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Exploration of the Availability, Quality, and Projection of Clean Water Needs According to the Community's Perspective in the Gajahmungkur Village

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ABSTRACT

Gajahmungkur Village is one of the coverage areas of the Kaligarang Water Treatment Plant where the amount of clean water demand for citizen and customers in the current year and the coming years is not yet known. The IPA Kaligarang which distributes clean water to various regions in the city of Semarang, also does not yet have data related to the availability of its water sources over the same time period. Researchers will examine the availability of water sources in the Kaligarang River, which will be processed through the IPA Kaligarang, and examine the clean water demand of citizen and customers in Gajahmungkur Village. Community perspectives are also involved in this research as an aspect that can affect the sustainability of clean water sources in the Kaligarang River. The availability of the Kaligarang River as a raw water source is only sufficient to meet the clean water demand of customers from 2020 to 2023, while it is insufficient from 2024 to 2028. The Kaligarang River is also unable to meet the clean water demand of citizen from 2020 to 2023 and in the projection year. The clean water demand of citizen and customers in the projection year has an average of 4.65 liters/second and 0.89 liters/second, respectively. The processed water obtained from the predetermined samples does not show any pollution, as evidenced by the test values and each parameter being below the threshold.

Keywords: Projection of clean water demand, availability of clean water, Gajahmungkur Village.

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1. INTRODUCTION

Clean Water is a primary neef for living beings, especially humans. Humans require clean water as a fundamental necessity for survival (Akadun et al., 2020). The continuously growing population will be directly proportional to the demand for clean water in a given area. Until now, many local governments have still been unable to control population growth (Suhendra & Rianto, 2019). As a result, the availability of clean water sources becomes, the main priority for handling across all regions (Cosgrove & Loucks, 1969).

The availability of clean water sources is closely related to the fulfillment of clean water needs (Andani, 2012). Ideally, the ratio of available clean water sources is greater than the fulfillment of water needs (Mishra, 2023). However, various environmental pollution phenomena occurring in the upstream part of the Watershed have an impact on the degradation of the carrying capacity of the environment in that area (Zuriyani, 2017). The decreasing availability of clean water sources is a concrete impact of the degradation of the carrying capacity of the environment in the upstream watershed DAS (Noperissa & Waspodo, 2018; Pristianto & Butudoka, 2023). The water also experiences a decrease in quantity and quality in terms of physical, chemical, and biological aspects (Pudjiastutik, 2013). Based on this, a study on the needs and availability of clean water needs to be conducted.

Previous studies on the availability and need for clean water have been conducted by several researchers in different study locations, such as those conducted by (Salim, 2019) in North Bekasi District, (Nofrizal & Saputra, 2021) Tigo Nagari District, (Azkia, 2021) Pulau Laut District, and (Khaero, 2021) ini Gangga District. These studies only analyzed the availability and need of clean in each study location, without involving the community's perspectives on the need for and availability of clean water. In fact, the community becomes the determinant of whether the sustainability of clean water management can be carried out or not (Figueroa & Kincaid, 2010). Therefore, the community's perspectives are very important to be involved in the analysis of the need for and availability of clean water in a region.

Semarang City is a city in Central Java that ranks 10 as the city with the densest population in Indonesia. The population of Semarang City is directly proportional to its need for clean water (BPS Kota Semarang, 2023). To meet the clean water needs of its residents, the Kaligarang River is used as one of the raw water sources (Marlena et al., 2012). In producing clean water form the Kaligarang River, there is a Water Treatment Plant managed by PT. Tirta Gajah Mungkur. The produced clean water will be distributed to the coverage areas of the Kaligarang Water Treatment Plant, namely Candi, Malabar, Papandayan, Purigede, Sisingamaraja, Sultan Agung, West Semarang, and Gajahmungkur (Adela et al., 2017).

Previous researchers have not examined the needs and availability of clean water sources from the Kaligarang River, nor have they involved the community's perspectives. With the growing population and environmental pollution phenomena in the Kaligarang watershed, the quantity and quality of the water have the potential to decrease. This could

threaten the continuity of PERUMDA Tirta Moedal as the water distributor in producing clean water for the community. Water needs can be met by considering the available clean water sources. By involving analysis of various factors, such as population needs, water use for various purposes, environmental issues, and water resources available to meet those needs. Therefore, this study aims to examine the needs and availability of clean water sources as well as the projection of clean water needs according to the community's perspective in the Gajah Mungkur Village area (Arief & Masduqi, 2018).

2. METHODS

Sampling

The researchers determined the sloving method in determining the sample because this method is able to reduce the error rate in determining the sample by lowering the degree of accuracy. The Slovin formula for determining the sample is as follows:

$$n = \frac{N}{1 + Ne^2}$$

Description:
n = sampel size number of respondents
N = population size
e = percentage of allowable sampling error tolerance; e= 0.1

Based on the calculation results using the Slovin method, the sample in this study is 74 kk. The sample will be grouped according to the coverage area of PERUMDA Tirta Moedal, which is sourced from IPA Kaligarang 1, using the Cluster Random Sampling technique. The Cluster Random Sampling method is one of the area sampling techniques used to determine samples when the object to be studied is very broad. The formula for determining Cluster Random Sampling is as follows:

$$fi = \frac{Ni}{N}$$

Then the sample size per cluster was obtained using the following formula:

$$\text{Ni} = fi \; x \; n$$

Description:
Fi = Cluster fraction sample
Ni = Number of individuals in the cluster
N = Total Population Size
n = number of members included in the sample

The sample obtained using the cluster random sampling method is 74 KK (Tabel 1). The sample is dominated by the Papandayan area. Papandayan becomes the area with the largest number of customers compared to other regions because the area is closest to the distribution from the IPA Kaligarang.

Table 1. Population and research sample

No	Region Name	Number of Customers (KK)	Sample (KK)
1	Malabar	38	10
2	Papandayan	251	64
Total		282	74

Analysis of Clean Water Needs

Projection of the population up to 2030 using the arithmetic and geometric methods. The formula used in the arithmetic method is as follows:

$$Pn = Po + r \cdot n$$

$$r = \frac{Pn\ Po}{n}$$

The formula used in the geometric method is as follows:

$$Pn = Po + (1 \cdot r)^n$$

Description:

Pn = population in the final year
Po = population in the initial year
r = population growth rate
n = difference between the final and initial years

Losses

Annual production volume Annual consumption received by customers within 1 year. Calculated using the calculation formula (Badan Pendukung Pengembangan Sistem Penyediaan Air Minum, 2015).

$$\frac{Production - consumption}{production}\ x\ 100\%$$

The Service Capability of PERUMDA Tirta Moedal

The service capability towards customers uses the calculation formula (Triadmodjo & Haryanto, 2001):

$$\frac{Clean\ Water\ Production\ PERUMDA\ Tirta\ Moedal}{Total\ Clean\ Water\ Demand\ of\ Customers}\ x\ 100\%$$

Calculating year x:

a. Total population projection
b. Domestic customers
c. Non – domestic customers = domestic customers result x 30%
d. Total customer projection = domestic + non – domestic
e. Customer water demand = total customer projection result x 20 liters/person/day.

Service capacity of PERUMDA Tirta Moedal for the population

$$\frac{Clean\ Water\ Production\ PERUMDA\ Tirta\ Moedal}{Total\ Clean\ Water\ Demand\ of\ Citizen}$$

a. Total projected population
b. Non – domestic customers = total projected population x 30%

c. Total projected population = domestic + non – domestic
d. Clean water needs of the population = total projected population x 100 liters/person/day.

total clean water needs of the population

Clean Water Availability

Calculating the services of PERUMDA Tirta Moedal for customers

$$\frac{Total\ Clean\ Water\ Production\ PERUMDA\ Tirta\ Moedal}{Total\ Clean\ Water\ Demand\ of\ Customers}\ x\ 100\%$$

Calculating the services of PERUMDA Tirta Moedal for Population

$$\frac{Total\ Clean\ Water\ Production\ PERUMDA\ Tirta\ Moedal}{Total\ Clean\ Water\ Demand\ of\ Population}\ x\ 100\%$$

Descriptive Analysis of Public Perceptions Towards the Need and Availability of Clean Water

The researchers conducted interviews with questions related to the needs and availability of clean water for samples that are customers of PERUMDA Tirta Moedal in Gajahmungkui Village.

3. RESULTS AND DISCUSSION

Population Projection

Researchers used data on population and customer projections, customer service, customer and resident water needs, as well as customer and resident service targets in projecting the clean water needs in Gajahmungkur Village.

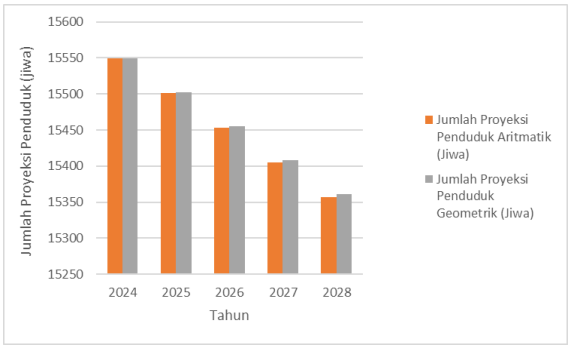

Figure 1. Population Projection of Gajahmungkur Village for 2024 – 2028

The arithmetic method produces a lower population projection value compared to the geometric method. The geometric method also has a higher correlation coefficient value and a lower standard deviation value compared to the geometric method (**Figure 2**).

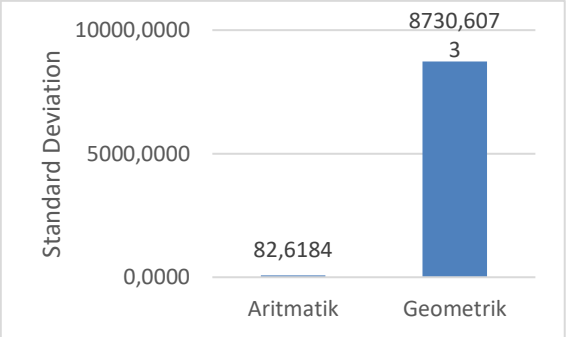

Figure 3. Calculating Standar Deviation

Based on Table 2, the calculated average population growth rate in Gajahmungkur Sub-district increased by 2% annually over a certain period. This represents the annual growth calculated as a percentage of the population in the previous year.

Table 2. Population Growth Rate

No.	Year	Population	Population Growth Rate
1	2018	14,106	
2	2019	15,837	12%
3	2020	14,870	-6%
4	2021	15,801	6%
5	2022	15,541	-2%
6	2023	15,597	0.4%
Avarage			2%

An annual growth of 2% indicates that the population is increasing steadily; however, when compared to higher figures, this growth may be considered slow depending on the conditions of a particular area.

Table 3. Customers Growth Rate

No.	Year	Number of Customers	Customers Growth Rate
1	2018	161	
2	2019	204	26%
3	2020	258	26%
4	2021	267	3%
5	2022	274	3%
6	2023	282	3%
Avarage			12%

Based on Table 3, the average customer growth rate of 12% is a positive indicator of the company's performance.

Losses

PERUMDA Tirta Moedal faces a common problem experienced by water companies, namely the loss of clean water during the distribution process through pipes to consumers (Febriany, 2014; Maulana, 2023). Researchers used production and clean water usage data owned by PERUMDA Tirta Moedal to calculate water losses over a specified time period. The water loss results for PERUMDA Tirta Moedal from 2020 to 2023 are 7.84%, 7.84%, 10.78%, 13.17%, and 15.49% respectively, as can be seen (**Figure 3**).

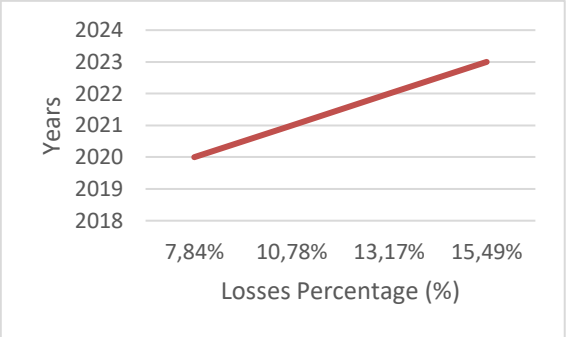

Figure 3. Percentage of Water Losses in the Distribution Process of PERUMDA Tirta Moedal

According to Figure 2, the percentage of water loss has been increasing yearly. Yekti et al., (2020) stated that this event indicates that water distribution infrastructure maintenance activities are not yet optimal. Suboptimal water distribution infrastructure maintenance can be influenced by several factors, one of which is the lack of employee competence. Mustafidah (2019) explained that the level of employee competence has a significant impact on reducing water loss in PERUMDA Air Minum in a region. This can cause the company to suffer significant losses in the future if infrastructure maintenance activities are not promptly evaluated (Makbul, 2021).

Clean Water Needs of Customers

The customers of Perumda Air Minum Tirta Moedal in Gajahmungkur Sub-district have experienced increasing growth rates since 2020. This has led to a rise in the clean water demand of Perumda Air Minum Tirta Moedal's customers in the area. The calculated clean water demand from 2020 to 2023 was 12,384 liters/day, 12,816 liters/day, 13,152 liters/day, and 13,536 liters/day, respectively (Table 4).

Table 4. Projection of Clean Water Needs of Customers

Year	Total Project Customers (people)	Clean Water Needs Customers (Liters/day)
2024	288	13.824
2025	294	14.112
2026	300	14.400
2027	306	14.688

Referring to Table 4, the clean water produced by Perumda Air Minum Tirta Moedal is sufficient to meet the clean water needs of customers in Gajahmungkur Sub-district during the projection years, from 2024 to 2027.

Clean Water Needs of The Population

The population of Gajahmungkur Sub-district has a cleanwater needs from 2020 to 2023, which were 26,507 liters/day, 28,167 liters/day, 27,703 liters/day, and 27,803 liters/day, respectively (Table 5).

Table 5. Clean Water Needs of Population

Year	Population (People)	Clean Water Needs of Population (liters/day)	Clean Water Production (liters/day)

2020	14,870	26.507	80.804
2021	15,801	28.167	82.154
2022	15,541	27.703	82.722
2023	15,597	27.803	86.434

Referring to Table 6, the clean water production capacity of Perumda Air Minum Tirta Moedal through the Kaligarang Water Treatment Plant (WTP) is sufficient to meet the population's clean water demand during that period. The population growth in Gajahmungkur Sub-district is uneven, leading to fluctuating clean water demand. Despite this, the population exceeds the number of customers, resulting in higher water demand from the population than from customers, both in the base year and projected years (Table 6).

Table 6. Projection of Clean Water Needs of Population

Years	Population (People)	Clean Water Needs of Population (liters/day)
2024	15.549	27.803
2025	15.501	27.703
2026	15.453	28.167
2027	15.405	26.507
2028	15.357	28.231

The current production capacity can meet the projected clean water demand in Gajahmungkur Sub-district, which ranges from 26,507 to 28,231 liters/day (Table 6).

Service Capacity of Perumda Air Minum Tirta Moedal for Customers

The researcher assessed the service capability of Perumda Air Minum Tirta Moedal by calculating the ratio of clean water production at the Kaligarang Water Treatment Plant (WTP) to the customer water demand. The findings indicate that since 2020, the service capability has remained below 100%, suggesting that the production has not fully met the customer demand during this period (Figure 4).

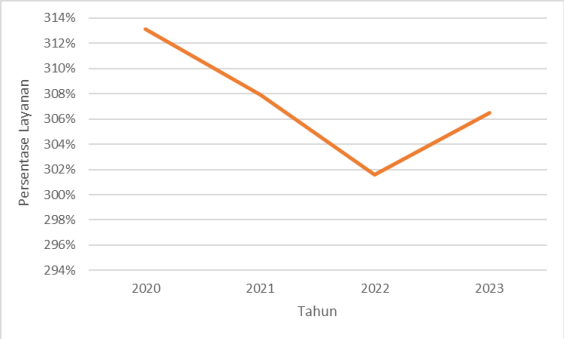

Figure 4. Digram of Customers Water Services of PERUMDA Tirta Moedal 2020 - 2023

Referring to Figure 4, Perumda Air Minum Tirta Moedal achieved over 100% service coverage each year from 2020 to 2023, indicating its capacity to fully meet customer water demands during this period (Table 7).

Table 7. Perfomance of Perumda Air Minum Tirta Moedal in Serving Customers

No.	Year

		Number of Customers (People)	Customers Water Consumption (Liters/day)	Service Coverage Percentage
1	2020	258	12.384	652%
2	2021	267	12.816	641%
3	2022	274	13.152	629%
4	2023	282	13.536	639%

Perumda Air Minum Tirta Moedal effectively navigated common challenges faced by water utilities during the COVID-19 pandemic from 2021 to 2023. Despite the implementation of public activity restrictions (Permana & Agustine, 2022), the company maintained optimal operations to meet customer demand for clean water. During this period, the number of customers in Gajahmungkur Sub-district increased, yet the Kaligarang Water Treatment Plant consistently met their water needs, as detailed in (Table 7).

Service Capacity of PERUMDA Tirta Moedal for the Population

Between 2020 and 2023, Perumda Air Minum Tirta Moedal successfully distributed clean water to residents of Gajahmungkur Sub-district, achieving service coverage percentages of 305%, 292%, 299%, and 311% respectively, as illustrated in (Figure 5). These figures indicate that the company's water production significantly exceeded the consumption needs of the local population during this period

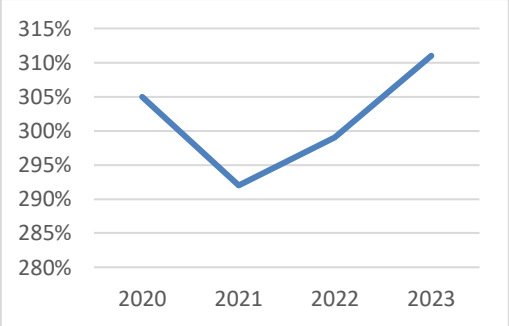

Figure 5. Population Water Service Coverage by Perumda Air Minum Tirta Moedal (2020–2023).

Based on Figure 5, Perumda Air Minum Tirta Moedal consistently achieved service coverage percentages exceeding 100% for the clean water needs of Gajahmungkur Sub-district residents from 2020 to 2023. This indicates tat the company successfully distributed clean water to the entire population during this period (Table 8).

Table 8. Perumda Air Minum Tirta Moedal Service To The Population

No	Year	Population (People)	Water Consumption (Liters/day)	Service Coverage Percentage
1	2020	14,870	26.507	305%
2	2021	15,801	28.167	299%
3	2022	15,541	27.703	292%
4	2023	15,597	27.803	311%

Between 2020 and 2023, Perumda Air Minum Tirta Moedal consistently achieved service coverage percentages exceeding 100% for the clean water needs of Gajahmungkur Sub-district residents. This indicates that the company successfully distributed clean water to the entire population during this period.

Projected Service Capacity of Perumda Air Minum Tirta Moedal for Customers

Between 2024 and 2027, Perumda Air Minum Tirta Moedal is projected to achieve clean water service coverage percentages of 530%, 519%, 508%, and 498%, respectively, for its customers in Gajahmungkur Sub-district (Table 9). These figures indicate that the company is expected to consistently meet the clean water needs of its customers, with service coverage exceeding 100% each year. This suggests that Perumda Air Minum Tirta Moedal will be able to comprehensively distribute clean water to the population during the projected period

Table 9. Projection Customers Service Capacity of Perumda Air Minum Tirta Moedal

No.	years	Projected Number of Customers	Customer Water Consumption (Liters/day)	Service Coverage Percentage
1	2024	288	13.824	530%
2	2025	294	14.112	519%
3	2026	300	14.400	508%
4	2027	306	14.688	498%

Based on Table 9, the projected clean water service coverage for customers of Perumda Air Minum Tirta Moedal in Gajahmungkur Sub-district is expected to decrease from 530% in 2024 to 498% in 2027. This decline is attributed to the increasing number of customers over the projected period. Consequently, the company's service capacity is anticipated to rise from 2024 to 2028, as depicted in Figure 6.

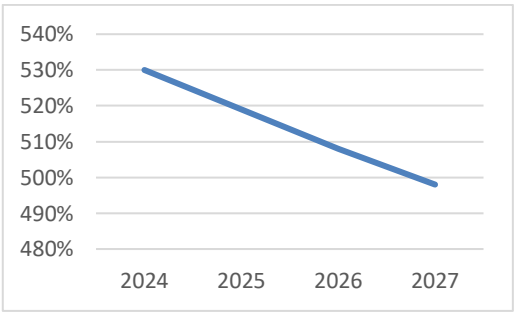

Figure 6. Diagram of Projected Clean Water Service Coverage for Customers by Perumda Air Minum Tirta Moedal in Gajahmungkur Sub-district

The projected increase in the number of customers, as depicted in the diagram, is attributed to the population growth rate in Gajahmungkur Sub-district used in the projections. By utilizing the average production data from 2020 to 2023, the Kaligarang Water Treatment Plant (WTP) is expected to continue meeting the clean water needs of customers during the projected period from 2024 to 2027.

Projected Service Capacity of Perumda Air Minum Tirta Moedal for the Population

The clean water production at the Kaligarang Water Treatment Plant (WTP) has been steadily increasing since 2020. This growth is projected to sufficiently meet the clean water needs of residents in Gajahmungkur Sub-district. According to (Table 10), the projected service coverage percentages for the population from 2024 to 2028 are 263%, 264%, 260%, 276%, and 259%, respectively. These figures indicate that IPA Kaligarang is expected to

continue providing adequate clean water supply to the community throughout the projected years

Table 10. Projected Service Capacity of Perumda Air Minum Tirta Moedal for the Population

No.	year	Projected population	Clean Water Needs (Liters/day)	Service Coverage Percentage
1	2024	15,549	27.803	263%
2	2025	15,501	27.703	264%
3	2026	15,453	28.167	260%
4	2027	15,405	26.507	276%
5	2028	15,357	28.231	259%

The projected decline in Gajahmungkur Sub-district's population from 2024 to 2028 is expected to reduce the ratio of clean water demand to the total production capacity of Perumda Air Minum Tirta Moedal. Consequently, the company is anticipated to enhance its service coverage in meeting the clean water needs of Gajahmungkur residents during the projection period, with improvements observed each year (Figure 7).

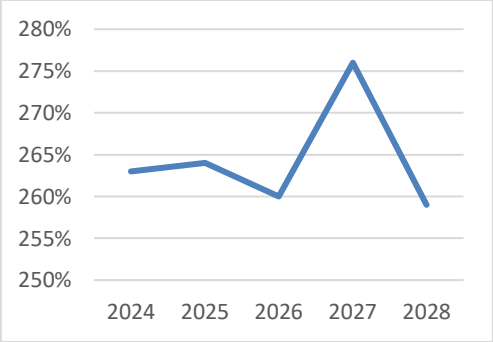

Figure 7. Projected Water Service Coverage of Perumda Air Minum Tirta Moedal for Residents of Gajahmungkur Sub-district

The population service capacity projection through the Kaligarang IPA is expected to meet the population's clean water demand at over 100% of the needs of residents in Gajahmungkur Subdistrict from 2024 to 2028 (Figure 7).

Raw Water Quality of the Kaligarang River

The researchers tested the raw water quality from the source, namely the Kaligarang River, for several parameters such as pH, turbidity, TDS, temperature, and Total Coliform. In its implementation, the researchers were accompanied by PERUMDA Tirta Moedal and PT. Tirta Gajah Mungkur in the raw water sampling. The results of the raw water quality testing on the parameters can be seen in (Figure 8).

Parameters	Unit	Threshold Value	Time Analysis				Average
			8-Jun	13-Jun	22-Jun	26-Jun	
pH	–	6- 9	7.50	7.55	7.44	7.40	7.47
Turbidity	NTU	3000	33.6	19.1	7.4	25.2	21.3
TDS	mg/l	1000	131.8	126.9	111.8	104.2	118.7
Temperature	°C	Air Temp. ± 3	23.3	28.0	26.1	25.8	25.8
Total Coliform	Total/100ml	1860 x 10^3	14 x 10^3	20 x 10^3	26 x 10^3	51 x 10^3	15 x 10^3

Figure 8. Raw Water Parameter Test Result

Community Knowledge of the Quantity and Quality of Clean Water Received

The results of the researcher's interviews on the respondents' knowledge of the clean water received found that more than 90% of the community received clean water with good quality and suitable for use, both at the present time and in the past. The community stated that this was based on the flow rate of the water received being able to meet their daily needs with normal color, taste, and odor. In storing the water received, the community generally uses tubs and tanks.

The researcher obtained data that 84% of the community have known that the Kaligarang River is the raw water source they use. On the other hand, there are 16% of the community who have not known this information. The level of public awareness in this matter has a very significant impact in supporting the efforts of maintenance and preservation of the river water quality.

All communities in the study area believe that the Kaligarang River can meet the water supply needs for their area based on the interview results. This is because the water they receive is relatively stable and the flow rate is consistent.

Pipes are used as the main means of distributing water from the source or the treatment plant that is carried out.

Community Behavior Towards

In accommodating the water received, the community generally uses tanks and reservoirs. Based on the results of surveys and interviews in this study, there are several ways the community utilizes water, which are used for drinking, cooking, bathing, and others. Based on the interview results, the frequency of draining the water storage containers in the study area is very diverse and is categorized as <4 days, <7 days, 1 week, >1 week, >1 month.

Cost Incurred by PERUMDA Tirta Moedal Customers

The community is divided into several categories based on the length of their subscription, namely <1 year, 10 - 20 years, 20 - 30 years and >30 years. The length of subscription to PERUMDA Tirta Moedal can influence the perception and satisfaction of customers towards the clean water services received.

In the cost category of Rp50,000 - Rp149,000, 37% of the community pay at this price. This is relevant to their water usage and relatively stable consumption. In the Rp150,000 - Rp250,000 category, 47% of the community pay at this price. Households in this cost range have higher water consumption due to larger household size or use of water for small industrial activities. And 16% of the community pay for water needs >Rp250,000.

4. CONCLUSIONS

Based on the result, the conclusion of this research is:

1. The projected clean water demand for the population from 2024 to 2028 is 27,803; 27,703; 28,167; 26,507; and 28,231 liters/day, respectively. For customers from 2024 to 2027, the projected demand is 13,824; 14,112; 14,400; and 14,688 liters/day.

2. The service capacity of Perumda Air Minum Tirta Moedal for customers in 2020–2023 was 652%, 641%, 629%, and 639%, and in 2024–2027 it is projected at 530%, 519%, 508%, and 498%. For the population, the capacity in 2020–2023 was 305%, 292%, 299%, and 311%, and in 2024–2028 is projected at 263%, 264%, 260%, 276%, and 259%. This indicates that the Kaligarang River as a raw water source is sufficient to meet clean water needs for customers (2024–2027) and the population (2024–2028).
3. The raw water quality of the Kaligarang River in June 2024 meets the standards set by Government Regulation No. 82 of 2001. The treated water in the Malabar and Papandayan areas meets the quality standards of the Indonesian Ministry of Health Regulation No. 492/MENKES/PER/IV/2010.

5. ACKNOWLEDGEMENTS

Continuous monitoring of water resources, especially the Kaligarang River, is essential to ensure the long-term fulfillment of clean water needs. Strengthening water management infrastructure is also necessary to optimize distribution, considering the significant increase in service coverage for customers from 2024 to 2027. Although the quality of raw and treated water currently meets standards, regular monitoring remains important to anticipate future challenges such as rising demand or potential changes in water quality.

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