Enhanced Effluent Quality of Anaerobic Baffled Reactor (ABR) with Ozone and Aerobic Activated Sludge for Livestock Wastewater Treatment

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Abstract

ABR used to treat wastewater with high COD level such as livestock wastewater. ABR treatment consists of compartments which are limited by vertical bulkhead growth with attached bacteria. However, ABR treatment only capable degraded COD level by 50 – 53%. This value did not qualify to be discharged into the environment. Therefore, ABR treatment need further treatment with ozone treatment and aerobic activated sludge. There were two treatments in this study, which are ABR with ozone treatment and aerobic activated sludge (S1) and ABR with aerobic activated sludge (S2). COD degradation with ozone treatment showed low efficiency, 31.1 ± 1.5 % but BOD/COD level increased. Aerobic activated sludge with batch system showed efficiency of COD degradation as 95.3 ± 2.2 % (with ozone treatment) and 78.6 ± 4.5 % without ozone treatment. The final concentration effluent for livestock wastewater was 167.7 ± 62 mg/L. Aerobic activated sludge with continuous system was conducted to test that result and it average efficiency only decreased into 85%. This concentration was qualified to be discharged into environment.

Keywords: Activated sludge; anaerobic baffled reactor; livestock; ozone; wastewater

1. Introduction

Growing world population raise the demand livestock products [1]. The increasing of livestock wastewater in developing country due to high consumption of meat. Livestock wastewater majorly used as fertilizer, but it only degraded its organic matters. Whereas, its inorganic matters cannot be degraded properly and become residue that could threated environment especially water pollution like decreasing of water quality because of high nutrients. Livestock wastewater as organic waste that is consist of protein, carbohydrate, fat, mineral salt, can act as growth media and microbes breeding. Degradation process in wastewater makes the level of BOD, COD, NH_3, H_2S and pH changing and also raises bad odor like urea, Sulphur, and heavy metals. Heavy metals will affect leads to plant growth and heavy metals accumulation to plant [2, 3]. Besides that, the decreasing of DO level excessively can cause degradation of water quality. Generally, water body has capability to do self-purification, but with the increasing number of pollutants into water body caused autogenously purification of water body decrease. It is indicated with the changing of physical, chemical and biological in water body.

Anaerobic Baffled Reactor (ABR) is one of modification septic tank reactor with compartment addition [4]. ABR used to treat wastewater with high level COD like livestock wastewater. ABR treatment consists of compartments which are limited by vertical bulkhead growth with attached bacteria. Commonly, ABR consist of compartments that is arranged series. ABR combines sedimentation process with sludge decomposition partially in the same compartment, basically that compartment is sedimentation pond without moving parts or chemical materials adding. However, efficiency of COD degradation in ABR system still under 85% and yet qualified to standard quality [5, 6]. Hence, advanced treatment needs to be conducted to increase treatment's efficiency [7]. This study conducted ozone treatment and aerated activated sludge as advance treatment.

Plasma discharge technique is one of technic to produces ozone gas (O_3) as strong oxidation that is effective in wastewater treatment. Ozone can increase biodegradability of wastewater. Ozone including into strong oxidant after Fluor (F), but safe and environmentally friendly, because in the end of reaction,

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Table 1. Characteristics of livestock wastewater effluent

No	Parameters	Value	Unit
1	COD	9046 ± 193	mg/L
2	BOD_5	3479 ± 58	mg/L
3	TSS	1432 ± 189	mg/L
4	VSS	10575 ± 227	mg/L
5	NH_3-N	34.7 ± 0.7	mg/L
6	TKN	2589 ± 345	mg/L
7	pH	7.6-8.2	
8	BOD/COD	0.38	
9	C/N	4.02	

ozone (O_3) reform into oxygen (O_2). Some studies stated ozone is a process which increased biological treatment's efficiency [8, 9, 10]. Moreover, ozone appropriate as post-treatment in ABR method [11].

Ozone process cannot degrade all of organic materials chemically, so off the treatment can further with aerobic activated sludge treatment. The combination of ABR and aerobic activated sludge treatment had applied and successes to increase efficiency of organic materials removal [7, 12, 13]. This method requires air supply and it can maintain a high microbe concentration to absorb and accelerate the removal of organic matter.

The fact that ABR method's result yet still qualified into quality standard of wastewater, make this method need to be improved. Advanced processing that is used is ozone, aerated activated sludge and combined ozone and activated sludge. The objective of this study was to evaluate the performance of an anaerobic baffled reactor (ABR) with post treatment ozone, aerated activated sludge, and combined ozone and activated sludge in the treatment of livestock wastewater.

2. Materials and Methods

2.1. Livestock wastewater

Livestock wastewater sourced from farm in Denpasar, Bali. COD level of that livestock wastewater after treatment was high, 9046 ± 193 mg/L, and was difficult to treat with aerobic process and also requires high power. Nowadays, those livestock wastewater only treated by ABR process and its effluent not fulfilling the quality standard. The main physic-chemical and biological characteristics of livestock wastewater used in this study are shown in Table 1.

2.2. Reactor

In the ABR, wastewater is flowed continuously from raw wastewater tank by HRT 6 in 12 hours. ABR has a volume of 25 L and also 3 baffle compartments (Fig. 1). Next, wastewater is flowed into ozone reactor with a capacity of 10 L in the batch system. Ozone generator that is used have doses 1200 mg per hour. The procedure is continued by aerobic activated sludge with batch system and repeatedly. The aerobic system is classified into two, which are with ozone and without ozone.

2.3. Analysis procedure

The analysis parameters are DO, BOD_5, COD, pH, TKN and NH3-N established on standard method APHA AWWA. Essential parameter in this research is COD value that measured periodically. Each wastewater is retrieved as much as 20 mL from sampling port then analyzed based on each paramaters.

3. Results and Discussion

3.1. ABR treatment

The average characteristics of influent and effluent after the ABR treatment at 6 and 12 h HRTs are summarized in Fig. 2. The average effluent COD values at 6 h HRT were found to be around 4489.7 mg/L, respectively, while at 10 h HRT average COD values were of the order 4182 mg/L, respectively. At both HRTs COD removal averaged 50-53% indicating poor amount of removal.

The result of ABR treatment similar to the result of anoxic treatment of piggery wastewater which produced COD removal for 54.5% for anoxic activated sludge and 51-60% for ABR [14, 15]. As well as the result of NH_3-N, removal which merely produced 50-58% of value. This product is not complied the standard quality of wastewater of livestock industry.

The product of COD removal in process indicates low value compared to another research which produced more than 80% [16, 17]. The high removal fluctuation is produced by Pirsaheb et al.,with COD influent value of 15.000 mg/L by removal efficiency value of 43.01% and 95.13% respectively [18]. This matter is probably happened in consequence of highly NH3-N concentration in the wastewater. Much as ammonia is the essential nutrition for bacteria's growth, but if it is highly concentrated, it also can hinder methanogenesis during aerobic digestion process [19]. The after-process measurement result indicates COD/BOD value of 022±0.03, which is this value reveals the low biodegradability.
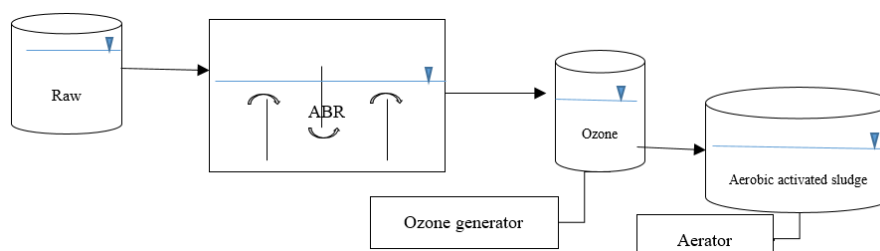

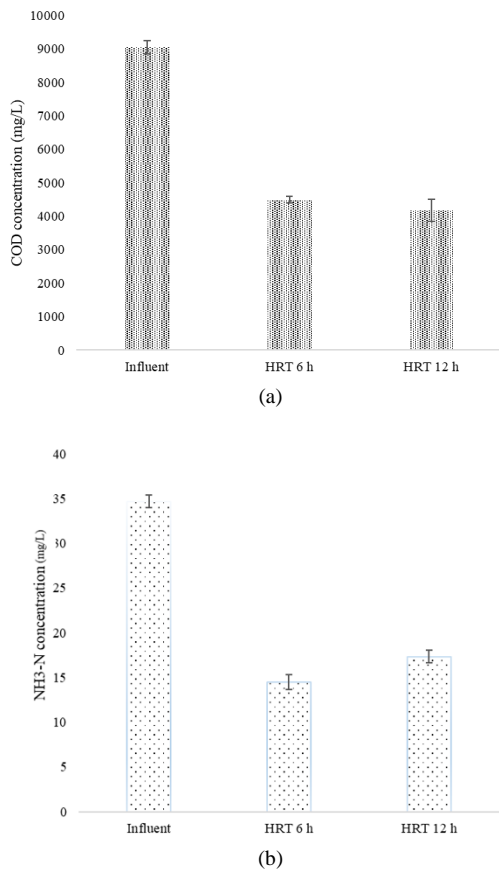Figure 1. Flow chart of livestock wastewater treatment process

(a)

(b)

Figure 2. The results of livestock wastewater treatment with ABR tanks with different HRT (a) COD (b) NH₃-N

3.2. Ozone treatment

Indirect ozone reaction into OH· radicals is dominantly functioning in the organic compound removal to produce higher quality of removal efficiency. This research stabilizes ozone mechanism is the method that can be used to remove organic material composition [8]. COD as organic removal (Fig. 3) and NH_3-N as nutrient removal indicates the quite low value of 31.1±1.5% and 19.2.1±2.1%. The result of BOD measurement indicates no difference with the average efficiency of 1%. There is a quite high increasing of BOD/COD value, from 0.25±0.02 to 0.37±0.01. Increasing the BOD/COD value showed in Fig. 4.

Some other parameter which determines the effectively of ozone mechanism is BOD as organic material indicator that can be degraded biologically. Another research that used UV/H_2O_2 oxidation process from effluent ABR increasing BOD/COD ratio of 0.4 to 0.6 [17]. NH_3-N also indicates poor effluent, which is 12.6±1.1 mg/L with efficiency value of 29.7±1.4 %. With reference to pH value in the ozone treatment, it indicates normal pH (7.2-7.5), where based on Khuntia et al., the optimum pH to be used in ammonia removal is up to 9 [19].
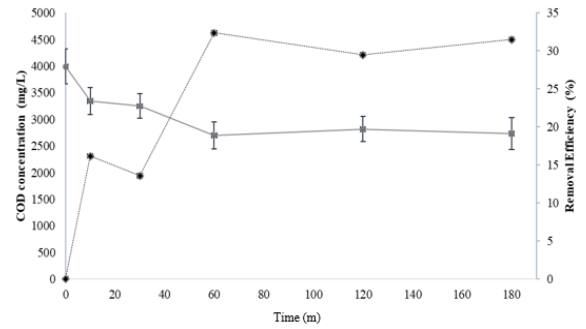

Figure 3. Degradation of COD as organic compounds with ozone pre-treatment
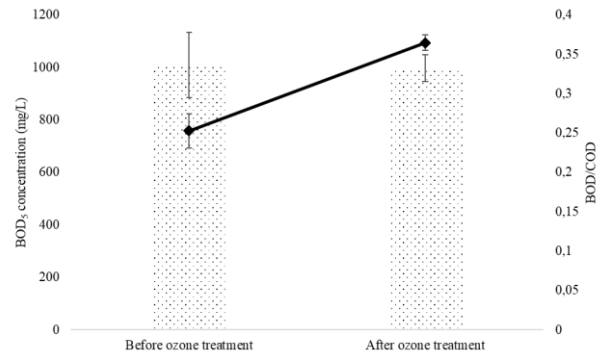

Figure 4. Changes in the value of BOD and biodegradability (BOD/COD) with ozone pre-treatment

3.3. Aerobic activated sludge treatment

In the aerobic activated sludge process, the used MLVSS concentration is about 831 mg/L at start-up. Which the sustained DO value is up to 4 mg/L to initiate the optimum aerobic processing [20]. The result can be viewed at the Fig. 5. COD removal efficiency with time detention of 60 days for S2 has reached the efficiency 95.3±2.2% with a value of 167.7±62 mg/L. NH_3-N removal only reached 52±6.2%.
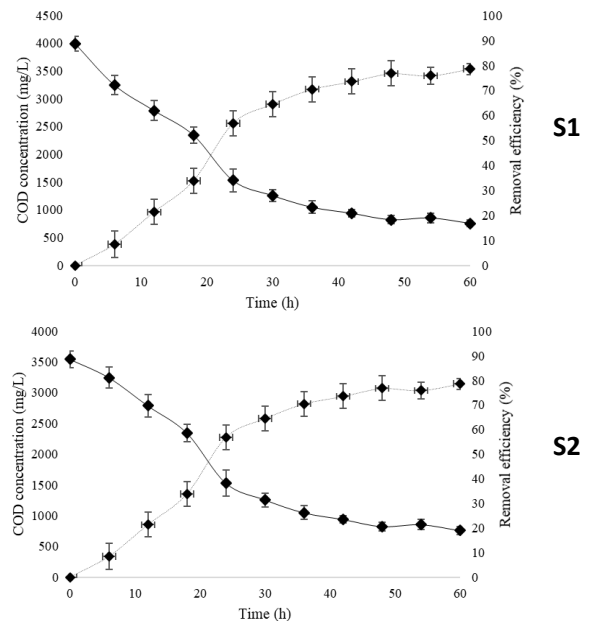

S1

S2

Figure 5. Removal of COD values by active sludge treatment process (S1= without ozone pre-treatment and S2 = with ozone pre-treatment)
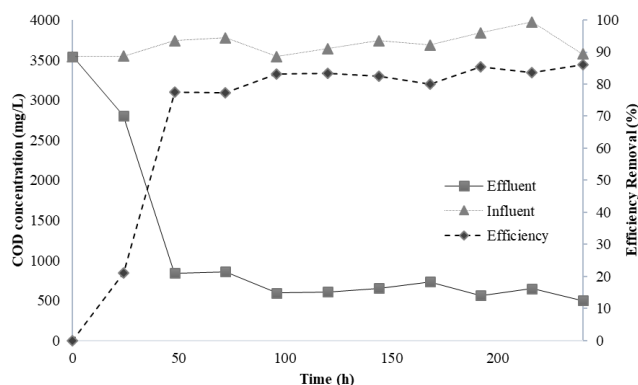
Figure 6. Removal of COD values by the active sludge treatment process in the continuous process with 48 hours HRT

In the meantime, the result of without-ozone process (S1) only produces COD and NH_3-N efficiency of 78.6±4.5% and 41.2±7.1%. Combined of activated sludge and ozone value have passed the threshold standard class in Indonesia. Next, the process output is tested by continually system with HRT 48 hours, which is the result reached the maximum COD efficiency 86% (Fig. 6) and NH_3-N efficiency only 39%.

This outcome of aerobic activated sludge treatment is established by another research which combined the ABR process with aerobic process that produces removal efficiencies 98% and 100% [21]. The result in continuous system is established by Pratiwi *et al.,* statement, the further decrease of HRT [10], the COD removal declined apparently. Another research also stated the combined anaerobic/aerobic process with HRT 19.7 and 1.22 days producing COD removal about 97% and 91% [22].

As a result of that matter, it needs the adjustment of HRT value in the treatment process of livestock wastewater. To remove the suspended particles can use bio flocculants which non-toxic and more eco-friendly solution [23]. For nutrient removal like NH_3-N can use phytoremediation or constructed wetland. Contracted wetland has ability to metabolize/absorb certain chemicals like NH_3-N [2, 24, 25].

4. Conclusions

The result of COD removal with ABR system is quite low, which is 50-53%. The results indicate that in the batch system, ozone can increase BOD/COD and decrease the COD only 31.1±1.5%. Significant removal of COD in both reactors occurs at the first hour, but reactor with ozone treatment has higher removal efficiency of COD than without ozone treatment. The removal efficiency of COD in the both reactors was 95.3±2.2%% and 78.6±4.5% respectively. In the continually process test (HRT 48 H) by ozone treatment, the COD removal maximum value is only 85%.

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