Addition of Fixed Bed Biofilm in Sequencing Batch Reactor to Remove Carbon-Nitrogen for Apartment Wastewater

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Abstract. The addition of media to grow biofilms in the Sequencing Batch Reactor (SBR) process, is an advance technology that aims to improve the performance of the reactor as a waste water treatment. SBR works by utilizing microbes that are suspended in the sludge resulting from the SBR process. With the media being added as a place to grow biofilms, there is a consortium of bacteria suspended with attached bacteria. Anaerobic phase is added to give anaerobic bacteria a chance to develop, thus accelerating the breakdown of organic content in liquid waste. Research methods include the best weight of biofilm growing media, namely coconut fiber and palm fiber. And the best stabilization time, to reduce the organic content of wastewater. The research result obtained N-total removal was 93.21 % and COD removal reached 92.11 %. The identification of the dominant bacteria growing in biofilms and those suspended have the same characteristics. The microorganisms which dominantly grew and were found in the media were micrococcus and bacillus.

1. Introduction
One of alternative treatments that is applicable for wastewater treatment is a biological treatment namely biodegradation. Biodegradation is an oxidation process of organic compounds by microorganisms in waters, soils and management installation [1,3]. The breakdown of organic substances into simple compounds by microorganism can be carried out aerobically (with air) and anaerobically (without air) or the combination of both (aerobically and anaerobically) [1,14]. Factors affecting microorganism growth in biological oxidation process include oxygen in wastewater, nutrient (as food, wastewater must contain enough N and P so that biological sludge can develop and grow optimally), pH and temperature [5,12].

SBR system is a system of activated sludge operated in batch. The process unit in SBR system is identical to the process unit of activated sludge, namely aeration and sedimentation to separate biomass. In activated sludge system, both processes are carried out in two different tanks; while, in SBR system, the processes are accomplished in the same tank. Another uniqueness of the SBR system is it does not need sludge circulation [6, 11]. The addition of bacteria adhesion media that act as biofilms aims to increase the effectiveness of SBR. The effectiveness of the performance of the use of coconut fibers as a biofilm adhesion media in SBR is not only influenced by the surface area or media size, but also by the mass of the media. But it must also be taken into account, the optimal mass of media, thus further increasing the performance of SBR.
Media to grow biofilm, palm fibers and coconut fibers. Fibers are black and hard fibers which protect
the base of the leaves of palm or palm leaves (*Arenga pinnata*, *Aren*) which is a palm-producing plant
that grows throughout the Indonesian land very well, especially at an altitude of 400 to 1000 meters
above sea level. Whereas coconut fiber is part of mesocarp (blanket) in the form of crude coconut
fibers. Coconut fiber is usually referred to as waste which is only stacked under the stands of coconut
plants and then left to rot or dry. In Figure 1. Display of palm fiber and coconut fiber

![Figure 1. The appearance of (a) coconut fibers and (b) palm fibers](image)

Coconut (*Cocos nucifera*) is one of the most recognized members of the palm plant and is widely
distributed in the tropics. Coconut tree is a type of single house plant with plant stems growing straight
up and not branching. Palm fibers produced by palm trees have physical properties including: in the
form of strands of thread (fiber) black, less than 0.5 mm in diameter, rigid and resilient (not easily
broken). The most important difference from palm fibers and coconut fibers on the diameter of the
thickness of each strand. Fibers are thicker than coconut coir [4,6]

2. Materials and methods
This study was conducted on laboratory scale using 7 L of reactor volume with volume work of 5 L.
The wastewater sample used in this study was domestic wastewater collected from apartment. Each
collection took 60 L wastewater. Palm fibers and coconut fibers were selected as the adhesion media
that act as biofilms of this study. These media were cut into 2 cm long. Media weight of 0 gram (as a
control), 25 grams, 35 grams, 45 grams. Anaerobic time of 6 hours, 8 hours, 10 hours, pH were 6-9.
Temperature on the rang 29°C - 31°C, Mixed Liquor Suspended Solids (MLSS) concentration more
than 2000 mg/L.

This study was accomplished through two processes, namely seeding biofilm, this seeding process was
carried out until the media was grown with biofilm. The next process was acclimatization process. To
keep the microorganisms adapting to the domestic wastewater substrates, activated sludge
acclimatization was conducted first for 23 hours. Acclimatization process was done in stages where
the volume of wastewater was increased 30% for each subsequent acclimatization process.

Main Process was performed after finishing the acclimatization process. This process included: fill,
aerobic, aerobic, settle and draw. The following table presents the residence time during running
process.

| Step (phase)                  | Unit | Total time 23 hours | Total time 25 hours | Total time 27 hours |
|-------------------------------|------|---------------------|---------------------|---------------------|
| Fill                          | minute | 20                  | 20                  | 20                  |
| Anaerobic process (stabilization) | hour | 6                   | 8                   | 10                  |
| Aerated (react)               | hour  | 15                  | 15                  | 15                  |
| Settle                        | hour  | 1,5                 | 1,5                 | 1,5                 |
| Draw                          | minute | 10                  | 10                  | 10                  |
The sketch and arrangement of SBR using palm fibers and coconut fibers as media is presented in the Figure 2 below.

Figure 2. Sketch and Reactor Design

3. Results and Discussions

After the acclimation process is completed by producing a good decrease in COD value, then entering the SBR process with 100% wastewater in the SBR operation process with the addition of coconut fibers and coconut fibers

3.1. The removal of chemical oxygen demand, nitrogen total and total suspended solids

The following Figure 3 the percentage of COD removal released during running process by using the media of palm fibers and coconut fibers.

![Figure 3](image)

Figure 3. The relationship between residence time and the percentage of COD removal with the variation of (a) palm fibers (b) coconut fibers weight during running process

Based on the Figure 3 In the reactor with coconut fibers, it released the optimal decrease efficiency of COD in the media weight that was 35 grams respectively 80.23 %, 81.93 %, and 85.11 %. And, for the reactor that used both media, palm fibers 25 gram in weigh and coconut fibers 45 gram in weigh, it could not release the value of decrease efficiency of COD well. It was because the weight of the media affected on the decrease of COD concentration. The increasing mass or weight of the media effects on the wide attachment area for biofilm; meanwhile, the increasing mass or weight of the media also triggers dangerous collision during aeration process and mixing process and it causes a big detachment
process [7, 9]. Therefore, it can be said that media with 25 grams and 45 grams in weigh were not ideal weight to get optimal decrease efficiency of COD in this treatment.

The percentage of Nitrogen Total removal released during the running process can be observed through Figure 4 below.

![Figure 4](image1)

**Figure 4** The relationship between residence time and the percentage of N Total removal with the variation of (a) palm fibers, and (b) coconut fibers, weight during running process

The Figure 4 show that N-total could be removed optimally. It can be seen from the percentage of the removal reaching 70%. The optimal removal was reached by adding the use of palm fibers 35 gram as the media in every residence time respectively 75 %, 77.94 %, 79.31 %. Meanwhile, the optimal N-total removal was also reached by the additional use of coconut fibers 35 gram in every residence time respectively 78.13 %, 82.35 %, 86.21 %. Optimal efficiency occurred in the reactor using coconut fibers because the surface of coconut fibers is rougher than the surface of palm fibers is [6].

The percentage of TSS removal reached during running process by using palm fibers and coconut fibers is presented in the Figure 5 below.

![Figure 5](image2)

**Figure 5.** The relationship between residence time and the percentage of TSS removal with the variation of (a) palm fibers, (b) coconut fibers, weight during running process

Referring to Figure 5, it can be seen that the percentage of TSS removal increased from one residence to another residence time. The optimal decrease of TSS removal was in residence time 27 hours in the reactor using palm fibers 35 gram and coconut fibers 35 gram with decrease efficiency 58.82%. However, fluctuated decrease of efficiency value appeared in the control reactor and coconut fibers 45 gram. The decrease of efficiency value of TSS removal was caused by the amount of suspended solids
carried during the effluent removal stage. Factor affecting the decrease value in TSS removal might because of suspended solids in the faucet from where the effluent came out; therefore, when the effluent was released, the solid in the faucet would also be released along with the effluent. The SBR effectiveness will be performed optimally if it is combined with the use of additional media that will prevent SBR from bulking [8,10].

3.2. **Optimal anaerobic phase on sequencing batch reactor**

According to the removal efficiency of COD, TSS and N-Total reached, it can be assumed that stabilization time may affect the value of effluent concentration and the efficiency of the removal. This study found that the longer stabilization time is used, the longer total residence time will be. Denitrification process is a reduction process nitrate compounds into nitrogen [10]. To decompose nitrogen maximally denitrification process needs carbon [8]. Meanwhile, for TSS parameter, stabilization time does not affect the decrease efficiency of TSS removal. The fluctuated decrease of efficiency value of TSS is caused by the detachment on the media that causes TSS parameter increase and sedimentation time less optimal. Here is the chart of the decrease of COD, TSS and N-Total during running process in the reactor by using coconut fiber 35 gram as the additional media.

**Figure 6.** The relationship between contact time and the percentage of the removal of COD, N-Total and TSS using coconut fibers 35 during running process

Figure 6, in wastewater treatment using SBR, anaerobic-aerobic conditioning is performed. In this study, stabilization time is a condition where the aeration phase was inactivated for: 6 hours in total residence time 23 hours, 8 hours in total residence time 25 hours, and 10 hours in total residence time 27 hours, and it was followed by the aerobe phase where aeration was reactivated for 15 hours. Based on the Figure 8, the effect of stabilization time on the decrease of COD and N-Total is the longer stabilization time is operated, the higher value of the decrease efficiency will be.

3.3. **Identification of microorganism in sequencing batch reactor**

The identification of microorganism in SBR using additional media was conducted to find the types of microorganism taking a part in the process of removing organic pollutant during the reactor was operating. In this treatment, microorganisms take important role in decomposing organic materials in wastewater. This identification was conducted to identify the characteristics of bacteria as biofilm in coconut fibers and palm fibers, that dominant genus of microorganisms that took a part in SBR was *Micrococcus* that was aerobe and *Bacillus* that was fluctuated. This identification was conducted in biofilm attaching/sticking to the media. *Bacillus* and *micrococcus* play a role in denitrification process. In the anaerobic condition (oxygen free) with the existence of organic substrate (carbon),
denitrification organism such as bacillus, *Micrococcus*, can use nitrate as the electron acceptor during the process of respiration.

4. Conclusion
The use of SBR with additional media could degrade organic compounds well. The efficiency of COD removal in palm fiber 35 gram in weight reached 73.26%, 77.11%, and 77.6% in each residence time. In the reactor with coconut fibers 35 gram, the decrease efficiency of COD reached respectively 80.23%, 81.93%, and 85.11% in each residence time. However, for the TSS parameters, it was not optimally reached as the optimal removal released was 58.82% for all media. Residence time affected on the decrease of parameter concentration, in which 27 hours was the best residence time used to decrease organic compounds in the domestic wastewater. Microorganism in the SBR that degraded organic compounds in the domestic apartment wastewater were *Micrococcus*, and *Bacillus*.

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