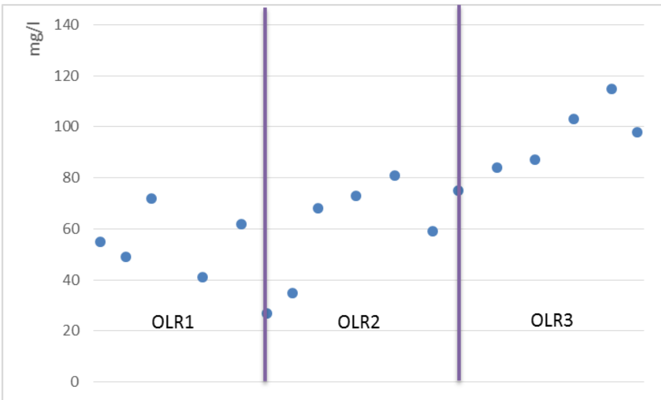

Fig .4. The changes in SS outlet through 3 OLRs

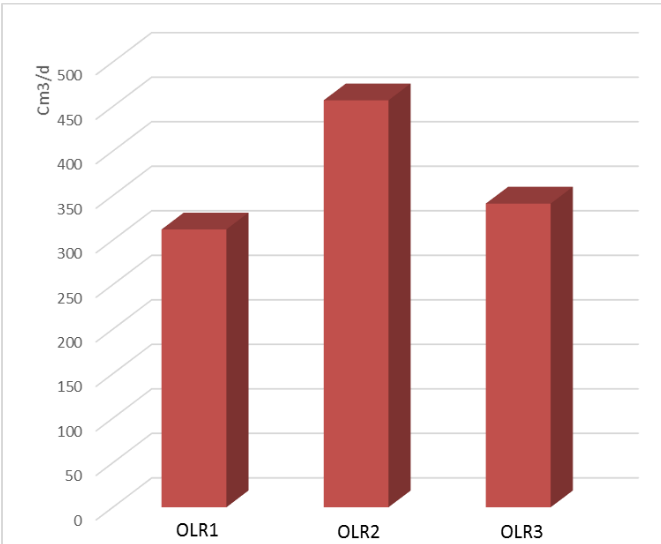

Fig .5. The changes in methane gas producing as by-product through 3 OLRs

The model was operated continuously for 120 days (including 30 days for startup), one loading rate each month, from 1.5 to 6.5 kg COD/m3/d.

Figure 2, 3 show that there were little changes in BOD and COD of raw wastewater, the average of COD inlet was 1164 (mg/l) during all operating time while was 887 (mg/l) with BOD. At first OLR1 (1.5 COD/m3/d), the average outlet of COD was 131 (±16) (mg/l) and the efficiency removal remained stable at around over 88%, that was significantly high. This figure of BOD was nearly 90%. Regarding OLR2 (3.5 COD/m3/d), there was clear that the outlet of both COD and BOD was slightly higher than OLR1 with 146 (±16) (mg/l) and 103 (±10) (mg/l), respectively. It could be seen that the efficiency removal reached 87 (±2) % and 89 (±2) %, respectively.

Figure 4 unveils that the model could remove SS efficiently. The concentration of inlet SS often maintained at around over 500 (mg/l) while the outlet was stable at 80 (mg/l) and tended to increase through OLRs.

Methane gas is a by-product that appears in any anaerobic process using bacteria and people often utilize this kind of gas for producing electricity, lighting, burning, etc. During the operating period, this system produced about 300 cm3/d at the first OLR and rose dramatically to 450 cm3/d before went down again to around 310 cm3/d.

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4. CONCLUSIONS

The results achieved in this research revealed that the anaerobic process could be applied as an effective solution for fish processing wastewater in tropical regions such as Vietnam, India where fishery resource play an important role in the economy. Based on the results, here the following conclusions could be drawn:

The optimum HRT and OLR for treating fish processing wastewater through the anaerobic process were 3.5 kg COD/m3/d and 5 hours. As these conditions, the average removal efficiency for COD and BOD5 was 87 and 89 percent, respectively. The SS concentration effluent often below 120 mg/L. The methane volume produced of 450 cm3/d.

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