A TURBIDITY REMOVAL STRATEGY FROM THE WATER RESOURCES OF BANDUNG CITY, INDONESIA

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A TURBIDITY REMOVAL STRATEGY FROM THE WATER RESOURCES OF BANDUNG CITY, INDONESIA

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ABSTRACT: Cikapundung and Cisangkuy River are the sources of raw water used by Bandung City. The special characteristics of these water resources are the fluctuations of flow and turbidity in the dry season and the rainy season with the highest turbidity > 600 NTU. The turbidity fluctuation is not significantly followed by the coagulant dose changes. This research was conducted in order to evaluate and strategize the optimal performance of the water treatment plant based on the evaluation of the processed water. The laboratory analysis was carried out to find the dominant parameters, namely turbidity, with the steps such as 1) comparing the coagulation process that has been or has not been through preliminary sedimentation using coagulant polyaluminium Chloride (PAC); 2) observing the stability and efficiency of sediment that resulted by coagulation process for the several variation of time; 3) analyzing the efficiency of the preliminary sedimentation and coagulation process. The results of laboratory analysis show that the optimum time of the deposition processes is 35 minutes with a decrease in turbidity of about > 80%. The highest efficiency of sedimentation processes occur at the initial turbidity of 514 NTU in the amount of 85.02%. The optimum coagulant dosage without using the preliminary sedimentation is reached at initial turbidity of 147 NTU with an efficiency of 99.76%; while those using the preliminary sedimentation are achieved at initial turbidity of 514 NTU with an efficiency of 99.46%. Based on these analyses, it is necessary to adjust the operational process of preliminary sedimentation.

Keywords: Coagulant, Strategy, Turbidity, Water resources, Preliminary sedimentation

1. INTRODUCTION

Cikapundung and Cisangkuy river are the sources of raw water used by Bandung City. The increasing of drinking water demand was higher inversely proportional than the decreasing of the availability and quality of raw water. The special characteristics of raw water are the fluctuations of flow and turbidity in the dry season and the rainy season with the highest turbidity > 600 NTU[1]. Based on observations and data from PDAM (Regional Water Company) Bandung City, raw water sources still meet water quality standards for drinking water even though the turbidity of raw water is often high because of the season changes. Turbidity of water sources is strongly influenced by rainfall fluctuation each month. Rain in the upriver brings many particles of mud, sand and plant debris and even manure that affect turbidity in the river. In the rainy season the turbidity value of raw water can reach ± 600 NTU, whereas in the dry season only ± 100 NTU. At this time, there is a quite important problem in the processing of raw water, because the affixing of coagulants do not inline with the fluctuations of raw water turbidity value every month[2]. In ideal conditions, a good quality of water sources are allocated for drinking water with the aim of improving human health, while the water sources that relatively have low quality can be allocated to the industrial and agricultural needs [3] . The aim of this research is to determine the turbidity removal strategy of Cikapundung River and Cisangkuy River as raw water sources with finding the optimum dosage of coagulant. This research was conducted by comparing the result of coagulation process with and without silt deposition as the ilustration of pre-sedimentation process to optimize the performance of existing water treatment plants.

2. MATERIALS AND METHODS

This research was conducted with experimental methods. The experiments were done to determine the optimum dosage using Polyaluminum Chloride (PAC) coagulant through two ways, ie. with and without silt deposition. This research was conducted at the Laboratory of Environmental Engineering Department, Pasundan University, Bandung - Indonesia. The analyzed variables in this research were the water turbidity (NTU) and the coagulant dose (ppm) which were analysed using jar-test method.

The data collection technique was started with

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the preparation phase such as literature review and field observations. The next stage was collecting secondary data such as the existing data of turbidity fluctuations and coagulant dosage. The next phase was determining the optimum dosage of coagulant using jar test method in two ways, with and without silt deposition. The deposition process used Imhoff cone as a pre-sedimentation process approach. The time variations of the deposition were conducted to determine the optimum time of silt deposition. It was done by checking the turbidity every 5 to 60 minutes for each turbidity variations and calculating the stability of turbidity decreases. The best strategy for turbidity removal was based on the optimum coagulant dosage and whether used or not the pre-sedimentation process. Flow diagram of the research can be seen completely in Figure 1.

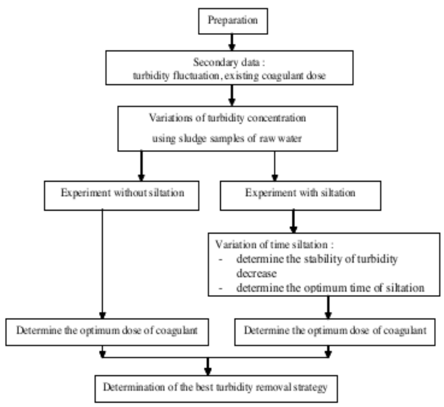

Fig. 1 Flowchart of research

3. RESULTS AND DISCUSSION

Figure 2 and 3 show the turbidity fluctuations in the raw water and coagulant dosage in the existing treatment process from April to August 2014 which represent the dry season and September to December 2014 for rainy season.

Figure 2 and 3 show that turbidity fluctuations were occured in both the rainy season and the dry season. Turbidity fluctuations in the rainy season show the highes concentrations, which reached > 600 ppm. Based on the pictures, its can be seen that the turbidity fluctuations do not result a significant changes in the use of coagulants.

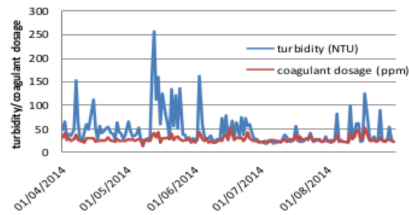

Fig. 2 Turbidity fluctuation and existing coagulant dosage (April – August 2014)[1]

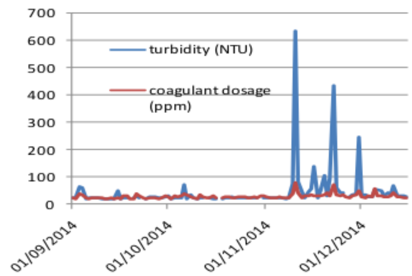

Fig. 3 Turbidity fluctuation and coagulant dosage existing (September – December 2014)[1]

3.1 Determination of The Optimum Coagulant Dose With and Without Silt Deposition

3.1.1 Comparison of the optimum coagulant dose using the same initial turbidity concentration

The experiments were performed by comparing the optimum dose of coagulant carried out with and without the silt deposition.

Table 1 The comparison of the optimum coagulant dosage using the same initial turbidity concentration

Without silt deposition		With silt depositiom		
Initial turbidity (NTU)	Optimum coagulant dose (ppm)	Initial turbidity (NTU)	Turbidity after desposition	Optimum coagulant dose (ppm)
634	98	606	111	40
543	94	514	77	38
435	90	450	70	38
374	40	361	64	30
231	36	223	53	32
147	28	147	47.29	24
99	18	84	36.9	14
25.35	16	28.73	20.98	14

Based on Table 1, it can be seen that the higher of initial turbidity value, the much coagulant dose need. Table 1 and Figure 4 show that the optimum

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coagulant dosage with and without silt deposition have a considerable margin at the high turbidity (> 400 NTU). The silt deposition process at high turbidity can reduce turbidity significantly, more than 80%, so the coagulant dosage can be less than the other.

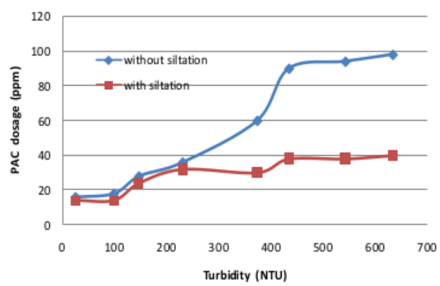

Fig.4 Coagulant dosage with and without siltation process

3.1.2 *Comparison of optimum coagulant dose based on turbidity concentration after deposition process*

The optimum coagulant dose were determined by comparing the optimum coagulant dose on the initial turbidity concentration after the silt deposition process.

Table 2 The comparison of optimum coagulant dosage using the initial turbidity concentration after silt deposition process

Without silt deposition		With silt deposition		
Initial turbidity (NTU)	Optimum coagulant dose (ppm)	Initial turbidity (NTU)	Turbidity after desposition	Optimum coagulant dose (ppm)
112	22	606	111	40
79	20	514	77	38
51	20	147	47.29	24
25.35	16	28.73	20.98	14

According to the table 2 the optimum of coagulant dosage without silt deposition is smaller than the turbidity results from the silt deposition. Here is a comparison graphs of determining the optimum coagulant dose for turbidity removal without silt deposition and using silt deposition.

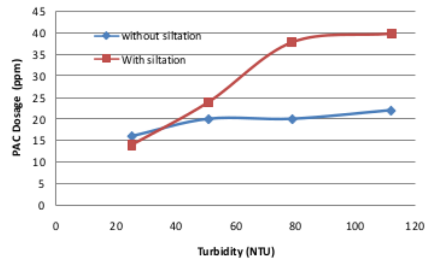

Fig.5 Determination of coagulant dosage using deposition turbidity results

Figure 5 shows that the optimum coagulant dose to remove turbidity from water that has been deposited is greater than the optimum coagulant dose without deposition treatment. Its can be done because the particles in the water sample helps coagulant to react if the turbidity of water sample was not deposited in advance.

3.2 Variation of Time Precipitation To Pre-sedimentation Experiment

The following explaination will be displayed settling time efficiency and the percentage of turbidity reduction.

3.2.1 Precipitation efficiency

The efficiency of deposition was conducted to determine how many percentages for turbidity removal. The experiment was conducted every 5 minutes within 60 minutes.

The results of laboratory experiments that the efficiency of turbidity reduction for 60 minutes for initial turbidity 604 NTU is 89.07%, 559 NTU is 88.73% and 426 NTU is 85.68%.

The experimental results can be seen in Figure 6.

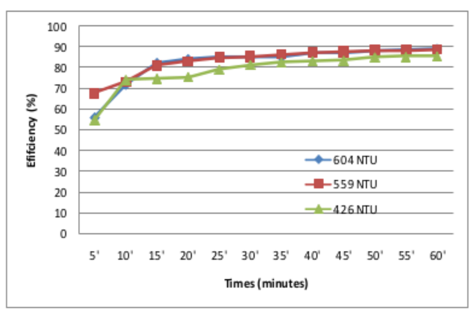

Fig. 6 Efficiency of turbidity reduction without siltation

3.2.2 The stability of Precipitation

The stability of deposition was conducted to determine the time that was need to make the deposition in stable condition, ie two sequential time difference of less than 10% in terms of turbidity before.

The test was done to achieve a steady state condition, ie with fluctuation of 10% . The results of laboratory experiments show that the efficiency of turbidity reduction during the 60 minutes are 89.07% for 604 NTU, 88,73% for 559 NTU, and 88.73% for 426 NTU.

The results of laboratory experiments stated that the turbidity reduction was stable if the precentage of reduction taken at 2 consecutive time less than 10%. The test was done to achieve steady state with the reduction fluctuation of 10%.

Time deposition taken at the initial turbidity of 604 NTU was in 30th minutes with % reduction in 1.11%; at the initial turbidity of 559 NTU, the taken time was in the 35th minutes with % reduction 8.43%; and at the initail turbidity of 426 NTU, the taken time was in 40th minutes with % reduction 4.05%.

3.3 Pre-sedimentation Efficiency and Coagulant Dosage

3.3.1 Efficiency turbidity removal with sludge deposition (pre-sedimentation)

The efficiency of sedimentation was conducted to determine the highest reduction in turbidity performed on sludge deposition process using Imhoff cone. Table 3 below presents data initial turbidity removal efficiency after using Imhoff cone deposited by turbidity variations.

Table 3 Turbidity removal efficiency after using imhoff cone (represent sedimentation process)

Initial Turbidity (NTU)	Turbidity after deposition (NTU)	Efficiency (%)
606	111	81.68
514	77	85.02
450	70	84.44
361	64	82.27
223	53	76.23
147	47.29	67.83
84	36.9	56.07
28.73	20.98	26.98

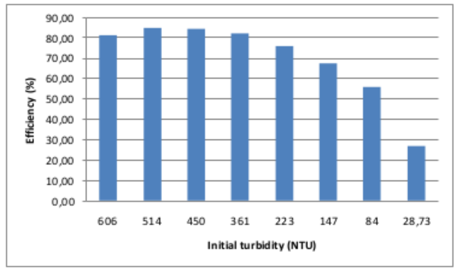

Fig. 7 Turbidity removal efficiency after using omhoff cone (represent sedimentation process)

Table 3 and Figure 7 show that turbidity removal efficiency is greatest at the initail turbidity of 514 NTU in 85.02%. The high turbidity is due to many contained materials such as mud and sand that deposited many small compound turbidity materials. The experiments result that turbidity removal efficiency could be devoted to planning pre-sedimentation on water characteristics of this sample if the efficiency was > 50% which started from turbidity of 84 NTU.

3.3.2 Efficiency Coagulant Dosage Without Sludge Deposition

Table 4 below shows the efficiency of the use of coagulant dosage without sedimentation process.

Table 4 The efficiency of the coagulant dose without sedimentation process

Turbidity (NTU)	Optimum dose (ppm)	Turbidity (NTU)	Efficiency (%)
634	98	4.89	99.23
543	94	4.48	99.17
435	90	2.18	99.50
374	60	4.62	98.76
231	36	4.04	98.25
147	28	0.36	99.76
112	22	3.52	96.86
99	18	2.55	97.42
79	20	2.36	97.01
51	20	4.66	90.86
25.35	16	0.74	97.08

Efficiency of turbidity removal in the experiments was almost the same, that was > 90%, with the highest efficiency was on the initial turbidity of 147 NTU that doses achieving 28 ppm to get the final turbidity of 0.36 NTU with an efficiency of 99.75%.

3.3.3 Efficiency Coagulant Dosage With Sludge Deposition

Table 5 below shows the efficiency of the coagulant dosage with sedimentation process.

Table 5 The efficiency of the coagulant dose with sedimentation process

Initial Turbidity (NTU)	Optimum dose (ppm)	Turbidity (ppm)	Efficiency (%)
606	40	3.48	99.43
514	38	2.78	99.46
450	38	4.29	99.05
361	30	3.34	99.07
223	32	2.19	99.02
147	24	4.77	96.76
84	14	2.9	96.55
28.73	14	1.08	96.24

The highest efficiency occurs at the initial turbidity of 514 NTU using optimum coagulant that dose achieving 38 ppm to get final turbidity of 2.78 NTU with an efficiency of 99.46%.

4. CONCLUSION

There are several conclusions from the research as follows:

1. In the rainy season, fluctuations in raw water turbidity increased significantly in the range of 300-600 NTU.
2. The optimum time of siltation was 35 minutes, with of turbidity removal > 80%.
3. The highest turbidity removal efficiency with the use of coagulants without siltation was occured at the initial turbidity of 147 NTU with an efficiency of 99.76%
4. The highest efficiency of coagulation without siltation was occured at the initial turbidity of 514 NTU with an efficiency of 99.46%

5. ACKNOWLEDGEMENTS

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