EVALUATION ON SERVICE COVERAGE OF JATIWEKAS WATER TREATMENT PLANT OF TULUNGAGUNG REGENCY WATER SUPPLY COMPANY

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Abstract

Water Supply Company (WSC) of Tulungagung Regency uses treated water from the Jatiwekas WTP for distribution. Water Treatment Installation (WTI) Jatiwekas has three processing units, i.e., WTP with a capacity of 50 L/s (WTP 1), WTP with a capacity of 100 L/s (WTP 2), and WTP with a capacity of 40 L/s (WTP 3). The Jatiwekas WTP consists of flocculation, sedimentation, filtration, and reservoir. The objective of this study is to evaluate the WTP and calculate water demand by considering 90% service coverage. The research was conducted by field observations to obtain information. Based on SNI 6773:2008, most of the Jatiwekas WTP has met the requirements of the package type WTP, except for WTP 3 which has not met because its capacity exceeds the design of the WTP package unit, which only has a discharge rate of 1-50 L/s while the capacity of WTP 3 reaches 100 L /s. The Jatiwekas WTP does not meet the design criteria of the Directorate General of Public Works of Republic Indonesia, which states that the service coverage for small towns with a population of 20,000– 100,000 is 90%, to achieve 90% service coverage, the Jatiwekas WTP needs to increase water production capacity by 123.9 L/s.

Keywords: *evaluation of building suitability, service coverage, Water Treatment Plant (WTP), WTP package unit*

Introduction

Providing a healthy and safe drinking water quality to the community is necessary (Alfiah et al., 2021). Tulungagung Regency is one of the regencies in East Java. Administratively, Tulungagung Regency has 19 sub-districts with 271 villages and sub-districts. Several sub-districts in Tulungagung are service areas of Water Supply Company (WSC) Tulungagung which receive treated water from Tirta 4/ WTP Jatiwekas. The WTP has three processing units, i.e., WTP 1 with a capacity of 50 L/s, WTP 2 with 100 L/s, and WTP 3 with a capacity of 40 L/s. Based on SNI 6774:2008 concerning specifications for water treatment installation units, it is stated that raw water includes water from surface water sources, groundwater basins, and or rainwater that meets specific quality standards as raw water for drinking water. The Jatiwekas WTP treats raw water in surface water from the Song River, which is ± 9.3 km from the Jatiwekas WTP.

The Jatiwekas WTP consists of flocculation, sedimentation, filtration, and reservoir. Jatiwekas WTP is included in the package type WTP. According to SNI 6773: 2008 concerning Specifications for Packaged Water Treatment Installation Units, the WTP compact unit can

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treat raw water through certain physical, chemical and/or biological processes in a compact form to produce drinking water that meets the applicable quality standards. Packages are designed and manufactured from steel plate, plastic or fiber so that they can be assembled and moved elsewhere. The treatment process is selected based on the raw water quality to be treated. The capacity of the water treatment installation compact unit has a discharge rate of 1–50 L/s. WTP package components consist of principal components and supporting components. The main components of the WTP package are water intake, flow meter, chemical solution adder, mixer, coagulation, flocculation, sedimentation, filtration, and disinfection. The supporting components of the WTP package consist of a reservoir and distribution. Many urban water sources are polluted (Yustiani et al., 2019). Thus, a complete treatment plant is necessary.

The WTP package unit has general requirements such as the WTP package product must be approved by the authorized agency/institution, the WTP package unit must be able to drain drinking water in accordance with the Minister of Health Regulation No. 492/MENKES/PER/IV/2010 concerning Drinking Water Quality Requirements, the WTP package unit must also be installed on stable soil, the outer and inner surfaces are not deformed and watertight, the selection of the type of treatment process must be based on the quality of the raw water, especially turbidity and color of raw water. Units selection is quite essential to provide the best product economicallay (Kusumadewi et al., 2019).

The WTP compact unit has technical requirements to produce drinking water from certain raw water quality. They are maximum turbidity of 600 NTU or 400 mg/L SiO_2, the appearent color does not exceed 100 Pt Co and the temporary color follows the turbidity of the tub water, other elements meet the requirements of raw water according to Government Regulation No. 82 of 2000 concerning Water Quality Management and Water Pollution Control. When river water in certain areas contains color, iron and or organic matter exceeding the above requirements but low turbidity (< 50 NTU), it is used WTP system DAF (Dissolved Air Flotation) or other systems that can be accounted for. In addition to water quality, flow meters are also included in the technical requirements of the WTP package unit. Flow meter as a technical requirement is used to measure the discharge from raw water and drinking water such as water meter, V-notch, flowmeter, and floating meter. Another technical requirement is the size of the building which can be seen in the Revision of SNI 19-6774:2002 concerning Procedures for Planning the WTP Unit Package. The objective of this study is to evaluate the WTP and calculate water demand by considering 90% service coverage.

Methodology

The study was conducted using a field observation system to determine the water treatment process from the Jatiwekas IPA, to determine the suitability of the Jatiwekas IPA with the packaged IPA based on SNI 6773:2008, to determine the service coverage of the Jatiwekas IPA. The water treatment process is carried out by direct observation, while the service coverage is known from data from WSC Tulungagung. Service coverage is carried out by comparing active connection data with residents of the coverage area.

Result and Discussion

Water Treatment System in Jatiwekas WTP

WTP 1 was built in 2008 with steel construction. Raw water from the Song River is tapped using a hole pipe that has a 2.5 meter long with a tapering end. At the end of the pipe, there is given a coarse filter, a coarse filter and a perforated pipe serves to filter out large garbage. The raw water is then channeled using a 400 mm diameter pipe.

The water that enters the 50 L/s WTP is added with chemicals in the form of Aluminum Sulfate which has previously been dissolved with water in the tank profile and then pumped using a dosing pump. This coagulant has high performance in water treatment (Widiyanti, 2018), (Postolachi et al., 2016). The aluminum sulfate solution will be mixed with raw water as it passes through the blades on the static mixer pipe. Raw water coming from the static mixer will enter from the bottom and then pass through the plunge tub. A natural stirring process occurs when raw water passes through this plunge tub because it utilizes a hydraulic jump. Subsequent treatment, the water will enter the sedimentation unit at the 50 L/s WTP which uses a hexagonal tube as a place to attach the floc particles resulting from the coagulation-flocculation process. This sedimentation type has relatively high particulate removal (Maharani et al., 2017). After the water from the sedimentation goes to the outlet through the spillway, the water will enter the filtration unit. In this 50 L/s WTP filtration unit uses a multimedia filter consisting of silica sand and anthracite. The filtration media layer of a mixture of silica sand and anthracite coal used in the 50 L/s WTP is 30 cm above the support that contains the nozzle. The treated water of 50 L/s WTP is accommodated in ground reservoirs with a capacity of 500 m^3 as many as 5 pieces with a total capacity of 2,500 m^3.

WTP 2 was built in 2009 with a concrete construction building. The water from the Song River that has been tapped will be channeled to WTP 2. The next stage, the water will be added with Aluminum sulfate using a dosing pump and then flowed using a plunge tub. In this water treatment plant with a capacity of 100 L/s, the flocculation unit is a cyclone flocculation with a hexagonal shape with six compartments. Water from the flocculation unit enters the sedimentation building. Water from the sedimentation unit will enter the filtration unit without going through the processing in the filtration unit because the filtration unit is damaged where several nozzles are released, then the filter media in the form of silica sand has been removed. The treated water from WTP 2 is accommodated in a ground reservoir with a capacity of 500 m^3 as many as 5 units and a total capacity of 2,500 m^3.

The WTP 3 was built in 2018 with steel construction and comes from Hungary. The water from the Song River that has been tapped is then channeled to WTP 3. In this WTP 3, there is a pipe for adding aluminum sulfate solution before the static mixer. On the red pipe before the static mixer there are two injection sites where one is for pre-chlorine and the other is for Aluminum sulfate. However, only aluminum sulfate was used from the two injections, while pre-chlorine was not used. In WTP 3, flocculation is used with hydraulic stirring in the form of a baffle channel. The baffle channel used is the horizontal baffle channel. It is a hydraulic stirring to increase unit performance (Pratama and Nursiana, 2020). The sedimentation unit at WTP 3 also uses a hexagonal tube as a place to attach the flocs resulting from the coagulation-flocculation process. Subsequent treatment the water will go to the filtration unit. The 40 L/s WTP filtration unit uses a multimedia filter consisting of silica sand and anthracite. Filtration will also remove pathogens (Cescon and Jiang, 2020). If the water in the filtration unit touches a predetermined level due to a decrease in the filtering speed, where the filter media is clogged with accumulated solids so that it needs to be washed. The function of backwashing is to remove clogged solids and return the media to be cleaner so that mud balls and cracks do not form in the filter media. After the water is treated at WTP 3, the water will be flowed first to a reservoir with a capacity of 330 m3. WTP 3 water from the 330 m^3 reservoir will be channeled to a ground reservoir with a capacity of 2,500 m^3.

Evaluation of Jatiwekas WTP Building

Based on SNI 6773:2008 and the socialization and dissemination module of standard guidelines and manuals regarding Specifications for Packaged Water Treatment Installation Units, package type WTP can be applied to treat raw water with a maximum turbidity of 600 NTU. To find out the suitability of the Jatiwekas WTP with the Package WTP, see the Table 1.

Table 1. Compatibility of Jatiwekas Natural Sciences with Package Types of Natural Sciences Based on SNI 6773:2008

SNI 6773:2008	Jatiwekas WTP	Note
Water Treatment Unit Package Components		
Main component:		
1. The raw water intake unit consists of surface water and ground water.	The unit for taking raw water comes from surface water, namely the Song . River	It complies with SNI 6773:2008
2. The water flow meter consists of sharp threshold, turbine, pitot, electromagnetic and ultrasonic.	WTP 1 and WTP 2 flow meters use a sharp threshold, while WTP 3 uses a flowmeter.	It complies with SNI 6773:2008
3. Adding chemical solutions in the form of dosing and gravity pumps.	The Jatiwekas WTP uses a chemical solution in the form of a dosing pump.	It complies with SNI 6773:2008
4. Mixers are mechanical, hydraulic, in-line and compressor.	The mixer used to stir chemicals at the Jatiwekas WTP is a mechanical type with a paddle shape.	It follows SNI 6773:2008, where the mixer used is a mechanical type with a paddle shape.
5. Coagulation in the form of hydraulic and mechanical.	The coagulation used to stir chemicals at the Jatiwekas WTP is a hydraulic type in the form of a static mixer for WTP 1 and WTP 3, and a plunger for WTP 2	It complies with SNI 6773:2008
6. Flocculation in the form of hydraulic and mechanical.	The flocculation used to stir chemicals at the Jatiwekas WTP is a hydraulic type in the form of a baffle channel.	It complies with SNI 6773:2008
7. Sedimentation in the form of gravity and floating.	Sedimentation at the Jatiwekas WTP is in the form of gravity because the floc attached to the tube settler will descend into the mud zone using a gravity system.	It complies with SNI 6773:2008
8. Filtration in the form of a quick sand filter.	WTP Jatiwekas uses filtration with a fast sand filter type, namely a multimedia filter consisting of silica sand and anthracite.	It complies with SNI 6773:2008
9. Disinfection in the form of a dosing pump.	WTP Jatiwekas uses a dosing pump to apply disinfectant in the form of post chlorine.	It complies with SNI 6773:2008
Supporting components:		
1. The reservoir is a reservoir	The Jatiwekas WTP uses a reservoir to accommodate the water produced by the ground reservoir type.	It complies with SNI 6773:2008
2. Distribution in the form of gravity and pumping.	Distribution in the form of gravity and pumping.	It complies with SNI 6773:2008
General requirements		
1. The WTP package unit must be able to drain water as drinking water	The water produced by the Jatiwekas WTP is in accordance with the Minister of Health of the	It complies with SNI 6773:2008

SNI 6773:2008	Jatiwekas WTP	Note
according to the Minister of Health of the Republic of Indonesia No. 907/MENKES/SKVII/2002 on Drinking Water Quality. 2. Must be installed on a stable ground. 3. The outer and inner surfaces are not deformed and watertight. 4. Selection of the type of treatment based on the quality of raw water turbidity and color.	Republic of Indonesia No. 907/MENKES/SK/VII/2002 on Drinking Water Quality which is tested every six months. The Jatiwekas WTP is also built on stable soil, while the WTP package building is also watertight because it is made of concrete and steel and is not deformed.	
	Technical Requirements	
Raw water quality requirements: 1. Maximum turbidity 600 NTU. 2. The original color content is not more than 100 Pt Co and the temporary color follows the turbidity of the raw water.	Raw water comes from the Song River. Based on data on August 23, 2021, the average turbidity value of the Song river is 15.01 NTU. Meanwhile, the average turbidity value of raw water from 23 – 29 August 2021 is 13.18 NTU.	Comply when compared between SNI 6773:2008.
Requirements for measuring flow meters to measure the flow of raw water and drinking water can use a water meter, V-notch, flowmeter, floating meter.	In WTP 1 and 2, Vnotch is used to measure the raw water flow, while in WTP 3, a flowmeter is used.	When compared with SNI 6773:2008, the Jatiwekas WTP is in accordance with the technical requirements regarding flow measuring instruments.
Sedimentation unit size requirements: 1. Flat wall shape has a minimum thickness of 10 mm for 50 L/s WTP capacity. 2. The form and type of settler is a tube settler with a diameter of 5-6 cm for WTP with a capacity of 50 L/s.	WTP Jatiwekas which is made of steel has a sedimentation unit with a flat wall with a thickness of ± 10 mm, while for WTP 2 made of concrete it also has an average wall thickness of more than 10 mm. while for the type of settling, all WTP use a tube settler with a hexagon shape with a diameter of 5.5 cm.	WTP Jatiwekas complies with SNI 6773:2008.
The feeder and stirrer tanks are made of steel with a chemically resistant inner lining or fiberglass or the like which is resistant to chemical solutions. The coagulant bath must be able to hold the solution for 24 hours, have 2 tanks for stirring and add, the coagulant bath must be protected from outside influences.	The tank for adding and stirring the coagulant used by WTP Jatiwekas is in the form of a tank profile made of polyethylene. The adder and stirrer tanks are in a separate room. The WTP has 2 coagulant tanks consisting of a stirrer and an adder, a tub that can hold the solution for 24 hours, the material from the adding tank/tank and the stirrer are made from materials that can withstand aluminum sulfate.	When compared with SNI 6773:2008, Jatiwekas WTP is quite appropriate.

When compare to SNI 6773:2008, the Jatiwekas WTP has mostly met the requirements of the package type WTP. One of the requirements that must be met is the capacity of the packaged type WTP unit having a discharge of 1 – 50 L/s, which means that WTP 1 and WTP 3 meet these requirements while WTP 2 does not meet these requirements because the processing capacity is 100 L/s. The Jatiwekas WTP has fulfilled the general requirements for the SNI 6773:2008 WTP package unit. Furthermore, for the technical requirements, most of the Jatiwekas WTP have met the requirements listed in SNI 6773:2008.

Capacity Evaluation of Jatiwekas WTP And Service Coverage

The first Jatiwekas WTP capacity evaluation uses connection or customer data obtained from WCS Tulungagung. The data contains the number of active connections from home connections and public faucets. If based on the clean water planning criteria, each WCS branch serves customers in the small city category because the population is between 20,000 – 100,000 people. Based on the clean water planning criteria, 1 SR serves 5 people with a consumption unit of 120 L/person.day while 1 KU/HU serves 100 people with a consumption unit of 20 L/person/day.

Table 2. Results of Calculation of Water Needs Based on Connection/Customer Data

WSC Service coverage	Population		WSC Connection		Population Serviced		Water Demand		
	Total	90% coverage	Active Connection		House	Communal	L/day		Amount (L/s)
			House	Communal	for 5 each	for 10 each	House (120 L/p/d)	Communal (20/p/d)	
Tulungagung	65,952	59,357	11,145	16	55,725	1,600	6,687,000	32,000	77.77
Sumbergempol	71,164	64,048	356	0	1,780	0	213,600	0	2.47
Boyolangu	83,281	74,953	614	0	3,070	0	368,400	0	4.26
Karangrejo	43,439	39,095	892	0	4,460	0	5,352,000	0	*6.19*
Kauman	51,776	46,598	2,530	0	12,650	0	1,518,000	0	17.57
Gondang	58,671	52,804	901	0	4,505	0	5,406,000	0	6.26
Total	374,283	336,855	16,438	16	82,190	1,600	9,862,800	32,000	114.52

The results of the calculation of water needs based on connection data served by the Jatiwekas WTP can be seen in Table 2. The next step is to find out the water loss and its treatment capacity. This water loss in Indonesia is quite high. Water loss in distribution usually caused by many reasons (Oberascher et.al, 2020).

Q water loss equals to clean water times 20%, therefore Q water loss is 29% of 114.52 L/s, which is 22.9 L/s. Thus total Q is 11.873.088 L/day. To determine the processing capacity can be done by calculating the maximum daily Q (Qhmax), with the calculation 11,873,088 L/d times 1.25, i.e., 171.78 L/s.

Suppose the Jatiwekas WTP wants to meet the clean water planning criteria in accordance with the Planning Criteria of the Directorate General of Human Settlements. In that case, Public Works Department which has service coverage of 90% for a small town scale, then the Jatiwekas WTP must increase the processing discharge of the Jatiwekas WTP. This limitation is increasingly felt due to the increasing competition in the use of clean water, while the efforts made to fulfill the need for clean water are felt to be insufficient because not all people can easily enjoy clean water (Afiatun et al., 2018). Table 3 shows the calculation of water demand in the service area.

Table 3. Results of Calculation of Water Needs Based on Service Areas

WSC Service Unit	Population			Service Type						Water Demand			
	Total	Coverage		%		Person		L/p/d		L/d			Total (L/s)
		%	Person	H*	C**	H*	C**	H*	C**	H*	C**	Total	
Tulungagung	65,952	90	59,357	70	30	41,550	17,807	120	20	4,985,988	356,140	5,342,128	61.83
Sumbergempol	19,788	90	17,809	70	30	12,466	5,343	120	20	1,495,920	106,860	1,602,780	18.55
Boyolangu	22,324	90	20,092	70	30	14,064	6,028	120	20	1,687,680	120,560	1,808,240	20.93
Karangrejo	16,487	90	14,838	70	30	10,387	4,451	120	20	1,246,440	89,020	1,331,460	15.46
Kauman	51,776	90	46,598	70	30	32,619	13,979	120	20	3,914,280	279,580	4,193,860	48.54
Gondang	46,889	90	42,200	70	30	29,540	12,660	120	20	3,544,800	253,200	3,798,000	43.96
Total	223,216	90	200,894	70	30	140,626	60,268	120	20	16,871,108	1,201,360	18,080,468	209.27

The results of the calculation of water needs based on data from the Jatiwekas WTP service area can be seen in Table 2. The next step is to determine the water loss and its treatment capacity.

Q water loss = Qair service area × 20%
Q water loss = 209.27 L/s × 20%
Q loss of water = 41.85 L/s
Qtotal = Qair of service area + Qloss of water
Qtotal = 209.27 L/s + 41.85 L/s
Qtotal = 251.12 L/s = 21,696,768 L/day
Q_hmax= Q_(Total)×f_hm
= 21,696,768 L/day × 1.25
= 27,120,960 L/day = 313.9 L/s

The Jatiwekas WTP must increase the processing discharge of the Jatiwekas IPA which was originally 190 L/s or 16,416,000 L/day to 313.9 L/s or 27,120,960 L/day if you want to achieve 90% service coverage. The water supply development was able toimprove income distribution including in Tulungagung Regency (Nugroho & Anny, 2004).

Conclusion

WTP Jatiwekas has three processing units, namely WTP with a capacity of 50 L/s (WTP 1), WTP with a capacity of 100 L/s (WTP 2), and WTP with a capacity of 40 L/s (WTP 3). The Jatiwekas WTP consists of one flocculation, sedimentation, filtration, and reservoir. Based on SNI 6773:2008, the Jatiwekas WTP has mostly met the requirements of the package type WTP. The Jatiwekas WTP does not meet the Planning Criteria of the Directorate General of Public Works, which states that the service coverage for small towns with a population of 20,000–100,000 is 90%. When the service coverage reaches 90%, the Jatiwekas WTP needs to increase water production capacity by 123.9 L/s.

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