Service improvement of regional water company (PDAM) at Surakarta City

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Abstract. The regional water company (PDAM) Surakarta City is a regional company that serves drinking water needs for the people in Surakarta. In 2018, PDAM Surakarta City served 58871 customers and more than 5000 former customers. Illegal connections by former PDAM customers became one of the most dominant factors in the loss of commercial and non-physical water in PDAM Surakarta City. To reduce non-physical water leakage and improve services at PDAM Surakarta City, a study was conducted involving former PDAM customers with a total of 5000 respondents. The purpose of this study is to identify the water sources currently used by former PDAM customers and the reasons for the service discontinuation; identify the interest of former PDAM customers to reconnect; find indications of illegal connections by former customers of PDAM Surakarta City. A survey method was used with the mWater application and data analysis using SPSS. The results of the study explained the reasons for former PDAM customers to stop subscribing to the service because of the uncertainty of water flows, the poor water quality, the high water tariff, and the arrears of the customers. The former customers who are interested in reconnecting consist of 126 respondents. 2296 former customers who are demolished by invisible PDAM water lines, 84 respondents whose PDAM water meters are still installed, and 16 respondents there are former PDAM water line disconnections which are now connected to hoses/pipes, and as many as 500 respondents there are remnants of former PDAM demolition pipes. Based on the findings in the field, indications of illegal connections from 5000 respondents are strong indications as many as 5 respondents, moderate indications as many as 50 respondents, weak indications as many as 1125 respondents, and no indications as many as 3820 respondents.

1. Introduction

PDAM Surakarta is a regional company that serves the drinking water needs of the people in Surakarta. In 2018, PDAM Surakarta had 58871 customers and more than 5000 former customers [1]. The illegal connection by former customers PDAM is one of the most dominant factors on the water loss of commercial and non-physical in PDAM Surakarta. To reduce non-physical water leakage and improve services at PDAM Surakarta City, a study was conducted on the former PDAM customers with a total of 5000 respondents. Illegal connection was figured out by directly observing the former location of a household connection. This research was carried out to identify reasons for former PDAM customers to disconnect the service; to identify the interest of former PDAM customers to reconnect; and to identify indications of illegal connections by former PDAM customers. It is expected that the results of the study could be the basis for PDAM Surakarta City to improve services and reduce the level of non-physical water leakage. This study uses the mWater application and a chlorine indicator test kit. This research was a follow up
2. Theoretical Approach
Water loss can be defined as a number that shows the difference between the volume of water supply and the volume of water consumed. Water loss is the amount of water lost and does not become revenue for the water company [3].

The most important water loss and must be minimized is the wasted water loss. Irresponsible water, meaning the difference between water production and water use which includes water lost due to physical water loss and non-physical water loss. The rate of water loss is a number in percentage that shows the large amount of water that is produced but cannot be collected or cannot become revenue for the company.

The causes of non-physical water loss are unauthorized water consumption, customer water meter inaccuracies, and data handling errors. Non-physical water loss to the water meter is caused by an error in reading the water meter, accuracy of water meter numbers, tampering water meter, damaged water meter, the loss of water meter, and illegal connection.

A water meter is a type of measuring instrument for the volume of water in the pipeline network to serve users, both individuals and groups, by paying attention to technical and non-technical aspects, so that the community can easily obtain water in a certain amount, quality according to the requirements of drinking water for health. As pitch nontechnical required in the operation and maintenance of water meters y i a i u can be read by the clerk or the community itself, so it is easy to know the use of water for sure [4].

Study Liu et al. [5] revealed that quarterly paper bills could provide water consumption information for households. The smart measurement provides increment of specific information which was welcome by most customers. Davies et al. [6] found the effectiveness of Smart Metering in the observed society, with regard to long-term behavior change by omitting additional intervention after the removal of the technology. Taken into account the follow-up initiatives, including education and incentive programs, is expected to increase water savings. Ornaghi and Tonin [7] proved the beneficial of measurement was higher than the costs, showed by 22% reduction in consumption after metering. The reduction percentage was much higher than the assumed policy target.

2.1. Home Connection
The house connection is the pipe and its equipment, starting from the tapping point to the water meter. [8]

The main functions of the house connection are:
- flowing water from the distribution pipe to the consumer's home;
- monitoring the debit of water delivered to consumers.

The minimum equipment that must be present at the house connection is:
- tapping pipe;
- water meter and water meter protector or flow restrictor;
- opening / closing valve to regulate the flow of water;
- pipe and equipment.

2.2. Illegal Connection
The illegal connection is the connection of drinking water carried by individuals or entities by way of tap water to drink directly from the pipeline taps without going through the water meter.

The illegal water connection can occur in active or former customer by using a bypass on the water meter, a pipe is installed around the water meter. The bypass pipe is buried underground and is very difficult to detect. This type of non-physical water leakage is usually carried out by industrial and commercial customers, where a small volume of water consumption passes through the water meter while the rest passes through the bypass pipe.
2.3. Chlorine Indicator Test Kit
The chlorine indicator test kit is a tool to measure the level of chlorine concentration in water. The type of chlorine which is often used in the chlorination process is chlorine (Ca(ClO)2) which functions to purify and disinfect germs. However, the use of chlorine must also be considered carefully and must be based on the existing safe limits. The chlorine limit requirement for drinking water according to the Regulation of the Ministry of Health of the Republic of Indonesia Number 492/MENKES/PER/IV/2010 concerning the requirements for drinking water quality is a maximum of 5 mg/l [9]

2.4. Using mWater [10]
The mWater platform can be used in different data-driven workflows by end-users. Users typically focus on Surveying, Monitoring, Evaluation, & Learning, and Management.

- **Surveying**- Data collection using Surveys on a one-off basis.
- **Monitoring, Evaluation, and Learning**- Data collection using Sites and Surveys on a repeated basis that informs programming and adapts the monitoring process.
- **Management**- Assignment of in-field actions and reporting to identify, update, resolve, and approve issues in the field.

![Figure 1. Process Surveying](image1)
![Figure 2. Monitoring, Evaluation, and Learning](image2)
![Figure 3. Management](image3)

**Plan** - The planning phase involves establishing the data-driven process's objectives, creating surveys, and preparing mobile devices.
**Train** - The training phase provides the data managers, collectors, and consumers with the capacity to use mWater Portal and Surveyor.
Deploy - The deployment phase is where roles and permissions are established, defining who can Collect, View, Modify and Approve survey responses. Once deployed, the survey automatically appears on the Surveyor app for the data collectors.

Collect - The data collectors use Surveyor to fill in survey responses and create Sites.

Update - Data collectors revisit the same Site to perform longitudinal monitoring.

Respond - Data collectors receive notifications on their device informing them of a Survey Assignment or an Issue to respond to in the field. They perform the necessary action and respond to the assignment/issue.

Clean - The cleaning phase involves survey and site approvals and the visualization of systematic data errors for correction.

Report - Reporting is done through visualizations, including interactive maps, charts, calendars, summaries and tables. These functions are then shared in various formats, including live Maps/Dashboards/Consoles, PDF reports, and Excel/CSV.

3. Methodology

This study was conducted 15th of February – 1st of April 2021 using mWater, involving 30 enumerators and 2 field coordinators. The subjects studied were 5000 former customers of PDAM Surakarta City.

The research was organized into four daily work steps involving the enumerator and the field coordinator. The four steps of daily work are:

a. **First Step**: A brief meeting between the enumerators and the field coordinators. In the field coordinator meeting carried out the following activities:
   - Check the survey (facilities and infrastructure for enumerators) before going to the field/collecting data.
   - A brief refresher on survey understanding with the mWater application, especially on the first day.
   - Develop a strategy for the sequence of the locations surveyed with enumerators based on the village clusters.

b. **Second Step**: The enumerator collects and inputs data using the mWater application from respondents to respondents.

c. **Third Step**: The field coordinator monitors each enumerator data input result and downloads data from the mWater application. Then save it to Xls / CSV format, then check every data input from the enumerator. Downloading and checking data are carried out every day. If there are problems or difficulties for the enumerators in the field, the field coordinator can solve them. Enumerator communication in the field with the field coordinator can be done through social media. Including solutions when there is a data input error.

d. **Fourth step**: meeting of work results. After the day’s data collection, an afternoon or evening meeting is held (according to the agreement between the field coordinator and enumerator) to do the following:
   - The field coordinator facilitates the enumerators to share their experiences.
   - Enumerators share experiences (difficulties and problems encountered, data input process, or other matters).
   - The field coordinator provides solutions if there are problems encountered in the field.
   - The field coordinator will inform the results of the achievements of each enumerator. If a data input error is considered the field coordinator to be very large, the enumerator must repeat the data input on the next day.
   - Remind the enumerator to charge the smartphone at night so that in the morning, there will be no problems in data input (or the enumerator brings the power bank while in the field).

Data analysis methods used in the 5000 survey of former customers PDAM was a **quantitative and descriptive method**. This method was used to analyse non-numerical data or data that cannot be translated into numbers. While descriptive is an analysis that provides an understanding and explanation of the condition of the water meter for household customers in the survey area by using.
frequency tables, graphs, and cross tabulations. To facilitate the analysis, SPSS software was used as statistical data processing program.

4. Results of The Study
A total of 5000 respondents consisted of respondents with various occupancy status: 3232 respondents with occupied residence, 239 respondents with vacant land/demolished building, 77 respondents with project occupancy status (demolition/renovation of houses), and 1452 respondents with the status of occupancy vacant/unoccupied houses (houses in the process of buying and selling/renting or abandoned).

Table 1. Address Matching of Former Customers with Current Responder’s Address

| Compatibility of former customer’s address with current respondent's address | Number of Respondents | Percentage |
|---|---|---|
| The same | 1133 | 35.06 |
| Address needs to be completed | 1450 | 44.86 |
| Address changed | 649 | 20.08 |
| Total Amount | 3232 | 100 |

Table 1 shows 3232 respondents whose occupancy status is inhabited and the suitability of the former address. customer with the respondent's current address. The result shows that 1133
respondents stated that the address of the former customer and the current respondent's address was exactly the same (meaning that the address of the former customer had not changed and was complete with RT/RW), 1450 respondents stated that the address needed to be completed (meaning the address of the former customer was not complete, it needed to be completed such as completing the house number, RT/RW), and 649 respondents stated that their address had changed (meaning that the address of the ex-customer had a change in street name/house number/RT/RW/ Sub-district, such as the expansion of RT and RW areas.

Of the 3232 respondents, 334 respondents whose occupancy status was occupied and claimed to use the service of Surakarta Local Water Company, a respondent at Local Water Company at Karanganyar Regency, a respondent with Surakarta City KSM Program and 2896 respondents did not use the service of the water company.

Table 2 shows that number of respondents whose occupancy status is inhabited and not registered as customers of PDAM Surakarta City are 2896. The reasons discontinuing the service from Surakarta water company consisted of: water running only at certain times, water stopped running at all, water quality was not good, water tariffs were too high, and arrears.

| Interest in Continuing the Service of PDAM | Number of Respondents | Percentage |
|--------------------------------------------|------------------------|------------|
| Yes                                        | 106                    | 3.66       |
| Yes, if there is a special program or discount | 20                    | 0.69       |
| No                                         | 2299                   | 79.39      |
| Don't Know                                 | 471                    | 16.26      |
| Total Amount                               | 2896                   | 100        |

Table 2 shows of 2896 respondents, 106 respondents expressed their interests in continuing the service, 20 respondents were interested in continuing if there was a special program or discount program, 2299 respondents were not interested in continuing the service, and 471 respondents who did not know if they were interested in continuing the service.

Table 3. The Last Location of PDAM’s Installed Water Meter

| Last Location of PDAM’s Installed Water Meter | Number of Respondents | Percentage |
|---------------------------------------------|-----------------------|------------|
| The remnants of demolished buildings (water pipelines are not visible) | 2296 | 79.28 |
| PDAM water meter is still installed          | 84                    | 2.90       |
| There is PDAM water pipeline which was cut and connected to other pipes | 16 | 0.55 |
| There is a remnant of the pipe that was demolished by the PDAM | 500 | 17.27 |
| Total Amount                                | 2896                   | 100        |

Table 3. shows the condition of the last installed PDAM water meter. The results showed 2296 respondents’ pipelines were not visible, 500 respondents with the remnants of pipes from PDAM demolition, 84 respondents whose PDAM water meters were still installed, and 16 respondents showed signs of cut of PDAM water lines, which is now connected to the other pipes. The traces of the demolition of the PDAM water pipelines are not visible, meaning that the former demolition has been buried (covered with cement/tile/soil). The PDAM water meter is still installed, meaning that the respondent has not discontinued and has not paid for PDAM water service but the water meter has not
been revoked by the PDAM. There is a remnant of the pipe that was demolished by the PDAM, which means that the channel that was cut off is closed with a cap.

### Table 4. The Chlorine Content in The Water

| The Chlorine Content in Water | Number of Respondents | Percentage |
|------------------------------|------------------------|------------|
| There is                    | 16                     | 0.55       |
| There is not any            | 2880                   | 99.45      |
| Total Amount                | 2896                   | 100        |

Table 4 shows of 2896 respondents, 16 respondents have water source which indicates the presence of chlorine levels, and 2880 respondents has water source which does not indicate the presence of chlorine levels.

### Table 5. Illegal Connection Indication

| Occupancy Status                | Strong | Moderate | Weak | Not All | Total |
|---------------------------------|--------|----------|------|---------|-------|
| Inhabited                       | 5      | 48       | 1032 | 2147    | 3232  |
| Vacant land/demolished building | -      | 1        | 7    | 231     | 239   |
| Under a project                 | -      | -        | 9    | 68      | 77    |
| Vacant houses/uninhabited       | -      | 1        | 77   | 1374    | 1452  |
| Total                           | 5      | 50       | 1125 | 3820    | 5000  |

Table 4 shows that from 5000 respondents, there are 5 respondents with strong indications of illegal connections, 50 respondents with moderate indications, 1125 respondents with weak indications, and 3820 respondents with no indications of illegal connections.

There are four categories of illegal connection indications, such as:
- **Strong indications**: physical evidence of pipe connections
- **Moderate indications**: there is physical evidence of a pipe connection without detectable chlorine content on the water or only detectable chlorine without pipe connection.
- **Weak indication**: respondents were not able to show the source of water.
- **There is no indication of illegal connections**

### 5. Conclusions

Of 5000 respondents, 5 respondents show strong indications of illegal connection, 50 respondents were indicated as moderate, 1125 respondents showed weak indications, and 3820 respondents show no indication of illegal connections.

The Local water company at Surakarta City has made these following efforts to fix the problems:
- Coordination with branches to conduct inspections on the 16 respondents as the former disconnection of PDAM water lines which are now connected to hoses/pipes.
- Coordination with branches to carry out inspections on the 84 respondents whose PDAM water meters are still installed.
- Responding to 106 respondents who expressed their interests in continuing the service and 20 respondents expressing interest in continuing the service of Local water company at Surakarta City if there is special programs or discount for reconnection.
• Coordinating with branches to carry out inspections for indications of illegal connections.

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