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Research Paper

THE EFFECT OF AERATION MODE ON SUBMERGED AEROBIC BIO FILTER REACTOR FOR GREY WATER TREATMENT

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Abstract: This research studied the effects of continuous and intermittent aeration on submerged aerated bio filter (SAB) reactor. Three reactors were set up parallel to treat artificial grey water by using sucrose: $C_{12}H_{22}O_{11}$ with concentration of 300 mg COD L^{-1}. The bio ball media was used as support material to attach microorganisms. All reactors were operated under batch and continuous conditions. Air supply to each reactor was continuous, two hours on and off intermittent and four hours on and off intermittent modes. Up flow rate of 0.048 m^3 day^{-1} and air flow rate of 3.5 L h^{-1} were applied for continuous reactor. The results showed that all reactors have no significant differences on removal efficiency of COD (81-87%) as well as DO concentration and ammonium removal.

Keywords: Ammonium, Aerated treatment, bio ball media, COD, grey water

INTRODUCTION

Domestic wastewater is estimated to contribute about 70 % of organic loading in rivers in urban areas in Indonesia. As example, the Citarum River as the main water resource of Saguling Dam, West Java contributes about 260 ton of domestic wastewater every day and increasing COD, BOD, nitrogen and phosphate every year from 2002 until 2005 in both dry and rainy seasons [1-2] around the Saguling Dam. The management system of domestic wastewater in urban areas generally consists of centralized system and decentralized system. The centralized system collects the wastewater and then transports it through the sewer systems to the domestic wastewater treatment plant, while the decentralized system treat the waste water on site usually in small scale, such as septic tank and pit latrine. Most of domestic wastewater in Indonesia comes from grey water from washing, bathing, kitchen, which is flowing through the sewer or drainage system without treatment. This condition increases the pollution of the water body,

which is shown by some parameters like the decreasing of dissolved oxygen concentration and the increasing of turbidity concentration, organic material and other materials. The quality of grey water in Indonesia from some cities show that the concentration range of some parameters like organic loading, TSS, ammonium, and oil & grease are 300-317 mg COD L^{-1}, 23-200 mg L^{-1}, 2-10 mg L^{-1}, 71-123 mg L^{-1} [3-5]. In general, 47% of organic material in grey water is contributed by domestic water, 26% of suspended solid, 12% of total nitrogen and 67% of total phosphate [6].

Attached growth reactor under an aerobic condition is one alternative technology to treat wastewater, for example a submerged aerobic bio filter (SAB). This system has higher efficiency than active sludge systems, especially for low organic loading [7]. However, compared to anaerobic conditions, it's more expensive in energy use (for its continuous aeration) and the organic degradation is not always significant. The SAB reactor consists of aeration system to supply the air and a fixed media. Aeration in SAB reactors are intends to give air to biological metabolism under aerobic condition, stabilize the biological process, and to avoid retaining on media by increasing the air flow rate. The range of air flow rate is between 5-15 $Nm^3\ h^{-1}.m^2$. The fixed media is used to attach microorganism which then work as a bio film; it can be submerged or floated under the water, depends on the operating system chosen. The COD removal is done better with floating media in SAB reactors than submerged media [8]. The intermittent aeration in SAB system could reduce the use of energy when the aeration system is turned down, especially at night [9]. However, little was known for the effect of intermittent aeration to the removal efficiencies of organic matter and some other parameters, such as dissolved oxygen, ammonium and phosphate. Therefore, this research attempted to compare the capacity of SAB reactors on reducing COD, ammonium and phosphate on different conditions of aeration time.

MATERIALS AND METHODS

The entire research was performed at the Water Research Laboratory of Environmental Engineering Study Program of ITB, using three reactors under aerobic conditions. These experiments used artificial domestic wastewater using sucrose: $C_{12}H_{22}O_{11}$ as organic compounds with concentration similar to 300 mg COD L^{-1}. The microorganisms were obtained from septic tanks and sewerages around Ganesha Street in Bandung, West Java, Indonesia.

During the acclimatization, 400-500 mg L^{-1} of glucose was used as carbon source while aqueous solution of NH_4Cl, KH_2PO_4, $FeSO_4.7H_2O$, $MnSO_4$, and $Ca(OH)_2$ was used as nutrient source, with COD:N:P ratio equal to 100:5:1. After acclimatization phase, the reactors were run under batch and continuous condition using sucrose with COD concentration 300 mg L^{-1} and Compost (NPK) with composition of NH_4 8,30%, NO_3 6,70%, P_2O_5 9%, K_2O 20%, MgO 2%, and $FeSO_4.7H_2O$. Each reactor was operated in different conditions: a continuous aeration, two hours on and off aeration and four hours on and off aeration.

Under the continuous condition, the reactor was operated up flow with flow rate of 0.048 $m^3\ day^{-1}$ and air flow rate of 3.5 L h^{-1}. The reactor is 14 cm in diameter, 180 cm in height, and 18 liters in volume (Fig. 1). The support material for attaching the microorganism was bio ball which was made of polypropylene with diameter 3.33 cm, height 2.6 cm and weight 4.7 ± 0.2 g. The support media is filled to 90 cm and the sampling point took each 30 cm in width.

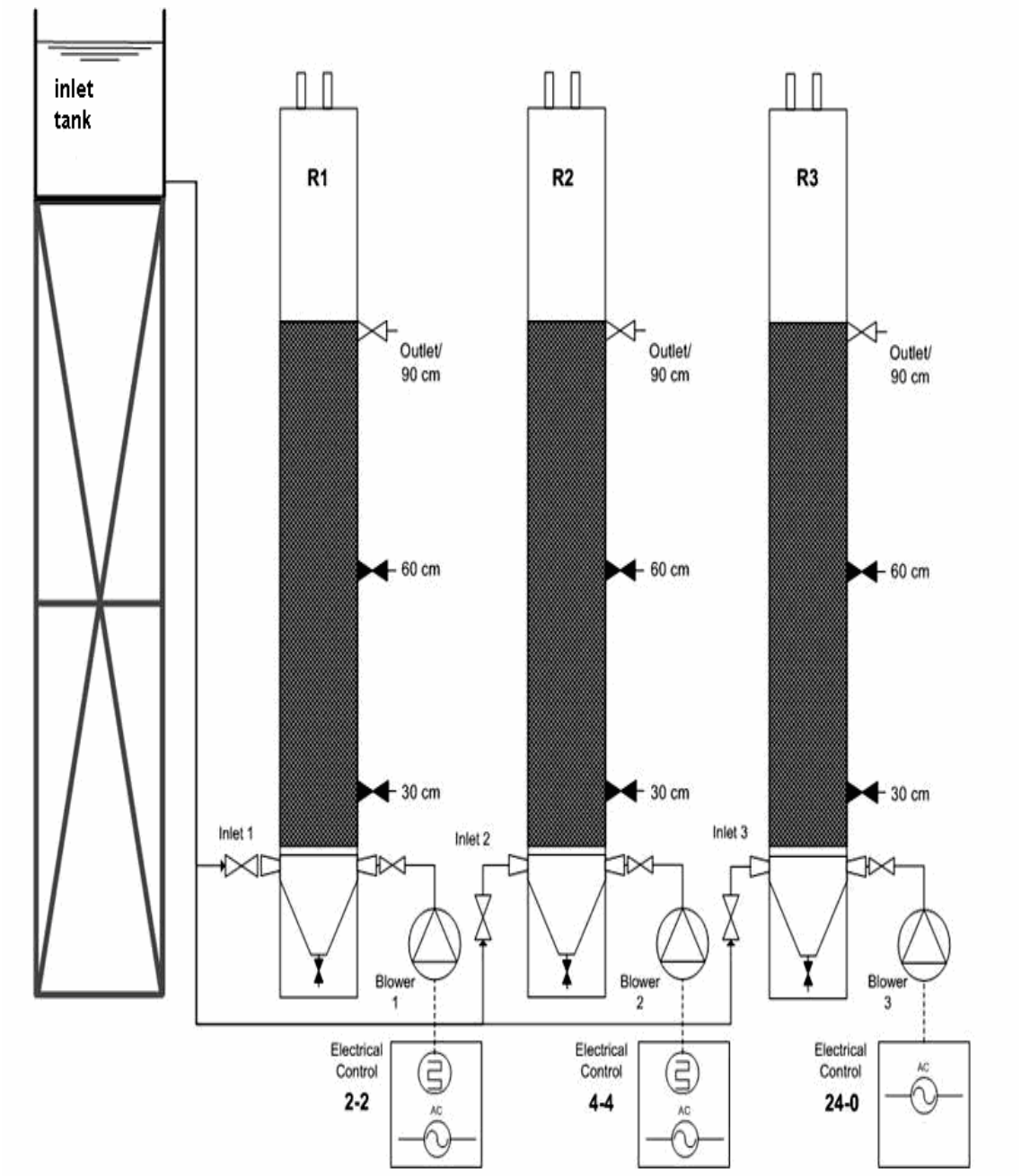

Fig. 1: The schematic of bioreactor made from plexy glass

The concentration of COD, temperature, DO, and pH was measured every 3 hours for about 18 hours. The concentration of TS was analyzed after the end of the experiment. The procedure of COD and ammonium analysis were based on Standard Method 5220 C and 4500-NH_3-F [10]. The equipment used in this experiments were Spectrophotometer (U-2001 UV/Vis Spectrophotometer from Hitachi), Analyst Weightier (Meter Toledo AB204), 105 ^oC Heater (VWR Scientific Model 1320), pH-Meter (Cyberscan 1000), Centrifuge (Hermle Z-230), Plate Stirrer (Thermolyne Chimeras 2) and COD Reactor (HACH).

The decrease of pollutants was calculated by using this equation:

$$\alpha_S = \left(1 - \frac{C_S}{C_0}\right) \times 100\% \qquad (1)$$

Where: α_S = pollutant decrease (%)
C_S = pollutant concentration at the end of the experiment (mg L^{-1})
C_{S0} = pollutant initial concentration (mg L^{-1})

The rate of COD removal was calculated by this equation:

$$r_{SCOD} = \frac{\Delta C}{\Delta t} \times \frac{1}{C_B} \qquad (2)$$

Where: r_{SCOD}= rate of COD removal (hour. mg TSS)$^{-1}$
ΔC = reduction concentration of COD in period range (mg L^{-1} COD)
Δt = period range ($t_{end} - t_0$) (hour)
C_B = biomass concentration (mg L^{-1} TSS)

RESULTS AND DISCUSSION

Table 1 shows the COD removal on different aeration time under batch experiments. The initial concentration of each batch reactor was 300 mg L^{-1} S_{COD} and achieved the steady state condition after 18 hours. Based on equation (1) and (2), the COD degradation in batch reactor were about 86 % ± 2 % with removal rate of COD: 0.013 h^{-1} for continuous aeration, 0.014 h^{-1} for both 2 and four hours intermittent aeration. This shows that under batch condition the aeration time has no significant effect to the S_{COD} removal rate.

Table 1: COD removal on different aeration time under batch experiments

Time, hour	Concentration of COD, mg L^{-1}		
	Continuous aeration	Two hours on and off aeration	Four hours on and off aeration
0	300	320	310
3	210	140	200
6	80	130	160
9	58	70	48
12	42	62	60
15	40	60	40
18	28	24	34

The COD removal on different aeration time under continuous experiments was shown in Table 2. Even though the efficiency of COD degradation under 4 hour intermittent aeration can attain to 87 % , which is higher than continuous aeration (83%) and 2 hour intermittent aeration (81%), yet there is no significant effect to the COD removal rate. The average COD removal rate of every reactor is 0.034 h^{-1}.

Table 2: COD removal on different aeration time under continuous experiments

Time, hour	Concentration of COD, mg L^{-1}			
	Influent	Effluent		
		continuous aeration	Two hours on and off aeration	Four hours on and off aeration
3	345	40	28	42
6	300	48	73	40
9	330	73	48	33
12	367	53	68	48
15	335	58	78	44
18	346	73	98	58

The DO and Ammonium concentration is one important factor that affected the microorganism during the experiment. Table 3 shows the profile of DO concentration in each sampling points in all reactors.

Table 3: The profile of DO concentration in each sampling points under continuously experiments

No	Length, cm	Concentration of DO, mg L^{-1}		
		continuous aeration	Two hours on and off aeration	Four hours on and off aeration
1	30	4.35	4.07	4.98
2	60	4.48	4.24	4.95
3	90	4.87	4.44	5.29
	Average	4.56	4.25	5.07

The average DO concentrations for all reactors can attain to 4 mg L^{-1} and the concentration increase by staging the sampling points in continuous aeration and two hours intermittent aeration. In this research, the lowest averaging DO concentration is attained by two hours intermittent aeration which only achieved a DO concentration of 4 mg L^{-1} because of limited diffusion factor on the bio film. The limiting factors of reaction in suspension reactors is causing DO concentration only achieveing 2-3 mg L^{-1} [11-12]. The low concentration of DO by using two hours intermitten aeration shows the high activities of the microorganism. During the four hours off aeration time, the DO concentration inside the reactor decreased because there was not enough oxygen supply, especially after three hours long idle time. In contrary, the DO concentration in the four hours intermittent aeration is relatively stable around 5 mg L^{-1} because of the continuous aeration.

Table 5 shows the profile of Ammonium concentration in each sampling points under continuous experiment. The ammonium concentration increases by staging the sampling points in reactors with intermittent aeration. Theoretically, under aerobic condition ammonium will change through nitrification process into nitrate and nitrite which then causes the decreasing of ammonium concentration in the effluent. However, four hours intermittent aeration had the lowest efficiency in ammonium removal even tough it used continuous aeration. This could be happen

because the powder of NPK goes up flow together with the flow of air. A possible short circuit between bed and bio was created by continuous aeration and four hours intermittent aeration. Intermittent aeration time could reduce the short circuit possibility, happened in two hours intermittent aeration time. The highest ammonium removal occurred December 2008 (Table 6), because the biomass accumulates around the second sampling points so a short circuit flow could be avoided.

Table 5: The profile of Ammonium concentration in each sampling point for continuous reactor

No	Length, cm	Concentration of Ammonium, mg L^{-1}		
		Continuous aeration	Two hours on and off aeration	Four hours on and off aeration
1	30	0.50	0.53	0.34
2	60	0.75	1.07	0.93
3	90	0.54	1.18	1.61
	Average	0.60	0.93	0.96

Table 6: The removal of COD and Ammonium and the increasing of DO concentration

No	Item	Continuous aeration	Two hours on and off aeration	Four hours on and off aeration
1	Removal of COD, %	82.79	80.42	86.94
2	Removal of Ammonium, %	77.59	51.04	33.20
3	Increasing of DO, %	25.44	19.62	32.94

Comparison between the submerged aerated bio filter (SAB) and Biological Aerated Filter (BAF) [8, 13] showed that the S_{COD} removal achieved 80 % and the maximum ammonium degradation achieved 50 %.

CONCLUSIONS

Intermittent or continuous aeration by influent concentration of 300 mg/L COD and 2.5 mg L^{-1} ammonium has no significant effect to the rate of organic removal under Submerged Aerated Bio filter reactor. The average COD removal for continuous aeration, two hours and four hours intermittent aeration are 83 %, 81 % and 87 %, respectively. The lowest dissolved oxygen occurred in two hours on and off aeration which is around 4 mg L^{-1}. Aeration mode affected the efficiency of ammonium removal. Efficiency of ammonium removal for continuous aeration, two hours and four hours intermittent aeration are 75 %, 61 %, and 60 %, respectively.

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