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Study on Fish Processing Wastewater Treatment by Swim-bed and Stick-bed Processes

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ABSTRACT

This research focuses on fish processing wastewater treatment by a system including anaerobic, anoxic and aerobic processes. There are two kinds of materials used in the system as biomass carrier that are Biofix and Biofringe. Stick bed with Biofix was used in anaerobic and anoxic tank; Swim bed with Biofringe used in aerobic tank. Fish processing wastewater was fed continuously to the systems with various organic loading rates (OLR) from 1.5 to 4.5 kg COD/m^3·d. The initial results show that at organic loading rate of 1.5 kg COD/m^3·d, COD, TKN, T-P removal efficiencies are 93%, 60% and 55%, respectively.

Keywords: Biofix; biofringe; fish wastewater; stick-bed; swim-bed

1. INTRODUCTION

Fish processing wastewater can be very high in dissolved and suspended organic materials. Normally suspended solid and nutrients such as nitrogen and phosphate can be as high as 100–300 mg/L for total nitrogen and 50–100 mg/L for total phosphorus (Vietnam environment administration, 2009). Fats, oil, and grease are also present in high amounts. Main components of fish processing wastewater are blood, skin, oil, and fat. Some fish processing wastewater treatment technologies have been applied, but still face many problems such as cost, effective, sensitive with toxic (Nguyen et al., 2012).

Wastewater treatment process combining three methods including aerobic, anoxic, and anaerobic has been applied for high organic concentrations wastewater such as fish processing wastewater. This system has circulation flow from aerobic tank to anoxic tank to increase the processing efficiency of nitrate treatment. Swim–bed technology as an innovative attached growth process is presented for high rate wastewater treatment. Biofringe is a highly effective versatile contact material that keeps a high volume of bacteria internally and externally and never releases bacteria all at once time (Cheng et al., 2004). When swim bed technologies are combined with adhesive like Biofringe material, it provides many advantages such as less sludge produced, high processing performance, less space, no need for coagulation pretreatment even for high concentrations of oil and suspended solids because of longer sludge retention time (Cheng, 2006; Qiao et al., 2008).

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Stick–bed Biofix is a special contact media made of polyester monofilament as a frame and absorbent acrylic fiber as a sludge holder. Biofix has many good points such as: high surface area retained maximum sludge volume, holding sludge tightly and high stability. With its innovative effects, this Biofix will lead to new applications in wastewater treatment by biological process. Therefore swim–bed technology combining with stick–bed processes with the addition of two materials above will increase the efficiency in wastewater treatment (Nguyen and Le, 2011).

2. MATERIALS AND METHOD

2.1 Wastewater

Fish processing wastewater was collected from a market in District 12, Ho Chi Minh city, Vietnam. Upon collection, the sample was stored in a cold room. For this study fish processing wastewater was diluted with clean water to intended concentration to serve as an influent. When diluting wastewater with tap water, BOD and COD concentration decreased, however the ratio of BOD/COD didn't change much. Because the concentration of BOD and COD in clean water is low, it didn't affect the ratio of BOD/COD. The characteristics of influent fish processing wastewater were COD: 2200 mg/L; TKN: 130 mg/L; $N\text{-}NH_4^+$: 109 mg/L; $P\text{-}PO_4^{3-}$: 22 mg/L.

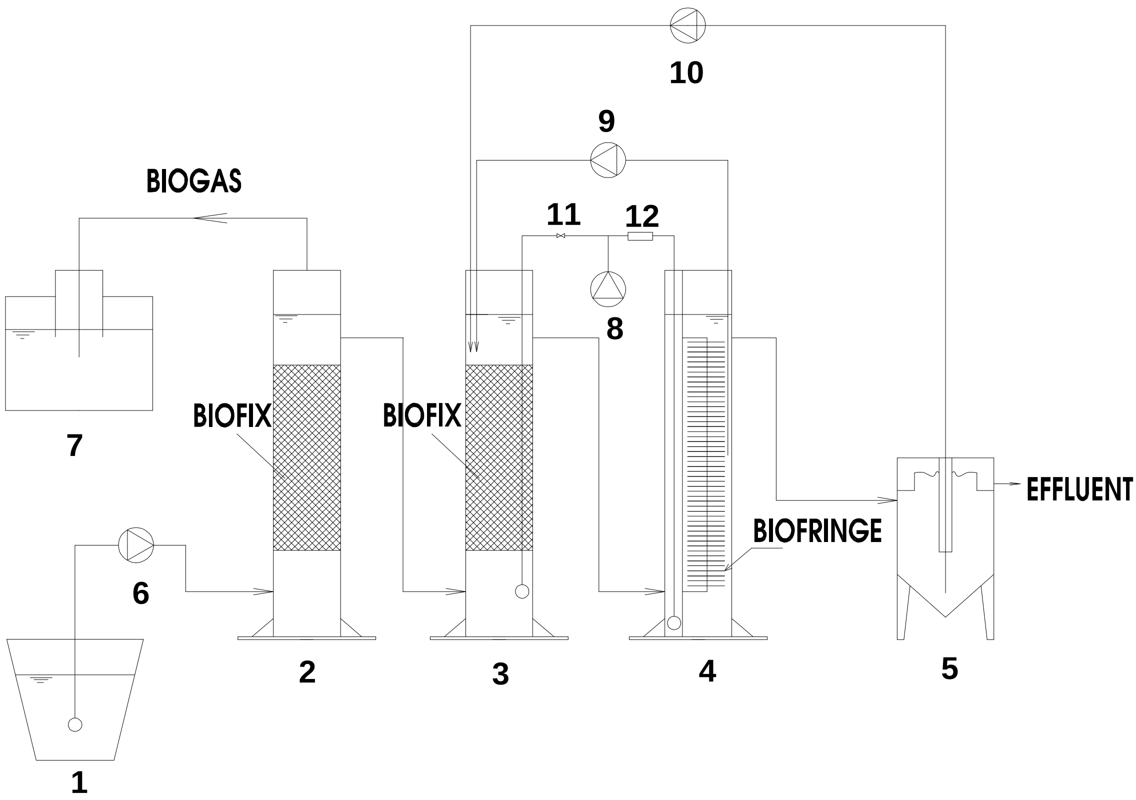
2.2 Experience Pilot

A pilot–scale system included three main reactors in the order of anaerobic, anoxic, and aerobic reactors. All reactor tanks were made by acryl resin. Details drawing of the study system are shown in Figure 1. Volume of each of three main reactor tanks was 10 liters. Three Biofix sheets were installed inside the anaerobic reactor and the anoxic reactor tanks with a total of 480 cm^2 along the height of the tanks. The wastewater was pumped up flow and contact with Biofix before moving to anoxic tank and making up flow. Air was added into anoxic tank by air pump. DO was about 0.5 mg/L (Cheng et al., 2004; Tchobanoglous et al., 2003). DO was measured and controlled every day of the experiment. Airflow was adjusted by an airflow meter. Airflow rates were maintained about 2.0 L/minute to maintain the DO concentration. After that, the wastewater flowed into an aerobic tank which was installed with 500 mm Biofringe material. Air was introduced to the aerobic tank for mixing oxygen with wastewater and roiling sludge. Airflow was adjusted by an airflow meter. Finally, wastewater after treatment flowed into a clarifier tank for settling down sludge. Samples were taken after clarifier tank and analyzed to calculate the efficiency of the process.

Two pumps were used to circulate the sludge from the clarifier tank to the anoxic tank and the effluent from the aerobic tank to the anoxic tank to supply nitrite, nitrate, and ammonia to the anoxic tank. Fish processing wastewater was fed continuously to the system with organic loading rates (OLR) from 1.5 kg $COD/m^3\cdot d$, 2.5 kg $COD/m^3\cdot d$, 3.5 kg $COD/m^3\cdot d$ and 4.5 kg $COD/m^3\cdot d$ by changing wastewater flow rate 19 L/d, 31 L/d, 44 L/d and 57 L/d with HRT is 1.6 day, 1 day, 0.7 day, 0.5 day respectively.

2.3 Analysis

Some parameters of wastewater were logged daily including DO by a DO meter and pH by a pH meter model WQC-22A. Samples were tested for soluble COD, TKN, phosphorus ($P\text{-}PO_4$), and suspended Solids (SS) using standard methods (standard methods for the examination of water and wastewater) (APHA, AWWA, WPCF, 1998).



1. Raw wastewater; 2. Biofix anaerobic tank; 3. Biofix anoxic tank; 4. Biofringe aerobic tank;

5. Clarifier tank; 6. Influent pump; 7. Biogas collector; 8. Air pump; 9. Circulation pump

10. Circulation pump 2; 11. Valve; 12. Airflow meter

Figure 1 Schematic of fish wastewater treatment system

Table 1 Characteristics of fish wastewater quality before and after treatment (average index)

	ORL (kg COD/m^3·day)	**COD (mg/L)**	**P-PO_4^- (mg/L)**	**TKN (mg/L)**	**SS (mg/L)**
Input	−	2350	27	136	528
Output	1.5	68	6	40	21
	2.5	75	8	42	23
	3.5	89	8	45	26
	4.5	145	11	47	33

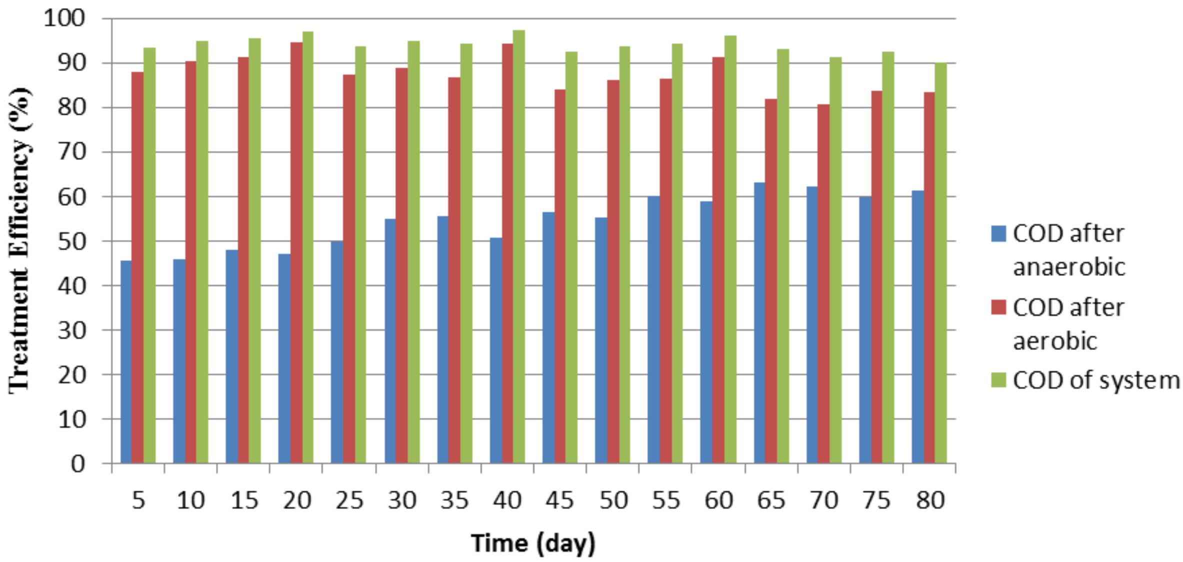


Figure 2 COD removal efficiency at each stage of the pilot system

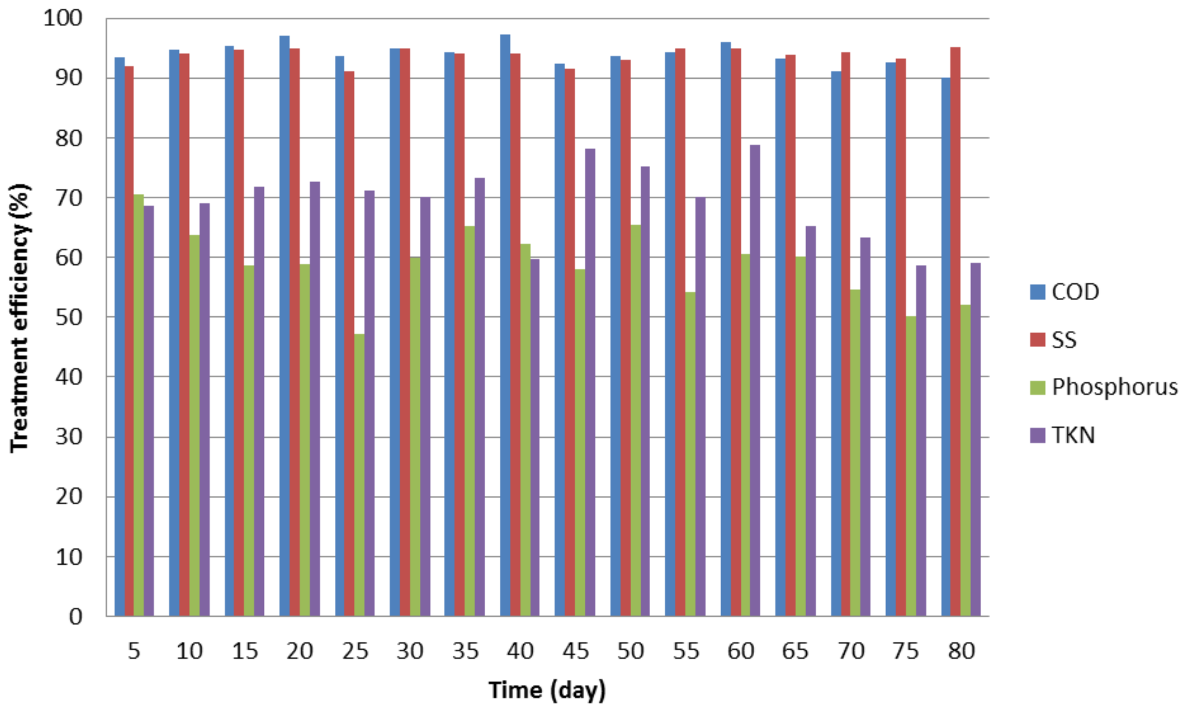


Figure 3 Effective treatment of pilot scale

3. RESULTS AND DISCUSSION

The characteristics of fish wastewater treatment by pilot system are shown in Table 1 and Figure 2.

During this study DO levels were checked regularly in order to control the operation of the processes. Other indicators were measured every 5 days to evaluate the effectiveness of the model. COD concentration varied from 2163 to 2517. COD concentration at Output varied from 55 mg/L to 140 mg/L. At an organic loading rate of 1.5 kg COD/m^3· day, the COD, phosphorus, TKN, and SS removal efficiencies were 97.2%, 65%, 75%, and 95.8%, respectively. At an organic loading rate of 2.5 kg COD/m^3· day, the treatment efficiency of COD, TKN, phosphorus and SS was 96.2%, 59.8%, 76.8% and 95.5%, respectively. At an organic loading rate of 3.5 kg COD/m^3· day, the effective treatment varied (92.4–96.2% for COD, 56.7% for TKN, 74.2% for phosphorus, and 94.3% for SS). At an organic loading rate of 4.5 kg COD/m^3· day, the treatment efficiency of COD, TKN, phosphorus and SS was 91.8%, 61.6%, 54.3% and 94.1%, respectively.

COD was firstly removed in anaerobic – Biofix tank. The microorganism consumes organic matter as food source to create new biomass, producing biogas, CO_2, H_2S, H_2O. The wastewater flowed from the bottom to the top of tank making reverse flow, thus organic matters were removed by combination of two grow process adhesion and free. COD concentration at anaerobic – Biofix output was between 836 mg/L to 1302 mg/L with average removal efficiency of 55.1%.

In anaerobic – Biofringe tank organic nitrogen was converted to ammonia. Converted ammonia was then combined with existing ammonia in wastewater and converted into nitrite and nitrate in the aerobic – Biofix tank by Nitrosomonas spp and Nitrosobacter spp. Source of nitrite and nitrate was circulated back to the anoxic - Biofix tank for denitrification, with volume of circulation was about 400. The average concentration of nitrate at output of the system was about 1.72 mg/L.

Low phosphorus removal effective can be explained: In anaerobic tank, Phosphate Accumulation Organisms (AOPs) used Volatile Fatty Acids (VFA) as storage product and released phosphorus from polyphosphate inside cells. In aerobic tank, energy was generated from oxidation reaction of some storage product and increased storage polyphosphate inside cell, thus increase effective treatment of phosphorus by remove sludge. Wastewater has SS concentration from 395 to 528. SS in wastewater is mostly easily biodegradable because the result from volatile suspended solid (VSS) analysis showed that the ratio of VSS/SS was high. The value of ratio varied from 0.7 to 0.8 thus after treatment by anaerobic – Biofix and aerobic – Biofringe SS concentration decreased to 15 mg/L and 36 mg/L. SS removal efficiency was more than 93%. With various COD removal efficiency 90.1% – 97.2%, Swim – bed Biofringe and Stick – bed Biofix combination system got higher treatment efficiency than other anaerobic and aerobic convention system and also capable to treat nitrogen and phosphorus.

CONCLUSIONS

This system has high effectiveness in COD, SS, TKN, and phosphorus removal which corresponded to 96%, 95%, 75%, and 63%, respectively. Compared with other convention systems, wastewater treatment system combining three processes anaerobic, anoxic and aerobic with contact material had a much higher treatment efficiency. In addition, the quality of wastewater after treatment was always lower than the standard QCVN 24:2009 /BTNMT column B (National Technical Regulation on Industrial Wastewater of Vietnam government).

The results obtained in this research demonstrate that the Swim-bed Biofringe and Stick-bed Biofix combined processes could be used effectively in fish processing wastewater treatment for tropical regions. This study is needed to find a suitable treatment for fishing processing wastewater; however, more researches with higher organic load rate and different kinds of wastewater should be done before applying this technology widely.

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