Evaluation of the Drinking Water Treatment Plant of PDAM Tirta Wijaya, Cilacap Regency

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ABSTRACT
Water is one of the essential factors in fulfilling human needs. The existence of water on earth is very abundant, but the quality doesn't meet the standards. The system value of a Drinking Water Treatment Plant (DWTP) can be seen from 3 aspects, quality, quantity, and continuity of water produced. The dry season, increasing population, and the age of DWTP will be faced in maintaining the three aspects of value. Seeing the several conditions experienced by PDAM Tirta Wijaya, it is necessary to evaluate to determine the performance of each unit, the quality of raw and production water, the fulfillment of water needs, the operation during the dry season, and the optimization that needs to be done. Direct observation at DWTP Kesugihan was selected as the method. The water demand in 2029 is 1170.7 l/s, according to the results of the examination of DWTP Kesugihan. The flocculation, sedimentation, and filtration units do not comply with SNI 2774-2008. The results of this study prove that the DWTP unit's performance is quite good. The quality of raw water is still worth considering, the quality of production water has met quality standards, DWTP Kesugihan has not been able to meet water needs as much as 80 percent coverage in 2029, and there is no operational standard during the dry season. Optimization of DWTP Kesugihan by increasing the height of the filtration unit to 6.5 m, the nozzle diameter to 0.05 m, and the number of nozzles to 500 and making SOPs for the dry season.

Keywords: *Drinking Water; Treatment Plant; Quality of Production Water*

1. INTRODUCTION

Water is one of the essential factors in meeting human needs. The existence of water on earth is very abundant, ranging from springs, rivers, reservoirs, lakes, seas to the ocean. The water area is larger than the land area. However, not all of them can be used by humans to meet their daily needs. One of them is the need for clean water and drinking water. Water utilization as drinking water and clean water cannot be done directly but requires a processing process first. Processing is carried out so that the water can meet the standards of clean water and drinking water. According to Omer [1], the general parameters of drinking water consist of physical, chemical, biological, and radioactive.

PDAM Tirta Wijaya is a company that serves drinking water needs in Cilacap Regency. The Kesugihan Water Treatment Plant (WTP) is one of the WTP units owned by PDAM Tirta Wijaya. The WTP Kesugihan at PDAM Tirta Wijaya is the first WTP owned by PDAM Tirta Wijaya so that it has the oldest age of 34 years [2]. According to Dewi *et al*. [3], the value of a system from a WTP can be seen from 3 aspects: the quality, quantity, and continuity of the water produced. These three requirements must be met to achieve a specific goal while keeping technical and non-technical factors in mind. PDAM Tirta Wijaya faces annual challenges in maintaining continuity and quality, particularly during the dry season when seawater intrusion at the Kesugihan WTP occurs. The increase in the population and its activities in Cilacap Regency will go hand in hand with the target customers. To achieve the quantity aspect, namely the fulfillment of customer needs, PDAM Tirta Wijaya needs to calculate and evaluate the amount of water production compared to population growth. In technical calculations, planning is carried out using projected population growth in the next 10-20 years.

Drinking water is water that has been processed or without processing that meets health requirements and can be drunk directly (Permenkes No.492/2010) [4]. In Indonesia, the standard that applies to clean water is based on the Regulation of the Minister of Health of the Republic of Indonesia Number 416/Menkes/Per/IX/1990 concerning Requirements and Monitoring of Water Quality and Regulation of the Minister of Health No. 492

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of 2010 concerning Drinking Water Quality Requirements.

2. METHOD

From March to April 2021, this study was conducted at DWTP Kesugihan. The information was gathered by direct observation, testing, computations, and secondary data collection from other organizations. Raw water quality, work unit dimensions, treated water quality, and interview data observations are all examples of primary data gathering. Secondary data collection includes raw and processed water quality, where information on processing is taken from the Central Statistics Agency (BPS) report of the Cilacap Regency in 2021 [5].

The dimension data of the existing unit will be calculated according to the current equation, and the results will be compared with SNI 6773-2008 - Specification of Water Treatment Installation Package Unit [6]. The quality of raw water will be compared with Government Regulation No. 82 of 2001, and the quality of treated water will be compared with PERMENKES 492 of 2010. Population data will be projected and processed into total water demand data for the next ten years. Interview data will be used to analyze the management of DWTP operations during the dry season. From all data processing, DWTP optimization can be planned.

3. RESULT AND DISCUSSIONS

PDAM Tirta Wijaya, Cilacap Regency, provides clean water to customers has used a complete treatment process (DWTP) and raw water from springs that only use a collection tank and filtration. DWTP Kesugihan is included in subsystem II with service coverage in Cilacap (Central Cilacap, North Cilacap, and South Cilacap), Kesugihan, Jeruklegi.

The DWTP of PDAM Tirta Wijaya has three sources of raw water that are used according to priority, namely the Gerak Serayu Weir Irrigation, an artificial reservoir, and the Serayu River. The production process will use raw water sources from the Serayu River, the last resort if the Gerak Serayu Weir irrigation and artificial reservoirs are not used. Each source of raw water has its intake pump channeling through the transmission pipe to the coagulation unit.

The intake building and pump housing construction are made of iron and concrete and are currently in good condition. The mouth of the tapping channel directly connected to the raw water source is equipped with a bar screen. Filtering of raw water at the intake is carried out to prevent coarse objects from being carried into the installation.

The Kesugihan DWTP uses the hydraulic fast stirring method in the coagulation unit. Hydraulic stirring itself is a mixer that utilizes the turbulence of water caused by the flow of water [7]. Coagulation in DWTP Kesugihan occurs in the spiller tub. The coagulation process starts from entering coagulant liquid (Poly Aluminum Chloride) using a dosing pump on the transmission pipe and continues in the dividing tub (Spiller) to 2 clarifier units. Table 1 shows the value of coagulation under the quality standard.

The flocculation unit has the goal of converting microflocs into macroflocs. The Flocculation Unit is inside the Clarifier, which hangs right in the middle of the Clarifier. The flocculation and sedimentation unit is a tubular tub with twin 200-liter-per-second units. The flocculation process at DWTP Kesugihan uses a diffuser pipe as the flocculator where slow stirring is carried out by utilizing the flow of water that enters through the diffuser pipe hole. The process begins with the inflow pipe, then passes through zones 1 and 2 with a total of 8 diffusers, zone 3 with 12 diffusers, zone 4 with a total of 16 diffusers, and finally to the sedimentation unit with a capacity of 16 diffusers. The flocculation height was not under the quality standards, as shown in Table 2.

Table 1 Coagulation Calculation Results

Description	Unit	Value	Standard
Mixing time	second	4.76	1 – 5
G	/second	958	> 750

Table 2 Flocculation Calculation Results

Description	Unit	Value	Standard
Settling time	second	4.76	1 – 5
G	/second	958	> 750
Maximum Flow Speed	m/second	1.22	0.5 – 1.5
Head	m	8.75	2 - 4

With a height of 5 meters and a depth of 3.5 meters, the Sedimentation Unit at DWTP Kesugihan is situated surrounding the Clarifier. After the water passes through the Flocculation Unit zone 4 with a downward flow direction, the water goes to the Sedimentation Zone with an upward flow direction. A settler plate with a 60°

inclination arises on the upper surface of the Clarifier in the Sedimentation Unit. The plate settler is used to speed up the sedimentation process (Table 3).

After the deposition process is carried out in the Clarifier, the water goes to the Filtration Unit. In the DWTP KESUGIHAN Filtration Unit, there are eight filtration tanks. Table 4 shows the filtration calculation of water quality, and the parameters of backwash time, anthracite thickness, buffer media thickness, and % nozzle are not under the SNI 6778-2008 standard.

Water passed through the filtration unit will be stored in Clear Water Storage (CWS) or the final storage for clean water. However, before entering the CWS, the water first gets chlorine injection from the pipe using a dosing pump with a dose of 12 mg/liter. Volumetric discharge or discharge of chlorine affixing in the disinfection unit can be determined using the chlorine requirement approach using the following calculations [8]:

Chlorine Requirement = Chlorine Dose x Operating Discharge

CR = 12 mg/l x 400 l/s = 4.800 mg/s

$$Affixed\ debit = \frac{chlorine\ requirement}{chlorine\ density}$$
$$= \frac{4800\ mg/s}{3.124\ g/cm^3} = 1350.7\frac{mg}{s}$$
$$= 5.53\ l/hour$$

Under Government Regulation No. 82 of 2001 [9], the source of raw water for drinking water is included in class I (one) category, where class I water is water designated for drinking water. Seven parameters are not under the quality standard of PP No. 82 of 2001, as shown in Table 5. The comparison of parameters that do not meet the quality standard is 0.24; based on this comparison and the parameter values are not too far from the quality standard, the raw water deserves to be considered raw water for DWTP Kesugihan.

Table 3 Sedimention Calculation Results

Description	Unit	Value	Standard
Surface Load	m^3/m^2/hour	1.49	0.5 – 1.5
Settling time	Second	958	> 750
Maximum Flow Speed	m/second	1.22	0.5 – 1.5
Head	m	8.75	2 - 4

Table 4 Filtration Calculation Results

Description	Unit	Value	Standard
Filtering speed	m/hour	9.17	6 – 11
Backwash speed	m/hour	47.7	36 - 58
Backwash time (Td)	Minute	5.64	11 - 15
Expansion	%	30.56	30 – 50
Anthracite thickness	mm	300	300 - 700
Quartz thickness	mm	600	400 - 500
Buffer medium thickness	mm	250	80 - 100
nozzle slot width	mm	0.03	<0.5
percentage of the nozzle slot area	%	1.49	>4

Table 5 Raw water quality parameters

Parameter	Unit	Value	Quality Standard
Iron (Fe)	mg/l	0.42	0.3
Manganese (Mn)	mg/l	0.86	0.1
Coopper (Cu)	mg/l	0.59	0.02
Total Suspended Solids (TSS)	mg/l	153	50
Chemical Oxygen Demand (COD)	mg/l	16.4	10
Phospate (P)	mg/l	0.888	0.2
Chloride (Cl)	mg/l	0.1	0.03

The independent testing and testing conducted by the relevant agencies showed that the treated water quality had complied with the PERMENKES 492/2010 quality standard (Table 6). The water demand is calculated using the arithmetic technique and is based on population forecasts for the following ten years. The choice of method is based on the value of r (correlation) and standard deviation [10].

The DWTP Kesugihan service areas in 2029 include household, non-domestic, and water losses (Table 7). The total need for clean water in 2029 is 1064.272 l/second. The discharge of water treated by the DWTP is different from the total demand for clean water. The water discharge treated by DWTP must consider the maximum daily factor (MDF). The standard of water usage is based on the city category. The maximum daily factor (MDF) is 1.1 [11]. The following formula can be used to calculate the demand for treated water or processing discharge:

$$Q_{production} = Q_{total}\ x\ 1.1 = 1064.272\ l/s\ x\ 1.1 = 1170.7\ l/s$$

It can be seen that the demand for treated water ($Q_{Production}$) is 1170.7 liters/second. When compared with the availability of water, the water shortage is 770.7 liters/second

The dry season is when rain is rare or rainfall is of low value. The dry season usually lasts from April to September [12]. Based on the results of interviews conducted, it can be seen that the management of dry season operations is carried out based on incidental actions. The action in question is that if seawater intrusion occurs, the intake point will be moved to a further intake. However, if seawater intrusion worsens and reaches the second intake point, production activities will be stopped.

Table 6 Comparative Results of Correlation Test and Standard Deviation

Method	r value	Deviation Standard
Arithmetic	1	31737.941
Geometric	0.999538	38000.8748
Least Square	1	34003.843

Table 7 Projected population

Year	Population
2019	462322
2029	567184

3.1. DWTP Optimization

Filtration Unit

Backwash time (Td)

Design criteria: 10 -15 minutes

Design plan (Td): 10.5 minutes

$$Td = \frac{container\ volume}{Q_{bw}} \rightarrow 10.5\ minutes = \frac{container\ volume}{0.202\ m^3/second}$$

$$container\ volume = 10.5\ minutes\ x\ 60\ \frac{second}{minute}\ x\ 0.202\ \frac{m^3}{s} = 127.26\ m^3$$

In the evaluation design, the existing diameter container (d) is used because height (h) makes it more possible in the construction work.

$$container\ volume = 3.14\ x\ d^2\ x\ 0.25\ h$$

$$h = \frac{container\ volume}{3.14\ x\ d^2\ x\ 0.25} = \frac{127.26\ m^3}{0.785\ x\ (5m)^2} = 6.48\ \rightarrow 6.5\ m$$

3.2. Nozzle Percentage

Design criteria: >4

Design plan (% Nozzle): 5

$$\%\ Nozzle = \frac{Nozzle\ area}{medium\ area}\ x\ 100\% \rightarrow Nozzle\ area = \frac{\%\ Nozzle\ x\ medium\ area}{100\%}$$

$$Nozzle\ area = \frac{5\%\ x\ 19.625\ m^2}{100\%} = 0.98125\ m^2$$

Adjusting the number of nozzles from 600 to 500, then the nozzle diameter:

$$Nozzle\ area = 0.25\ x\ 3.14\ x\ D_{nozzle}{}^2\ x\ number\ of\ nozzles$$

$$D_{nozzle} = \sqrt{\frac{Nozzle\ area}{0.25\ x\ 3.14\ x\ no.\ nozzles}} = \sqrt{\frac{0.98125\ m^2}{0.25\ x\ 3.14\ x\ 500}} = 0.05\ m$$

Standard Operating Procedures (SOP) for the dry season need to be made. SOP needs because employees' alertness is not always maintained for various reasons. With the applicable SOP, operators do not need to wait for orders from employees with higher authority to prevent unwanted things.

4. CONCLUSION

The current performance of DWTP Kesugihan can be categorized as quite good because there are only three units that are not under SNI 6774-2008 and produced water that has complied with PERMENKES RI No.492 of 2010. DWTP Kesugihan's raw water, the Irrigation of the Serayu Gerak Weir, an artificial reservoir, and the Serayu River does not meet the class 1 water quality standard as the drinking water quality standard. However, based on the number of parameters that exceed the quality standard, only 7 of the 32 parameters and the parameter values that exceed the quality standard are not too far from PP. 82 of 2001, the raw water can still be considered under economic considerations. The production water produced by DWTP Kesugihan has met the quality standards stated in the PERMENKES RI No.492 of 2010. The production capacity of DWTP Kesugihan cannot meet the water needs of the next ten years. In 2029, the DWTP Kesugihan service area has awater requirement of 1170 L/second with 567182 people. DWTP Kesugihan needs to increase its production capacity by 770.7 L/second to meet customer needs in 2029 with 80% customer coverage. The operation of the production process is carried out incidentally and based on the direction of the leader who has the authority. Moving the intake point to a more distant point is used as a measure to counter seawater intrusion. Stopping the production process is the next step if seawater intrusion has reached the second intake point. DWTP Kesugihan has good production quality. The optimization of DWTP is chosen based on the easiest option to implement. DWTP Kesugihan can be optimized by changing the height of the filtration tank to 6.5 meters, changing the nozzle hole on the filtration unit to 500, and changing the nozzle diameter to 0.05 m. The subsequent optimization is done by adding a Standard Operating Procedure (SOP) for operators during the dry season.

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