Treatment of performance evaluation at Cisauk water treatment plant, Cisauk Sub-district, Tangerang

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Abstract. Cisauk Water Treatment Plant (WTP) is one of the water treatment plants operated by PDAM Tirta Kerta Raharja, Tangerang District, which supply drinking water for Sub districts of Cisauk and Suradita with a capacity of 50 L/sec. This research conducted to evaluate the treatment performance of each unit at Cisauk WTP and compare the quality of water produced with the drinking water standard of PERMENKES No. 492 of 2010. Evaluation of WTP process is conducted by analysing the quantity and quality of produced water, and then calculate of design parameter for each unit. The processing unit consists of intake, hydraulic coagulation, hydraulic flocculation, sedimentation, filtration and ground reservoir. The coagulant used was NUSACHEM with dose of 35 mg/L and the disinfectant used was gas and liquid chlorine with dose of 3-5 mg/L. Through the WTP evaluation of treatment, not all units fulfil the design criteria based on SNI 6774 of 2008. However, the quality of the water produced fulfil the drinking water quality requirements of PERMENKES No. 492 of 2010.

1. Introduction

Population growth and increased human activity along watersheds cause a decrease in water quality [1,2]. Cisadane River is one of the rivers in Indonesia where urbanization, industrialization and agriculture are the main sources of pollution. Cisadane River has a very important function as a source of raw water for the community [3]. Water quality of Cisadane River further downward decreases with higher levels of pollution [4]. Enhancing the quality of water before being used by consumers depends on the efficiency of the processing of drinking water in processing plants which must be safe and within the standard criteria for public health [5,6].

The water which consumed by residents in Indonesia must meet the requirements of the Republic of Indonesia Minister of Health Regulation (PERMENKES) No.492/MENKES/PER/IV/2010 concerning Quality Requirements for drinking water as stated at Peraturan Menteri Kesehatan Republik Indonesia Nomor 492 [7], which includes physical, chemical and biological requirements [8]. Water treatment plants play an important role in efforts to meet the quality of clean water or drinking through physical, chemical and bacteriological processing [9]. Water suppliers use a variety of treatment processes to remove contaminants from raw water. The most commonly used processes include filtration, flocculation, sedimentation and disinfection for surface water [10].

PDAM Tirta Kerta Raharja Tangerang Regency is a government service company that provides clean water services that have a number of drinking water treatment plants, one of which is Cisauk WTP which serves the Cisauk District and Suradita Village. Cisauk WTP has a capacity of 50 L/sec with a processing
unit in the form of intake, coagulation, flocculation, sedimentation, filtration and reservoir. The raw water source used is the Cisadane River. The assessment of the technical condition needs to be considered comprehensively both in structural and technical terms and in operational and technological terms while it is necessary to take into account the quantity and the quality of the produced water [11]. The reference technical specifications of drinking water treatment plants should use the applicable standards, namely Indonesia National Standard (SNI) 6774-2008 concerning the procedures for planning water treatment plant package units and literature on WTP design as stated [12]. Based on these problems, the performance of the Cisauk water treatment plant (WTP) is carried out so that the design criteria for the Cisauk WTP can be used as a reference for the construction of a new WTP. This research is the first study about Cisauk WTP design criteria and water quality of Cisadane river in tropics area.

This study aims to (1) Measure the performance of each unit of the Cisauk Drinking Water Treatment Plant (WTP); (2) Comparing the quality of production water produced by the Cisauk’s WTP with drinking water standards.

2. Method

2.1. Data collection

This research using primary data, which collect from daily activities of each unit of WTP, either head loss, velocity, detention time, include quality of discharge from every unit. Secondary data was obtained from PDAM Cisauk’s Monthly report.

2.2. Data analysis

2.2.1. Calculation and evaluation of existing Conditions of Installation. The operational system analysis of the Water Treatment Plant unit can be review from the results of the calculation of the WTP unit design criteria with planning design criteria according to the literature [13]. Evaluation for WTP can be calculate by equations below:

\[
V = \frac{Q}{A} \quad (1)
\]

\[
T_d = \frac{V}{Q} \quad (2)
\]

\[
G = \left( \frac{\rho \times g \times Q \times h}{\mu \times V} \right)^{1/2} \quad (3)
\]

\[
G \times T_d = G \times T_d \quad (4)
\]

\[
N_{Re} = \frac{V_o \times R}{\partial} \quad (5)
\]

\[
N_{Fr} = \frac{V_o^2}{g \times R} \quad (6)
\]

Explanation:

- \( Q \) = Flow rate (m\(^3\)/sec)
- \( A \) = Area (m\(^2\))
- \( T_d \) = Detention time (sec)
- \( V \) = Basin Volume (m\(^3\))
- \( G \) = Velocity gradient (/sec)
- \( \rho \) = Mass density of liquid (kg/m\(^3\))
- \( g \) = gravity (m/sec\(^2\))
- \( h \) = water depth (m)
The performance of the sedimentation stage and filtration stage are evaluated as a removal efficiency between the turbidity of the raw water and treated water turgidities in the treatment plant [14]. The calculation is a percentage removal as the following equation:

\[
\text{Removal Efficiency (\%) } = \frac{\text{Turbidity in raw water} - \text{Turbidity in treated water}}{\text{Turbidity in raw water}} \times 100\% \tag{7}
\]

2.2.2. Analysis of the quality water. Analysis of the quality of water produces for drinking water quality standards contained in PERMENKES No. 492 of 2010. Measurement of turbidity parameters on water quality using a turbidity meter.

2.2.3 Evaluation result. The design criteria obtained will be compared with the design criteria based on SNI 6774-2008 concerning the Procedure for Planning a Water Treatment Plant Package Unit. Design criteria for intake compared with design criteria based on Al-Layla 1977 and G. Td value compared with design criteria based on Qasim 2000 because both criteria not include in SNI 6774-2008. The evaluation results are also compared with some of the studies that have been carried out.

3. Results and discussion

WTP evaluation was conducted on the existing WTP of PDAM Tirta Kerta Raharja, Tangerang Regency, namely Cisauk WTP with a capacity of 50 L/sec. The source of raw water treated comes from the Cisadane River. The distance of the intake building with the WTP building is 1.1 Km. The scheme of the Cisauk WTP treatment plant is shown in figure 1.

- **Intake**, Intake is a unit to accommodate raw water which will be channeled to drinking water treatment plant. Intake at Cisauk WTP uses the River Intake type equipped with a bar screen, carrier channels and collecting wells. The tapped raw water flows gravitationally towards the collecting channel, then the water is pumped to the WTP using a transdimensional pipe with diameter of 250 mm. The distance of the intake building to the WTP is 1.1 km.
- **Coagulation**, Coagulation unit of Cisauk WTP uses a hydraulic stirring type. On top of the coagulation tank, raw water from the intake is flowed through a pipe with a diameter of 250 mm, then the water in the tub is added with a NUSACHEM coagulant at a dose of 35 mg/L.
- **Flocculation**, Cisauk WTP has 1 flocculation unit. The type of flocculation unit used is hydraulic flocculation with the vertical flow and consists of 4 compartments. The flocculation tub serves to form a larger floc from the initial floc.
Sedimentation, the sedimentation unit of Cisauk WTP is divided into 3 tanks, each of which has a discharge of 0.017 m³/sec. Each sedimentation tank is equipped with a 60º plate settler, 2 gutter pieces, and 6 mud chambers.

Filtration, the filtration unit consists of 3 tanks with the same dimensions and cylindrical shape. The type of filtration used is a rapid sand filter. In this unit using a single filter media is silica sand and buffer media is gravel.

Reservoir, Reservoir unit used is ground reservoir. Reservoir is divided into 2 tanks with different dimensions. In the reservoir, the chemicals used as disinfectants are chlorine. Chlorine functions for kill harmful bacteria and protozoa in the water and inhibit the growth of moss [15]. The dosage used in the field is 3-5 mg/L.

The results of the calculation of Cisauk WTP unit evaluation are in table 1.

### Table 1. Evaluation results of Cisauk WTP Unit.

| No | Unit                                | Result                   |
|----|-------------------------------------|--------------------------|
| 1. | Intake                              | v: 0.06 m/sec            |
|    |                                     | Td collecting wells: 6.03 min |
| 2. | Hydraulic Coagulation               | Td1: 31.4 sec            |
|    |                                     | G1: 326.7/sec            |
|    |                                     | G1.td1: 10258.38         |
|    |                                     | Td2: 13.2 sec            |
|    | G2: 544.26/sec                      |
|    | G2.td2: 7184.23                     |
| 3. | Floculation (Vertical Baffle Channel)| Td Total: 5 min 33 sec   |
|    |                                     | G1: 102.32 /sec          |
|    |                                     | G1 x td: 8942.77         |
|    |                                     | G2: 100.29/sec           |
|    |                                     | G2 x td: 7983.08         |
|    |                                     | G3: 88.75/sec            |
|    |                                     | G1 x td: 6443.25         |
|    |                                     | G4: 82.26/sec            |
|    |                                     | G4 x td: 6548.33         |
| 4. | Sedimentation (Plate Settler)       | Td: 17.64 min            |
|    |                                     | Surface Loading: 4.08 m³/m².hr |
|    |                                     | Nre: 21.72               |
|    |                                     | Nfr: 1.15 x 10⁻⁵         |
| 5. | Filtration (Rapid Sand Filter)      | Filtration rate: 17.94 m/hr |
|    |                                     | Backwash rate: 57.32 m/hr |

Based on the results of evaluation calculations in table 1. it can be compared with the design criteria according to several literature studies as follows:

- Intake, the design criteria for velocity at the unit intake is >0.6/sec and the detention time in the collecting well is <20 minutes [16]. Compared to the results of the evaluation calculation in Table 1. the velocity of the intake unit is not compatible with the design criteria.

- Coagulation, the design criteria for detention time value in the coagulation unit is 1-5 seconds and the gradient is >750/sec [12]; detention time value is 57.26 seconds and the gradient is 458.21/sec [17]. Compared to the results of the evaluation calculation in table 1. the detention time and gradient values in the coagulation unit did not match the design criteria. The value of
G. Td in the coagulation unit is 30000-60000 \[18\]; G. Td in the coagulation unit is 26236.57 \[17\]. Compared to Table 1, the value of G. Td WTP Cisauk is not compatible with the design criteria. Too-high velocity will cause the coagulation to rupture due to excessive shear force. Besides that, the speed will also require detention time to do the coagulation process \[19\].

- Flocculation, the design criteria for detention time value in the flocculation unit is 30-45 minutes and the gradient is 60-5/sec \[12\]. Compared to the results of the evaluation calculation in Table 1, the detention time and gradient values in the coagulation unit did not match the design criteria. The value of G. Td in the flocculation unit is 30000-60000 \[18\], compared to Table 1. The value of G. Td WTP Cisauk is not compatible with the design criteria. The smaller the value of G, the greater the collision that occurs and form a larger herd, so that the formed floc is easily removed. If the value of G is too fast it can cause the flock to break again \[19\].

- Sedimentation, the design criteria for detention time on sedimentation units are >4.2 minutes, surface loading of 3.8-7.5 m³/m².hours, with Reynold numbers (N_{RE}) is <2000 and Froude numbers (N_{FR}) is >10⁻³ \[12\]; detention time value is 41.4 minutes, surface loading of 2.5 m³/m².hr, with Reynold numbers (N_{RE}) 0.0022 and Froude numbers (N_{FR}) 2.61 x 10⁻³ \[9\]. Compared to the results of the evaluation calculation in Table 1, it can be concluded that the design criteria for WTP Cisauk sedimentation unit fulfill the requirements of SNI 6774-2008. The value of surface loading rate design criteria greatly affects the efficiency Removal of particles from water \[20\].

- Filtration, the design criteria for filtration rate on filtration unit are 15.1 m/hr and backwash rate are 18 m/hr \[21\]. Compared to the results of the evaluation calculation in Table 1, the filtration rate and backwash rate do not fulfill the design criteria.

3.1. Quality of water production Cisauk WTP

Analysis of water quality through laboratory tests is crucial, because the results of the analysis can be useful to determine whether or not the water can be used by residents for daily needs, constraints faced in terms of water quality, and solutions for residents \[22\]. Water quality analysis Cisauk WTP production is carried out by the Lab. PDAM Tirta Kerta Raharja. The parameters analyzed according to PERMENKES No. 492 of 2010. Data on production water quality for turbidity parameters are shown in Table 2.

### Table 2. Quality of production water at Cisauk WTP.

| Explanation       | Raw Water | Sedimentation Water | Filtration Water |
|-------------------|-----------|---------------------|------------------|
|                   | NTU   | PH  | NTU | PH  | Removal Efficiency | NTU | PH  | Removal Efficiency |
| Minimum            | 24    | 6.8 | 2.9 | 6.6 | 87.91%          | 0.3 | 6.6 | 89.65%            |
| Maximum            | 600   | 7.3 | 9.9 | 7   | 98.35%          | 2.15| 7.2 | 78.28%            |
| Average            | 120.6 | 7.2 | 5.8 | 6.8 | 95.19%          | 1.0 | 6.9 | 82.75%            |

The treatment process has eliminated most of the parameters that are not permitted in raw water, where Table 2 shows that turbidity is eliminated through sedimentation and filtration. The treatment process has eliminated most of the parameters that are not permitted in raw water, where Table 2 shows that turbidity is eliminated through sedimentation and filtration. Turbidity permitted in drinking water is as much as 5 \[7\]. The turbidity of water treated by Cisauk WTP has met drinking water standards, where the percent allowance for high turbidity is 99.64%. The research at Khanaqin City Water Treatment Plant has a high percentage of removal for turbidity which reached 97.88% \[21\].

Based on the results of the Cisauk WTP evaluation, there are several values does not fulfill with design criteria according to the SNI 6774-2008. However, this WTP can process water well enough so that the treated water can fulfill water quality standards according to PERMENKES No. 492 of 2010.
4. Conclusion
Based on the results of Cisauk WTP evaluation, there are several design parameters do not qualify the design criteria according to several literature studies. However, the quality of the production water produced by the Cisauk WTP has fulfilled drinking water quality standards according to PERMENKES NO. 492 of 2010, so that the design criteria at Cisauk WTP can be used as a reference for planning new water treatment plants.

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