Evaluation of Zona Air Minum Prima (ZAMP) Program in Ngagel Tirto Surabaya

D Erianik\textsuperscript{1*} B D Marsono\textsuperscript{1} and E S Soedjono\textsuperscript{1}

\textsuperscript{1}Department of Environmental Engineering, Faculty of Civil, Environmental and Geo Engineering. Institut Teknologi Sepuluh Nopember Surabaya 60111, Indonesia

*Corresponding author’s e-mail: erianikdewi@gmail.com

Abstract. Zona Air Minum Prima (ZAMP) is a special area where the water distributed to customers has met the quality standard to be directly consumed without needing to be boiled first. PDAM Surya Sembada Surabaya implemented the Zona Air Minum Prima (ZAMP) program starting on May 2018 in Ngagel Tirto by serving 152 house connections. However, to implement the ZAMP program in Surabaya, there are various challenges and constraints both from technical and community factors. Therefore, to find out the condition of the implementation of ZAMP program, an analysis of the operational aspects and utilization aspects of potable water by customers of ZAMP program is needed. The method that we used in this research was by taking water quality samples for measurement of total coliform and residual chlorine parameters as well as the pressure at customers’ house connections, water quality analysis in laboratory, distribution network analysis with WaterCAD v8i, questionnaires and literature studies. In operational aspect, the distribution system is almost continuous for 24 hours with an average production capacity that has been able to fulfill the customer water usage during peak hours. The pressure at the farthest point of distribution network has met the minimum criteria. About 70% of water samples have met the quality standard of potable water for total coliform parameters. In utilization aspect of potable water by the customer, the percentage of customers who directly consume potable water from the tap is 0%. However, about 73% of respondents are interested to consume potable water if PDAM can guarantee that the water quality has met the quality standard of potable water until the water reaches the tap of customers’ house.

Keywords: Ngagel Tirto, Operational aspect, Utilization aspect, Zona Air Minum Prima

1. Introduction
In order to meet the target of the national midterm development plan (RPJMN) of the Ministry of PUPR (Public Works and Public Housing) known as 100-0-100 especially 100% access to drinking water, PERPAMSI (Association of Indonesian Drinking Water Companies) in collaboration with USAID (United States Agency for International Development) helps PDAMs in Indonesia to innovate in order to improve services to customers (Pasaribu, 2005). One of the efforts to improve service to customers by PDAM of Surabaya is by implementing the Zona Air MInum Prima (ZAMP) program in which the water that is distributed to customers has met the quality standard to be directly consumed without the need to be boiled first (Gumilar, 2015). The ZAMP program is returning the PDAM’s function as a drinking water supply company because the existing PDAM service only provides clean water (Haq and Masduqi, 2014).
PDAM Surya Sembada Surabaya started implementing the Zona Air Minum Prima (ZAMP) program in May 2018 in Ngagel Tirto by serving 152 house connections. However, to implement the ZAMP program in Surabaya, there are various challenges and constraints both from technical and community factors. The challenge of the community factor is people's doubt on the quality of water distributed by PDAM of Surabaya. This is due to several cases where PDAM’s water in customers' homes being murky, smelly and having sediment. Hence, to fulfill the needs of drinking water, people depend on bottled drinking water (Sugiharto, 2015). So far, PDAM Surabaya has never conducted a study of acceptance of potable water that has been distributed to ZAMP customers. Challenges and constraints from technical factors include ZAMP’s need for a special distribution system with many criteria that must be fulfilled and more complicated maintenance requirement to distribute potable water to PDAM customers.

Therefore, to find out the condition of the implementation of ZAMP program, an analysis of the operational aspects and utilization aspects of potable water for customers of ZAMP program is needed. In this study, the evaluation is done based on aspects of operation and utilization. The operational aspects cover the distribution system, the pressure on the distribution network, and the quality of the distributed water. The utilization aspect is the percentage of ZAMP customers who consume potable water of PDAM based on the results of questionnaires.

2. Material and Methods

2.1 Location study
The location of this thesis research study is in DMA 201 that served 152 house connections in Ngagel Tirto IV, Ngagel Tirto V, Bratang Satu 1F and Bratang Satu 1G Street, as can be seen in Figure 1.

2.2 Operational Evaluation of Zona Air Minum Prima (ZAMP)
ZAMP operational evaluation in Ngagel Tirto was carried out on the technical component which includes the distribution unit and service unit in which the existing conditions are compared with the criteria.

1. Distribution Unit
The distribution units that we studied included production capacity and continuity, fluctuations of water usage, water losses level, distribution networks and pressure on the network.

   a. Production Capacity and Continuity
   Based on secondary data from PDAM of Surabaya during Desember 2018 until Februari 2019, then analyzed the production capacity of the installation and the continuity of the water distribution whether it has been continuous for 24 hours.

   b. Fluctuations of Water Usage
   Secondary data of the records from a flow meter in DMA 201 inlet from PDAM of Surabaya from December 2018 until Februari 2019 were acquired. We then analyzed the customer fluctuations of water usage for 24 hours which are presented in the table to determine the average, maximum, minimum water usage and water consumption patterns of ZAMP customers in Ngagel Tirto.

   c. Water Losses Level
   Secondary data of the records from a flow meter in DMA 201 inlet and customer water bill in DMA 201 from PDAM of Surabaya from December 2018 until Februari 2019 were acquired. The level of water loss was then analyzed by calculating the difference between the distributed water and the sold water.
d. Distribution Network

The distribution network study included analyzing reservoir capacity using the tabulation method, identifying the type of pipe (whether it used food grade material), analyzing pump capacity and the suitability of DMA-forming instruments with the criteria of Permen PUPR No. 27 of 2016 regarding the Implementation of Drinking Water Supply Systems.

e. Pressure

Pressure measurements were taken at 5 customer house connections then the results were compared with the results of network analysis using WaterCAD v8i in EPS (Extended Period Simulation) conditions according to the customer's water usage pattern based on water usage fluctuation data. In discussing the results of network analysis using WaterCAD v8i, pressure analysis was carried out at the farthest point (critical) during minimum to maximum usage hours. Then, the data was compared with the pressure criteria on Permen PUPR No. 27 of 2016 regarding the Implementation of Drinking Water Supply Systems.

2. Service Unit

In the service unit study, the evaluation was about the quality of drinking water distributed to customers with total coliform and residual chlorine parameters that were analyzed based on primary data from the analysis of water quality in 33 customer house connections. Analysis of the examination results of total coliform parameters in the laboratory using the MPN method was compared with PERMENKES No. 492/MENKES/PER/IV/2010 regarding Requirements for Drinking Water Quality. Analysis of the examination results of the residual chlorine parameters in the field using comparator Lovibond and DPD tablets was compared with PERMENKES No. 736/MENKES/PER/VI/2010 regarding Water Sampling Techniques.
2.3 Evaluation of Utilization of Potable Water by Customers of ZAMP program
The utilization aspect that we studied is the percentage of ZAMP customers who consume potable water of PDAM from the tap to meet consumption needs. Data analysis is based on primary data which is the results of questionnaires to customers who have been served by the ZAMP program and also homeowners of the houses where the water samples were taken from for water quality analysis. Then, we also analyzed the customer's interest of potable water from PDAM in the future.

3. Results and Discussion

3.1 Operational Evaluation of Zona Air Minum Prima (ZMP) Program
1. Distribution Unit
   a. Production Capacity and Continuity
   The ZAMP installation capacity was 20 m$^3$/hour. ZAMP water treatment plants include micronfilter, membrane ultrafiltration and UV disinfection units. The potable water production capacity increased every month. In December 2018 the average production capacity was 15,089 m$^3$/hour, it increased to 19,455 m$^3$/hour in January 2019 and increased again to 19,856 m$^3$/hour in February 2019. The average production capacity of potable water of PDAM Surabaya in December 2018 until February 2019 is 18,134 m$^3$/hour.
   
   The ZAMP installation and distribution system had been continuous for 24 hours a day. However, there were several days when the installation did not operate continuously for 24 hours (off for about 2-3 hours a day) due to technical problems such as power failure, raw water running out because the sensor of the raw water tank was damaged or it was being repaired either in the installation or distribution pipe. Even though the installation is off, customers would still get water supply by passing water from the Ngagel III IPAM reservoir. So, it can be concluded that the distribution system was almost continuous for 24 hours.
   
   b. Fluctuation of Water Usage
   Fluctuation of water use data is important because the capacity of the system must be sufficient to fulfil peak water needs. Average fluctuations of water usage of ZAMP customers in the last 3 months can be seen in Table 1.

| Hours | Flow (m$^3$/hour) | % | Factor |
|-------|-----------------|---|--------|
|       | a               | b=a/Q tot | c=a/Q average |
| 1     | 9,855           | 3.09% | 0.742  |
| 2     | 9,791           | 3.07% | 0.737  |
| 3     | 10,415          | 3.27% | 0.784  |
| 4     | 11,624          | 3.64% | 0.875  |
| 5     | 13,426          | 4.21% | 1.010  |
| 6     | 14,668          | 4.60% | 1.104  |
| 7     | 15,606          | 4.89% | 1.174  |
| 8     | 16,120          | 5.05% | 1.213  |
| 9     | 15,108          | 4.74% | 1.137  |
| 10    | 14,935          | 4.68% | 1.124  |
| 11    | 13,857          | 4.35% | 1.043  |
| 12    | 13,691          | 4.29% | 1.030  |
| 13    | 13,309          | 4.17% | 1.002  |
| 14    | 13,327          | 4.18% | 1.003  |
Based on Table 1, it can be seen that the average water usage was 13,288 m$^3$/hour. Maximum water usage occurred at 08.00 WIB with a debit of water usage 16,120 m$^3$/hour. Minimum water usage occurred at 02.00 WIB with a debit of water usage 9,791 m$^3$/hour. The peak hour factor of water usage is 1.21 and it is within the range of the peak hour factor of PUPR Regulation No 27 of 2016 regarding the Implementation of a Drinking Water Supply System, which is about 1.15-3. This indicates that the there was no significant fluctuations of water usage in the service area of water distribution so that at peak hours and minimum usage hours, the water supply did not experience a significant decrease. The average production capacity of 18,134 m$^3$/hour is greater than the use of water during peak hours which is 16,120 m$^3$/hour. So, it can be concluded that the production capacity was adequate to meet the customer's water usage needs.

c. Water losses level

The level of water losses was calculated by the difference in the amount of water measured on the master meter and the amount of water measured on the customer's meter (Ferijianto, 2007). Based on Surabaya PDAM data, the average amount of water distributed during December 2018 until February 2019 was 9362,667 m$^3$/month. While the average amount of water recorded in customer bills during December 2018 until February 2019 was 5199 m$^3$/month. Based on the calculation results, the level of water losses in the 201 DMA during December 2018 until February 2019 was 44.5 %. Factors causing the quite high level of water losses, based on the survey, include customer cheats and inaccuracies in the customer's water meter, considering that the majority of customers in Ngagel Tirto had been a customer of PDAM for more than 30 years without the water meter ever being calibrated or replaced, and also there was no SOP for maintenance of pipe and accessories.

d. Distribution Network

The water storage tank produced in the ZAMP installation is made of 304 stainless steel with the Profile Tank PS 8000D and a capacity of 5 m$^3$. Type 304 is a type of stainless steel that is food grade, so it is safe to be used to collect ready-to-drink water (Ritonga and Idris, 2017). However, because the production system dictates that water will be directly pumped, when there is a disruption in the system, there would be no backup water supply because the capacity of the storage tank was too small. Therefore, it is necessary to recalculate the dimensions of the holding water tank so that the water supply is ready to drink continuously for 24 hours. Based on PDAM data, repairs at installations usually take around 2-3 hours to complete. It should then be necessary to calculate the capacity needs

| Hours | Flow (m³/hour) | % | Factor |
|-------|---------------|---|--------|
|       | a | b=a/Q tot | c=a/Q average |
| 15    | 14,336 | 4.50% | 1.079 |
| 16    | 13,535 | 4.24% | 1.019 |
| 17    | 14,487 | 4.54% | 1.090 |
| 18    | 14,848 | 4.66% | 1.117 |
| 19    | 14,425 | 4.52% | 1.086 |
| 20    | 13,982 | 4.38% | 1.052 |
| 21    | 12,762 | 4.00% | 0.960 |
| 22    | 12,304 | 3.86% | 0.926 |
| 23    | 11,588 | 3.63% | 0.872 |
| 24    | 10,910 | 3.42% | 0.821 |
| Sum   | 318,910 | 100% | 24 |
| Average | 13,288 | 4.17% | 1 |
| Maximum | 16,120 | 5.05% | 1.213 |
| Minimum | 9,791 | 3.07% | 0.737 |
of the production water tank if the disfunction of the installation for 3 hours occurs at minimum and maximum water usage using the tabulation method. The average production capacity of the installation was 18,134 m$^3$/hour. Then the tank capacity was calculated by the difference between production capacity and water usage every hour according to Table 1, then we accumulated the difference. Reservoir tank volume would be the difference between the largest cumulative and the smallest cumulative.

Based on the calculation results, the capacity of the production storage tank needed should a disfunction in the installation occurs for 3 hours when the minimum water usage hour was 92 m$^3$. While the capacity of the production storage tank needs when the disfunction in the installation occurs for 3 hours when the maximum water usage hour was 86 m$^3$. Therefore, what we used as reference in this plan was one when the minimum water usage hour with the capacity of the production water storage was 92 m$^3$. The chosen tank WAS Ruifeng brand stainless steel 304/316 with a capacity of 105 m$^3$. Sketches and dimensions of the tank can be seen in Figure 2 (a) and (b).

![Figure 2. Reservoir sketch (a) Top view (b) Front view](image)

In the current distribution unit, there were 3 units of distribution pumps but only 1 unit of those was operating. The average water flow distributed to consumer was 318,910 m$^3$/day. According to
Attachment III Permen PUPR Number 27 Year 2016 Regarding Technical Requirements of JP SPAM, the number of distribution pumps for the range of water flow from 120 to 450 m³/day should be 2 pumps i.e. 1 main pump and 1 backup pump. So, the number of distribution pumps installed had met the criteria.

Based on the data from the Surabaya PDAM Geographic Information System software, the pipe that was used in DMA 201 was PVC pipe with the same diameter in all pipelines, with external diameter being 90 mm and internal diameter 80 mm. The pipelines had been installed for less than 1 year. The use of PVC pipe material for potable water distribution did not pose any health risks (Tyagi, 2018). In the existing condition, DMA 201 at Ngagel Tirto had 1 class B flow meter at the network inlet, 6 boundary valves, 2 washouts at both ends of the pipe and 1 manometer at the network inlet. Evaluation of the completeness of the network that should have existed showed that there was no brant krant/air valve, Residual Chlorine Monitor (RCM) on the distribution network and manometer at the farthest point of distribution network (Farley et al. 2008).

e. Pressure

In this study, a pressure measurement was carried out at 5 points at the customer's house connection at 10.00 WIB. Results of the pressure values at all points, as can be seen in Table 2, met the criteria according to Permen PUPR No.27 of 2016 regarding the Implementation of Drinking Water Supply Systems, where the minimum pressure on the distribution network is 0.5-1 atm (0.52-1.03 kg/cm²).

| No  | Address                  | Pressure Measurement-1 (kg/cm²) | Pressure Measurement-2 (kg/cm²) | Average Pressure (kg/cm²) |
|-----|--------------------------|---------------------------------|---------------------------------|---------------------------|
| 1   | Ngagel Tirto V No.47A    | 1.4                             | 1.4                             | 1.4                       |
| 2   | Ngagel Tirto V No. 73    | 1.2                             | 1.2                             | 1.2                       |
| 3   | Ngagel Tirto V No. 41    | 1.35                            | 1.3                             | 1.3                       |
| 4   | Ngagel Tirto IV No. 58   | 1.2                             | 1.15                            | 1.2                       |
| 5   | Bratang Satu 1 F No.4    | 1.25                            | 1.2                             | 1.2                       |
| 6   | Distribution Network Inlet| 1.5                             | 1.5                             | 1.5                       |

Furthermore, to find out the hydraulic conditions in the distribution network, a network simulation using WaterCAD v8i software was run with a simulation time of 24 hours starting at 00.00. The results of the simulation can be seen in Figure 3. The analysis that we use in EPS (Extended Period Simulation) condition according to fluctuations of customer water usage can be seen in Table 1.
Figure 3. Modeling of ZAMP Existing Pipeline Systems in 201 Ngagel Tirto DMA Using WaterCAD v8i Software

Based on the results of the existing network analysis (without modification on the network), the pressure at all nodes (points) had met the criteria marked by the absence of nodes that have pressures below 10 mH₂O as indicated by color coding on the nodes that were blue. In this study, further evaluation was carried out at the farthest points in the existing condition, i.e. at critical point 1 (TK-1) located at the end of Bratang Satu 1F and critical point 2 (TK-2) located at the end of Bratang Satu 1G. The results of the analysis of critical points 1 (TK-1) and critical points 2 (TK-2) are as follows:

1. Based on the simulation results, the pressure at TK-1 was about 11.592-24.689 mH₂O where the pressure value met PUPR Regulation No. 27 of 2016 regarding Operation of a Drinking Water Supply System where it was mentioned that the minimum pressure on the distribution network should be 0.5-1 atm (5.17-10.33 mH₂O). The lowest water pressure occurred during maximum water usage period at 08.00 WIB with the pressure value being 11.592 mH₂O. The highest pressure occurred during the minimum water usage period at 02.00 WIB with the pressure value being 24.689 mH₂O. The correlation between pressure and flow of water usage is inversely proportional. When the debit of water usage is low, the pressure is high and vice versa (Murdi, 2017). The results of the simulation of pressure fluctuations at the critical point 1 (TK-1) distribution network can be seen in the graph in Figure 4 (a).

2. Based on the simulation results, the pressure at TK-2 was about 14.736-26.050 mH₂O and this value had met PUPR Regulation No. 27 of 2016 regarding Operation of a Drinking Water Supply System where it is mentioned that the minimum pressure on the distribution network should be 0.5-1 atm (5.17-10.33 mH₂O). The lowest water pressure occurred during maximum water usage period at 08.00 WIB with the pressure value being 14.736 mH₂O. The highest pressure occurred during the minimum water usage period at 02.00 WIB with the pressure value being 26.050 mH₂O. The results of the simulation of pressure fluctuations at the critical point 2 (TK-2) distribution network can be seen in the graph Figure 4 (b).
The next step was to make a comparison between the value of the pressure from the results of the existing distribution network simulation using WaterCAD v8i with the value of the pressure measurement in the field (in the customer tap located near of the node in the simulation model that created using WaterCAD v8i), as can be seen in Figure 5.

Based on the graph in Figure 5, it can be seen that there is a difference between the pressure value of the simulation results using WaterCAD v8i and the value of the pressure measured in the field. The value of the pressure from the network simulation results is greater than the direct measurement. Factors that influence the differences are as follow:

- The effect of water usage during the measurement hour may be less than the water usage debit that we input in the WaterCAD v8i simulation where the input flow was the average water usage discharged during December 2018 until February 2019. Because of that, the pressure value on the WaterCAD v8i network simulation results were bigger than the results of direct pressure measurement.
- The possibility of input of pressure valve coefficient value which was smaller than the valve settings installed in the field. Because of that, the pressure value on the WaterCAD v8i network simulation results were bigger than the result of pressure measurement.
- There is a possibility of leakage in the distribution network that made the results of water pressure value at the time of measurement low considering the results of the analysis of the level of water losses in the network showing that the losses were quite high.
2. Service Unit
In the service unit, the evaluation carried out was the analysis of water quality at the customer’s house connections. The results of the residual chlorine parameters analysis for 33 water samples can be seen in Figure 6 below. In the graph in Figure 6, it indicated that the concentration of residual chlorine in ZAMP customers were about 0.15 to 0.6 mg/L. However, there was residual chlorine that did not meet the PERMENKES No.736/MENKES/PER/IV/2010 quality standard, which was 1 sample point with residual chlorine of 0.15 mg/L (less than 0.2 mg/L) where the sampling point located at the end of the 201 DMA distribution network.

![Figure 6. Distribution of Residual Chlorine in ZAMP Customer's House Connections](image)

The results of the total coliform parameters analysis on 33 customer home water samples during February and March 2019 can be seen in Figure 7 below. Based on the graph in Figure 7, it indicated that 23 water samples met the requirements of PERMENKES No. 492/MENKES/PER/IV/2010 i.e. the total number of coliform in the potable water was 0 MPN/100 mL. But there were still 10 samples that did not meet the PERMENKES quality standard because the total coliforms in those water samples were 2 to 11 MPN/100 mL. Based on these data, it can be concluded that 70% of the water samples met the drinking water quality requirements in terms of the total coliform parameter.

![Figure 7. Distribution of Total Coliform in ZAMP Customer's House Connections](image)

The presence of coliform in 30% of the water samples tested, based on the results of the questionnaires, all occurred in houses that were more than 30 years old and all of them had never had any repairs or changes on their pipes. There were 2 houses using iron pipes and their house was more than 45 years old and they also never changed their pipes. The majority of customer pipes were more
than 30 years old and they had never undergone any repairs, replacement or maintenance. These might have caused the formation of sediments in the pipe after the customer's water meter. The existence of sediment might have then triggered the growth of coliform bacteria in the pipe (LeChevallier et al, 1996). In addition, dirty customer tap water could also cause the entry of organic compounds and microorganisms (Yani and Roosmini, 208). So, this might have been the cause of the presence of coliform bacteria in the water samples taken in ZAMP customers' house taps.

3.2 Evaluation of Utilization of Potable Water by Customers of Zona Air Minum Prima (ZAMP) program

Based on the results of a questionnaire that asked 33 ZAMP customer respondents in DMA 201, only 48% of the respondents already knew about the ZAMP program. From the 48% of respondents who already knew about the ZAMP program, their sources of the information about the ZAMP program were also varied. 56% who already knew about the ZAMP program found out about it from PDAM employees, 31% from their neighbors, while the other 13% found out about the ZAMP program from newspapers/TV/social media.

Only 9% of respondents in DMA 201 used PDAM tap water as a source of drinking water that they consumed daily. The rest of the respondents used either refillable water containers from official or water refilling depots. Based on the results of the questionnaire, it can be concluded that during the implementation of the ZAMP program of almost the last 1 year, it had not been able to change the pattern of drinking water consumption of the community from bottled drinking water to PDAM potable water. In addition, 12% of respondents boiled the water first before they consumed it. 75% of them were respondents who used the potable water of PDAM but boiled the water first before they consumed it because they were afraid of being sick. Another 25% of them are respondents who consued bottled drinking water but boiled their water first for reasons of fear of illness as well. This indicated that the respondents did not believe in the quality of the water they consumed every day.

Based on the results of the questionnaires that can be seen in the diagram in Figure 8, there were various reasons respondents did not use PDAM potable water today, about 43% of the respondents said the water was murky because they thought that PDAM potable water was less clear compared to the water they usually consumed. 40% of the respondents said that they were afraid of being sick because the PDAM's raw water used river water, whose condition they knew about, considering their location of residence near the intake. 7% of the respondents did not use PDAM potable water for drinking water sources because they were disturbed by the smell of chlorine in PDAM water. While the other 10% reasoned because they were already used to consuming bottled water.

![Figure 8. The Reasons of Respondents Not Using PDAM Water as a Source of Drinking Water for Daily Consumption](image-url)
So, it can be concluded that there were no customers who consumed potable water directly from the tap or it can be said that the percentage of ZAMP customers who consume potable water directly from the tap to meet consumption needs was 0%. However, after PDAM guaranteed that the water quality from them was ready to drink until the tap in the customers’ house, more than a portion of ZAMP respondents were interested in consuming PDAM potable water. Based on the results of the questionnaires, as many as 73% of the respondents were interested in it while 27% said that they were not interested in consuming potable water from PDAM.

Of the respondents who were not interested, as many as 67% said they were not interested because they were afraid of getting sick due to the raw water used by PDAM as well as seeing the recent condition that the distributed water quality was fluctuating and unstable so that they were afraid it could cause side effects to their health. This fluctuating water quality was due to several occurrences of a system bypass where the system bypass was not informed to customers. As many as 22% said that they were not interested because they were used to consuming bottled drinking water because the quality was always good (not fluctuating) and there had never been a disease caused by consuming bottled drinking water so they already believed in the quality of bottled drinking water which then became a habit. The other 11% were not interested because they did not like the smell of chlorine in PDAM water. Figure 9 below is a diagram of the reasons why respondents were not interested in consuming PDAM water for daily consumption even though there would be a quality guarantee from the PDAM.

4. Conclusions
Based on the discussion above, the conclusion in this study from the operational aspect is that the distribution system was almost continuous for 24 hours a day with the average production capacity being able to fulfill the customer water usage during peak hours. The pressure at the farthest point of the distribution network had met the minimum criteria. About 70% of the water samples met the quality standard of potable water for total coliform parameters. In utilization aspect of potable water by the customer, the percentage of customers who consumed potable water directly from the tap was 0%. However, about 73% of the respondents were interested to consume potable water if PDAM could guarantee that the water quality has met the quality standard of potable water until in the tap inside of the customers’ houses.
References

[1] M Farley, G Wyeth, Z Ghazali, A Istandar, and S Singh 2008 The Managers Non-Revenue Water Hand Book: A Guide to Understanding Water Losses (Sidney: Rainhill)

[2] K Ferijianto 2007 Kajian Kehilangan Air pada Wilayah Kajian PDAM (Studi Kasus PDAM Kota Bandung) Skripsi Jurusan Teknik Lingkungan FTSL ITB

[3] N A Gumilar 2015 Kajian Strategi Pengembangan Zona Air Minum Prima (ZAMP) pada Kelompok Pelanggan Rumah Tangga di Kota Bogor (Studi Kasus: Eksisting ZAMP di Kecamatan Bogor Selatan dan Bogor Timur) Jurnal Pembangunan Wilayah dan Kota 11 4 pp 455-470

[4] B Haq and A Masduqi 2014 Sistem Distribusi Air Siap Minum PDAM Kota Malang: Studi Kasus Kecamatan Blimbing Jurnal Teknik Pomits 3 2 pp 183-184 ISSN: 2337-3539

[5] M W LeChevallier, N J Shaw and D B Smith 1996 Factors Limiting Microbial Growth in Distribution Systems: Full-scale Experiment (Denver: AWWARF)

[6] Menteri Kesehatan Republik Indonesia 2010 Peraturan Menteri Kesehatan Republik Indonesia Nomor 492/MENKES/PER/IV/2010 tentang Persyaratan Kualitas Air Minum (Jakarta: Kementerian Kesehatan Republik Indonesia)

[7] Menteri Kesehatan Republik Indonesia 2010 Peraturan Menteri Kesehatan Republik Indonesia Nomor 736/MENKES/PER/VI/2010 tentang Tata Laksana Pengawasan Kualitas Air Siap Minum (Jakarta: Kementerian Kesehatan Republik Indonesia)

[8] Menteri Pekerjaan Umum 2016 Peraturan Menteri Pekerjaan Umum Nomor 27PRT/M/2016 Tentang Penyelenggaraan Sistem Penyediaan Air Minum (Jakarta: Kementerian Pekerjaan Umum)

[9] A S Murdi 2017 Analisis Tekanan-Debit pada Pipa Distribusi Sistem Air Bersih PDAM Tirta Pakuan Bogor Skripsi Program Studi Teknik Lingkungan Fakultas Teknik Universitas Indonesia

[10] S E Pasaribu 2005 Zona Air Minum Prima (ZAMP) Jurnal Sistem Teknik Industri 6 2 pp 123-127

[11] D I A Ditonga and M Idris 2017 Karakteristik Bahan Steel 304 Terhadap Kualitas Impak Benda Jatuh Bebas Jurnal Wahana Inovasi 6 2 pp 207-215

[12] N I Said and W Widayat 2001 Pemasyarakatan Unit Pengolahan Air Siap Minum Skala Industri Kecil Jurnal Teknologi Lingkungan 1 3 pp 233-246

[13] E Sugiharto 2015 Strategi Adaptasi Penghuni Rumah Susun dan Masyarakat Sekitarnya dalam Perolehan Air di Kelurahan Menanggal, Kota Surabaya eJournal Administrasi Negara 5 3 pp 6550-6564

[14] Tyagi 2018 Is Using PVC Pipe for Potable Water Safe?, <URL https://www.pvcfittingsonline.com/resource-center/using-pvc-pipe-for-potable-water/>

[15] S D Yani and D Roosmini 2008 Pengaruh Jarak Terhadap Penurunan Sisa Klor di Jaringan Distribusi Distribusi PAM Jaya Jakarta Daerah Pelayanan Jakarta Barat Program Studi Teknik Lingkungan FTSL, ITB