Evaluation at Cibinong Water Treatment Plant (WTP) in Bogor District

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Abstract. Cibinong WTP using raw water sources from the Ciliwung River. Processed water from the Cibinong WTP serves 5 sub-districts, namely, Tajur Halang, Bojong Gede, Cibinong, Babakan Madang and Citereup districts. The research covered raw water quality, evaluation of the existing WTP condition and optimization of work of operation unit and process. Cibinong WTP consist of unit intake, hydraulic coagulation, hydraulic flocculation, sedimentation plate settler, rapid sand filtration, and ground reservoir. The coagulant used is 5% alum with a dose of 25 mg / L and disinfectants that use liquid gas and chlorine at a dose of 1.4 mg / L. Specifications for installation of drinking water installations use standards that are in accordance with SNI 6774 in 2008 concerning procedures for processing plant package units. Water quality in accordance with the Minister of Health Regulation 492 of 2010 concerning drinking water quality requirements. Cibinong WTP has several units that have not met the 2008 SNI 6774 standard but, the quality of the water already in accordance with the regulation of Minister of health no 492/2010.

1. Introduction
The increasing growth of population in Cibinong sub-district, Bogor regency, by 4.63% per year, needs to be balanced with the capacity of water supplies. The balance of population’s growth and water supplies means a water supply of drinking water for public [1]. Raw water quality factor determines the processing efficiency [2]. Physically, there are some factors that can determine quality of the water, they are pH, smell, taste, colour, turbidity, temperature, and the amount of dissolved solids based on the standard that is in accordance with Regulations set by minister of health N0. 492 / Menkes / per / IV / 2010 as stated [3, 4]. Water is turbid, when the water contains much a particle of suspended solid so it forms into mud and dirt [5]. The level of turbidity can be known by using a turbid meter [6]. pH restriction is done because it will affect the taste, water corrosion and chlorination efficiency. If the pH is smaller than 6.5 and greater than 9.2 can cause some chemical compounds turn into poisonous water which can threatens people’s health, on this basis then Water pH ranges from 6.5 - 9.0 and range optimal is pH 7.5 - 8.7 [7]. The color and manganese reduction is related to the performance of the coagulation unit, flocculation, sedimentation, and filtration, while the remaining chlorine is related to the performance of the disinfection unit [8]. The farther water source that is used for water treatment plant (WTP) is, the more it is prone to pollution/contamination [9]. The most commonly processes include filtration, flocculation, sedimentation and disinfection or surface water [10].
Cibinong WTP is one of many WTPs located in PDAM Tirta Kahuripan. It provides water supplies for five sub-districts, namely Tajur Halang, Bojong Gede, Cibinong, Babakan Madang and Citereup [11]. This WTP unit consists of unit intake, hydraulic coagulation, hydraulic flocculation, plate settler sedimentation, and rapid sand filtration. The coagulant used in the coagulation unit is aluminum sulfate with a concentration of 5% with the dosage used 25 mg/L and for the use of chemicals in the disinfecting unit using gas and chlorine at a dose of 1.4 mg/L. However, there are some units that are not in accordance with SNI 6774 in 2008 [12]. The research focuses on the quality of produced water, the quantity of raw water, and the performance of the science building units. By doing the research, the writer expects to be able to provide some advices in order to overcome problems that exist in the drinking water treatment unit in Cibinong WTP.

2. Methods
The methods for research can be seen in figure 1.

![Figure 1. Method scheme for cibinong WTP research.](image)

The formulas in each unit used to calculate the Cibinong Science evaluation:

\[
\text{Volume, } V = \frac{Q}{A} \tag{1}
\]

\[
\text{Detention time, } Td = \frac{V}{Q} \tag{2}
\]

\[
\text{Gradien, } G = \sqrt{\frac{F}{\mu V}} = \sqrt{\frac{Q x p x g x h}{\mu x V}} = \sqrt{\frac{p x g x h}{\mu x t_d}} \tag{3}
\]

\[
\text{GTd} = G x t_d \tag{4}
\]

\[
\text{Surface loading, } So = \frac{Q}{A} \tag{5}
\]

\[
\text{Reynolds Number, } N_{Re} = \frac{V_o x R}{\mu} \tag{6}
\]

\[
\text{Froud Number, } N_f = \frac{V_o^2}{g x R} \tag{7}
\]

Explanation:

- \(V\) = Basin Volume (m³)
- \(Q\) = flow rate (m³/second)
- \(A\) = Area (m²)
- \(Td\) = detention time (second)
- \(G\) = velocity gradient (/second)
- \(\rho\) = Mass density of liquid (kg/m³)
- \(\mu\) = absolute viscosity (kg/m. second)
- \(h\) = water depth (m)
- \(g\) = gravity (m/second²)
- \(\mu\) = absolute viscosity (kg/m. second)
- \(G\) = Gradient time
- \(N_{Re}\) = Reynolds Number
- \(N_f\) = froud number
- \(V_o\) = Speed through plate / tube settler (m / s)
- \(R\) = hydraulic radius (m)
3. Results and discussion

3.1. Evaluation results of each unit
Cibinong WTP consists of unit intake, hydraulic coagulation, flocculation hydraulic, sedimentation plate settler, rapid sand filtration, and ground reservoir.

3.1.1. Intake. The intakes used in Cibinong WTP are direct intakes. These intakes are used to supply raw water to all Cibinong WTP. 3 pumps are used with a capacity of each pump of 115 liters/second with a pump head of 30 m.

3.1.2. Hydraulic coagulation. From the intake of water, flow to the coagulation tank with the help of a transmission pipe used pump. In the tub of coagulation, there is an overflow by gravity through a sink. The overflow that occurs is in the form of waterfall. In the coagulation unit using hydraulic coagulation which has 1 tub with coagulant used is 5% aluminium sulphate with a dose of 25 mg/L.

3.1.3. Hydraulic flocculation. This unit has 6 compartments with regular hexagon shapes (hexagonal) equipped with sluice gates that have a vertical flow direction.

3.1.4. Sedimentation plate settler. Cibinong WTP has two-unit sedimentation using plate settler.

3.1.5. Rapid sand filtration. The filtration unit used rapid sand filtration with a total of 6 tanks. The filter media used in this filtration unit is double filter media which is using silica sand 0.5-1 mm, silica sand 2-5 mm, and gravel 15-30 mm and using a nozzle as a buffer layer and the place where the backwash process taking place.

3.1.6. Ground Reservoir. Reservoir used in the Cibinong WTP unit is a Ground reservoir with a number of 1 tank with a capacity of 1000 m$^3$.

The following is the results of the calculation compared to the quality standards that can be seen in table 1.

### Table 1. The result of evaluation Cibinong WTP.

| No | Unit | Design criteria | References | Evaluation | Explanation |
|----|------|-----------------|------------|------------|-------------|
| 1. | Intake | v >0.6 m/second | Al-Layla, 1978 [15] | 1.53 m/second | Qualified |
|    | Td collecting wells | < 20 minutes | Bhaskoro and Ramadhan, 2018 [16] | 5.93 minutes | Qualified |

Because the intake design criteria in SNI 6774 year 2008 didn’t exist, this study used the literature from Al-Layla, 1977

| 2. | Hydraulic Coagulation | td 1 – 5 second | SNI 6774, 2008 | 17.1 second | Not Qualified |
|    | G >750/second | SNI 6774, 2008 | 1421.64/second | Qualified |
|    | 458.21 second | Bhaskoro and Ramadhan, 2018 | Not Qualified |
|    | G.td 30000-60000 | Qasim, 2000 [17] | 6572.522 | Not Qualified |
|    | 26236.57 | Bhaskoro and Ramadhan, 2018 |

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. [17][18]. But in the results of water quality, it can be seen that although the value of Gtd. does not meet, the quality of the water produced has met the quality standard.

| 3. | Hydraulic Flocculation (vertical Baffle Channel) | Compartments 1 | Td 30-45 minutes | SNI 6774-2008 | 2.4 minutes | Not Qualified |
|    | G 60 – 5/second | SNI 6774-2008 | 73.53/second | Not Qualified |

7 minutes | Satria Kharisma, 2013 |

7 minutes | Not Qualified |

7 minutes | Not Qualified |
3.2. Water quality production in Cibinong WTP

In the research conducted during April, the results of raw water quality during April 2018 can be seen in figure 1.
Figure 2. Graph of raw water quality, sedimentation and filtration.

Figure 2 shows that there has been a decrease in turbidity results in accordance with the Minister of Health Regulation 492 in 2010 (5 NTU). This WTP has been able to process water products so that treated water meets the quality standards and design criteria for WTP so that it can be used as a reference for other WTP with the same sources and characteristics.

4. Conclusion

Based on the calculation of the WTP unit, it can be seen that there are several Cibinong WTP units that are not meet the standard of SN 6774 in 2007 such as flocculation, sedimentation and rapid sand filter however, this WTP has been able to process water products so that the treated water meets the quality standards set by Minister of Health in Regulation No. 492 of 2010 about requirements for quality of drinking water and design criteria for this WTP can be used as a reference for other WTP with the same sources and characteristics.

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