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Performance Analysis of Malang City State Tap-Water Company (PDAM)

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Abstract*—The needs for water in Malang city are distributed by state tap-water company (PDAM). This research was done in the project area of DMA 1E Bangkon including Tunggulwulung, Tasikmadu, and Mojolangu urban community. The data was collected through a questionnaire distributed to 85 respondents from 549 persons who are the customer of Malang City PDAM. Questionnaire result was analyzed using test validity, test reliability, and Importance Performance Analysis (IPA). Water quality study was carried out by comparing the result from the laboratory of Malang City PDAM and drainage techniques' laboratory of soil and groundwater based on the water sample brought from the customer's home.*

***Keywords*—** *Performance Analysis, Quantity, Continuity, Water Quality.*

I. INTRODUCTION

Water is a vital need for the sustainability of human life. The earth contains a number of water more or less 1.4 x 10^9Km^3 consisted of ocean, sea, river, lake, iceberg, etc. However, the water categorized as fresh water is that of in river, lake, and groundwater.

Source of clean water we easily get derives from groundwater. However, not all water contained in the earth has a good quality and quantity which is capable of achieving daily needs. The decrease of groundwater-surface and seawater intrusion causes the reduction of groundwater quality. In Indonesia, a large amount of groundwater in the urban area has been polluted so that the urban society tends to use the service of clean water provision from PDAM to fulfill the needs of water for daily activities. For that matter, PDAM plays an important role to fulfill the needs of clean water. Source of clean water from PDAM derives from a river which is then processed first before being distributed to the customer. In an urban area, clean water provision is through a piping system managed by PDAM with gravity flowing or pumping. In order to fulfill the needs of clean water which is suitable for society, the operator of PDAM should notice the operation and management, distribution, and service to the customer to give a maximum service in accordance with customer's expectation.

This study will discuss the performance of Malang City PDAM in order to fulfill the needs of clean water in the working area of *District Meter Area (*DMA) 1E Bangkon covering Tasikmadu, Tunggulwulung, and Mojolangu urban communities of Lowokwaru Sub-district, Malang City. In those locations are frequently found distribution pipe leakage impacted on the connection continuity to the customer's home. In addition, this research aims to determine whether or not the quality of water received by the customer is in accordance with the quality provided by PDAM. In order to compare it, the researchers carried out a laboratory test by taking a sample from the customer home's connection. An analysis was conducted based on the questionnaire result which has been distributed to 85 respondents from 549 persons which are the customer of Malang City PDAM spread in the area of Tasikmadu, Tunggulwulung, and Mojolangu urban community.

II. LITERATURE REVIEW

A. Previous Research

Water quality of PDAM Banyumanik Semarang has fulfilled customer needs, but the continuity and quantity of water still needs to be increased due to insufficient water discharge (Agustina, 2007). The Housing Sector of Lingke, Syiah Kuala Subdistrict, Banda Aceh City, the water discharge, water pressure and continuity of the flow were carried out in real research to obtain the results of network performance analysis based on reliability, vulnerability and resilience (Idris, 2012). Way Rilau PDAM in Bandar Lampung faces problems in service to customers. The level of water loss is 41.81% with the amount of debt of Rp 52.3 billion and the number of complaints from the public regarding PDAM services (Apriadi, 2008).

B. Urban Infrastructure

Infrastructure refers to a physical structure that provides transportation, irrigation, drainage, building construction, and another public facility demanded to fulfill the needs of a human being in the socio-economic scope. Infrastructure system is a core facility or structure, equipment, installation built and required to make socio-economic system function well (Kodoatie, 2003). Specifically, American Public Works Association defines infrastructure as physical facilities developed by public agencies for the sake of government role in providing water, electrical power, waste disposal, transportation, and a balance service to facilitate socio-economic goal.

C. Flowing System of Clean Water

Clean water flowing system uses a pipeline system, which is water distribution by using a pipe as a facility of water distribution. Its service unit is able to use House Connection, Yard Connection, and Public Connection. In the event of distributing clean water with pipeline system, there are several drain systems that depend on the topography, the source of

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water location, height difference of drain location or service area. The pipeline system includes;

a. Gravity flow, clean water is distributed to the service area by utilizing pressure because of gravity in that location. It needs a different evaluation between source and service area which is high enough so that the pressure effort required can be maintained.
b. Pumping flow with elevated reservoir means before water being distributed to the service area, it is pumped up firstly and accommodated in reservoir and finally distributed by benefiting pressure as a result of the elevated reservoir.
c. Direct pumping flow distributes water to the service area by relying on the pressure from the pipe adjusted accordingly to the height of minimum pressure. Pipe thread in the distribution of clean water or drinking water is called pipeline. Actually, there are two systems of distribution network i.e. open network and closed network.

D. Test Reliability

Test reliability is carried out to find out the consistency or regularity of measurement result of an instrument if it is used as a measurement toll for an object or respondent. Measurement tool used to conduct test reliability is Alpha Cronbach technique. If Cronbach's Alpha value > 5%, so the respondent's answer is reliable. However, if it is < 5%, so the respondent's answer is not reliable.

$$r_{11} = \left[\frac{k}{k-1}\right]\left[1-\frac{\sigma_b^2}{\sigma_T^2}\right]$$

E. Test Validity

Test validity is a measurement used to determine whether the questionnaire is valid or not. A questionnaire is stated valid if the questions are able to disclose something which will be measured by that questionnaire (Ghozaku, 2009). If r_{count} value $\geq r_{table}$ (two-side test with significance of 5%), so the result of test validity is valid. However, if r_{count} value $\leq r_{table}$ so that the result of test validity is not valid.

$$r_{xy} = \frac{n\sum x_1 y_1 - \left(\sum x_i\right)\left(\sum y_i\right)}{\sqrt{\left(n\sum x_i^2 - \left(x_i^2\right)\right)\left(\sqrt{n\sum y_i^2 - \left(y_i^2\right)}\right)}}$$

$$r_{xy} = \frac{85(15.367) - (310)(4.137)}{\sqrt{\left(85(1.250)\right) - \left(310^2\right)}\left(85(14.495) - \left(4.137^2\right)\right)}$$

$$r_{xy} = \frac{23.725}{46.702,76} = 0,58$$

F. Importance Performance Analysis (IPA) Method

IPA method analysis is used to measure the level of someone's satisfaction with another party's performance conducted by comparing the level of expectation and the performance conducted by another side. IPA analysis step was started by finding the price of a suitability level. Suitability level is the comparison result between performance score and interest score. In order to know whether service performance is fit or not for the interest of customer, satisfaction level of customer is analyzed between interest and real service stated by letter Y and X, in which X is a performance level that gives satisfaction to the customer and Y is a customer's satisfaction level.

$$Tki = \frac{x_i}{y_i} \times 100\%$$

G. Water Quality

Quality requirement illustrates the quality of water from the raw water to the clean water. Drinking water quality requirement is actually determined by several standards which are different in some countries due to the condition of each country, development of science and advancement technology. For that matter, it has several standards of drinking water, among other things:

1. American drinking water standard
2. British drinking water standard
3. W.H.O drinking water standard

While in Indonesia, PDAM water quality refers to the PERMENKES No. 416/MENKES/PER/IX/1990 regarding the requirements and supervision of drinking water quality. Being reviewed from the quality perspective, drinking water or clean water has to meet the following requirement:

a. Physical Requirement
b. Chemical Requirement
c. Bacteriological requirements

H. Flowing System

Clean water flowing system uses pipeline system, which is water distribution uses pipe as a facility of water distribution. Its service unit is able to use House Connection, Yard Connection, and Public Connection. In order to distribute clean water by using a pipe, there are several systems of flowing that depend on the topography, location of the raw water source, high difference of flowing or service area. That flowing systems are:

a. Gravity flow
b. Pumping flowing with an elevated reservoir
c. Direct pumping flowing

I. PDAM Performance Indicator

PDAM performance refers to the Decision of Home Affairs Ministry Number 47 Year 1999 concerning Performance Assessment Guideline PDAM, there are three aspects i.e. financial aspect, operational aspect, and administrative aspect. Operational aspect consists of:

1. Service coverage
2. Distributed water quality
3. Water continuity
4. Utilization productivity of production installation
5. Unaccounted for water level
6. Water meter application
7. New connection speed
8. The average capability of complaining handle per month
9. Service easiness
10. Employee ratio per 1000 customer

J. Unaccounted for Water

Unaccounted for water problem is one problem which is very vital for drinking water management in Indonesia. The

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level of pipeline network leakage is difficult to measure carefully. Actually, PDAM uses the difference between production and sales to illustrate the effectiveness of drinking water service and the efficiency of the effort to decline unaccounted for water. Used but not paid water and unaccounted for water is categorized as non-revenue water. Based on the applicable provision, all connections of household or industry that uses PDAM service in the provision of clean water must apply water meter. Malang city government is obligated to give reasonable compensation for the utilization of water by a certain group of community. Hence, what categorized as non-revenue water can be considered nil and uncollectible water are put as unaccounted for water.

K. Connection Performance Indicator and Satisfaction Level

Actually, this research uses three indicators of connection performance, namely:

1. *Hydraulic performance* shows that the center of gravity is in pressure head and pressure variation.
2. Water quality performance means the center of gravity is in the water quality standard distributed to the consumer and the time of flowing is set to be able to fulfill the needs of the consumer.
3. Reliability performance means the center of gravity is in the ability of the connection system in fulfilling the needs of a consumer.

Connection performance indicator facilitates the fulfillment of clean water to the consumer; also, it will give good input to the development of clean water connection system of a city. For that matter, the indicator of good connection performance can fulfill the needs and expectation of customer so that able to achieve the level of customer satisfaction covering to:

1. Customer satisfaction is a description and expectation of consumer and assessment to the service of clean water provision.
2. Quality is the quality of a service from a system of clean water provision so that able to fulfill the needs of a customer and achieve the satisfaction level of customer.
3. Availability, being reviewed from the availability of facilities and infrastructure of clean water provision system, what included is the availability of water supply which can fulfill the needs of a customer.

L. Satisfaction Benchmark in Clean Water Provision

Satisfaction benchmark of clean water provision is something expected by society as the user of clean water service. It includes water availability especially when needed, and not bringing bad impact on human or environmental health. The availability of clean water quality fulfilling the quality standard will increase the satisfaction level of society who uses the PDAM service.

III. Research Concept Framework

A. Research Variable

This research needs primary and secondary data. Primary data is the data directly collected from the field observation such as questionnaire, customer's water meter recording, and water sample taking at customer's home connection. While a secondary data is the data collected from the certain institution namely Malang City PDAM covering the data from water quality laboratory, customer data, service zone map, and connection control data.

B. Research Framework

In order to analyze PDAM water flowing discharge, it can be done by carrying out a field research. One of the research activities was conducting an observation at 20 house connections to make a recording of PDAM water meter. The recording will be made for more or less 7 days in the morning, in the afternoon, and in the night at 6 a.m, 12 a.m, and 6 p.m, respectively. Recording of PDAM water meter discharge will be carried out at 20 house connections. While the data on water quality is directly collected from Malang City PDAM laboratory and then will be compared to the result of a laboratory test based on the sample obtained from the customer's connection home.

IV. Methodology

A. Research Method

Research on the performance analysis PDAM of Malang City on the level of customer satisfaction in the project of DMA Dawuhan 1E Bangkon is qualitative research

B. Time and Location

This research was done in the project area of DMA Dawuhan 1E Bengkok, while the sample was obtained from several urban communities i.e. Tasikmadu, Tunggulwulung, and Mojolangu, Lowokwaru Sub-district, Malang City. Total customer in DME 1E Dawuhan Bangkon was 549 customers. Primary data was collected from questionnaire distributed to 85 customers as a representative of PDAM customer and the recording of water meter in the customer's home connection for 7 days in the morning, in the afternoon, and in the night at 6 a.m, 12 a.m, and 6 p.m, respectively in 20 home connections which have been randomly started on 13 February 2018 until 19 February 2018. While the water sample is collected randomly from customer's home connection.

C. Data Collection Technique

A primary survey aims to obtain unwritten data or data with high accuracy. The primary survey was carried out by observing field which aims to result in unwritten data which only can be obtained from direct observation about service condition of clean water distribution in the project area of DMA Dawuhan 1E-Bangkon covering to Tasikmadu, Tunggulwulung, and Mojolangu urban community. Some activities conducted during the observation are among others recording customer's water meter and observing the physical condition of clean water flowed to some of the customer's home. Later on, the compilation and the distribution of questionnaire which aims to know satisfaction level of customer to the system performance of clean water distribution is conducted by Malang city PDAM, as well as a party directly involved in the provision of clean water in the

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project area DMA Dawuhan 1E-Bangkon, which is directly from the customer side about system expected.

Secondary survey is a data collection activity through literature review, previous result, map required to do research, demographic data, research area condition, or another written data obtained from the related institution.

V. Results and Discussion

A. Test Reliability

Test reliability was carried out to the survey result of 85 respondents from the total population of 549 customers in the project area DMA 1E Bangkon including Tasikmadu, Tunggulwulung, and Mojolangu urban community. Test reliability was conducted by using SPSS 20 application with 85 respondents and r_{table} value of significance 5% so that obtained 0.213 as the result. The result of test reliability, based on the analysis result by using SPSS 20 application, generates Cronbach's Alpha value by 0.602 to the 16 variables. Cronbach's Alpha value by 0.603 and r_{table} value 5% by 0.213, so the test reliability result of respondents answer is reliable. Calculating Cronbach Alpha coefficient.

$$r_{11} = \left[\frac{k}{k-1}\right]\left[1-\frac{\sum \sigma_b^2}{\sigma_T^2}\right]$$

$$r_{11} = \left[\frac{16}{16-1}\right]\left[1-\frac{11,478}{29,75}\right] = 0,655$$

Based on the calculation result, r_{count} value by 0.655 > r_{table} by 0.213 so that instrumental reliability can be trusted. While the result of analysis by using SPSS 20 obtains Cronbach's Alpha result by 0.620 with r_{table} of 0.213 so that the result of test reliability with SPSS 20 is reliable.

B. Test Validity

Variant 1 until 16 can be calculated with a similar way, the result of calculation above shows that r_{count} value of 0.58 > r_{table} 0.213, so the result is valid. Test validity calculation with r_{table} value (at 5% significance) and N=85, if df=N-2, so df=85-2=83, hence r_{table} value with df 83 is 0.213. The result of test validity with the assistance of SPSS 20, variables 1 until 16 are valid.

The example of variable 1 calculation for the correlation at the level of satisfaction and performance:

1. Performance Correlation

$$r_{xy} = \frac{85(15.503)-(347)(3.793)}{\sqrt{(85(1.423))-(347^2)}\left(85(15.607)-(3.793^2)\right)}$$

$$r_{xy} = \frac{1.584}{3.363} = 0,471$$

2. Interest Correlation

$$r_{xy} = \frac{85(16.225)-(372)(3.701)}{\sqrt{(85(1.650))-(372^2)}\left(85(15.061)-(3.701^2)\right)}$$

$$r_{xy} = \frac{2.353}{9.886} = 0,238$$

The result of calculation above shows that the performance correlation value of variable 1 is r_{count} 0.471 > r_{table} 0.213 so that interest level is valid. As with the interest correlation which obtains r_{count} by 0.238 > r_{table} by 0.213 so that the variable is valid. The results of variables calculations 1 to 11 are declared valid, except for variables 6 and 9.

C. Importance Performance Analysis (IPA)

Calculation of conformity level values:

1. Interest Level of new costumer administrative service
   (1x0) + (2x0) + (3x1) + (4x51) + (5x33) = 372
   The average interest:
   $$\frac{x_i}{n} = \frac{372}{85} = 4,38$$
2. Satisfaction level of new costumer administrative service
   (1x0) + (2x0) + (3x1) + (4x51) + (5x33) = 372
   The average satisfaction:
   $$\frac{x_i}{n} = \frac{347}{85} = 4,08$$

A variable calculation was then able to do as in calculation above. The following formula is to calculate the suitability level.

$$Tki = \frac{x_i}{y_i} \times 100\%$$

$$Tki = \frac{(1\times0)+(2\times0)+(3\times0)+(4\times51)+(5\times33)}{(1\times0)+(2\times0)+(3\times0)+(4\times51)+(5\times33)} \times 100\%$$

$$Tki = 1,07$$

That calculation formula is also applicable to calculate the suitability level of each variable. Later on is the calculation of the average score:

$$x = \frac{\sum_{i-1}^{n} y}{k} = \frac{44,62}{11} = 4,06$$

$$y = \frac{\sum_{i-1}^{n} x}{k} = \frac{43,54}{11} = 3,96$$

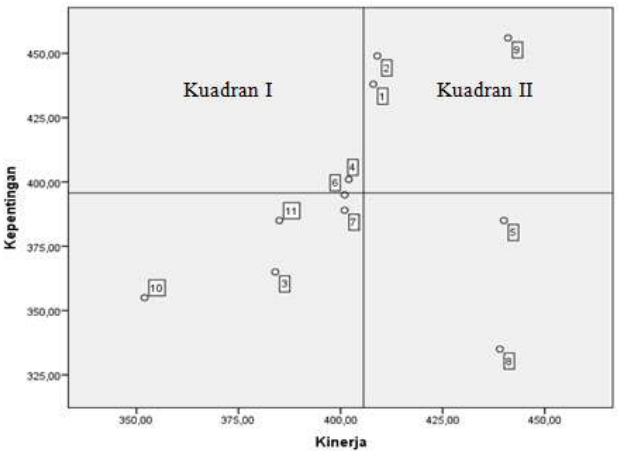

Fig. 1. Cartesian Diagram

IPA analysis result produces a quadrant divided into four parts restricted by 2 lines intersecting each other. X axis gets its average score from the average score of satisfaction level by 4.06 and Y axis gets its score from the average score of

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interest level by 3.96. Categorization of each variable of service performance of Malang City PDAM can be seen in Figure 1.

D. Water Quality

Water quality-based study is conducted by comparing laboratory result that has been conducted by PDAM in its laboratory in Malang City and water sample brought from customer's home and was observed in Irrigation Technique's Laboratory of Soil and Groundwater. Laboratory test is carried out based on the PERMENKES No. 492/MENKES/PER/IV/2012. Also, it bases on the questionnaire result that has been filled by respondents which according to the quality of water received by respondents as the customer. Variable for water quality received by the customer is now covering four alternatives:

1. Water Color, Odor and Taste
2. Color or odor or taste
3. Colorless, odorless, and tasteless
4. Colorless, odorless, and tasteless and can be directly consumed

Based on the questionnaire result, 85.9% indicates that water quality received today is colorless, odorless and tasteless. While another 14.1% states that the quality of water received today is colorless, odorless and tasteless, and can be directly consumed.

E. Pressure-Based System Analysis

Pressure-based system analysis is investigated by using Hanzen William's formula. The first analysis in Tunggulwulung urban village finds that the discharge is 71.1 liters/second, the diameter of the installed pipe is 600 meter, the length of pipe is 3.800 meters, early elevation is 586 m and the last elevation is 518 m. Calculation analysis:

$$Q = 0,2785 \times C \times D^{2,63}\left(\frac{586-518}{3800}\right)^{0,54}$$

$$\frac{71,1}{1000} = 0,2785 \times 140 \times D^{2,63}\left(\frac{68}{3800}\right)^{0,54}$$

$$D = \left[\frac{0,0711}{0,2785 \times 140 \times \left(\frac{68}{3800}\right)^{0,54}}\right]^{0,38}$$

$$D = \left[\frac{0,0711}{0,2785 \times 140 \times 0,114}\right]^{0,38}$$

$$D = 0,208\ m = 208\ mm$$

Hence, calculation diameter by 214 mm and the installed diameter by 600 mm have met the requirement.

$L = 3800,$

$$HL = \left(\frac{Q}{0,2785 \times C \times D^{2,63}}\right)^{\frac{1}{0,54}} \times L$$

$$HL = \left(\frac{0,0711}{0,2785 \times 140 \times 0,208^{2,63}}\right)^{\frac{1}{0,54}} \times 3800$$

$$HL = 67\ m$$

$$Hf\ mayor = HL \times \left(\frac{L}{1000}\right)$$

$$Hf\ mayor = 67 \times \left(\frac{3800}{1000}\right)$$

$$Hf\ mayor = 254,6\ m$$

Head minor assumption is 10%, so

$$Hf\ minor = 10\% \times 254,6\ m = 25,46\ m$$

$$Hf\ total = Hf\ mayor + Hf\ minor$$

$$= 254,6\ m + 25,46\ m$$

$$= 280,1\ m$$

$$Head\ statis = (586 - 518)\ m = 68\ m$$

$$Head\ total = 280,1\ m + 68\ m = 348,1\ m$$

$$\Delta H = Head\ total - Hf - \frac{v^2}{2g}$$

$$Hf = 280,1$$

$$\frac{v^2}{2g} = \frac{\left(\frac{Q}{A}\right)^2}{2g} = \frac{\left(\frac{Q}{\pi r^2}\right)}{2g}$$

$$= \frac{\left(\frac{0,0711}{3,14 \times 0,208}\right)^2}{2 \times 9,81}$$

$$= 0,0006$$

Remaining pressure = 348,1 – 280,1 - 0.0006 = 68 m.

The calculation result indicates that the pressure on the service area, Dawuhan-Tunggulwulung, has a tension of 68 m so that technically is able to distribute to the service area by using gravity. Moreover, the calculation in the service area, Dawuhan-Tasikmadu, and Dawuhan-Mojolangu, can be done by the similar method. The result obtained in Dawuhan-Tasikmadu and Dawuhan-Mojolangu has a tension of 83 m and 92 m, respectively so that technically those two are available to distribute to the service area by using gravity.

F. PDAM Performance to the Customer

Analysis result of Malang City PDAM performance, aside from bringing benefits to the PDAM side to be the reference in maintaining and improving performance, also provide a general description about service that has been conducted by Malang city PDAM to the customer. The general description includes clean water distribution to the customer reviewed from water quality, distribution system operated and the

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service to the customer. In addition, a customer pointed as a respondent is able to know how much discharge is used in a day to meet the household needs.

VI. Conclusion

From the research result and analysis that has been done, the conclusions are as follows:

1. The customer is satisfied with the today's service level of clean water distribution system from Malang City PDAM. Several factors producing satisfaction are satisfaction to the water quality, water flow, water meter condition, time period of service, complaint handle and the quick of field problem-solving.
2. Conclusion of Malang City PDAM performance:
   a. The result of water quality test at customer's home carried out by the researchers has fulfilled the requirement in light of PERMENKES NO. 492/MENKES/PER/IV/2012 as used as a reference by Malang City PDAM laboratory.
   b. Malang City PDAM is able to fulfill the needs of clean water especially in the project area DMA 1E Bangkon. Distribution flowing of clean water from Bangkon water reservoir to the flowing area i.e. Tasikmadu, Tunggulwulung, and Mojolangu are carried out by gravity.
   c. The level of unaccounted of water 30% is still high.
   d. Water meter condition at customer's home is not re-applied periodically
   e. The speed of new connection handling at customer's home is good enough around 6 days maximum 12 days.
   f. Fast response service in customer complaints
   g. The customer is satisfied with the service easiness of Malang City PDAM about how to register and pay bills.
3. Customer assessment of overall service provided by Malang City PDAM is good so they are satisfied with the service given. Such as registration for new members, water supply quality, water supply quantity and water supply continuity.
4. PDAM performance should consider variable about complain service due to that matter is an important variable which has to improve. Because all this time the complaints service facility is easy to use, but still cannot comply with the expectations of customers.

VII. Suggestion

In order to improve service performance, Malang City PDAM should conduct a routine survey about customer satisfaction by filling out questionnaire distributed online or offline. In addition, it needs field further checking on the water meter at the customer's home connection so that will be recorded if there is water meter which is not in accordance with the existing standard. This analysis result is expected to give input to Malang City PDAM to be able to maintain and improve its service performance. It is expected that further research can be carried out further research in accordance with the PDAM's corporate plan

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