Optimization of Sedimentation System through AHP and AHP-TOPSIS Methods in Water Treatment Steam Power Plant

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Abstract. Steam power plants consist of systems such as Water Treatment Plant (WTP) boiler, turbine-generator, and balance of plant. WTP system consists of sedimentation, desalination, and demineralization. The coagulation mechanism triggered by the mass grave of suspended solids during the sedimentation process, and if it is less than optimal, so will be modified by injecting coagulant-flocculant chemicals. The most common problem is the high dose chemicals used in the rain and tidal sea conditions. However, the output water quality that produced still does not reach the standard requirements. This condition would affect the high costs of water treatment operations. It also would have an impact on the poor feed the next system. The jar-testing technique is research using process and operational variables that theoretically influence the efficiency of the coagulant-floculant such as doses, setting times, and rotates agitator. Evaluation of experiments using water quality criteria and data results processed by AHP and AHP-TOPSIS. The sensitivities of both methods are analyzed thus compared to select a consistent alternative that obtained sequence the first alternative for D60W30P80 and the second alternative for D40W20P80. The optimal sedimentation process could potentially save 40-60\% of the water treatment operational cost while operating conditions achieved.

1. Introduction

Pre-treatment water in the aqueous settling basin is a treatment of reduction in suspended reliable content carried by water and is known as the sedimentation process. This experiment took the subject of WTP at the steam power plant in Bangka-Belitung Island with feed seawater depending on seasons and tides, as shown in table 1.

| Criteria     | Measuring values | Dry Season | Rain Season |
|--------------|------------------|------------|-------------|
| Turbidity    | NTU              | 6.6-8.5    | 30-40       |
| Conductivity | µS/cm            | ± 47000    | ± 47000     |
| pH           | value            | ± 8        | ± 8         |
| TSS          | mg/L             | ± 20       | ± 30        |
The cost structure operational steam power plant is divide into two, namely operation and maintenance cost. Operating costs scope are water treatment, steam treatment, and expenses of human resources management, while maintenance cost includes all a maintenance system such as preventive, predictive, proactive, and corrective maintenance. Based on data historical costs in the steam power plant, there are high operational costs of corrective maintenance with scope in water treatment maintenance. WTP consists of several series of systems, and each system produces a product that becomes the feed water for the next system so that the resulting initial feed water qualities are expected the water treatment steam power plant standard requirements. Water treatment scopes such as sedimentation, multimedia filter, Reverse-Osmosis (RO) membrane desalination type, and demineralization.

A problem that often occurs is a short lifetime of the RO membrane, caused by sludges and give effect membrane leakage. The indication is increasing the differential pressure (DP) between the inlet and outlet of the RO membrane. Operating costs for the replacement are quite high with a short time, thus causing an increase in water treatment operating costs. The problem is explored for improvement and is known because less than optimal sedimentation process so that it brings sludge to the RO membrane with indication is the standard value of turbidity $\geq 5$ NTU. Failure of this system has an impact on the next chain systems. Suspended solid that reaches the membrane indicates that minimizing sludge in the sedimentation pond is not sufficient, so it requires evaluation and experiment for trial-error. Therefore, it is essential to focus on improving the early stage of the WTP system, a pre-treatment water system to solve the problem.

The pre-treatment water system in the WTP is a sedimentation system, includes the coagulation-flocculation system. The application here uses additional coagulant-flocculant chemicals because the physical sedimentation process is not yet optimal. The previous scientist gives information that combines coagulant-flocculant is more optimal than coagulant alone and they experimented at industrial textile wastewater [1]. The most common problem in this system is high doses usage of coagulant-flocculant during the rainy and tidal sea conditions are high compared to the dry season. However, the system output water quality still does not reach the water treatment standard requirements.

The previous scientist provides information that using too high and too low doses of coagulants-flocculants does not get optimal results. Above the optimum dosage, re-stabilization may occur due to particulate charge reversal, whereas a lower than optimum dosage may not have for homogenization [2]. Thus, an in-depth study to analyze the cause of this phenomenon needed. The output water quality result of the sedimentation system of the rainy season described in table 2.

### Table 2. The comparison of water quality on rainy season and standard.

| Criteria    | Units | Measuring values | Standard |
|-------------|-------|------------------|----------|
| Turbidity   | NTU   | 8.43             | <5       |
| Conductivity| μS/cm | 48700            | <48900   |
| pH          | value | 7.5              | 7-8      |
| TSS         | mg/L  | 10               | <10      |
| TDS         | g/L   | 24.2             | <24.2    |

Based on table 2, it knows that criteria such as turbidity, Total Suspended Solids (TSS), and Total Dissolved Solids (TDS) do not yet reach the water treatment steam power plant standards at measurement sampling products of the rainy season. The sedimentation system's effectiveness consists of the coagulation-flocculation process closely related to the criteria for the value of turbidity and experiment using the Poly-Aluminum Chloride (PAC) type coagulant can reduce turbidity by 96% [3].
Another experiment using PAC and Poly Acryl Amide (PAM) to determine the effect of the optimum dose using operating conditions such as stirrer rotation and residence time [3] [4]. The jar-test technique use in laboratory-scale experiments with the question taken close to real conditions in the field. The jar-test principle is to conduct repetitive experiments with various variables so that the information about the variable selection that produces the right measurable criteria [1] [2] [3] [4] [5]. Jar test to optimize the dosage of PAC gives information that optimal sludge deposition influenced by pH, turbidity, and alkalinity. The experiment uses a pH of 7, rotating speed of the paddle to 150 rpm, then reduce by 30 rpm for floc formation, and each variable jar test measures using the turbidity criteria [2]. Jar-test results are data criteria with combination process and operation variables of coagulation-flocculation as alternatives. The selection of the best alternative is difficult to ensure the achievement of the decision through a series of activities that analyze the alternative decision solutions, the parameters, and constraints that exist, and then choose the best rather than accept the right choice first and immediately. The selection of the best combinations of coagulation-flocculation often encounters conflicting situations [6] [7]. These alternatives are likely in TDS and TSS reduction, but they still rejected because of the impact of the increase of turbidity and conductivity.

Based on these conditions, it recommends the multicriteria decision making (MCDM) approach used to accommodate alternative selection with multicriteria consideration. It complicates for selection type of MCDM, as each type has advantages and disadvantages. The election often based on the issue structure, the priorities to achieve, and the existence of constraints [6] [7].

2. Method

2.1 Tools and materials
The tools used for this experiment, such as jar-test kit (VELP JLT6), analytic pipette volume (M100, 10-100µL), beaker glass, TSS meter (HACH DR 6000), analytic balance (KERN ABS 220-4), sample bottle, TDS meter (LAQUA HORIBA), pH meter, conductivity meter (METTLER TOLEDO), and turbidity meter (HACH 2100Q).
The materials used such as seawater, demineralized water, coagulant type Poly-Aluminum Chloride (PAC) at a concentration of 25% w/w with continuous injection 30 ppm, and flocculant type anionic Poly Acryl Amide (PAM) diluted to obtain a solution of 0.3% w/w with continuous existing injection 2000 ppm.

2.2 Jar test
The jar-test in this paper type 1 liter beaker glass with the experimental procedures: (i) Placing seawater in beaker glass, then measuring water quality criteria before the coagulation-flocculation system; (ii) Adjusting the rotate agitator at 150 rpm (rapid mixing) accompanied by coagulant addition for 1 min then followed by slow mixing at 40/60/80 rpm as a symbol “P” accompanied by flocculant, which both chemicals follow the doses reduction 20/40/60/80% as a symbol “D”, and then settling times are 10/20/30/40 min as a symbol “W”; (iii) The end of the experiment is to let the sample to measure water quality using pipette volume 5 cm below the water surface; (iv) Measuring water quality using criteria and get data after the coagulation-flocculation system. In this experiment, the results obtained before and after variable treatments.

2.3 Experimental structures
The hierarchy structure for the selection of processes and operations of the sedimentation system, according to figure 1. The decision hierarchy structure obtained by the following: (i) The experiment objective is selection the best alternatives processes and operations of the sedimentation system; (ii) The water quality criteria such as turbidity, conductivity, pH, TSS, and TDS; (iii) The alternatives are a combination of doses reduction (D) 20/40/60/80%, settling times (W) 10/20/30/40 min, and rotates agitator (P) 40/60/80 rpm.
2.4 Data Selection
The jar-test results data are shown 48 alternatives, according to figure 1 as a result of the combination of doses reduction (D), settling times (W), and rotates agitator (P). The water quality of each alternative is measured before and after the coagulation-flocculation process using criteria such as turbidity, conductivity, pH, TSS, and TDS. From the 48 alternatives, the equalization criteria unit calculates with the percentage of increase/decrease of water quality value compare to standards. That calculation performed to obtain real data in the field that presents a 100% dosage.

The next step is to select alternative decisions by data with better criteria or objectives that are more than one in conflicting situations. This judgment uses expert who has experience in water treatment operation. The objective of this selection is to distinguish acceptable or unacceptable alternatives based on the selection of criteria which can cause the selected alternative option to become worse. These judgments are obtained 14 alternatives, according to table 3.

Table 3. The selection data results.

| Alternative symbols | % Increase/decrease of parameters |
|---------------------|----------------------------------|
|                     | Turbidity | Conductivity | pH    | TSS  | TDS  |
| D20W10P40           | 67.1      | 0.63         | 1.50  | 39.4 | 0.42 |
| D20W10P60           | 81.4      | 0.21         | 0.45  | 63.9 | 0.42 |
| D20W30P40           | 72.7      | 0.21         | 1.05  | 60.0 | 0.42 |
| D20W30P80           | 80.1      | 0.42         | 1.00  | 40.0 | 0.42 |
| D20W40P40           | 70.7      | 0.00         | 1.57  | 56.1 | 0.00 |
| D20W40P80           | 67.6      | 0.21         | 1.47  | 30.0 | 0.42 |
| D60W10P60           | 76.1      | 0.42         | 1.24  | 40.6 | 0.42 |
| D60W10P80           | 71.5      | 0.21         | 0.38  | 34.4 | 0.42 |
| D60W20P60           | 67.6      | 0.00         | 0.19  | 29.0 | 0.00 |
| D60W20P80           | 82.9      | 0.21         | 0.14  | 43.8 | 0.42 |
| D60W30P80           | 80.4      | 0.84         | 0.97  | 62.9 | 0.00 |
| D80W10P60           | 76.2      | 0.00         | 0.71  | 53.1 | 0.00 |
| D80W10P80           | 74.6      | 0.00         | 0.28  | 54.1 | 0.00 |
| D80W20P80           | 69.9      | 0.21         | 0.25  | 45.0 | 0.42 |

2.5 The application of MCDM technique
The MCDM technique is an alternative selection process method for obtaining the optimal solution of some decision alternatives by taking criteria or objectives that are more than one in conflicting situations. The MCDM approach has many advantages in terms of transparent, open, and explicit
when selecting targets and criteria involving stakeholders or decision-makers. The process makes analysis open and easy to make changes if needed. The tendency of the uncertain (relative) criteria can use by scoring and weighting. MCDM can be used to screen, prioritize, ranking, or select alternatives based on a human judgment from a series of conflicting criteria with several choices [6] [7]. The previous scientists also have cases of criteria conflict using the MCDM type analytic hierarchy process (AHP) network process (ANP) to select investment in solar thermal power plant projects [8]. AHP used to asset prioritization in maintenance scheduling [9]. The optimum blend selection is complicated because it depends on the criteria so it requires an AHP method to simplify [10]. AHP also used to evaluation of performance leachate concentrate treatment [11].

ELimination Et Choix Traduisant la REalité (ELECTRE) is used to select maintenance key performance indicators [12] and also used for the application of reinforcement of hydropower strategy [13]. Preference Ranking Organization Methods for Enrichment Evaluations (PROMETHEE) used to determine water and environmental resources management strategies with criteria and objectives [7]. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) used to rank several alternative solvents [14].

AHP method is a measurement theory with pairwise comparisons and is based on an expert decision-maker to arrange the priority scale developed by Saaty in mid-1970. In solving multi-criteria problems, an AHP method used to obtain priority based on the decision-maker preference assessment by pairwise comparison representing the essential ability of humans to gradually develop their perceptions, comparing a pair of equivalent solutions to the given criteria. In an AHP method, a relative scale of interest with a Saaty’s Scale of 1-9 and performed by expert judgment. The form of the calculation of this method is the decision matrix, and the system consistency ratio (CR) involving component consistency index (CI) and random index (RI) used in the consistency calculation. The calculation performed by using equation (1) and (2).

\[
CI = \frac{(\lambda_{max}-n)}{(n-1)}\tag{1}
\]

\[
CR = \frac{CI}{RI}\tag{2}
\]

AHP method is generally used extensively by previous scientists, however, in ranking decisions, it has a weakness because it is still based on the relative importance of expert judgment so that to improve, the scientist uses a combination of methods such as the use of AHP-TOPSIS combination to overcome the uncertainty of information loss in group decision making [15]. Goal programming, AHP, and TOPSIS used for the selection of the most critical electrical equipment so that it can determine the maintenance strategy combination [16], AHP-TOPSIS to the selection of an industrial boiler in the soda-ash production plant [17], and to determine cost-benefit decisions in evaluating in ballast water treatment systems [18]. Hybrid AHP and fuzzy TOPSIS to make comparative site selection for solar farm sites [18] [19], and AHP-ELECTRE to evaluate urban transportation projects [20].

When assessing priority rankings, an AHP systematic methodology used through expert judgment based on the relative significance level for criteria weighting. The alternative decision will satisfy the decision-maker according to the desired expectation level and trust in the process. In this paper, AHP and AHP-TOPSIS methods proposed. Although TOPSIS uses the concept of a popular and straightforward method, it often gets input because of its inability to provide space for uncertainty and perception for decision-makers [12]. This study used a combined AHP-TOPSIS method with the principle of using expert judgment perception in uncertainty criteria assessment.

TOPSIS submitted by Hwang and Yoon (1981) and used to determine the ideal positive and negative solution. The best alternative selection is the data that had the shortest distance from the perfect definite answer and the furthest distance from the perfect negative solution. TOPSIS is commonly used to rank alternatives because of its ability to identify the best solution by the system to determine the closest to the positive ideal solution and the worst from a negative ideal solution [18]. Here are the steps of AHP-TOPSIS methods [21].

Step 1. Compiling a normalized decision matrix.
\[ r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad i = 1, 2, \ldots, m; \quad j = 1, 2, \ldots, n \]  

Step 2. Arranging the weight of the normalized decision matrix.

\[ V_{ij} = r_{ij} x w_j \quad i = 1, 2, \ldots, m; \quad j = 1, 2, \ldots, n \]  

\[ \sum_{j=1}^{n} w_j = 1 \]  

Step 3. Determining the positive and negative ideal solution.

\[ A_i^+ = \{ (v_{ij}^+, v_{j2}^+, \ldots, v_{jn}^+) \} = \{ \{ \max_i v_{ij} \mid j \in S_b \}, \{ \min_i v_{ij} \mid j \in S_c \} \} \]  

\[ A_i^- = \{ (v_{ij}^-, v_{j2}^-, \ldots, v_{jn}^-) \} = \{ \{ \min_i v_{ij} \mid j \in S_b \}, \{ \max_i v_{ij} \mid j \in S_c \} \} \]  

Step 4. Calculating the Euclidean distance between the positive and negative ideal solutions for each variable.

\[ D_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_{ij}^+)^2} \quad i \in I \]  

\[ D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_{ij}^-)^2} \quad i \in I \]  

Step 5. Calculating the relative closeness to a positive ideal solution for each alternative.

\[ CC_i^+ = \frac{D_i^-}{D_i^+ + D_i^-} \quad i = 1, 2, \ldots, m \]  

Step 6. Selecting a priority ranking by selecting \( CC_i^+ \) maximum.

### 3. Results and Discussion

#### 3.1 Criteria weighting

The criteria are selected based on standard water treatment steam power plant manuals and studies conducted by previous scientists [1] [2] [3] [4] [5]. The criteria weighting proposed using the AHP method with the decision-maker by expert judgment according to the determining qualification. The criteria weighting used to give relative importance among criteria also indicate the degree of influence on water quality. The criteria weighting obtained by the scoring system using a pairwise system of Saaty Scale 1-9 with 1 for equivalent importance about two criteria and 9 for absolute dominance/very important [6] [7]. The scoring system is performed by expert judgment who has experience in water treatment operation according to requirements. The next step is to calculate running using Expert Choice v11 (EC 11) software assistance and the result criteria weighting, as in figure 2.

![Figure 2](image-url)  

**Figure 2.** The criteria weight by expert judgment using the EC 11 software.

Based on figure 2, knows that expert judgment has a tendency to decide turbidity criteria has the highest priority to evaluate water quality, thus followed by TSS. Other criteria measured also affect but less than others. The inconsistency level of that calculation also obtained not to exceed the predetermined standard.
3.2 **Priority ranking selection**

3.2.1 **AHP method.**

In this paper, an AHP method proposed and used for the determination of criteria weighting and priority ranking to select the best processes and operations of the sedimentation system. The selection of AHP for problem-solving due to the simplicity and easy calculation based on expert judgment assessment. Besides, the authors compare the ranking results with the AHP-TOPSIS method combination. The initial stage of the data is a scoring system with a reference limit set by an expert judgment with knowledge and experience in the water treatment steam power plant. The scoring of all criteria aims to create a unit equation so that the authors can compare the criteria with each other. The author decides to use a scoring range of numbers 1-9 where one (1) is poor water quality, and nine (9) is the best. The resulting data then presented in table 4.

| Alternative variables | Scoring results | Turbidity 0.433a | Conductivity 0.097a | pH 0.034a | TSS 0.353a | TDS 0.084a |
|------------------------|-----------------|-------------------|---------------------|-----------|-----------|-----------|
| D40W10P60              | 2               | 9                 | 3                   | 4         | 9         |
| D40W20P80              | 9               | 6                 | 2                   | 9         | 9         |
| D40W30P40              | 5               | 9                 | 2                   | 9         | 9         |
| D40W30P80              | 9               | 9                 | 4                   | 4         | 9         |
| D40W40P40              | 4               | 9                 | 3                   | 8         | 2         |
| D40W40P80              | 7               | 9                 | 4                   | 2         | 9         |
| D60W10P60              | 7               | 9                 | 3                   | 4         | 9         |
| D60W10P80              | 4               | 5                 | 3                   | 3         | 9         |
| D60W20P60              | 2               | 3                 | 2                   | 2         | 9         |
| D60W20P80              | 9               | 3                 | 3                   | 5         | 9         |
| D60W30P80              | 9               | 9                 | 4                   | 9         | 2         |
| D80W10P60              | 7               | 9                 | 2                   | 8         | 2         |
| D80W10P80              | 6               | 4                 | 2                   | 8         | 2         |
| D80W20P80              | 3               | 4                 | 2                   | 6         | 9         |

*a Criteria weight.

The alternative decision matrix with the scoring system arranging thus presented so that with the equivalence all criteria units could be compared with another. Then it is subsequently calculate running to determine the priority ranking using the EC 11 software assistance. The result data presented in figure 3.

![Figure 3. The priority ranking using an AHP method with EC 11 software.](image)
Based on the data obtained in figure 3, the priority ranking for 14 alternatives presented. This result still based on the weight performed by the expert judgment so that if there is a change of decision, the level of consistency rank could not be determined yet, so it requires a sensitivity analysis to determine changes in position if there is an interesting change of decision-makers.

3.2.2 Combination of AHP-TOPSIS methods.
TOPSIS is one type of MCDM that can accommodate real data obtained for priority ranking considerations [14] [15] [16] [17] [18]. When it combined with an AHP method which has advantages in weighting the criteria determinant because of its ability to provide uncertain criteria decisions. This combination expected to complement each other’s so obtained optimal alternative ranking. The following division combined an AHP-TOPSIS method performed: (i) Determine the criteria weights using an AHP method; (ii) Calculate using the TOPSIS method as equation (3) until (10) so the final step has obtained a sequence of priority ranking. The final calculation results shown refers in Table 5.

Table 5. The priority ranking use AHP-TOPSIS.

| Alternative rankings | Alternative variables | CC⁺ values |
|----------------------|-----------------------|------------|
| 1                    | D60W30P80             | 0.764      |
| 2                    | D40W20P80             | 0.622      |
| 3                    | D40W30P40             | 0.583      |
| 4                    | D40W10P60             | 0.514      |
| 5                    | D40W30P80             | 0.477      |
| 6                    | D60W10P60             | 0.473      |
| 7                    | D60W20P80             | 0.442      |
| 8                    | D40W40P40             | 0.433      |
| 9                    | D80W20P80             | 0.413      |
| 10                   | D80W10P80             | 0.410      |
| 11                   | D80W10P60             | 0.407      |
| 12                   | D40W40P80             | 0.320      |
| 13                   | D60W10P80             | 0.313      |
| 14                   | D60W20P60             | 0.009      |

3.3 Sensitivity analysis

3.3.1 Sensitivity analysis of the AHP.
The criteria weighting has a significant influence on the priority ranking sequence. Decision-makers may, at any time, change the provisions that affect the decisions. Therefore, sensitivity analysis recommended using the principle of altering the weighting criteria with the assistance of EC 11 software until there is a significant level of priority ranking changes generated. The proposed sensitivity analysis used is the weighting of the criteria by +10, +20, and -10 percent for each turbidity and TSS which two top priorities. The effect of changing the criteria weights on turbidity, as shown in figure 4-6.
Based on the results of the sensitivity analysis, change in turbidity weight obtained consistent ranking priorities: (i) for change in +10% weight priority sequence 1-3 as shown in figure 4; (ii) +20% weight priority sequence 1-3 as shown in figure 5; and (iii) -10% weight priority sequence 1-3 as shown in figure 4.

The effect of changing the criteria weights on TSS, as shown in figure 7-9.
Based on the results of the sensitivity analysis, change in TSS weight obtained consistent ranking priorities: (i) for change in +10% weight priority sequence 1-5 as shown in figure 7; (ii) +20% weight priority sequence 1-2 as shown in figure 8; and (iii) -10% weight priority sequence 1-3 as shown in figure 9.

Globally, it can conclude that the proposed AHP method after sensitivity analysis tests obtained two consistent priority rankings for the first alternative D60W30P80 and the second alternative D60W30P80.

3.3.2 Sensitivity analysis of the AHP-TOPSIS.

The sensitivity analysis used in AHP-TOPSIS methods refers to the change in criteria weighting in the AHP method because that combines the use of the criteria weights from the AHP method and calculates the ranking system from TOPSIS. Value of changes following the AHP method using the EC 11 software. Based on the results of AHP-TOPSIS methods after sensitivity analysis +10, +20, and -10 percent change in criteria weight, consistency of sequence priority ranking such as: (i) for consistent sequence alternatives of turbidity are sequence 1-8, sequence 1-3, and sequence 1-4; (ii) for consistent sequence alternatives of TSS are sequence 1-4, sequence 1-3, and sequence 1-7.
Globally, it can conclude that the proposed combined AHP-TOPSIS methods after sensitivity analysis tests are obtained three consistent rankings for the first alternative D60W30P80, the second alternative D40W20P80, and the third alternative D40W10P60.

3.3.3 The comparison of priority ranking between AHP and AHP-TOPSIS methods.

The sensitivity analysis results between the two methods, namely, AHP and AHP-TOPSIS, obtained a consistent order of priority ranking alternatives, namely D60W30P80 for first rank and D40W20P80 for the second rank.

3.3.4 The effect of experimental results on water treatment steam power plant.

Infield applications, the coagulant-flocculant dosage can be reduced by optimizing operating conditions such as residence time and mixing. Residence time refers to sufficient time in the settling pond so that the fine floc formed combines and gets bigger and then settles due to mass gravity. Mixing in this experiment is analogous to the rotates agitator which references the operating conditions of the coagulant rapid mixing so that the homogenization process achieved. While to the flocculant, stirring is slow to realize. A state when the floc has begun to form, it does not break due to flow turbulence.

4. Conclusion

This experiment proves that the use of too large a dose coagulant-flocculant still will not optimize the sedimentation system even when reducing the dose, it can improve water quality. The requirement is the operating conditions achieved. The optimal sedimentation process could potentially save 40-60% of the water treatment operational cost.

The recommendation from this study's result is to evaluate the sedimentation pond, including the under flow-upper flow bulkhead, the surface area of the pond, and the location of the coagulant-flocculant injection point so that the settling time of 20-30 min achieved. Besides, it is also necessary to observe flow velocity and floc formation for the evaluation of mixing (rotate agitator).

It is still necessary for further research, such as a pilot experiment test, as a calibration process for the simulation system to improve the validity of the results recommended.

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