Improved Performance of Water Supply System Sawah Liek and Tungku Sadah PDAM Kota Padang Panjang

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Abstract

Sawah Liek and Tungku Sadah have increased turbidity during the rainy season, 629 NTU. Sawah Liek and Tungku Sadah are 845 m and 888 m above sea level and flow by gravity at Sungai Andok Reservoir, 802 m. Sawah Liek has a production of 5 l/s for 428 customers and Tungku Sadah 10 l/s for 2,806 customers. One of the causes of turbidity fluctuation during rain is planting activities which degrade the area of land cover, increase runoff and minimize infiltration into the area that the flow from the source decreases every year. Water consumption for customers of Sawah Liek is 202 l/person/day and Tungku Sadah 62 l/person/day is smaller than the category of small towns of 130 l/person/day. The installed slow sand filter is unable to handle the turbidity during the rain in exceeds of 50 NTU. The maximum produced by the installed slow sand filter is 2.67 l/s. Changes in the function of the filter installed at a high-speed sand filter can increase production to 26.7 l/s and overcome turbidity fluctuations can be accomplished by improving the system with a complete treatment facility or an incomplete processing facility consisting of a screen, a large chamber, coagulation, and flocculation, filtration and disinfection.

Keywords: *Sawah Liek, tungku sadah, turbidity, rain, water treatment improvement*

Abstrak

Sistem penyediaan air Sawah Liek dan Tungku Sadah mengalami peningkatan kekeruhan di musim hujan, 629 NTU. Sawah Liek dan Tungku Sadah berada di elevasi 845 m dan 888 m yang mengalir secara gravitasi ke reservoir Sei Andok, 802 m. Produksi Sawah Liek 5 l/s dengan 428 pelanggan dan Tungku Sadah 10 l/s dengan 2.806 pelanggan. Fluktuasi kekeruhan di saat hujan, salah satunya disebabkan kegiatan perkebunan yang mendegradasi luasan tutupan lahan, memperbesar limpasan dan memperkecil infiltrasi di kawasan sehingga debit sumber setiap tahun menurun. Tingkat pemakaian air pelanggan Sawah Liek 202 l/orang/hari dan Tungku Sadah 62 l/orang/hari lebih kecil dari kategori kota kecil 130 l/orang/hari. Saringan pasir lambat terpasang tidak mampu mengatasi kekeruhan pada saat hujan yang melebihi 50 NTU. Produksi maksimum saringan pasir lambat terpasang 2,67 l/s. Perubahan fungsi saringan terpasang menjadi saringan pasir cepat dapat meningkatkan produksi menjadi 26,7 l/s dan mengatasi fluktuasi kekeruhan dapat dilakukan penyempurnaan sistem dengan instalasi pengolahan lengkap atau instalasi pengolahan tidak lengkap yang terdiri dari *bar screen, fine screen, great chamber*, koagulasi dan flokulasi, filtrasi dan desinfeksi.

Kata Kunci: *Sawah Liek, tungku sadah, kekeruhan, hujan, penyempurnaan pengolahan air*

1. Introduction

The Regional Drinking Water Company (PDAM) of Kota Padang Panjang is a government-owned enterprise providing drinking water for the City of Padang Panjang [1]. Sawah Liek and Tungku Sadah surface water are 2 (two) of the 6 (six) clean water sources that are utilized and connected in a clean water supply system in Kota Padang Panjang [2]. Based on measurements of researchers in the field, the source of Sawah Liek is at an altitude of 845 m above sea level and flows by gravity into the Sungai Andok Reservoir 200 m³ which is located at an altitude of 802 m above sea level. Sawah Liek's water production in 2019 was 8.9 l/s, and this production has decreased compared to the installed capacity of 10 l/s. The Sawah Liek system serves the service area of Padang Panjang Barat and Panjang Timur Subdistricts, with details of Kampung Manggis, Kampung Teleng, Jalan Pahlawan, Silaing Bawah, and Kampung Rao-Rao with 428 customers. Meanwhile, the Tungku Sadah source is located at an altitude of 888 m above sea level and flows by gravity towards the Sungai Andok Reservoir 200 m³. The production discharge of the Tungku Sadah source is 18.92 l/s from an installed capacity of 25 l/s with service areas of Padang Panjang Barat

and Padang Panjang Timur sub-districts with details of Tanah Hitam, Cubadak, Koto Panjang, Koto Katiak, Ngatau, Ekor Lubuk, Batas Kota Padang Kayo, Kampung Koto, and Urip Sumuharjo with 2,806 customers.

The surface water of Sawah Liek and Tungku Sadah currently experiences a decrease in the amount of production in the dry season and an increase in turbidity during the rainy season [3]. The increase in turbidity during the rainy season creates problems in the service area, in which the quality of the water distributed to the 3,234 customers does not meet the quality standards of clean water especially during the rains [3]. Technical efforts were made to overcome this turbidity problem, PDAM Kota Padang Panjang stopped water distribution to customers during the rains, while during the dry season, the flow rate could not reach the installed capacity [3]. The decrease in the quality of Sawah Liek and Tungku Sadah raw water in the rainy season and a decrease in quantity in the dry season resulted in the disruption of services to 3,234 customers of PDAM Kota Padang Panjang which became the concern of this research.

This research was directly conducted by the author and is a preliminary study intended to identify, analyze, and formulate improvements in the performance of the Sawah Liek and Tungku Sadah clean water supply systems. It examines the aspect of quantity, quality, and continuity, in short, medium, and long-term programs. The scope of the problem that will be the focus of this research is why the clean water supply system for Sawah Liek and Tungku Sadah is not able to achieve clean water quality, especially during the rainy season? Why are the Sawah Liek and Tungku Sadah raw water sources unable to reach the installed capacity? and what kind of technical formulation to improve the performance of the Sawah Liek and Tungku Sadah clean water supply systems in the short, medium, and long term?

2. Material and Methods

Based on the quality and quantity problems of Sawah Liek and Tungku Sadah sources during the rainy and dry seasons, to analyze the performance of the clean water supply system, data on the characteristics of raw water sources and treatment units and their design standards are needed [4]. The data and information are classified into qualitative and quantitative data obtained directly (primary) and indirectly (secondary) [5]. Primary data were obtained from field measurements using measuring instruments including descriptive qualitative data through observation.

Primary data acquisition consisted of (1) Source flow discharge using a Current Meter owned by the Hydraulics Laboratory of the Environmental Engineering Department, Universitas Andalas; (2) Turbidity of raw water during the dry and rainy seasons using a Turbidity Meter owned by PDAM Kota Padang Panjang; (3) Source elevation, installation location water treatment, and transmission network (pipe length, pipe type, pipe diameter, and elevation) using the Global Positioning System (GPS); (4) Measurement of the type and dimensions of the installed drinking water treatment plant through observation and measurement using a meter. Measurement of point elevation using GPS is done by placing the GPS on the ground to find out information on the height of the point in meters. While the distance from one point or node to another is measured by a running meter that follows the installed piping path.

Secondary data was obtained through the basic data of PDAM Kota Padang Panjang and the literature review. The data obtained from observations, measurements in the field are compared, analyzed, and evaluated with a literature approach, especially the standard literature on the design of a clean water supply system related to the installed system. The results of this analysis will recommend technical formulations to answer existing problems that can improve the performance of the Sawah Liek and Tungku Sadah clean water supply systems, PDAM Kota Padang Panjang in the future.

3. Results and Discussion

Sawah Liek Drinking Water Supply System and Tungku Sadah

PDAM Kota Padang Panjang serves 92% of the population of Kota Padang Panjang with 7,934 active customers. SPAM Sawah Liek and Tungku Sadah are 2 (two) sources of clean water that are connected to a system with a distance of 1 km from the source to the reservoir with a 6-inch diameter PVC pipe. The results of field surveys conducted by researchers using GPS equipment, Turbidity Meters, Current Meters, and measuring meters, obtained the following data. The source of raw water used is classified as sub-surface water on the city highlands towards the Kuburan Cina. This condition can be seen from the researchers' observations of soil and rock outcrops at the source and water flowing from the surface of rocks and soil originating from higher areas as illustrated in **Figure 1**.

Figure 1. Soil outcrop of raw water sources as subsurface flow in Sawah Liek and Tungku Sadah
Source: Pictures taken directly by a researcher, 2019

When measurements were made in the summer and rainy season, the turbidity of the raw water source reached 0 NTU or it can be considered as very clear with a capacity of 5 l/s in Sawah Liek and 10 l/s in Tungku Sadah. During the rainy season, the discharge experiences an extreme increase, which overflows and spreads from the tributary to a depth of 629 NTU. Processing of 6 units of the slow sand filter with a surface size of 2 x 2 m² per unit to treat 2 sources located in adjacent reservoirs. The slow sand filter unit at the time of this study was not functioning, considering it was unable to cope with turbidity fluctuations that occurred during the rainy season. Other treatment units, coagulation, flocculation, and sedimentation processes are not available at this water treatment plant. Schematically the SPAM for Sawah Liek and Tungku Sadah is presented in **Figure 2**.

Figure 2. Schematics of the Sawah Liek and Tungku Sadah service areas
Source: Pictures taken directly by a researcher, 2019

Water Treatment Plant

Sawah Liek and Tungku Sadah raw water is a group of runoffs with dry season discharge 5 l/s and 10 l/s respectively. Since it was built, the Sawah Liek Raw Water in 2005 has a capacity of 10 l/s and the Sadah Furnace in 1997 is 25 l/s. The decrease in the average flow rate since it was built until the time this research was conducted was 0.36 l/s per year in Sawah Liek and 0.68 l/s per year in Tungku Sadah. In the rainy season, the flow rate cannot be calculated because the flow spreads and overflows from the cross-section of the tributary of the intake location. The intake construction resembles Broun capturing [6] which is technically a catcher building for this type of spring, this is identified because the source flow discharge is very small. At the detention time of 1,200 s [7], the dimensions of the building that have been built by the standards are presented in the following **Table 1**.

Table 1. Dimensions of the source intake building

Water sources	Flow capacity (l/s)	Time (s)	Heigh (m)	Volume (m ³)	large (m ²)	Length x Width (m ²)
Sawah Liek	5	1.200	1,5	6.000	4	2 x 2
Tungku Sadah	25	1.200	1,5	30.000	20	4 x 5

Source: Results of preliminary calculations by a researcher, 2019

One of the causes of a decrease in surface runoff is the change in land vegetation cover in the catchment area, namely the use of this area at several points as plantation land, such as Cinnamon. Changes in forest land cover into plantation areas, increase runoff to flow into rivers and reduce infiltration processes as infiltration [8]. The condition of this flow will continue to decline if there is no rejuvenation of forest areas and the prohibition of plantation activities by relevant stakeholders, communities including local governments. Turbidity fluctuations in raw water during the rainy season reach 629 NTU bringing material to the soil surface and this will be worse with land clearing for plantation activities and the possibility of landslides due to steep terrain [9]. Turbidity fluctuations require high removal efficiency at treatment plants, namely 96% of 25 NTU as the standard value for clean water and 99% of 5 NTU as the standard value for drinking water [10].

Average Water Usage Rate

428 customers from Sawah Liek source with a capacity of 5 l/s and 2,806 customers from Tungku Sadah source, so the average daily usage of customers from Sawah Liek source is considered very good, in which 202 l/person/day. This value has exceeded the average use of clean water for small towns, which is 130 l/person/day, while for the source from the Tungku Sadah it is 62 l/person/day with a production capacity of 10 l/s or half of the clean water usage of small towns as shown in the figure. presented in **Table 2**, [11], so that the Tungku Sadah service area requires additional supplies from other sources, especially during the dry season.

Table 2. Average water usage rate of Sawah Liek and Tungku Sadah water sources

Water sources	Customer (unit)	Number of people per customer (person/customer)	Flow capacity (l/s)	Flow capacity		Small town average clean water usage standard
				(l/person/s)	l/person/day	l/person/day
Sawah Liek	428	5	5	0,002336	202	130
Tungku Sadah	2.806	5	10	0,000713	62	130

Source: Results of preliminary calculations by a researcher, 2019

The currently installed slow sand filter unit can effectively function at a turbidity value of 50 NTU [12]. The filtration velocity of the slow sand filter unit is 0.1-0.4 m/hour [13], so the units built with an area of 2 x 2 m² (4 m²) as many as 6 units are only able to process a maximum flow of 2.67 l/s. Quantitative improvement in the performance of the filtration unit occurs by changing the function as a fast sand filter unit by changing the filter media from 0.15 - 0.35 mm to 0.5 - 1.0 mm as the effective size with a fast sand filter velocity of 4 - 21 m /hour [13], so it can function at a minimum capacity of 26 l/s.

The efficiency of removing turbidity takes place when it reaches 25 NTU for turbidity as clean water and 5 NTU for drinking water [10], so a complete treatment system improvement [14] is the best alternative, but on the other hand, the system with complete treatment is only used when it rains. Therefore, it is necessary to review the financial feasibility of the plan which was conducted by the company in the

long term. The second alternative to increase the optimization of the installed building is to function as a fast sand filter by changing the media size in the range of 0.5-1.0 mm and controlling the minimum flow rate at a velocity of 4 m/hour. The performance of this filter unit will be better by the addition of a hydraulic coagulation and flocculation unit using pipes and baffle channels. The addition of this unit will increase the removal of particles in raw water when it rains. Removal of coarse particles, soil, and sand can be a modified intake by adding a fine screen unit, great chamber, and pre-sedimentation [15]. The addition of a fine screen unit, great chamber, pre-sedimentation as a unit of the catchment building, and a coagulation-flocculation unit before filtration is also intended to function only during rain [16].

Details of the implementation of this program need to be carried out in detail specifically related to engineering design and comprehensive research on raw water sources. Financial aspects of PDAM Padang Panjang, and other stakeholder inputs, considering this research is a preliminary study to guide phasing programs and activities to PDAM Kota Panjang, especially in overcoming problems at Sawah Liek and Tungku Sadah sources. The scheme and performance for the removal of turbidity from these alternatives are as follows:

Alternative 1:

Figure 3. 1st Scheme performance improvement of drinking water supply system
Sawah Liek and Tungku Sadah

Source: The author's design as a researcher, 2019

Alternative 2:

Figure 4. 2nd Scheme performance improvement of drinking water supply system
Sawah Liek and Tungku Sadah

Source: The author's design as a researcher, 2019

The total turbidity removal efficiency of 629 NTU in alternative 1 at the minimum efficiency level is 96.34% (23 NTU) and 99.68% (2 NTU) at the maximum efficiency level, while alternative 2 at the minimum efficiency level is 93.96% (38 NTU) and 99.72% (8 NTU) at maximum efficiency. Alternative 1 is the best, namely a series of coarse and fine screen units, great chamber and pre-sedimentation, coagulation, flocculation, sedimentation, filtration, and disinfection to achieve turbidity of clean and drinking water quality standards [10] as fully presented in table 3 below.

Table 3. Design of the turbidity removal efficiency of each alternative

Parameter	Raw Water Turbidity (NTU)	Coarse Screen	Fine Screen	Efficiency removal (Great Chamber and Pre-sedimentation)		Efficiency removal (Coagulation, Flocculation, and Sedimentation)		Efficiency (Filtration)	
Alternative 1	629	Remove coarse material with 2-3 inch openings	Set aside coarse material	40 %	75 %	40 %	75 %	90 %	95 %
		with a flow rate of 0.6 m/s	opening 3/16 -3/8 inch 629	377 NTU	157 NTU	226 NTU	39 NTU	23 NTU	2 NTU
Alternative 2	629			40 %	75 %			90 %	95 %
				377 NTU	157 NTU			38 NTU	8 NTU

Source: Results of preliminary calculations by a researcher, 2019 based on [4] and [13]

To achieve efficiency in reducing raw water quality at the source when it rains, the performance design for the removal of the turbidity parameters for each of the alternatives mentioned above becomes the basis for the preparation of the detailed engineering design (DED) for each unit.

4. Conclusion and Recommendation

Conclusion

The high turbidity of Sawah Liek and Tungku Sadah raw water during rainy seasons, one of which is caused by plantation activities in the watershed area. Changes in land cover increase rainfall run-off and reduce infiltration areas so that the source flow rate decreases every year. The installed intakes meet the design criteria. The average water consumption level of Sawah Liek customers is very good, 202 l/person/day, and the Tungku Sadah 62 l/person/day which is lower than the average use of a small town of 130 l/person/day. The processing unit is not complete where the slow sand filter is not able to overcome the turbidity during the rainy season and can only function properly at a discharge of 2.67 l/. The increase in the function of the installed filter into a fast sand filter can produce 26.7 l/s to overcome turbidity fluctuations during the rain which is equipped with system improvement activities, namely a complete system or an incomplete system consisting of a bar screen, fine screen, great chamber and pre-sedimentation, coagulation and flocculation and filtration, disinfection.

Recommendation

To improve the performance of the Sawah Liek and Tungku Sadah drinking water supply systems in the short-term period, further research needs to be carried out by applying detailed engineering design (DED) activities of alternatives 1 and 2 according to the design period. It also can be conducted by the formulation of alternative investment financing schemes 1 and 2 related to the company's capabilities and strategies. The medium-term period is the implementation of construction work from the selected DED for each alternative, testing the system built and operating and maintaining the system. Meanwhile, in the long-term period, it can be done by rejuvenating the forest location as a watershed area to maintain source flow discharge and quality and prohibition plantation activities in the area. "I"

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