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Abstract. The removal of phosphorus and nitrogen in food wastewater previously difficult to removed. We investigated the removal of nitogen and phosphorus from food wastewater, especially *tempeh* wastewater. The ABR design was used using five baffled. This design was used to optimize the anaerobic process that occurs. Meanwhile, the RBC waste processors, using three stages with the shape of the surface of the disk used wavy and split. Selected design forms a disk surface as a contact medium with such special design, to optimize biofilm and oxygen transfer. This research was conducted in a laboratory scale. Operasional conditions for the units, by controlled the pH and varyed the load of nitrogen and phosphorus in the food wastewater. Removal eficiencies for total nitrogen was 91% and for total phosporus was 88%, respectively. However those removal eficiencies decrease with the increase in the N/BOD_5 ratio of wastewater.

1. Introduction

Commonly, food processing-based home industry has a problem in its wastewater. Those home industries commonly released the waste directly to the environment without any wastewater processing. The disposal was directly to the ditch that the final destination was river, so it caused tainted/polluted river water quality. food processing-based home industry and potentially contaminated the environment was varied. Chosen food processing industry, in this study was *tempeh* production. Tempe was food that was made of varied fermented *Rhizopus* mold. The waste produced contained total nitrogen and phosphorus load, in wastewater, and toxic characterized for organism in the water. This was the reason of nitrogen and phosphor level reduction importance from the wastewater.

Biological processing was frequently used as the alternative of most effective and low-cost way because the result did not need special treatment. One of the biologically wastewater processing technique that used the ability of microorganism was the combination of Anaerobic Baffled Reactor (ABR) with Rotating Biological Contactor (RBC). ABR was wastewater processing tool that used anaerobic microorganism that grew suspension in wastewater [1]. Meanwhile, the study that was related to waste processing which contained total nitrogen and phosphorus was mostly done. But in this study, the ABR design that was done has six stages and RBC design was using modified surface, serrated and split shaped disk. The combination of two reactors with enhanced design was novelty in this study. The selection of RBC in this process was due to the low operational and maintenance cost, though it was quite expensive in the beginning, it was also more efficient if it was regarded in area

and energy needs. [2]. It was proved in Kader, 2013 [3], which were comparing the energy used in grey water wastewater processing with using Bio Reactor Membrane (MBR) and RBC, the needed energy were 1.7 kWh/m^3 and 1.2 kWh/m^3 . Compared with the other reactors, RBC provided more complex wastewater processing. [4], mainly RBC Provided contact media surface which commonly good for microbe with pollutant inside the wastewater [5]. In the last decade, began to be developed materials and shapes of contact media that was more innovative, in the purpose of increasing the working effectively of RBC. Those several studies, the contact media was pipe-shaped [6]. wavy [7], rough and splitted [8,9], rotating drum [10], net-like rotating biological contactor (NRBC) [11].

Anaerobic Baffle Reactor (ABR) is anaerobic suspended treatment system in a baffle reactor. Meanwhile, the suspended growth is more advantageous than the attached growth because it does not need supporting media and is not easily plugged up. ABR is an Upflow anaerobic Sludge Blanket (UASB) installed in series, but it does not need any particle in its operation, so that the shorter start-up period is required. Furthermore, a series of vertical partition is put in the ABR to make the wastewater flow under and over from inlet to outlet, so that there will be a contact between wastewater and active biomass. The concentration profile of organic compounds varies along the ABR. This might cause the population growth of microorganism different between that of put in one compartment and another. This depended on the condition of specific environment produced by the compound as a result of decomposition [12,13]. The bacteria in the bioreactor will float or settle in accordance with the characteristics of flow and gas produced. However, it can move horizontally to the top of reactor slowly so that it can increase its cell retention time. Furthermore, while the contacted wastewater with active biomass was flowing, the effluent was free from biological solids. This configuration could show the high rate of COD elimination [14, 15].

2. Research Methods

The study was done with designing ABR and RBC reactor which were implemented in *tempeh* wastewater. The design of experiment tools in this study, was based on the calculation. Explained in Table 1**.**

Table 1. Reactor Design and Operating Parameters for The Laboratory Scale RBC and ABR

REACTOR	SPECIFICATION	VALUES
RBC	Number of Stages	3
	No. of Disc/Stage	10
	Diameter of the Disc (mm)	200
	Spacing Between the Disc (mm)	8
	Total Surface Area of Discs (m^2)	7.79
	Working Volume (L)	65.6
	Submergence (%)	33
	Rotations Per Minute	4
ABR	The width of Settling Tank (m)	0.33
	Depth of Settling Tank (m)	0.43
	Up flow velocity (m/hour)	1.8
	The number of chamber	6
	Depth of outlet (m)	0.75
	L : D	0.5 : 0.75

In this experiment, a series of laboratory scale processing plants, which include inlet tank, equalizing tank, ABR reactor, RBC reactor and clarifier. Flow system was used in gravity, except the flow from the inlet tank to equalizing tank, was used pump. Meanwhile, the schematic experimental setup, explained in figure 1. Wastewater that was used in this study was *tempeh* wastewater with the initial characteristic of *tempeh* wastewater that fluctuate, at COD = 23230 mg/L, BOD_5 = 11615 mg/L, TSS = 5500 mg/L pH = 5 total Nitrogen in range 300 mg N/L, Total P = 90 mg/L. The bacteria that was developed was from the wastewater of *tempeh* itself. In this study, dilution were performed

for concentration of COD, was in the range between 3000 mg/L – 8000 mg/L. Total nitrogen and phosphorus, TSS was following the result of COD concentration setting and ph was set to neutral.

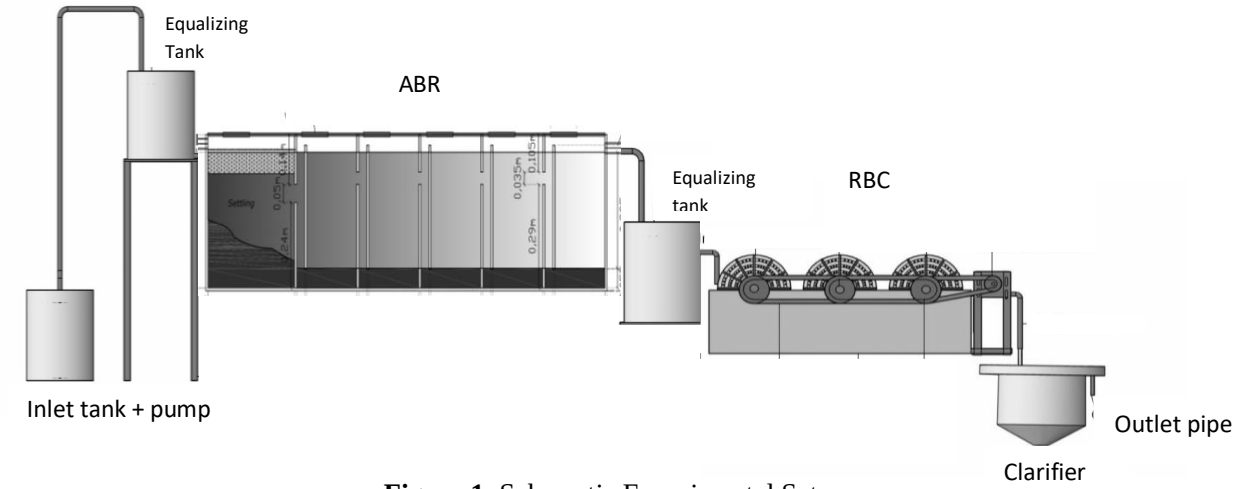

Figure 1. Schematic Experimental Setup

3. Result and Discussion

The ability to eliminate organic load in *tempeh* wastewater, using ABR reactor followed by RBC, is shown in the discussion below.

3.1. Seeding dan Aklimatisasi

The seeding process was carried out to grow bacteria in ABR and RBC, wherein each reactor had different microbiological characteristics. The different characteristics were, ABR required anaerobic microbes, while RBC microbial aerobics. For the seeding process, the two reactors were individually processed, because of these different characteristics. After a one-month seeding process, it was characterized by growing microbes as expected.

The next step was the process of acclimatization; this process was done to adapt the existing bacteria in ABR and RBC to wastewater that would be processed. Acclimatization was carried out at concentrations of diluted waste, with dilution of 50% to 100%. The acclimatization was stopped when the outlet sedimentation sequences, obtains a final concentration value of 50% of the initial wastewater concentration. Below, **Figure 2**, the wastewater conditions in ABR, and **Figure** 3, the biofilm visualization attached to the experimental RBC result. In the ABR contactor, in the first compartment, which acts as a sludge precipitate, it appears to be covered with foam of bacterial oxidation in anaerobic conditions. Next, with the up flow of wastewater system from the first compartment to the next compartment, the oxidation process continues. So in the last compartment, the organic load was processed less, so the foam was formed slightly (**Figure** 2)

Figure 2. Surface condition of wastewater in each compartment of ABR, (a) At the end of acclimatization, (b) At running processing process

In **Figure 3**, the subsequent treatment process was RBC, which utilizes aerobic microorganisms to degrade the organic load of wastewater. In first stage which was the first wastewater recipient, it got a heavier load than second stage and third stage. So the biofilm that was formed was thicker than the other stages. The healthy biofilm color that sticked to the disc was yellowish white. At the end of acclimatization, the third stage looks biofilm that stick was still thin, with a thickness of 0.6 mm. This was due to this third stage, the organic load is low (**Figure 3a**). At the end of the process, there was a 10% increase in biofilm thickness compared to the end of acclimatization (**Figure 3 b**)

Figure 3. Biofilm formation in RBC, (a) at the end of acclimatization, (b) at running processing system

The results of the dominant microbial identification test to decompose the *tempeh* wastewater, both in ABR and RBC was Bacillus sp, while in the second dominant RBC were *Pseudomonas sp*. *Pseudomonas sp* were bacteria living in aerobic conditions identified in RBC reactor, but not found in ABR. While bacteria *Bacillus sp* was a bacteria that could survive in the worst condition that was facultatif anaerob. In this case, Bacillus sp bacteria were able to adapt to an anaerobic ABR environment, so that the organic wastewater load was able to degrade.

3.2. Removal for total nitrogen load and total phosphate of tempeh wastewater

The ability of ABR and RBC, to remove total Nitrogen and phosphorus loads in tempeh wastewater, proved to be effective. Total nitrogen concentration before treatment in the range of 332 mg / L, could be removed 90.9% in hydraulic retention time (HRT) 34 hours (see **Figure 4**.)

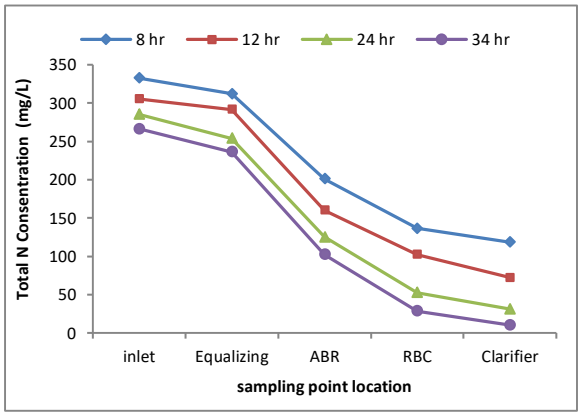

Figure 4. Total nitrogen concentration in variation of hydraulic retention time

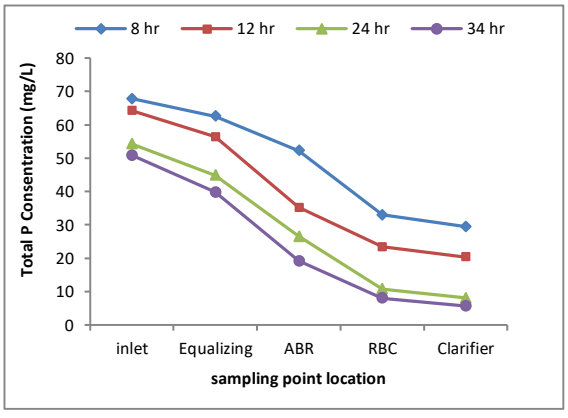

Figure 5. Total phosphorus concentration in variation of hydraulic retention time

In **Figure** 4. the best total Nitrogen decrease was found in ABR and RBC reactors. A combination of ABR and RBC reactors, which had different systems that were anaerobic and aerobic. With anaerobic ABR, and RBC aerobic, able to denitrificate well, proven in HRT 24 and 34 hours, could decrease in the range of 80% - 90%.

Meanwhile, to eliminate the total pollutant load Phosphorus (**Figure 5**), obtained a maximum of 88.8% in HRT 34 hours. The total content of phosphorus in this tempeh waste has the smallest concentration compared to total nitrogen, COD, BOD and TSS. And in this study can reduce total phosphate in the range of 80% - 88%, at HRT 24-34 hours.

3.3. Removal for organic loads of COD, BOD and TSS of tempeh wastewater.

The organic content removal of COD (Chemical Oxygen Demand) and BOD (Biochemical Oxygen Demand) in the pilot plant (Equalizing, ABR, RBC and Clarifier). The results obtained could be seen in **Figures 6 and 7.** COD and BOD pollutant load reduction was maximal in the range 80 - 90% at HRT 12-34 hours.

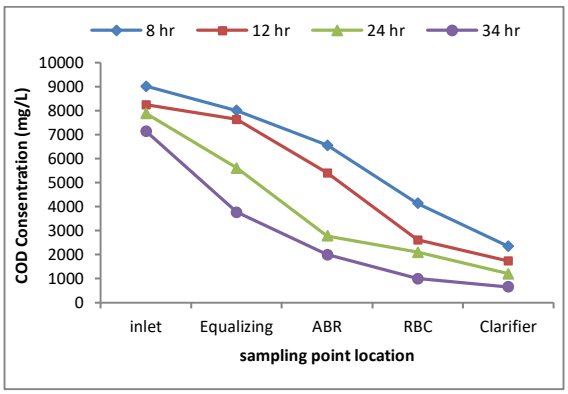

Figure 6. COD Concentration on HRT Variation

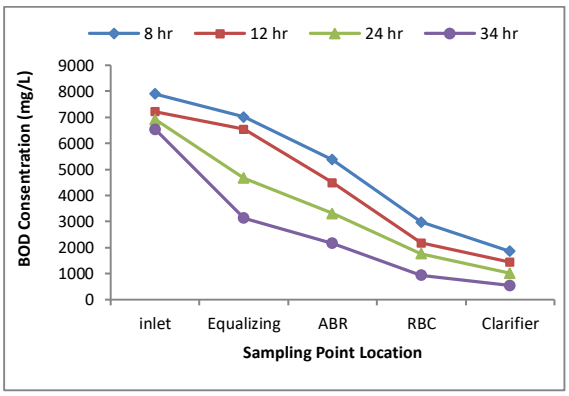

Figure 7. BOD Concentration on HRT Variation

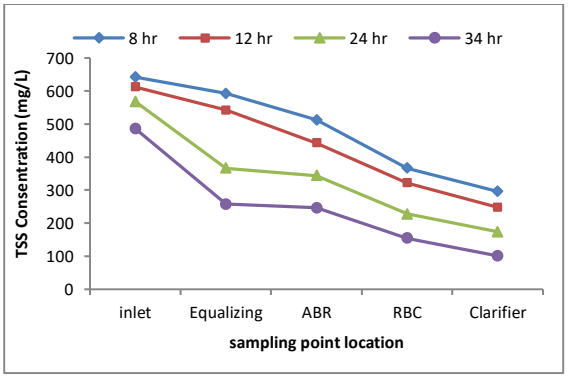

Figure 8. TSS Concentration on HRT Variation

While removing total suspended solid load (TSS) in this study, could be lowered in the range of 60 - 79%. This was due to the TSS load in the wastewater of dominance in the form of fine suspended. So that could be seen in **Figure 8.**, TSS concentration could significantly removed in RBC and clarifier. But overall a series of laboratory scale waste-processing was capable of well removing the total nitrogen-phosphorus content and organic load in *tempeh* wastewater.

In this study, when compared with the results of previous studies [8, 14] in terms of the efficiency of the ABR-RBC, RBC, and ABR processing systems for treating wastewater containing total nitrogen and phosphorus, ABR-RBC was the best. But if it was reviewed to decrease the organic content, such as BOD, COD and TSS alone, it was less important to combine ABR and RBC.

4. Conclusions

A series of laboratory treatment plants ABR and RBC laboratory scale has been successfully applied to food waste especially *tempeh* wastewater. In this study, it has successfully eliminated 80-90% for total load of nitrogen and phosphorus. As for the load BOD and COD, can be eliminated 90%, at HRT 34 hours. Only on the total suspended solid load, the removal is 60-79%. Overall, in the laboratory-scale RBC and ABR designs, it succeeded in removing organic content, particularly denitrification and total phosphorus parameters.

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