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CHARACTERISTICS OF RAW WATER SOURCES AND ANALYSIS OF THE OPTIMAL MODEL OF THE MIXING PROCESS WITH PARAMETER DESIGN IN CLEAN WATER PUMP INSTALLATIONS

Mastiadi Tamjidillah
Corresponding author
Doctorate, Associate Professor*
Email: mastiadit@ulm.ac.id
Muhammad Nizar Ramadhan
Master*
Muhammad Farouk Setiawan
Bachelor Student*
Jerry Iberahim
Bachelor Student*
*Department of Mechanical Engineering
University of Lambung Mangkurat
Jl. A Yani Km 35.5, Banjarbaru, Indonesia, 70714

The quality characteristics of raw water sources in the regional integrated drinking water supply system (SPAM) of Banjarbakula were investigated and found to maintain the supply of drinking water quantity and quality in accordance with drinking water standards. The optimum model for the mixing process of raw water and poly aluminum chloride (PAC) and pump stroke for the input of water sources from rivers to obtain a composition setting that is in accordance with the raw water sources of each region in the region was selected and determined. So the optimum parameter setting model between alum water, raw water and pump stroke for each raw water source is known and is regionally integrated as a result of a comprehensive study. The integration of Taguchi parameter design and response surface can complement each other and become two methods that go hand in hand in the process of optimizing clean water products. Parameter design provides a very practical optimization step, the basis for this formation refers to the factorial fractional experimental design. However, the absence of statistical assumptions that follow the stages of analysis makes this method widely chosen by researchers and practitioners. With the experimental design of the raw water mixing process, turbidity such as 5 lt/sec, 10 lt/sec, 15 lt/sec, 20 lt/sec and 25 lt/sec and % PAC concentration 5 ppm, 10 ppm, 15 ppm, 20 ppm and 25 ppm with a pump installation stroke of 5 %, 10 %, 15 %, 20 % and 25 % were used. In the process of adding PAC, always pay attention and observe the behavior of the attractive force of the floating particles (flock). The particles were then subjected to SEM (scanning electron microscopy) to determine the dimensions of the flock grains deposited

Keywords: characteristics, parameters, setting, supply, turbidity, mixing, concentration, pump, behavior, clean water

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1. Introduction

Raw water (water supply) is very necessary to ensure availability for the clean water treatment process. Good raw water quality describes good natural conditions, so it needs to be maintained to maintain quantity and continuity. Good and sufficient raw water is the hope of the clean water industry and society as consumers for a healthier life. However, the treatment process is important so that the quality is always maintained with raw water conditions that vary in quality. It is everyone's effort to use clean water efficiently to keep it always available, because water is a basic need that must be maintained for survival.

The characteristics of raw water quality vary, because the source comes from rivers with high turbidity levels above 5 NTU (nephelometric turbidity unit), so a water treatment process is needed to reduce the turbidity level. To meet the community's need for clean water that meets health standards, an adequate supply of raw water is needed to maintain the quality and availability for human life. Water sources from upstream must be considered so that these resources are sustainable by taking into account renewable environmental factors that are useful for other activities such as the use of other energy resources.

The quality of raw water decreases due to household activities, soil pollution, water pollution, logging activities and plantation land clearing. In addition to the decrease in raw water quality, this also causes an increase in temperature, sedimentation and organic content due to the opening of new land for agriculture and plantations in the upstream part of the river. The influence of activities upstream of the river causes the quality of raw water to decrease, which will be used as input for processing into clean water. So that an integrated treatment process is needed according to these conditions to get good quality clean water.

The clean water treatment process at the SPAM in the Banjarbakula region continues to be carried out for each region, from the treatment installation only PDAM Bandarmasih, which has a population of almost 200 thousand people, which has been served by 99 % of the community. While the City of Banjarbaru and Kab. Banjar until the end of 2020 with the number of customers reaching 625,000 people with a service coverage of around 80 %. Likewise Kab. Barito Kuala and Kab. Tanah Laut is still below the national target, which is 68 % and the PBB MDGs (Millennium Development Goals) target of 80 %.

In clean water treatment, to reduce the level of turbidity from the water supply, it is necessary to add an appropriate coagulant process to reduce it according to clean water standards. The dose of coagulant is determined using a parameter design with a variety of settings adopting the Taguchi method. For local Indonesia, the raw water source is from the river. It is different from other countries with the same water source, because forest conditions and environmental factors in the upstream of the river greatly affect the level of turbidity.

By improving the mixing process with various variations to get the optimum setting, the Taguchi's approach to lowering turbidity accelerates the formation of floating flocks during the mixing process. The coagulation process aims to reduce turbidity, color and odor through a chemical process used to remove colloidal particles that can disturb the environment. Colloidal particles cannot settle, there must be a suitable coagulant such as PAC to destabilize the particles so that microflocs are formed. The coagulation and flocculation processes in the clean water treatment process with the main parameter setting lowering the turbidity level will produce quality water according to health standards.

In the mixing process at the pump installation, it is necessary to set appropriate parameters to reduce the level of turbidity before and after the mixing process with variations in coagulant addition. Optimal settings will be obtained in this process. A positively charged coagulant is used to attract negatively charged colloidal particles as a flock, which will settle to the bottom of the channel. The behavior of the coagulant that catches floating colloidal particles is observed and scanning electron microscopy (SEM) is performed to determine the dimensions of the flock grains. The results of the deposition process of mixing with various contents of its compounds are given.

Therefore, the clean water treatment process in the WTP (water treatment plant) used for the community and the beverage industry is in accordance with health standards. The characteristics of the input water supply are the basis for determining the selection of coagulant. The input is influenced by organic, inorganic, industrial waste that has not been maximized by implementing waste treatment installations in the form of smelly, hazardous and toxic waste. If the water supply is affected by a large amount of organic waste from tropical forests so that the decrease in water quality is caused by high turbidity, then a coagulant is needed that can catch floating flocks before gravity takes the form of sedimentation.

2. Literature review and problem statement

In the process of mixing with water supply, which is influenced by organic waste predominantly with high turbidity, it is also necessary to improve the condition of the forest and the environment upstream. This condition affects the quality of the input water supply, so appropriate parameter settings are needed in the treatment process. Parameter setting is the main factor in the mixing process to get good quality. It is necessary to use a network system to detect organic waste in raw water supply [1], assess the quality of water sources from rivers and the value of turbidity and sediment aspects [2]. These colloidal particles cannot settle on their own and are difficult to handle physically. The addition of PAC coagulant destabilizes the particles to form microflocs [3]. The microflocs then agglomerate into macroflocs, which can be deposited through the flocculation process. The coagulation process is time-dependent and slow stirring in water. Generally, the flocculation period occurs for 10–30 minutes after the coagulation process [4]. The faster the mixing time, the larger the floc formed with the characteristics of the raw water source, stirring conditions, flocculation time, selected coagulant, and variations in the coagulation concentration will affect the performance of coagulation. The stirring process in the ink industry is faster to reduce waste water [5], while the beverage industry pays attention to the decrease in sediment by setting coagulant ppm [6].

In this clean water treatment plant, the water is supplied from a river with high turbidity above 5 NTU, so it is necessary to add an appropriate coagulant process to reduce turbidity and waste [7]. Many researchers use the addition of conventional coagulant variations with the Jartest method, which is carried out in the process of reducing turbidity [8], but it has not been fast and effective to reduce turbidity at 5–10 NTU levels, as well as using genetic algorithm approaches and artificial neural network methods to find an approach mathematical model is still debatable solution [9]. So it is necessary to propose an improvement in the quality of clean water from the start (off-line quality) with parameter settings that adopt the Taguchi method [10], with a green approach to the mixing process at various levels of turbidity by reducing floating organic waste. The use of chitosan is useful in reducing waste water and color from industry [11], but for water sources from rivers because organic is used other coagulants such as PAC [12]. For local Indonesia, the raw water source from the river is different from other countries with the same water source, because forest conditions and environmental factors in the river upstream greatly affect the level of turbidity. The choice of coagulant is different for each water supply from rivers or other water sources, with the Jartest technique can reduce turbidity, but the use of PAC is even faster in the mixing process [13], with chitosan on coagulation and flocculation reduces color at pH below 5, while river water tends to be above 5 [14].

Colloidal particles that are small and fine are generally negatively charged because river water contains organic or inorganic compounds that cannot be removed by ordinary sedimentation. PAC as a drinking water purification coagulant has a good speed in forming new flocs in the process of mixing clean water. As a basic element, aluminum forms repeating units in long molecular chains, which have a high positive charge and large molecular weight and can reduce flocs in purified water even in certain doses [15]. Thus, PAC combines neutralization and the ability to bridge flock particles so that coagulation takes place more efficiently [16]. PAC can easily neutralize the electric charge on the flock surface and can overcome and reduce the electrostatic repulsion between particles to as small as possible, thus allowing flocks to approach each other (covalent attractive forces) and form larger masses. PAC coagulants can reduce floating flocks in the water supply from rivers, and accelerate sedimentation and reduce non-oily waste water from clean water treatment to customers [17]. The use of PAC above 10 ppm can reduce waste water rather than the use of ultraviolet and chlorine disinfectants [18].

For scenarios of environmentally friendly conditions as a form of sustainable use, natural resources are preserved by taking into account the hydrological cycle of water resources. The use of water resources, especially those from rivers, is very high and worrying. The availability of water supply and its safety are approaching the gray zone and continue to increase, with factor analysis contributing to urban water management [19]. Using fuzzy and TOPSIS can provide information on the availability and contribution of options for the use of water resources [20]. Water quality is strongly influenced by the condition of the river upstream, either organic or inorganic waste. There are several scenarios to make water available for downstream industrial inputs such as drinking water needs. However, the quality of drinking water must be feasible for consumers by reducing disinfectants, which are waste. There are several decision-making criteria to reduce the waste, among others, paying attention to the processing/treatment.

The quality characteristics have been widely studied, both in the manufacturing industry, the water industry and the chemical industry, in the opinion that water sources from upstream must be considered so that the availability and quality of water are better. However, this resource must be sustainable by taking into account renewable environmental factors that are useful for other activities such as the use of other energy resources. The quantity factor must be considered to ensure the availability of raw water [21].

Research on the relationship between raw water quality parameters, chlorine requirements and disinfectant content of drinking water has been carried out [22]. The use of appropriate chlorine will minimize disinfectants so that the quality of drinking water supplied to customers will be maintained according to standards. The model obtained for clean/drinking water treatment conditions in Malaysia shows that there is a relationship between the need for chlorine to reduce disinfectants and improve product quality, the parameters of raw water content also affect the final product and require treatment in its processing.

In the mixing process at the pump installation, it is necessary to set appropriate parameters to reduce the level of turbidity before and after the mixing process with variations in coagulant addition. Optimal settings will be obtained in this process. A positively charged coagulant is used to attract negatively charged colloidal particles as a flock, which will settle to the bottom of the channel. The behavior of the coagulant that catches floating colloidal particles is observed and scanning electron microscopy (SEM) is performed to determine the dimensions of the flock grains. The results of the deposition process of mixing with various content of its compounds are given.

With the condition of the input water supply characteristics in clean water treatment, especially the mixing process segment to reduce the level of turbidity due to organic waste, it is necessary to set parameters from the beginning before and after the mixing process.

3. The aim and objectives of the study

The aim of the study is to obtain the optimal parameter setting model was to reduce the level of turbidity and investigate the behavior of floating flocks in the mixing process.

To accomplish the aim, the following objectives were set:

– to determine the turbidity characteristics of water before and after the mixing process;

– to determine optimal parameter setting in the mixing process of PAC (coagulant), raw water and pump stroke;

– to determine the behavior of the flow and floating flocks, as well as to determine the microstructure of the mixing process.

4. Materials and methods

Before the mixing process, normality test and turbidity contour level were used to test the data whether the data were normally distributed for the turbidity parameter and information on the distribution of the data, while the counter explained the position of the data distribution in sampling, which was determined about the raw water turbidity parameters and the turbidity of the mixing process. The dosing pump is designed to drain the PAC coagulant flow fluid into the water fluid. This pump generates a coagulant flow rate by the mixing method set from the valve to deliver the liquid PAC discharge into the dosed reservoir. This pump is very helpful in the process of mixing clean water treatment for coagulant variations, which are controlled internally to vary the flow rate and dosage amount.

Taguchi's method is used for parameter setting and integration of the most influential waste output to improve the quality of clean water products, reduce turbidity levels with variations in coagulant doses, optimal mixing process. The target of this method is to make clean water products less sensitive to noise, so it is called a robust design [26] like the concept below:

– the turbidity characteristics of water before and after the mixing process, with the experimental design of the raw water mixing process (turbidity) such as 5 lt/sec, 10 lt/sec, 15 lt/sec, 20 lt/sec and 25 lt/sec and % PAC concentration 5 ppm, 10 ppm, 15 ppm, 20 ppm and 25 ppm with a pump installation stroke of 5 %, 10 %, 15 %, 20 % and 25 %;

– by the parameter settings above, the optimal parameter settings are obtained to reduce the level of turbidity;

– observing and identifying the behavior of floating flocks to sedimentation for SEM.

According to [23], the advantages of the Taguchi method compared to other experimental designs are because it is more efficient in experiments involving many factors but the number of experimental units required is relatively small, the product is more consistent and less sensitive (robust) to variability caused by factors that cannot be controlled (noise). The objective function of the Taguchi method for a robust design that is resistant to noise is derived from measuring product quality using a quadratic loss function in a broader definition to produce an optimal design or parameter setting. Signal to noise ratio (SNR) in the experimental design system of this method provides a comparison of quantitative values for response variations to determine the optimum parameter settings.

The most important hope in the robust design of the Taguchi method, especially parameter setting, is to examine the effect of variability on factors and experimental levels using statistical tools. To help full factorial, large, time-consuming and costly experiments, Taguchi suggests using orthogonal arrays (OA) to represent the range of possible experiments. After conducting the experiment, all experimental data were evaluated using analysis of variance (ANOVA) to determine the optimum parameter settings [24, 25].

This method is to determine the factors that influence an optimum response with its characteristics. The Smaller The Better (STB) quality characteristic indicates that the smaller the characteristic parameter, the better the quality. Larger The Better (LTB) indicates that the larger the characteristic parameter, the better the quality will be, and the Nominal The Better (NTB) quality characteristic means that the quality will be said to be getting better if it is close to the nominal (target) that has been set through parameter design and response for clean water with various concentrations and levels [26, 27].

The conceptual development of the model structure based on the setting of clean water parameters and the optimization model for the mixing process can be seen in Fig. 1 below.

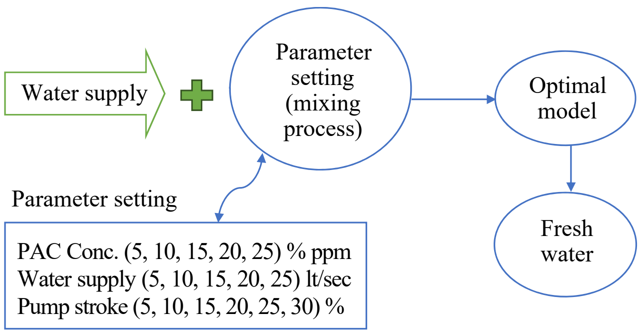


Fig. 1. Parameter setting model in the mixing process

In parameter setting, there is coagulation to remove and separate colloidal particles from natural organic minerals such as mud. These colloidal particles cannot settle naturally having a diameter of less than 1 mm causing color and turbidity. In Fig. 2 below, it can be seen that section 3 is the mixing process for the PAC variation to reduce the level of turbidity, to observe the behavior of the floating flock. In section 4, there is an attractive force that tends to form aggregates while the repulsive force causes a stable colloidal dispersion.

The water supply contained in section 1 flows to section (2) naturally precipitated by gravity, flowing through a transparent glass channel, which is dripped with coagulant with the specified setting. The quality of clean water can be seen in section (5, 6), then in the laboratory test to get the level of turbidity according to health standards.

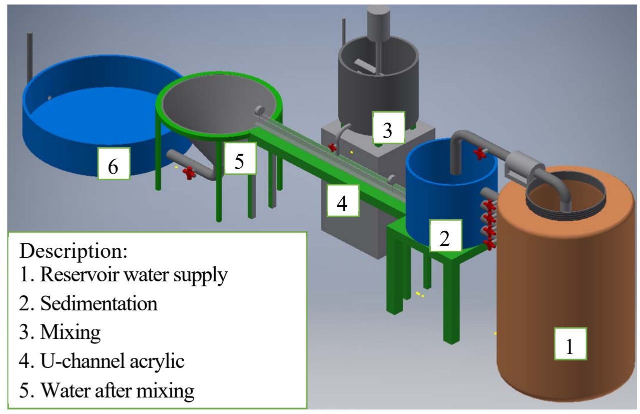


Fig. 2. Research installation

5. Research results of the characteristics of water quality in the clean water treatment plant

5. 1. Turbidity characteristics of water before and after the mixing process

Parameter setting conducted in the mixing process, as shown in Fig. 3 below, shows that the turbidity value of water supply is above 5 NTU (nephelometric turbidity unit), which is the standard value for clean water. With the medium level of concentration (11 to 15 ppm), it is shown that the decrease of turbidity value is in the range of 4–5 NTU at pH 7.1. The turbidity value of water supply and mixing process can also be seen in the contour plot (Fig. 4), which presents the dispersion of turbidity values with a more detailed range system in the position of turbidity value at each change of PAC concentration.

The turbidity level of water supply is averagely 5.8 NTU and the reduction of turbidity of the mixing process is averagely 4.5 NTU as the addition of medium level in coagulant concentration, but the fluctuation approximates the normal distribution as shown in Fig. 5 below.

The variation of turbidity of water supply is influenced by the condition of downstream river, weather and environment of the forest (*a*) and the decrease of turbidity in the mixing process is due to the coagulant setting process (*b*). As the coagulant ppm is getting higher, the turbidity would reduce until reaching the optimum concentration level at the medium level in the condition of water supply, which is 5–7 NTU.

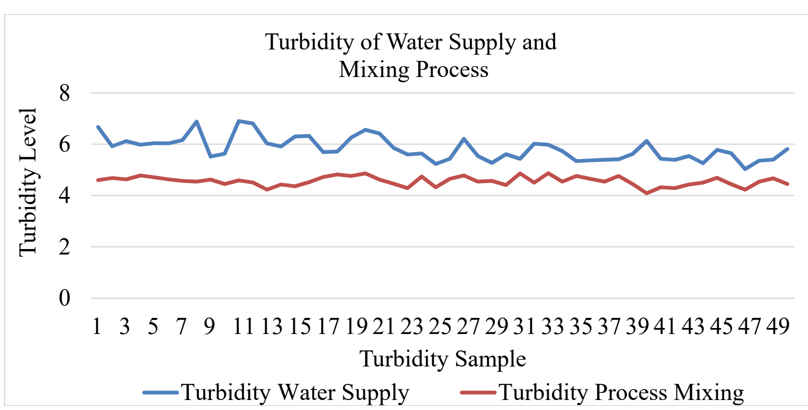


Fig. 3. Turbidity level of water supply and mixing process

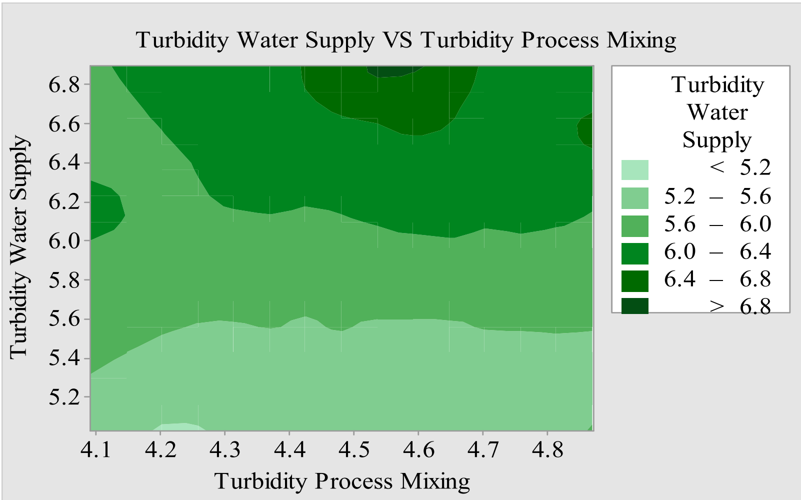
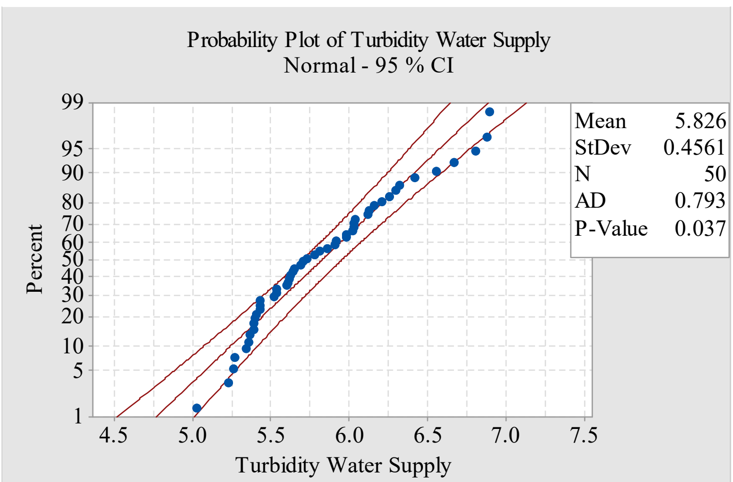
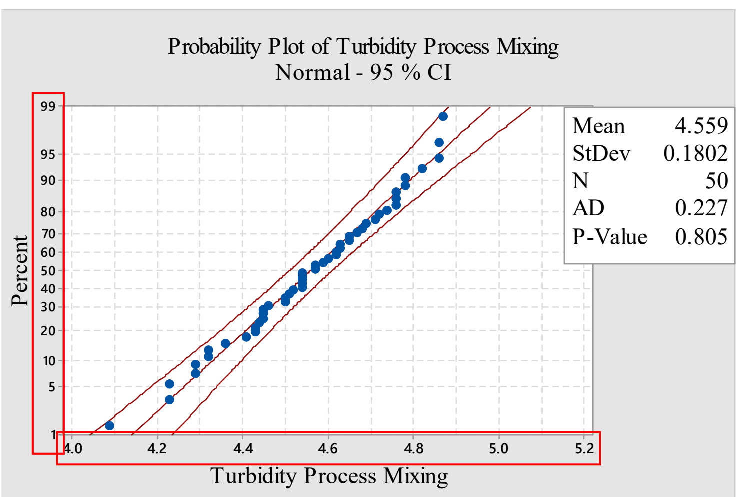


Fig. 4. Contour plot of turbidity of water supply and mixing process



a



b

Fig. 5. Normal turbidity: *a* – water supply; *b* – mixing process

5. 2. Optimal parameter setting in the mixing process of PAC (coagulant), raw water and pump stroke

In the mixing process, turbidity is decreased with the addition of coagulant variations by setting the parameters of the Taguchi method with low level (5–10 ppm), medium level (11–15 ppm) and high level (16–20 ppm) as shown in Table 1 below.

Table 1

Level factor

Parameter	Code	Level 1	Level 2	Level 3	Level 4
Alum conc. (% ppm)	A	5	10	15	20
Water supply (lt/sec)	B	5	10	15	20
Pump stroke (%)	C	15	20	25	30

The change in the concentration level of PAC coagulant starts from low level, medium level, and high level simultaneously with the setting of water supply and pump stroke. The decrease of turbidity level seems better as the raise of coagulant concentration level has positive ions. The positive and negative ions depict the effect and response of variable concentration, water supply, and pump stroke as shown in Fig. 6 and Table 2 below. The plot effect of S/N ratio is in the optimum process of parameter design of the mixing process at various concentration levels.

Table 2

Main effect of the mixing process

Level	PAC	Water supply	Pump stroke
1	4.793	4.775	4.813
2	4.877	4.900	4.782
3	4.775	4.848	4.868
4	4.865	4.787	4.848
Delta	0.102	0.125	0.085
Rank	2	1	3

By looking at the fluctuation of water supply and mixing process turbidity, the model of the mixing process can be predicted at the medium level of 14 and 15 ppm coagulant. Averagely, the prediction model of the mixing process collects the maximum at medium level, which is 15 for the condition of 5–7 NTU.

Optimal mixing process =15 % ppm conc. PAC+15 lt/sec+15 % pump stroke.

The optimal model can be decreased or increased fluctuatively at each 2 point range change of turbidity, for instance 5–7 NTU, 7–9 NTU, and so on. For more detail, every change of ppm concentration, water supply and pump stroke can be seen in Fig. 7 below. At the position of medium level, it can be seen that the turbidity value of the mixing process is at 4.8 NTU and 4.9 NTU, which are close to the health standard. The higher % ppm of PAC causes the turbidity to decrease and the water color turn to transparent. The effect of over PAC would not be harmful to the human body but with a continuous excessive dosage, it would cause side effects in the form of toxins within the human body.

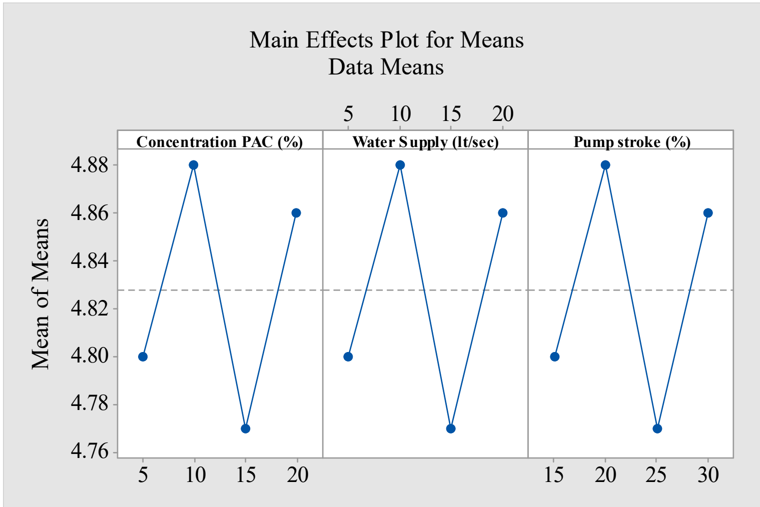
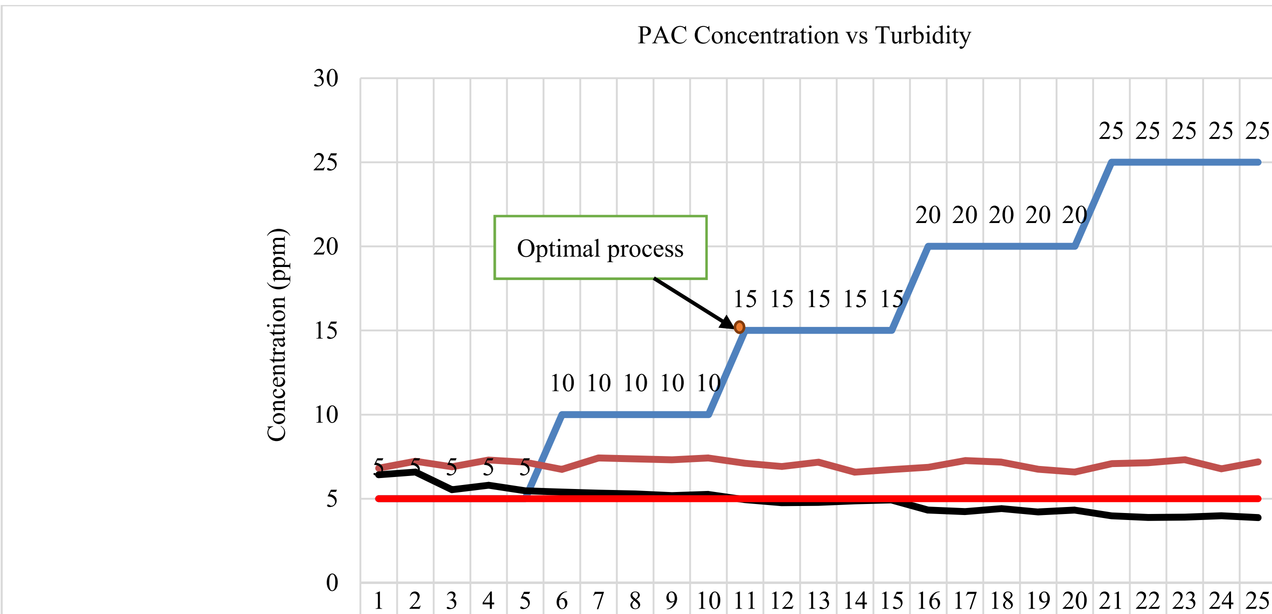


Fig. 6. Response table of variable PAC concentration, water supply, pump stroke



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Conc. PAC (% ppm)	5	5	5	5	5	10	10	10	10	10	15	15	15	15	15	20	20	20	20	20	25	25	25	25	25
Turbidity Water Supply	6,8	7,2	6,9	7,3	7,2	6,7	7,4	7,4	7,3	7,4	7,1	6,9	7,2	6,6	6,7	6,9	7,3	7,2	6,8	6,6	7,0	7,1	7,3	6,8	7,2
Turbidity process mixing	6,4	6,6	5,5	5,8	5,5	5,4	5,3	5,3	5,2	5,3	4,9	4,8	4,8	4,9	4,9	4,3	4,2	4,4	4,2	4,3	4	3,9	3,9	4	3,9
Standart (max 5)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Turbidity standart

Fig. 7. Variation of PAC concentration at each level

In Fig. 7 above, it can be seen that the PAC concentration % at medium level 15 produces a turbidity level of 4.9, close to 5 NTU health standards, so that point becomes optimal. If you add more PAC at levels 20 and 25, the clean water is close to white color, which can be harmful to health if used continuously because of the effect of high coagulant content.

5. 3. Determination of the behavior of the flow and floating flock, as well as determination of the microstructure of the mixing process

Each change of PAC concentration level causes the change of water turbidity value, colloid behavior and floc formation in the mixing process. Coagulant characteristic whose charge is positive ion would attract negatively charged colloid that is often called as the effect of Van der Waals' attractive force. Proper addition of coagulant concentration would reduce the zeta potential repulsive force in the colloid, thus there are more positive ions than negative ions, which causes a faster floc formation process. With sedimentation process and flock filtration, it would gravitationally precipitate at the bottom surface to furthermore be thrown away since the sedimentation is known as waste in the industry of clean water.

In the mixing process, each variation of water supply, PAC ppm and % pump stroke will affect the level of turbidity due to the addition of coagulant, which will attract negative ions into the flock. Increasing coagulant and pump stroke in the form of pump speed in rpm will accelerate the process of flock formation. Fig. 8, a presents large flocks so that the effect of Van der Waals forces can still be seen. A large attraction by the coagulant will accelerate flock formation.

To observe the Brownian motion, which is in the form of zig-zag line or dash line, the portrayal of molecular kinetic flocs requires a camera magnification of 1000 with the type of digital SEM. In Fig. 8, b, the distance among flocs is getting bigger due to the addition of rpm, then the particle flies slowly to the bottom in groups following the gravitation principle.

are used to see changes in the decrease in turbidity parameters at each level. It can be seen that the mixing process will reduce turbidity by adding variations in the coagulant setting parameters of low level (5–10 ppm), medium level (11–15 ppm) and high level (16–20 ppm) for quality improvement responses. As shown in Fig. 8, c, flock position is not visible in floating conditions and the response of clean water quality increases with the addition of coagulant, but gravitationally settles to the basic plate with a small diameter and separates each grain.

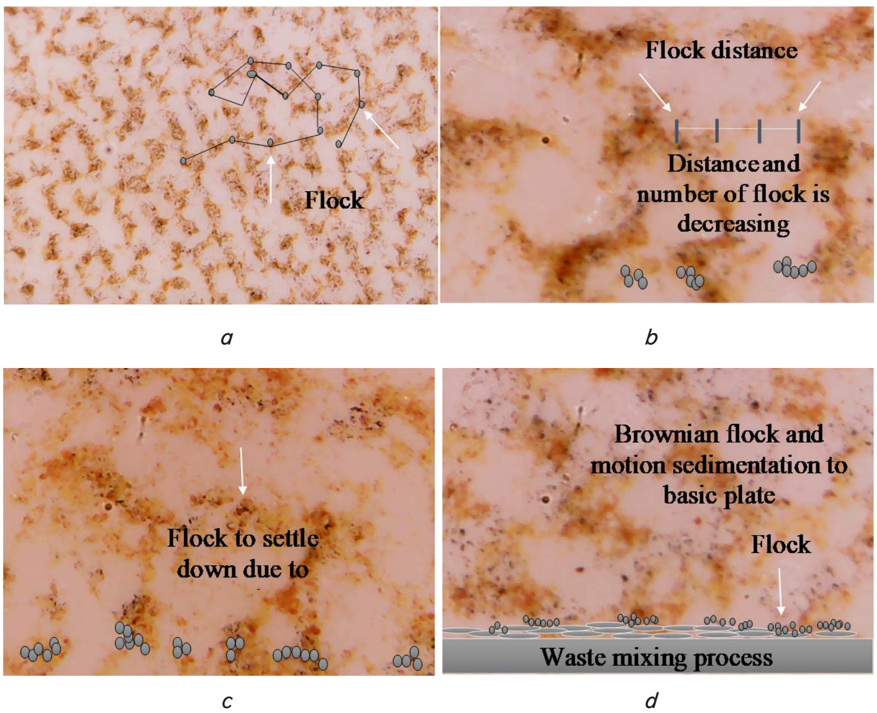


Fig. 8. SEM image of flock: *a* – 5 % ppm; *b* – 10 % ppm; *c* – 15 % ppm; *d* – 20 %–25 % ppm

The level of turbidity of the input water supply is influenced by upstream conditions of the river, organic waste, erosion and a decrease in the quality of the tropical forest environment. It is necessary to set the parameters from the beginning to ensure the composition of the settings in the mixing process to reduce the level of turbidity in the mixing process. The higher the coagulant ppm, the lower the turbidity until it reaches the optimal concentration level at the medium level at a water supply condition of 5–7 NTU with a medium level of 14 and 15 ppm coagulant. Addition of coagulant concentration gradually at medium level starting at point 11–15 ppm (see Fig. 7) at 5–7 NTU conditions (close to max=5 health standard), gradually the floating flock gets smaller and settles to the basic plate like sedimentation as shown in Fig. 8, *d*.

The characteristics of the input water supply as the starting point for selecting parameter settings, because the quality of clean water for the community must be ensured according to health standards. Quality design is set from the beginning of production in the mixing process segment. The new alternative model proposed in the mixing process of % PAC, raw water and % pump stroke in existing conditions exceeds the established health standard. A specific and integrated processing process is required because of the high level of turbidity, using parameter settings while reducing waste and flock with the principle of Green Taguchi.

Moreover, in Fig. 8, *c*, flocs start to precipitate downward closing by the basic plate together with coagulation and flocculation. Meanwhile, in Fig. 8, *d*, the group of flocs is visible until the basic plate with bigger grain and precipitates covering almost the whole surface of the basic plate.

6. Discussion of the research results of characteristics of raw water sources

In the mixing process by setting parameters with factors and levels to get the optimal turbidity conditions of organic waste. The level of turbidity will affect the addition of coagulant, the duration of the mixing process and the waste removed. Thus, turbidity conditions and processing in the mixing process greatly affect the quality of clean water. So we need a quality design from the start in the mixing process to get clean water that is good, fast, economical, efficient and meets consumer desires.

By setting the optimal parameters in the mixing process between % ppm PAC, raw water (lt/s) and % pump stroke. Levels and factors are carried out to obtain results that are in accordance with research conditions or input water supply. Changes in % PAC variation in the mixing process

The limitations of the proposed new model in the mixing process are related to the condition of the research object, while the method is also limited in setting parameters using experimental design principles in the early stages of setting. Have not adopted another method to estimate coagulant dose, while the assumption used is that the parameter data is the same every day.

The limitation of this model is related to the resource capacity of the clean water treatment section and the setting of additional equipment. So that a gradual change is needed, conventionally daily sampling in the mixing process describes the parameters that affect water quality. Especially for water sources from rivers that are specifically intruded by swamp water, the turbidity factor is the most influential factor for setting parameters in the mixing process.

For the process of developing clean water treatment processes that are affected by turbidity in river water sources, measurements of the turbidity level are carried out. This turbidity data is very important in the production process to carry out complex experiments for daily data, but specifically for water sources from rivers that are specifically intruded by swamp water, the turbidity factor is the most influential.

7. Conclusions

1. The variation of turbidity of water supply is influenced by the condition of downstream river and the decrease of turbidity in the mixing process is due to the coagulant setting process. The turbidity would reduce until reaching the optimum concentration level at the medium level in the condition of water supply, which is 5–7 NTU.

2. The decrease in turbidity level in the mixing process is due to changes in parameter settings, the higher the ppm of coagulant, the lower the turbidity until it reaches the optimum concentration level at the medium level in raw water turbidity conditions of 5–7 NTU.

3. In low level coagulants, the attractive force between coagulant and floc is not too large, but for medium and high level, the attraction is stronger because of the nature of the coagulant, which has positive ions. On the other hand, the effect of Brownian motion decreases with increasing % ppm of coagulant because the water tends to be white. If the concentration of coagulant is added again, the floc will decrease by gravity and accumulate to the bottom of the plate in the form of sediment waste.

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