# PROCESSING OF COAGULATION FLOCCULATION SEQUENCING BATCH REACTOR (SBR) IN KEBON AGUNG RIVER AS CLEAN WATER

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## ABSTRACT

River water treatment uses a Sequencing Batch Reactor (SBR) with cassava peel adsorbents, meranti wood powder, and PAC. After going through the Sequencing Batch Reactor, (SBR), it will give disinfection to reduce the levels of E. Coli and total coliform in the water. It is expected to be able to set aside levels of turbidity, color, TDS, taste, odor, total coliform, E.Coli, nitrate, nitrite, hardness, and organic matter ($KMnO_4$). The river water to be treated comes from the coagulation-flocculation process. Making variations of HRT and adsorbent. The hydraulic retention time variations compared were 6, 9, and 12 hours. There are 3 reactors with 1 control reactor, which includes a control reactor without adsorbent and one with PAC adsorbent. The conditions chosen at the reaction stage are aerobic. The removal efficiency of the color parameter is 8.4%, the total coliform parameter is 94.6%, the parameter e.coli 95.2%, the nitrate parameter is 52.6%, the nitrite parameter is 14.3%, and the organic matter parameter is 7.8%. At the same time, the parameters have increased by 2%. The best HRT in reducing pollutant levels in this study was 12 hours HRT for the SBR reactor with cassava peel adsorbent sowing placement, 6 hours HRT for the SBR reactor with meranti wood powder adsorbent sowing placement, and 6 hours HRT for the SBR reactor with top placement PAC adsorbent. The best effectiveness of the Sequencing Batch Reactor (SBR) in treating Kebon Agung River water is by adding meranti wood powder adsorbent by placing sprinklers.

**Keywords**: *SBR, Coagulation, Flocculation, Cassava Peel, Meranti Wood Powder*

## 1. INTRODUCTION

Kebon Agung River is located in front of the Campus UPN "Veteran" East Java and is a water channel that can be used as raw water as clean water. Geographically, Kebon Agung River is located in the southern part of Surabaya Jambangan District and empties into the seaside of East Surabaya at Rungkut District. Kebon Agung River has a length of 11 kilometers, about 7-12 meters wide (Pitaloka & Lasminto, 2017). Several factors can pollute the Kebon Agung River, such as laundry activities, domestic activities, and several industries around the Kebon Agung River.

Based on previous research, Sequencing Batch Reactor (SBR) is a cyclical process. Each cycle consists of phases charging, reaction, settling, draining, and phase preparation. SBR has the effectiveness of removing organic materials on domestic waste in the form of a total N reached 84.30%. (Febriana and Hendrasarie, 2022). While on the color parameter, SBR has the efficacy of eliminating The color parameter in batik industrial waste comes to 87.9% (Hendrasarie and Pratama, 2021).

There is a preliminary study in this study; namely, river water is processed first using flocculation coagulation to reduce water pollutant levels. The flocculation coagulation process is one method to separate suspended solids and colloidal particles. The coagulant used in this study was Poly Aluminum Chloride (PAC). PAC will be effective in pH 6-9 (Andriani *et al.*, 2017). In contrast to alum coagulant, excessive use of PAC will not cause the water to become cloudy (Jadid *et al*., 2019).

Based on this background, this research is about a water treatment river using a Sequencing Batch Reactor (SBR) with cassava peel adsorbent, meranti wood powder, and Powder Activated Carbon (PAC) as a control. There is preliminary research using coagulation and flocculation to reduce water pollutant levels. After going through SBR will be given disinfection to reduce levels of E.Coli and total coliform in water. With this research, it is expected to be able to set aside levels of turbidity, color, TDS, taste, odor, total coliform, E.Coli, nitrate, nitrite, hardness, and organic matter ($KMnO_4$) in Kebon Agung River water.

## 2. METHOD

### 2.1 Preparation of Tools and Materials

Tools: Jar test, Reactor, and Laboratory instruments
Materials: River water, PAC coagulant, adsorbent (cassava peel, meranti wood powder, and PAC), Chlorine disinfectant.

The adsorbent is made from cassava peel and sawdust meranti with a particle size of 100 mesh. In its manufacture, each adsorbent is activated in different ways. And there are Powder Activated Carbon acts as a control for both adsorbent variations in this study.
According to Nisya *et al*. (2022), before making the cassava peel into activated carbon, the cassava peel was cleaned, cut into small pieces, and dried in the sun to dry for 2 days. After drying, please put it in the oven for 3 hours at a temperature of 105˚C. After drying, the cassava peel was crushed to a 100 mesh sieve and put into a glass beaker containing 2% $H_3PO_4$ solution to be soaked for 24 hours. The cassava peel soak was then washed with distilled water to neutralize the pH and returned to the oven at 105˚C for 3 hours.

Activated carbon is inserted into the reactor between the fill phase and the aeration phase (reaction) with a dose of 4 g/L with a volume of treated water of 6 L. In this study, the adsorbent mass determined is 0.6 g/L with a volume of treated water 5L. The design of the SBR reactor used to treat the water of Kebon Agung River is as follows.

Table 1. SBR Reactor Diameter Design

| No. | Design | Unit | Score |
|---|---|---|---|
| | Reactor Volume | | |
| | total volume | L | 6 |
| 1 | Working volume | L | 5 |
| | mud volume | L | 2 |
| | Wastewater volume | L | 3 |
| | Reactor Dimensions | | |
| 2 | Diameter | cm | 20 |
| | T all | cm | 20 |
| 3 | Residence Time | o'clock | 1 1 ; 1.5; 2 |

The SBR design and reactor arrangement scheme used are as follows:

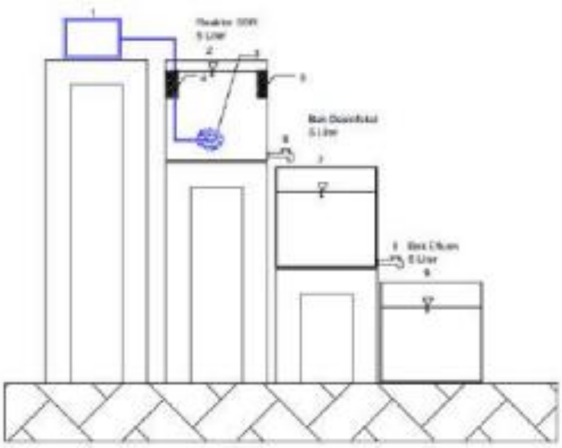

Figure 1. Schematic of the Reactor Arrangement
(Source : Research, 2022)

Information:
1. Air pump
2. 5 liter SBR reactor
3. Aerators
4. Adsorbent laying on the left side
5. Adsorbent laying on the right side
6. Reactor outlet to disinfection basin
7. Disinfection
8. Disinfection bath outlet to effluent bath
9. Treated water effluent bath

**Initial Characteristic Test**

Initial testing of river water was carried out in order to determine the characteristics and content values of each test parameter.

Table 2. Analysis Result

| No. | Parameter | Score |
|---|---|---|
| 1. | Turbidity | 12.5 NTUs |
| 2. | Color | 40.1 TCU |
| 3. | Dissolved solids (Total Dissolved Solid) | 398 mg/l |
| 4. | Temperature | 28°C |
| 5. | Flavor | Tasteless |


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| No. | Parameter | Score |
|---|---|---|
| 6. | Smell | Smell |
| 7. | pH | 7,2 |
| 8. | Total coliforms | 1.83 x 107 CFU/100 ml |
| 9. | E. coli | 1.83 x 107 CFU/100 ml |
| 10. | Hardness (CaCO3) | 186.3 mg/l |
| 11. | Nitrate | 0.19 mg/l |
| 12. | Nitrite | 0.014 mg/l |
| 13. | Organic matter (KMnO4) | 9.33 mg/l |
| 14. | *Dissolved Oxygen*(DO) | 1.2 mg/l |

**Flocculation Coagulation**

The dose of coagulant in this study was varied, namely 60, 70, and 80 mg/L. The fast stirring time was varied for 30 seconds, 45 seconds, and 60 seconds with a stirring speed of 140 rpm. As for the old stirring, variations were carried out for 10 minutes, 15 minutes, and 20 minutes with a stirring speed of 20 rpm. The best result from the above variation will be used as the influent SBR.

**Main Research**

The primary research is carried out after the coagulation-flocculation process ends. In this study, the reactor used was 5 L. Furthermore, the research was carried out by varying the HRT and adsorbent mass. The variations of hydraulic retention time compared were 6 hours, 9 hours, and 12 hours. After the effluent water is removed, it enters the disinfection stage to remove E.Coli levels in the water.

Table 3. HRT Timing

| Stage | Distribution of time per HRT (minutes) | | | Information aeration |
|---|---|---|---|---|
| | 6 hours | 9 hours | 12 hours | |
| *Fill* | 15 | 15 | 15 | *On* |
| *react* | 275 | 415 | 555 | *On* |
| *Settle* | 40 | 60 | 80 | *off* |
| *Draw* | 10 | 10 | 10 | *off* |
| *Idle* | 20 | 40 | 60 | *On* |
| Total | 6 hours | 9 hours | 12 hours | - |

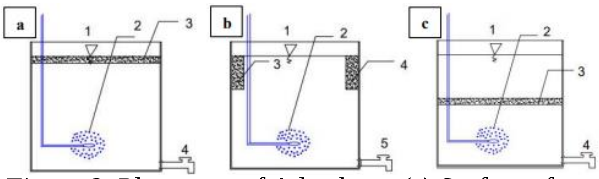


Figure 2. Placement of Adsorbent: (a) Surface of SBR, (b) Right and Left Side of SBR, (c) Sprinkled on In SBR (Source: Research, 2022)

Information 2.a:
1. 5 liter SBR reactor
2. Aerators
3. Adsorbents
4. Reactor outlet to disinfection basin

Information 2.b:
1. 5 liter SBR reactor
2. Aerators
3. Adsorbent laying on the left side
4. Adsorbent laying on the right side
5. Reactor outlet to disinfection basin

Information 2.c:
1. 5 liter SBR reactor
2. Aerators
3. Adsorbents
4. Reactor outlet to disinfection basin

**Advanced Research**

The addition of disinfection in the form of chlorine in this study was based on research conducted by Agustina and Komala (2014), adding chlorine at a dose of 0.5 mg/L and a contact time of 30 minutes. The elimination of E. Coli bacteria was 100%, and residual chlorine was 0.2 mg/L, while the efficiency of E.Coli bacteria in water samples was 99.61% with residual chlorine of 0 mg/L. The following is a matrix of variables in preliminary research, and it can be seen in Table 4.

Table 4. Preliminary Research Variable Matrix

| Coagulation-flocculation independent variable | | | |
|---|---|---|---|
| **PAC concentration** | **1 minute coagulation & 10 minute flocculation** | **2 min coagulation & 15 min flocculation** | **3 min coagulation & 20 min flocculation** |
| 60mg/L | *Jartest*A1 | *Jartest*A2 | *Jartest*A3 |
| 70 mg/L | *Jartest*B1 | *Jartest*B2 | *Jartest*B3 |
| 80 mg/L | *Jartest*C1 | *Jartest*C2 | *Jartest*C3 |

After the preliminary research was carried out, the best decrease in TDS and turbidity levels was obtained, followed by the main research using the best effluent from the preliminary research which can be seen in Tables 5, 6, 7, and 8.

Table 5. Main Research Variable Matrix (Adsorbent mass and HRT)

| SBR independent variable | | | |
|---|---|---|---|
| **Type of adsorbent** | **HRT 6 hours** | **HRT 9 hours** | **HRT 12 hours** |
| Cassava peel | A1 reactor | A2 . reactor | A3 reactor |
| Meranti Wood Powder | Reactor B1 | B2 . reactor | B3 reactor |
| PACs (control) | C1 reactor | C2 . reactor | C3 reactor |

Table 6. Main Research Variable Matrix (Table 5 and Adsorbent placement)

| SBR independent variable | | | |
|---|---|---|---|
| **Adsorbent placement** | **A1** | **A2** | **A3** |
| On | A1-1 . reactor | A2-1 reactor | A3-1 . reactor |
| Right & left side | A1-2 . reactor | A2-2 reactor | A3-2 . reactor |
| sown | A1-3 . reactor | A2-3 . reactor | A3-3 . reactor |

Table 7. Main Research Variable Matrix (Table 5 and Adsorbent placement)

| SBR independent variable | | | |
|---|---|---|---|
| **Adsorbent placement** | **B1** | **B2** | **B3** |
| On | B1-1 . reactor | B2-1 . reactor | B3-1 reactor |
| Right & left side | B1-2 . reactor | B2-2 . reactor | B3-2 . reactor |
| sown | B1-3 reactor | B2-3 . reactor | B3-3 reactor |

Table 8. Main Research Variable Matrix

| SBR independent variable | | | |
|---|---|---|---|
| **Adsorbent placement** | **C1** | **C2** | **C3** |
| On | C1-1 reactor | C2-1 reactor | C3-1 . reactor |
| Right & left side | C1-2 reactor | C2-2 reactor | C3-2 reactor |
| sown | C1-2 reactor | C2-2 reactor | C3-2 reactor |

## 3. RESULTS AND DISCUSSION

Before the primary research was carried out, a preliminary study, namely coagulation-flocculation, was conducted to reduce the pollutant parameters. The best results of the coagulant variation and the best stirring time on the TDS and turbidity parameters will be used for the coagulation-flocculation process on other parameters. The table below shows the results of the percentage removal for the turbidity and TDS parameters as follows:

Table 9. Result of Analysis of Calculation of Optimum Coagulant Dosage and Stirring Time of Pre-Treatment Process Tubidity Parameters

| Turbidity | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stirring time (minutes)** | **Initial rate (NTU)** | **PAC Dosage (mg/l)** | | | | | | **Clean water quality standard (NTU)** | **Informat ion** | **Drinking water quality standard (NTU)** | **Informati on** |
| | | **60** | | **70** | | **80** | | | | | |
| | | **Effluent rate (NTU)** | **% remo val** | **Effluent rate (NTU)** | **% removal** | **Effluent rate (NTU)** | **% removal** | | | | |
| 1 minute coagulation 10 minutes flocculation | 12.5 | 8.6 | 31.2 % | 8.22 | 34.2% | 7.77 | 37.8% | 25 | Fulfill | 5 | Not eligible |
| 2 minutes coagulation 15 minutes flocculation | 12.5 | 8.41 | 32.7 % | 8.14 | 34.9% | 6.4 | 48.8% | 25 | Fulfill | 5 | Not eligible |
| 3 minutes coagulation 20 minutes flocculation | 12.5 | 8.4 | 32.8 % | 7.65 | 38.8% | 5.77 | 53.8% | 25 | Fulfill | 5 | Not eligible |


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Table 10. Result of Analysis of Calculation of Optimum Coagulate Dosage and Stirrung Time of Pre-Treatment Process TDS Parameters

| TDS | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stirring time (minutes) | Initial level (mg/l) | PAC Dosage (mg/l) | | | | | | Clean water quality standard (mg/l) | Information | Drinking water quality standard (mg/l) | Information |
| | | 60 | | 70 | | 80 | | | | | |
| | | Effluent level (mg/l) | % removal | Effluent level (mg/l) | % removal | Effluent level (mg/l) | % removal | | | | |
| 1 minute coagulation 10 minutes flocculation | 398 | 113.62 | 71.5% | 108.77 | 72.7% | 104.02 | 73.9% | 1000 | Fulfill | 500 | Fulfill |
| 2 minutes coagulation 15 minutes flocculation | 398 | 110.51 | 72.2% | 107.22 | 73.1% | 100.82 | 74.7% | 1000 | Fulfill | 500 | Fulfill |
| 3 minutes coagulation 20 minutes flocculation | 398 | 110.42 | 72.3% | 105.62 | 73.5% | 85.22 | 78.6% | 1000 | Fulfill | 500 | Fulfill |

The effluent from the coagulation-flocculation process will be used as an influent in the Sequencing Batch Reactor (SBR) unit as the primary research of this research. The following is a table of the results of the percentage of removal parameters for color, temperature, taste, odor, total coliform, e.coli, nitrate, nitrite, hardness, and organic matter ($KMnO_4$) as follows:

Table 11. Coagulation Flocculation Analysis Results with 80 mg/l PAC Coagulant with a stirring time of 3 minutes coagulation and 20 minutes flocculation on Parameters Color, Temperature, Taste, Odor, Total Coliform, E.Coli, Nitrate, Nitrite, Hardness, and Organic Substances ($KMnO_4$)

| Coagulants PAC dose 80 mg/l, 3 minutes coagulation 20 minutes flocculation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| No. | Parameter | Initial Rate | Final Rate | % removal | Clean water quality standard | Information | drinking water quality standard | Information |
| 1. | Color (TCU) | 43.8 | 40.1 | 8.40% | 50 | Fulfill | 15 | Not eligible |
| 2. | Temperature (°C) | 28 | 28 | - | Air temperature ±3 | Fulfill | Air temperature ±3 | Fulfill |
| 3. | Flavor | Tasteless | Tasteless | - | Tasteless | Fulfill | Tasteless | Fulfill |
| 4. | Smell | Smell | Smell | - | No smell | Not eligible | No smell | Not eligible |
| 6. | Total coliform (CFU/100ml) | 18,300,000 | 988,200 | 94.60% | 50 | Not eligible | 0 | Not eligible |
| 7. | E.Coli (CFU/100ml) | 18,300,000 | 878,400 | 95.20% | 0 | Not eligible | 0 | Not eligible |
| 8. | pH | 7.2 | 7.3 | - | 6.5 - 8.5 | Fulfill | 6.5 - 8.5 | Fulfill |
| 9. | Total hardness (mg/l) | 186.3 | 190 | -2% | 500 | Fulfill | 500 | Fulfill |
| 10. | Nitrates (mg/l) | 0.19 | 0.09 | 52.60% | 10 | Fulfill | 3 | Fulfill |
| 11. | Nitrite (mg/l) | 0.014 | 0.012 | 14.30% | 1 | Fulfill | 50 | Fulfill |
| 12. | Organic Substance (mg/l) | 9.33 | 8.6 | 7.80% | 10 | Fulfill | 10 | Fulfill |

The data in table 11 shows the optimal HRT with cassava peel adsorbents for the parameters after going through the Sequencing Batch Reactor (SBR) process. The data in table 11 shows the results of the research parameter removal resulting from the coagulation and flocculation process with a dose of Poly Aluminum Chloride (PAC) 80 mg/l with a stirring time of 3 minutes coagulation and 20 minutes flocculation. The parameters of turbidity, color, TDS, total coliform, E. Coli, nitrate, nitrite, and organic matter decreased. While in the entire hardness parameter, there is an increase of 2%.

The data in table 12 shows the optimal HRT with meranti wood powder as an adsorbent on the parameters of turbidity, color, TDS, temperature, taste, odor, total coliform, e.coli, pH, total hardness, organic matter (KMnO4) and DO after going through the Sequencing Batch Reactor (SBR) process.

Table 12. Optimal HRT of Cassava Peel Adsorbent Against Parameters Turbidity, Color, TDS, Temperature, Taste, Odor, Total Coliform, E. Coli, pH, Total Hardness, Organic Substances, and DO

| **Cassava skin 12 hours, sow placement** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **Drinking water quality standards** | **Information** |
| Turbidity (NTU) | 5.77 | 2.87 | 23.20% | 25 | Fulfill | 5 | Fulfill |
| Color (TCU) | 40.1 | 17.8 | 55.60% | 50 | Fulfill | 15 | Not eligible |
| *Total Dissolved Solids*(TDS) (mg/l) | 85.22 | 68.59 | 24.20% | 1000 | Fulfill | 500 | Fulfill |
| Temperature(°C) | 28 | 27.3 | - | Air temperature ±3 | Fulfill | Air temperature ±3 | Fulfill |
| Flavor | Tasteless | Tasteless | - | Tasteless | Fulfill | Tasteless | Fulfill |
| Smell | smelled | No smell | - | No smell | Fulfill | No smell | Fulfill |
| Total coliform (CFU/100ml) | 988,200 | 15811 | 98.4% | 50 | Not eligible | 0 | Not eligible |
| E.Coli (CFU/100ml) | 878,400 | 11419 | 98.7% | 0 | Not eligible | 0 | Not eligible |
| pH | 7.2 | 7.3 | - | 6.5 - 8.5 | Fulfill | 6.5 - 8.5 | Fulfill |
| Total hardness (mg/l) | 190 | 84 | 55.79% | 500 | Fulfill | 500 | Fulfill |
| Organic Substance (mg/l) | 8.6 | 6.2 | 27.91% | 10 | Fulfill | 10 | Fulfill |
| *Dissolved Oxygen*(DO) (mg/l) | 1.2 | 7.14 | - | ≥4 | Fulfill | | |

Table 13. Optimal HRT of Meranti Wood Powder Adsorbent Against Parameters Turbidity, Color, TDS, Temperature, Taste, Odor, Total Coliform, E.Coli, pH, Total Hardness, Organic Substances, and DO

| **Meranti Wood Powder 6 hours, sow placement** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **Drinking water quality standards** | **Information** |
| Turbidity (NTU) | 5.77 | 2.24 | 61.20% | 25 | Fulfill | 5 | Fulfill |
| Color (TCU) | 40.1 | 12.3 | 64.1% | 50 | Fulfill | 15 | Fulfill |
| *Total Dissolved Solids*(TDS) (mg/l) | 85.22 | 28.83 | 66.20% | 1000 | Fulfill | 500 | Fulfill |
| Temperature(°C) | 28 | 27.3 | - | Air temperature ±3 | Fulfill | Air temperature ±3 | Fulfill |
| Flavor | Tasteless | Tasteless | - | Tasteless | Fulfill | Tasteless | Fulfill |
| Smell | smelled | No smell | - | No smell | Fulfill | No smell | Fulfill |

| Meranti Wood Powder 6 hours, sow placement | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **Drinking water quality standards** | **Information** |
| Total coliform (CFU/100ml) | 988,200 | 6917 | 99.3% | 50 | Not eligible | 0 | Not eligible |
| E.Coli (CFU/100ml) | 878,400 | 7466 | 99.15% | 0 | Not eligible | 0 | Not eligible |
| pH | 7.2 | 7.1 | - | 6.5 - 8.5 | Fulfill | 6.5 - 8.5 | Fulfill |
| Total hardness (mg/l) | 190 | 50 | 73.68% | 500 | Fulfill | 500 | Fulfill |
| Organic Substance (mg/l) | 8.6 | 4.58 | 46.74% | 10 | Fulfill | 10 | Fulfill |
| *Dissolved Oxygen*(DO) (mg/l) | 1.2 | 8.568 | - | ≥4 | Fulfill | | |

The data in table 13 shows the optimal HRT with PAC adsorbents for the parameters of turbidity, color, TDS, temperature, taste, odor, total coliform, e.coli, pH, total hardness, organic matter ($KMnO_4$) and DO after going through the Sequencing Batch Reactor (SBR) process.

Table 14. Optimal HRT of PAC Adsorbent Against Parameters Turbidity, Color, TDS, Temperature, Taste, Odor, Total Coliform, E.Coli, pH, Total Hardness, Organic Substances, and DO

| Powder Activated Carbon (PAC) 6 hours, top placement | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **Drinking water quality standards** | **Information** |
| Turbidity (NTU) | 5.77 | 4.05 | 29.80% | 25 | Fulfill | 5 | Fulfill |
| Color (TCU) | 40.1 | 20.8 | 48.10% | 50 | Fulfill | 15 | Does not meet the |
| *Total Dissolved Solids*(TDS) (mg/l) | 85.22 | 56.02 | 34.30% | 1000 | Fulfill | 500 | Fulfill |
| Temperature(°C) | 28 | 27.4 | - | Air temperature ±3 | Fulfill | Air temperature ±3 | Fulfill |
| Flavor | Tasteless | Tasteless | - | Tasteless | Fulfill | Tasteless | Fulfill |
| Smell | No smell | No smell | - | No smell | Fulfill | No smell | Fulfill |
| Total coliform (CFU/100ml) | 988,200 | 15317 | 98.5% | 50 | Not eligible | 0 | Not eligible |
| E.Coli (CFU/100ml) | 878,400 | 13176 | 98.50% | 0 | Not eligible | 0 | Not eligible |
| pH | 7.2 | 7.3 | - | 6.5 - 8.5 | Fulfill | 6.5 - 8.5 | Fulfill |
| Total hardness (mg/l) | 190 | 76 | 60.00% | 500 | Fulfill | 500 | Fulfill |
| Organic Substance (mg/l) | 8.6 | 6.12 | 28.80% | 10 | Fulfill | 10 | Fulfill |
| *Dissolved Oxygen*(DO) (mg/l) | 1.2 | 7.34 | - | ≥4 | Fulfill | | |

For various types of cassava peel adsorbent, the best HRT was obtained, namely 12 hours with the placement of the sowing adsorbent. For multiple types of meranti sawdust adsorbent, the best HRT was received, namely, 6 hours with the order of sowing adsorbent. Whereas in the Powdered Activated Carbon (PAC) adsorbent variation, the best HRT was 6 hours with the top adsorbent placed.

**The optimal HRT Sequencing Batch Reactor (SBR) for nitrate and nitrite parameters**

The following is a decrease in nitrate and nitrite parameters produced during the SBR operating process with optimal HRT which is presented in the Table 15.

In the nitrification process, ammonium decomposes into nitrites and nitrates. The nitrification process is divided into two stages, namely nitritation and nitration. At the nitrating stage, ammonium ions ($NH4+$) oxidation will occur to nitrite ions ($NO2$ -). While in the nitration stage, the oxidation of nitrite ions to nitrate ions (NO3-) will occur. The denitrification process is a process of reducing nitrate compounds to nitrogen gas. The process of nitrification and denitrification requires sufficient oxygen supply. A lack of oxygen supply makes it insufficient to oxidize ammonium to nitrate. With the presence of anaerobic and aerobic reactions, where aerobic reactions take longer than anaerobic reactions, the number of microorganisms for denitrification is very small, so they cannot compete with autotrophic microorganisms or microorganisms in the nitrification process

Table 15. Optimal HRT with Cassava Peel, Meranti Wood Powder, and PAC Against Nitrate and Nitrite Parameters Against Nitrate and Nitrite Parameters

| **Cassava peel<br>9 hours, top placement** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **drinking water quality standard** | **Information** |
| Nitrates (mg/l) | 0.09 | 0.0068 | 92.4% | 10 | Fulfill | 3 | Fulfill |
| Nitrite (mg/l) | 0.012 | 0.0068 | 43.3% | 1 | Fulfill | 50 | Fulfill |
| **Meranti Wood Powder<br>12 hours, sow placement** | | | | | | | |
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **drinking water quality standard** | **Information** |
| Nitrates (mg/l) | 0.09 | 0.003 | 96.7% | 10 | Fulfill | 3 | Fulfill |
| Nitrite (mg/l) | 0.012 | 0.0057 | 52.8% | 1 | Fulfill | 50 | Fulfill |
| **Powder Activated Carbon (PAC)<br>12 hours, side placement** | | | | | | | |
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **drinking water quality standard** | **Information** |
| Nitrates (mg/l) | 0.09 | 0.007 | 92.2% | 10 | Fulfill | 3 | Fulfill |
| Nitrite (mg/l) | 0.012 | 0.0102 | 15.0% | 1 | Fulfill | 50 | Fulfill |

## The Best Variable from Preliminary, Main, and Research Variables Advanced

Based on several variables in this study, the best variables were in preliminary, main, and follow-up research. Table 4.16 Table of the Best Variables from Preliminary Research Variables, table 4.17 Table of the Best Variables from Main Research Variables, and 4.18 Tables of Best Variables from Variables for Follow-up Research along with the outputs of the research.

Table 16. Table of the Best Variables from Preliminary Research Variables

| **PAC Coagulant Dose 80 mg/l, 3 minutes coagulation 20 minutes flocculation** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **Drinking water quality standards** | **Information** |
| Turbidity (NTU) | 12.5 | 5.77 | 53.80% | 25 | Fulfill | 5 | Not eligible |
| Color (TCU) | 43.8 | 40,1 | 8.40% | 50 | Fulfill | 15 | Not eligible |
| *Total Dissolved Solids*(TDS) (mg/l) | 398 | 85.22 | 78.60% | 1000 | Fulfill | 500 | Fulfill |
| Temperature(°C) | 28 | 28 | - | Air temperatur e ±3 | Fulfill | Air temperature ±3 | Fulfill |
| Flavor | Tasteless | Tasteless | - | Tasteless | Fulfill | Tasteless | Fulfill |
| Smell | smelled | smelled | - | No smell | Not eligible | No smell | Not eligible |
| Total coliform (CFU/100ml) | 18,300,000 | 988,200 | 94.60% | 50 | Not eligible | 0 | Not eligible |


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| PAC Coagulant Dose 80 mg/l, 3 minutes coagulation 20 minutes flocculation | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **Drinking water quality standards** | **Information** |
| E.Coli (CFU/100ml) | 18,300,000 | 878,400 | 95.20% | 0 | Not eligible | 0 | Not eligible |
| pH | 7.2 | 7.3 | - | 6.5 - 8.5 | Fulfill | 6.5 - 8.5 | Fulfill |
| Total hardness (mg/l) | 186.3 | 190 | -2% | 500 | Fulfill | 500 | Fulfill |
| Organic Substance (mg/l) | 9.33 | 8.6 | 7.80% | 10 | Fulfill | 10 | Fulfill |
| *Nitrate* | 0.19 | 0.09 | 52.60% | 10 | Fulfill | 3 | Fulfill |
| *Nitrite* | 0.014 | 0.012 | 14.30% | 1 | Fulfill | 50 | Fulfill |

Based on table 16, Table of the Best Variables of Preliminary Research Variables, the optimal dose for preliminary research (coagulation-flocculation) is 80 mg/l with a stirring time of 3 minutes coagulation and 20 minutes of flocculation. Followed by the primary research, namely Sequencing Batch Reactor (SBR) with Hydraulic Retention Time (HRT) variations of 6, 9, and 12 hours with the addition of 3 variations of adsorbents, namely cassava peel, meranti sawdust, and PAC and placement variations, namely top, side right and left, and sow. The following is table 17, The best Variable Table of the Main Research Variables.

Table 17. The best Variable Table of the Main Research Variables

| Meranti Wood Powder 6 hours, sow placement | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **Drinking water quality standards** | **Information** |
| Turbidity (NTU) | 5.77 | 2.24 | 61.20% | 25 | Fulfill | 5 | Fulfill |
| Color (TCU) | 40.1 | 12.3 | 64.1% | 50 | Fulfill | 15 | Fulfill |
| *Total Dissolved Solids*(TDS) (mg/l) | 85.22 | 28.83 | 66.20% | 1000 | Fulfill | 500 | Fulfill |
| Temperature(℃) | 28 | 27.3 | - | Air temperature ±3 | Fulfill | Air temperature ±3 | Fulfill |
| Flavor | Tasteless | Tasteless | - | Tasteless | Fulfill | Tasteless | Fulfill |
| Smell | smelled | No smell | - | No smell | Fulfill | No smell | Fulfill |
| Total coliform (CFU/100ml) | 988,200 | 6917 | 99.3% | 50 | Not eligible | 0 | Not eligible |
| E.Coli (CFU/100ml) | 878,400 | 7466 | 99.15% | 0 | Not eligible | 0 | Not eligible |
| pH | 7.2 | 7.1 | - | 6.5 - 8.5 | Fulfill | 6.5 - 8.5 | Fulfill |
| Total hardness (mg/l) | 190 | 50 | 73.68% | 500 | Fulfill | 500 | Fulfill |
| Organic Substance (mg/l) | 8.6 | 4.58 | 46.74% | 10 | Fulfill | 10 | Fulfill |
| *Dissolved Oxygen*(DO) (mg/l) | 1.2 | 8.568 | - | ≥4 | Fulfill | | |
| **Meranti Wood Powder 12 hours, sow placement** | | | | | | | |
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **drinking water quality standard** | **Information** |
| Nitrates (mg/l) | 0.09 | 0.003 | 96.7% | 10 | Fulfill | 3 | Fulfill |
| Nitrite (mg/l) | 0.012 | 0.0057 | 52.8% | 1 | Fulfill | 50 | Fulfill |

After the primary research, followed by further research, namely the addition of chlorine or disinfection, whose function is to reduce the content of e.coli and total coliform. In this study, the best variation was a chlorine dose of 3 mg/l with a contact time of 30 minutes. In addition, there is an inspection of residual chlorine in the influent and effluent so that the water is safe to use as clean water. The following table18, Table of the Best Variables of Advanced Research Variables from the two best variations of the primary research added with disinfection.

Table 18. The best Variable Table of the Advanced Research Variables

| **Chlorine dose 3 mg/l, contact time 30 minutes<br>HRT 6 hours Powdered Meranti Wood Sow Placement** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameter** | **Influent** | **Effluent** | **% removal** | **Clean water quality standard** | **Information** | **drinking water quality standard** | **Information** |
| Total coliform (CFU/100ml) | 6900 | 0 | 100% | 50 | Fulfill | 0 | Fulfill |
| E.Coli (CFU/100ml) | 7500 | 0 | 100% | 0 | Fulfill | 0 | Fulfill |
| Residual Chlorine | 0 | 0.2 | | | | 0,2-0,5 | Fulfill |
| **Chlorine dose 3 mg/l, contact time 30 minutes<br>HRT 12 hours Powdered Meranti Wood Sow Placement** | | | | | | | |
| **Parameter** | **Initial rate** | **Final rate** | **% removal** | **Clean water quality standard** | **Information** | **drinking water quality standard** | **Information** |
| Total coliform (CFU/100ml) | 14800 | 0 | 100% | 50 | Fulfill | 0 | Fulfill |
| E.Coli (CFU/100ml) | 9400 | 0 | 100% | 0 | Fulfill | 0 | Fulfill |
| Residual Chlorine | 0 | 0.2 | | | | 0,2-0,5 | Fulfill |

In table 18, the Best Variable Table of Continuing Research Variables, it can be concluded that all of the effluents do not contain E.Coli and total coliform levels, so they meet the quality standards for clean and drinking water. As well as residual chlorine by drinking water quality standards.

Table 19. Residual Chlorine Table

| **Parameter** | **Type of adsorbent** | **Adsorbent placement** | **HRT (hours)** | **Effluent (mg/l)** |
|---|---|---|---|---|
| Residual chlorine | Cassava peel | Top | 6 | 0 |
| | | Right & left side | | 0 |
| | | Sprinkle | | 0 |
| | | Top | 9 | 0 |
| | | Right & left side | | 0 |
| | | Sprinkle | | 0 |
| | | Top | 12 | 0 |
| | | Right & left side | | 0 |
| | | Sprinkle | | 0 |
| | Meranti Wood Powder | Top | 6 | 0 |
| | | Right & left side | | 0 |
| | | Sprinkle | | 0 |
| | | Top | 9 | 0 |
| | | Right & left side | | 0 |
| | | Sprinkle | | 0 |
| | | Top | 12 | 0 |
| | | Right & left side | | 0 |
| | | Sprinkle | | 0 |
| | PAC | Top | 6 | 0 |


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| Parameter | Type of adsorbent | Adsorbent placement | HRT (hours) | Effluent (mg/l) |
|---|---|---|---|---|
| | | Right & left side | | 0 |
| | | Sprinkle | | 0 |
| | | Top | | 0 |
| | | Right & left side | 9 | 0 |
| | | Sprinkle | | 0 |
| | | Top | | 0 |
| | | Right & left side | 12 | 0 |
| | | Sprinkle | | 0 |

**Results of Scanning Electrone Microscope (SEM) Analysis**

Scanning Electron Microscope (SEM) analysis was performed to determine the surface structure of each adsorbent. SEM analysis was carried out at the Instrument Laboratory of UPN "Veteran" East Java, the following are the results of SEM analysis on cassava peel adsorbents, meranti wood powder, and Powder Activated Carbon (PAC). Figure 39 (a) and (b) are the results of SEM analysis on cassava peel adsorbents before treatment. While in Figures 39 (c) and (d) are the results of SEM analysis on cassava peel adsorbent after treatment as an adsorbent on SBR to set aside water pollutant parameters.

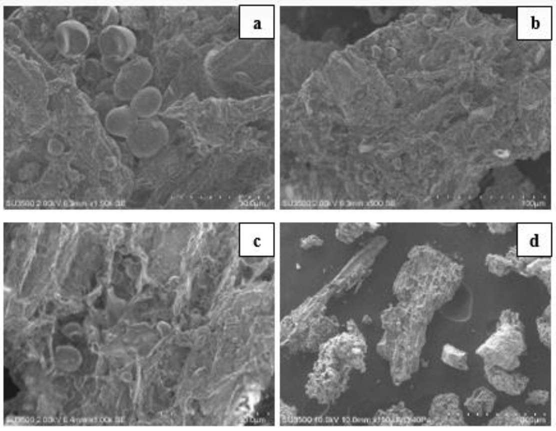


Figure 39. SEM analysis results of cassava peel adsorbent: (a) front view of cassava peel adsorbent before treatment, (b) side view of cassava peel adsorbent before treatment, (c) front view of cassava peel adsorbent after treatment, and (d) side view of cassava peel adsorbent after treatment
(Source: Research Documentation, 2022)

Based on the SEM analysis results above, the morphological structure of cassava peel before treatment as an adsorbent on SBR has irregular pore shape characteristics. So the role of water pollutant removal could be more optimal. Figures 39 (c) and (d) show that the pores covered by the adsorbate are microscopic. This is caused by 7.2% lignin, 13.8% cellulose, and 11% hemicellulose. Hemicellulose and lignin are impurities that cover.

Figure 40 (a) and (b) are the results of SEM analysis on meranti wood powder adsorbent before treatment. While in Figure 40 (c) and (d) are the results of SEM analysis on meranti wood powder adsorbent after treatment as an adsorbent on SBR to set aside water pollutant parameters.

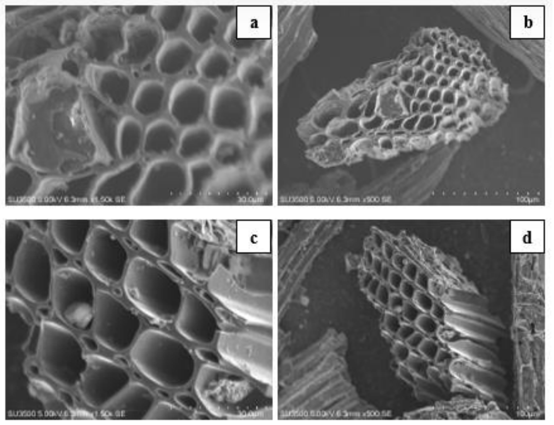


Figure 40. Meranti wood powder adsorbent SEM analysis results: (a) front view of meranti wood powder adsorbent before treatment, (b) side view of meranti wood powder adsorbent before treatment, (c) front view of meranti wood powder adsorbent after treatment, and (d) side view of meranti wood powder adsorbent after treatment.
(Source: Research Documentation, 2022)

The porous structure of meranti wood powder is like a wasp's nest and is regular and has a uniform shape. Based on the SEM analysis that has been carried out, the surface morphology and pore area of meranti wood powder before and after the adsorption process have differences, namely the meranti wood powder adsorbent that has gone through the pore adsorption process is smoother and cleaner, and has no spots on its surface compared to the wood powder adsorbent. Meranti, the pore surface area of the meranti wood powder adsorbent has a smaller size than the pore surface area of the meranti wood powder adsorbent before the adsorption process. In removing pollutant parameters, the adsorbent of meranti wood powder tends to be better than the adsorbent of meranti wood powder.

Figure 41 (a) and (b) are the results of SEM analysis on Powdered Activated Carbon (PAC) adsorbents before treatment. Whereas in Figure 41 (c) and (d) are the results of SEM analysis on the Powdered Activated Carbon (PAC) adsorbent after treatment as an adsorbent on SBR to set aside water pollutant parameters.

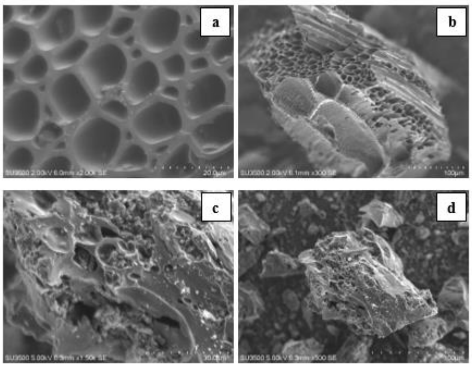


Figure 41. SEM analysis results of PAC adsorbent: (a) PAC adsorbent front view before treatment, (b) PAC adsorbent side view before treatment, (c) PAC adsorbent after treatment, and (d) PAC adsorbent after treatment (Source: Research Documentation, 2022)

The surface pore size of the PAC after adsorption has smaller pore characteristics than before the adsorption process. This is because PAC absorbs the adsorbate in the adsorption process. In this study, the PAC structure was more irregular than the PAC adsorbent so that the removal of several parameters was not superior to PAC. There are several possibilities such as the quality of the PAC and the expiration time of the PAC.

## 4. CONCLUSION

1. The coagulant dose and the best mixing time for coagulation-flocculation in reducing turbidity and TDS levels were 80 mg/l with a stirring time of 3 minutes of coagulation and 20 minutes of flocculation, with a percentage of 53.8% and 78.6%, respectively. The coagulant dose and exciting time were selected to reduce the levels of other parameters. The removal efficiency of the color parameter is 8.4%, the total coliform parameter is 94.6%, the parameter e.coli 95.2%, the nitrate parameter is 52.6%, the nitrite parameter is 14.3%, and the organic matter parameter is 7.8%. In comparison, the parameters have increased by 2%.
2. Hydraulic Retention Time (HRT) is the best in reducing pollutant levels of turbidity, color, TDS, taste, odor, total coliform, e.coli, total hardness, and organic matter in this study at 12 hours HRT for the SBR reactor with cassava peel adsorbent placed sow, 6 hours HRT for the SBR reactor with meranti wood powder adsorbent, and 6 hours HRT for the SBR reactor with PAC adsorbent. Top placement. This is obtained from achieving the highest percentage decrease in parameters from each SBR reactor. While the effective HRT for reducing nitrate and nitrite parameters was 9 hours HRT for the SBR reactor with the top placement of cassava peel adsorbent, 12 hours HRT for the SBR reactor with meranti wood powder adsorbent placed sow, and 12 hours HRT for the SBR reactor with side placement PAC adsorbent.
3. The best type of adsorbent in reducing pollutant levels in the 6-hour HRT was meranti sawdust for sowing. At 9 hours HRT, the type of adsorbent that effectively reduced pollutant levels was meranti wood powder adsorbent for sowing placement. At 12 hours HRT, sawdust placement of meranti had the highest removal efficiency. While the best placement of adsorbents in reducing pollutant levels at 6 hours HRT was the placement of sows with meranti sawdust adsorbent. At 9 hours HRT, placement of sow with meranti sawdust had the highest removal efficiency. At 12 hours HRT, placement of sow with meranti sawdust adsorbent had the highest removal efficiency.

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