Optimization of aeration time on GAS-SBR system to remove organic content in wastewater

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Abstract. In general, chicken slaughterhouses have slaughtering capacity of more than 40,000 chickens per day, resulting in high volume wastewater with high BOD and COD concentration. Therefore, appropriate wastewater treatment technology is needed. Granular Activated Sludge that uses Sequencing Batch Reactor (GAS-SBR) has ability to treat wastewater with high organic content. The study is conducted to analyze the ability of GAS to reduce organic content with variation of aeration time in reaction stage on SBR. Formation of Granular Activated Sludge (GAS) was cultured by reacting activated sludge and using a stirring of 20 rpm. SBR had a total work volume of 45 liters and was operated in 5 stages, namely the filling, the reaction with aeration, the settling, the decantation, and the stabilization stage. In this study the initial COD concentration in chicken slaughterhouse effluent (RPA) was 5440 mg/L. The result of the study was that highest removal of BOD and COD parameter occured at 3 hours’ aeration time with removal efficiency 75% and 72%, while for TSS was at 5 hours’ aeration time with removal efficiency 65%. It could be concluded that GAS in SBR system could be applied to remove high organic content parameters in wastewater.

1. Introduction
Chicken Slaughter House is a facility that has become important needs for human, especially for people with quite high consumption of chicken meat. Chicken slaughter house is a building with special design and construction that functions as a place to slaughter chickens for people consumption [1]. There are about 572 chicken slaughterhouses in East Jakarta that could slaughter more than 40,000 chicken a day [2]. High amount of chicken meat consumption had an impact on increase wastewater from the Chicken Slaughterhouse Industry [3]. Due to its content of carbohydrates, protein, salts and fats, chicken slaughter wastewater being a place for microbial growth. The process of decomposition on water have result in an increase in BOD, COD, TSS [4]. According to researcher [5], Chicken slaughterhouse wastewater contains COD 6406.4 mg/L, BOD 3215.28 mg/L, TSS 126 mg/L, fat and oil 15 mg/L, total ammonia 13.8 mg/L, detergent (MBAS) 5.85 mg/L and pH 7.19. All parameters were above the standard quality Government Regulation No. 5 of 2014 [6]. Sequencing Batch Reactor (SBR) technology can be used to reduce and break down the environmental wastewater pollutants due to chicken slaughterhouse. SBR is wastewater treatment based on activated sludge system in batches and operated in a fill-and-draw cycle, so aeration and settlement occurred in the same tank [7].

The SBR have 5 (five) stages of process: filling, aeration-reaction, settling, decant and idle phase (see Figure 1). SBR reported to be successful to treat both municipal and industrial wastewater [8]. The efficiency of SBR is 83.9±1.7% of COD and 94±1.3% of BOD, complete nitrification occurred as well
in the SBR [9]. It was reported that SBR treatment could remove COD as much as 90% from pharmaceutical wastewater and 97% from slaughterhouse effluent [10]. On treating wood fiber industry effluent, SBR also found could remove as much as 92%, 84%, 52% for COD, turbidity and TSS removal, respectively [11]. Other study obtained from suspended-growth and attached-growth modes of brewery wastewater in SBR and the results demonstrated removals up to 90% of total organic carbon, COD, BOD5, and suspended solids [12]. Another study determined that SBR can decrease organic content from chicken slaughterhouse water treatment in COD and BOD parameters at 72.83% and 72.23% at 2 hours’ aeration time with artificial waste water from chicken slaughterhouse [5]. By applying formation of aerobic granular sludge in SBR, there will be large biomass deposition, so it would be an advantage to minimize land requirement for precipitation [13].

![Figure 1. Cycle of sequencing batch reactor.](image)

2. Materials and methods
In this research, the 45 Liter reactor was made of acrylic material with dimension of 50 cm height, 30 cm length and 30 cm width as can be seen in Figure 2. An air pump with 4200 liters/hour oxygen supply capacity was installed in SBR (Sequencing Batch Reactor) to maintain the aeration. The wastewater influent of SBR was from Pulogadung Chicken Slaughterhouse, East Jakarta, while the active sludge as seeds for formation GAS were from the RAS (Return Activated Sludge) unit of Clarifier Wastewater Treatment in X Mall, North Jakarta.

![Figure 2. Sequencing batch reactor.](image)
In seeding process as the preparation stage the activated sludge was carried out with slow stirring (20 rpm) for about one month as well to make a formation of Granular Activated Sludge (GAS). Mixed Liquor Suspended Solid (MLSS) and Mixed Liquor Volatile Suspended Solid (MLVSS) were periodically checked to ensure the quantity of suspended solids and biomass content as long as seeding process. Furthermore, the activated sludge was acclimatized in SBR by gently adding chicken slaughterhouse wastewater to obtain such adaptable culture of biomass. The operation of the SBR started on 0.25 hours (15 minutes) for filling stage carried out and then turning on the air pump. The air pump was used to maintain variations of aeration process that were 3, 4 and 5 hours continuously. When aeration process was complete, then it started the settling process in 1.5 hours (90 minutes), continued with 0.25 hours (15 minutes) for decantation and 2-3 hours for stabilization time variations. The parameters analyzed for every cycle were BOD, COD, TSS, taken from the decantation results. The detailed of experiment research showed on the Table 1.

### Table 1. Variation of aeration time and stabilization time.

| Fill  | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
|-------|------|------|------|------|------|------|
| Aeration | 3    | 4    | 5    | 3    | 4    | 5    |
| Sedimentation | 1.5  | 1.5  | 1.5  | 1.5  | 1.5  | 1.5  |
| Decantation | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Stabilization | 2    | 2    | 2    | 3    | 3    | 3    |
| Total  | 7    | 8    | 9    | 8    | 9    | 10   |

3. Results and discussion

The study was arranged to obtain the effect of optimization performance of GAS-SBR in variations of aeration time. Therefore, the analysis of the allowance for several parameters which was COD, BOD, TSS was important to determine the performance of the GAS-SBR.

3.1. COD and BOD removal

The parameters regularly used to determine water pollution is COD and BOD. To show a decrease in water soluble oxygen content, COD and BOD is needed to analysis to determine whether the decomposition was easy or difficult [14]. The remaining pieces in the form of organs, blood and other chicken parts unused caused the high value of COD and BOD in chicken slaughterhouse wastewater [15]. Aeration and stabilization have effect for the evolved of COD and BOD, as can be seen in Figure 3 and 4.
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Figure 4. BOD removal.

At the concentration of COD 2048 mg/L GAS-SBR with 3 hours’ aeration time can reduce until 480-533 mg/L, while 4 hours aeration time can reduce until 1013-1120 mg/L and in 5 hours 1277-1333 mg/L. For concentration BOD influent of 1148 mg/L the removal in 3 hours’ aeration time was until 322-362 mg/L, in 4 hours 523-634 mg/L, and in 5 hours can reduce until 493-674 mg/L. These data represent that at 3 hours’ aeration time and 3 hours’ stabilization was the highest allowance for GAS-SBR to remove COD and BOD parameters with the removal efficiency of 75% and 72%, in each. This result was also support by other studies determined that SBR can decrease COD and BOD parameters at 72.83% and 72.23% with 2 hours’ aeration time [5]. Another studies achieved that the longer aeration time and stabilization time not give mean to higher removal organic content [16]. So this research tries to study some longer aeration time. The result of the research showed that the longer aeration time not assure better organic removing, since the removal efficiencies were decreased in aeration time of 4 and 5 hours. Other study had concluded that longer of aeration time not always make the high value of organic content removal, because it depends in many factors such as biomass concentration [17]. The effluent from this research still exceed the quality standard of Government Regulation No. 5 of 2014 [6]. Comparing with other study that obtain lower removal efficiency, 65% of COD and 61% of BOD from artificial wastewater with aeration time of 6 hours [18], this study has a significant improvement. Other researcher using other kind of treatment that was Anaerobic Baffled Treatment [19] that could reduce about 42-47% of COD.

3.2. TSS removal

TSS was often used for observations to determine water quality. TSS values could be used as indicator of high levels of pollution and cause inhibition in light penetration into water that will disturb photosynthesis process in water [20]. In addition, its presence increase water temperature that would reduce dissolved oxygen ultimately [21]. The removing TSS in GAS-SBR with variation of aeration time can be seen in Figure 5.
Figure 6 shows that at a concentration of 7 mg/L GAS-SBR TSS at 3 hours’ aeration time can reduce till 2.7-2.9 mg/L at 4 hours 2.9-3.0 mg/L and at 5 hours 2.4-2.7 mg/L. Based on these data, 5 hours’ aeration time and 3 hours’ stabilization give TSS removal efficiency of 65% as the highest removal that occurs in the GAS-SBR process. But it can be seen as well that there was no significant effect of aeration time in decreasing the TSS parameter, since the similar TSS concentration exist in all variation. Comparing with other study that revealed that SBR had highest efficiency removal of TSS with 4 hours’ aeration time [22,23], it could be mentioned that the aeration time must set in 4 or 5 hours to remove high TSS.

4. Conclusion
In this study, the best combination of aeration and stabilization time to remove COD and BOD was 3 hours’ aeration time and 3 hours’ stabilization, while for removing TSS was in 5 hours’ aeration and 3 hours’ stabilization time. It could be concluded that the longer aeration time not give better effect to remove COD and BOD in chicken slaughterhouse wastewater. In future research, it needs to study about the effect of other variation of stabilization time and the formation of GAS granulation in removing high organic content in wastewater.

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