Optimization of the Drinking Water Supply System by Reducing Water Loss Rate as a Sustainable Development Goal: Water and Sanitation in the City of Malang

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Abstract. The provision and management of clean water for the people of Malang is handled by Perumda Air Minum Tugu Tirta Kota Malang or previously known as PDAM Kota Malang. Optimizing and controlling the level of water loss in the Drinking Water Supply System of Perumda Air Minum Tugu Tirta Kota Malang as a sustainable development effort is a crucial step. By implementing concrete strategies to reduce water loss in the water supply system, it is possible for Perumda Air Minum Tugu Tirta Kota Malang to achieve more efficient use of water resources, environmental sustainability, community welfare, and financial sustainability. In this study, the survey method and descriptive method were used with qualitative and quantitative data that were processed. By implementing the strategy of optimizing the water supply system and reducing the level of water loss, it is possible to achieve sustainable development by increased availability of clean water, increased community access to safe drinking water, efficient use of water resources, and increased operational effectiveness of water companies.

Keywords: Drinking Water Supply System, Water Loss Rate, Sustainable Development Goals (SDGs).

1 Introduction

The City of Malang is a city located in the highlands, and its area is directly adjacent to Malang Regency. The City of Malang is the second-largest city after Surabaya in the Province of East Java, Indonesia. The city has an area of 111.077 km² with a population of 846,126 people spread across 5 sub-districts [5]. Great pressure on the management of water resources and sanitation infrastructure is caused by the rapid growth of the population by both migrants and local residents, accompanied by the development of city infrastructure that has continued to occur in recent years.

The provision and management of clean water for the people of the City of Malang is handled by Perumda Air Minum Tugu Tirta Kota Malang, or previously known as PDAM Kota Malang. The raw water sources used by Perumda Air Minum Tugu Tirta Kota Malang come from the springs at Wendit, Binangun, Sumbersari, Karangan, and others. The number of

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customers of Perumda Tugu Tirta Kota Malang in 2022 was 175,109 households, covering 80% of the area of the City of Malang; this continues to grow every year [8].

The City of Malang continues to strive to fulfill standards regarding the aspects of quantity, quality, and continuity to improve services for the provision of drinking water. Optimizing the drinking water supply system by reducing the level of physical and non-physical water loss is an effort to improve drinking water supply services. The percentage of water loss that occurs in the drinking water supply system of Perumda Air Minum Tugu Tirta Kota Malang up to May 2023 is 15.9%. This percentage is already below the national water loss tolerance standard of 20%. However, Perumda Air Minum Tugu Tirta Kota Malang continues to strive to maintain and reduce the percentage of water loss. This is a challenge for Perumda Air Minum Tugu Tirta Kota Malang because water loss in the drinking water supply system can occur at any time for different reasons. Physical water losses such as pipe leaks can occur at any time, which can hinder the distribution of water pressure to the community and other parties in need. Errors in meter reading, water theft, and similar incidents lead to non-physical water losses, which certainly can reduce the efficiency of the water supply system.

Optimizing and controlling the level of water loss in the Drinking Water Supply System of Perumda Air Minum Tugu Tirta Kota Malang as a sustainable development effort is a crucial step. By implementing concrete strategies to reduce water loss in the water supply system, it is possible for Perumda Air Minum Tugu Tirta Kota Malang to achieve more efficient use of water resources, environmental sustainability, community welfare, and financial sustainability.

2 Literature Review

2.1 Concept of Sustainable Development in the Water and Sanitation Sector

Water and sanitation sector development is an important component in achieving sustainable development. This concept includes sustainable water management, protection of water resources, increased access to safe drinking water, and proper sanitation. To ensure the availability of clean water and sanitation for the entire community, the sustainability of the water supply system is a priority. Sustainable development in the water and sanitation sector is based on the Sustainable Development Goals (SDGs). The SDGs in the water and sanitation sector have the purpose to achieve comprehensive access to clean water and adequate sanitation as well as the reduction of negative impacts on the environment. The concept involves several water- and sanitation-related programs such as water efficiency, wastewater treatment, and others. The aim becomes to increase access to clean water and sanitation that is safe and fit for use. The Sustainable Development Goals (SDGs) also set several indicators in measuring the achievements of the sanitation sector, such as the proportion of the population that uses safely managed sanitation services, the proportion of the population that has handwashing facilities with soap and water, and the number of villages or sub-districts that implement Community-Based Total Sanitation [16].

2.2 Challenges in the Water Supply System in the City of Malang

The City of Malang faces a number of challenges in its water supply system, including a high level of water loss. Based on previous studies, factors causing water loss in the City of Malang include pipeline leakage, water theft, and inefficient water use practices. These challenges hinder efforts to achieve sustainability in water supply in the City of Malang. Challenges in the water supply system in the City of Malang include high energy costs due to the dominance of the pumping system, resulting in higher energy costs compared to the national average. In addition, the existing distribution system relies on pumps that operate continuously without considering peak and minimum customer usage. Elevation differences in the service area also pose challenges in maintaining water pressure and flow rates. Furthermore, the existing distribution network consists of various types of pipes with different diameters, which can affect the efficiency of water distribution. Challenges in the water supply system in the City of Malang also include pipe leakage, water theft, and inefficient water use practices. These issues contribute to water loss and lower overall system efficiency. Pipe leaks cause water to be wasted and can result in reduced water pressure and flow rates. Water theft, which involves unauthorized connections or tampering with meters, further exacerbates the problem by diverting water from its intended users. In addition, inefficient water use practices, such as excessive water consumption or improper water management, contribute to pressure on the water supply system. These challenges need to be addressed to ensure sustainable and reliable drinking water supply in the City of Malang [2].

Through this literature review, it can be seen that optimizing the water supply system and reducing water loss are important steps in achieving Sustainable Development Goals in the water and sanitation sector in the City of Malang. Strategies and experiences from previous case studies can provide valuable insights into the challenges faced by the City of Malang in its efforts to achieve sustainability in water supply.

3 Method

This research used the methods of survey research and descriptive research with processed qualitative and quantitative data. Quantitative data for the research were obtained from secondary data collection, comprising (official) data from the BPS website and directly from Perumda Air Minum Tugu Tirta Kota Malang. Qualitative data for the research were also obtained from observations and interviews with several related agencies at Perumda Air Minum Tugu Tirta Kota Malang. This research method is expected to provide in-depth insights into optimization measures that can be taken to improve the water supply system and reduce water losses in the City of Malang in order to achieve sustainable development in the water and sanitation sector.

4 Results and Discussion

4.1 Water Loss Rate in the City of Malang

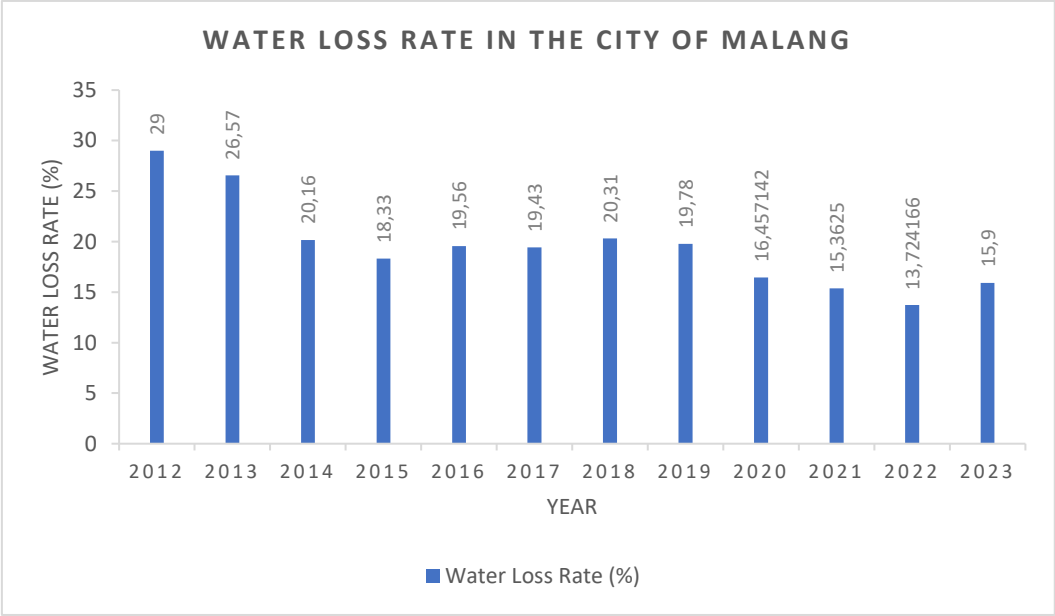

Fig. 1. Graph of Water Loss Rate in the City of Malang
(Source: Official Data of Perumda Air Minum Tugu Tirta Kota Malang, 2023)

In Figure 1, which shows the graph of the water loss rate in the City of Malang, it can be seen that there is a significant decrease in percentage every year. The highest water loss rate occurred in 2012 (29%) and the lowest water loss rate occurred in 2022 (13.724166%). However, in 2023, there was an increase of 2.18% from the previous year. This proves that there is a need for re-evaluation regarding the optimization of the water supply system in relation to the level of water loss.

4.2 Implementation of Optimization Strategies

This section presents the strategies and measures that have been implemented by Perumda Air Minum Tugu Tirta Kota Malang to optimize the water supply system and reduce the level of water loss.

4.2.1 Installation and Replacement of Main Water Meters

Installation and replacement of main water meters is carried out in two stages: on production water meters located in the raw water source units, and on distribution water meters located in the reservoir units. The production water meter functions to measure the volume of water entering the drinking water supply system from the raw water source. With the installation of production main water meters, Perumda Air Minum Tugu Tirta can accurately monitor the volume of raw water being taken in order to optimize water management and distribution. Meanwhile, the distribution main water meter is installed in a reservoir unit to measure the

volume of water entering and leaving the reservoir before being distributed to customers. The installation of distribution main water meters allows for better monitoring of water flow within the distribution system, assisting in the detection of leaks or other issues that may result in water loss. With the installation and replacement of main water meters at both stages, Perumda Air Minum Tugu Tirta can improve measurement accuracy and optimize efficient water management in the City of Malang.

4.2.2 Installation and Replacement of Consumer Water Meters

Perumda Air Minum Tugu Tirta Kota Malang installs and replaces consumer water meters in several situations. First, installation is carried out on consumer water meters that have not been installed before. This step is important to ensure that each customer has a water meter that functions properly and accurately in measuring drinking water usage. Furthermore, the replacement of consumer water meters is carried out if there is damage to the meter that has been installed. In this situation, the damaged water meter is replaced with a new one to ensure proper water measurement and avoid usage errors. Consumer water meters that are opaque and difficult to read are also considered inaccurate, and thus necessitate replacement to ensure accurate measurement. Finally, consumer water meters that have reached their technical life or are more than 5 years old are to be replaced with new ones. This replacement has the purpose to ensure continuous good quality and reliability of water measurement. Through the installation and replacement of consumer water meters under these conditions, Perumda Air Minum Tugu Tirta is committed to providing accurate, efficient, and fair services to customers, as well as improving overall drinking water management in the City of Malang.

4.2.3 Pipeline Rehabilitation

Pipeline rehabilitation is carried out with a focus on transmission pipes and distribution pipes that are prioritized based on location. In order to optimize the water supply system and reduce the level of water loss, Perumda Air Minum Tugu Tirta Kota Malang implements the use of HDPE (High-Density Polyethylene) pipes as one of the rehabilitation material options. Since the launch of the Non-Revenue Water (NRW) program in 2012, Perumda Air Minum Tugu Tirta Kota Malang has adopted the use of HDPE pipes and GI (Galvanized Iron) pipes for infrastructure improvement activities. The use of HDPE pipes, which have good characteristics in terms of corrosion resistance and leakage, is considered an effective and efficient option in addressing water loss issues. Meanwhile, GI pipes are still used in some rehabilitation cases that require higher mechanical strength. By using HDPE pipes and GI pipes, Perumda Air Minum Tugu Tirta Kota Malang strives to improve the quality of pipeline infrastructure, reduce the level of water loss, and ensure the sustainability of the water supply system in the City of Malang.

4.2.4 Pressure Management

Pressure management is one of the most critical components of an effective water loss management strategy. The level of water loss in a water distribution system is strongly related to the pressure generated by a pump or by the force of gravity. There are several methods that can be used to reduce pressure in the system, including the use of variable speed pumps and the division of pressure zones by elevation. However, the most common and cost-efficient method is the use of an automatic pressure reducing valve (PRV). PRVs are installed at strategic points in the network to reduce or maintain network pressure at predetermined levels. The function of the valve on the PRV is to maintain the preset downstream pressure regardless of fluctuations in upstream pressure or flow rate. Typically, PRVs are placed on the DMA

inlet pipe parallel to the DMA water meter. Before the PRV is operated, the setup process needs to be carried out. The steps in setting up the PRV cover measuring the pressure at the critical point location using a non-online pressure logger, measuring the pressure at the inlet and outlet of the PRV, opening the isolation valve and/or ball valve, opening the stop valve, releasing the air inside the bonnet by opening the PRV venting plug, setting the solenoid position to off when setting the low pressure, setting the pressure downstream by turning the pilot, and setting the additional pressure by turning clockwise or counterclockwise. After that, the solenoid valve is set to the on position when high pressure setting is performed, timer setting is performed, and the pressure value is verified through manual control on the solenoid (manual on-off). By following these steps, PRV setup is completed.

4.2.5 District Meter Area (DMA) Monitoring

Monitoring of the District Meter Area (DMA) is performed by comparing the water discharge into the DMA and the water usage of the customers within it. After obtaining information on the percentage of Non-Revenue Water (NRW) in the DMA, if the NRW percentage value exceeds 30%, measures to reduce NRW will be taken using the step test method and a survey of commercial losses. The step test method is used to identify and inspect components in the network that may cause water loss, while the commercial loss survey has the objective to identify and address water losses that occur due to commercial factors. By implementing this method, it is expected that Perumda Air Minum Tugu Tirta Kota Malang can reduce the level of NRW and improve the efficiency of the water supply system in a sustainable manner.

4.2.6 Water Quality Monitoring

Water quality plays an important role in the condition of pipes and accessories, as it can cause corrosion and scale formation. Corrosion can occur on almost any metal exposed to water, and some of the factors that affect it include dissolved oxygen (DO) concentration, total dissolved solids (TDS), pH, alkalinity, temperature, type of metal used, electricity, and the presence of bacteria. High DO and high TDS concentrations increase corrosion speed, while high pH and alkalinity can also accelerate corrosion. High temperatures also contribute to the acceleration of chemical reactions and corrosion. Metal types that are prone to oxidation or readily give away electrons will corrode more easily. Strong electricity can also cause corrosion, while certain bacteria can accelerate corrosion by producing CO_2 and H_2S. Scale formation and corrosivity can be identified through the calculation of the Langelier Index (LI) or Saturation Index (SI), which gives an indication of whether water is scale-forming or corrosive.

4.3 Evaluation of Implementation Results

The implementation of the optimization strategy carried out by Perumda Air Minum Tugu Tirta Kota Malang has several steps that are quite comprehensive. The installation and replacement of main water meters in the raw water source units and reservoir units allow better monitoring of the volume of water entering and leaving the water supply system, thus accurately optimizing water management and distribution.

Installation and replacement of consumer water meters is also an important step in measuring the use of drinking water by customers. Through the installation of consumer water meters, Perumda Air Minum Tugu Tirta can ensure each customer has a water meter that functions properly and accurately. Replacement of water meters that are damaged, opaque, or have

reached their technical age is also carried out to ensure proper water measurement and continuous good quality management.

Rehabilitation of pipelines, especially transmission and distribution pipelines prioritized by location, is a necessary step to reduce the level of water loss. The use of HDPE pipes and GI pipes in infrastructure rehabilitation provides a good option to overcome corrosion and leakage problems. By using the right materials, Perumda Air Minum Tugu Tirta can improve the quality of pipe infrastructure and ensure the sustainability of the water supply system.

Pressure management is also an important component of the water loss management strategy. The use of automatic pressure reducing valves (PRVs) helps reduce pressure in the network efficiently and effectively. By installing PRVs at strategic points in the network, Perumda Air Minum Tugu Tirta can maintain network pressure at a predetermined level, thereby reducing water loss due to pressure fluctuations or uncontrolled flow rates.

District Meter Area (DMA) monitoring is conducted to identify the level of Non-Revenue Water (NRW) in each DMA. The step test and commercial loss survey methods are used to reduce NRW by identifying and addressing components in the network that cause water losses, as well as commercial factors that affect water losses. Through DMA monitoring and the implementation of these methods, it is expected that Perumda Air Minum Tugu Tirta can sustainably improve the efficiency of the water supply system.

Water quality monitoring is also an important step in optimizing drinking water management. By paying attention to factors such as dissolved oxygen concentration, total dissolved solids, pH, alkalinity, temperature, metal type, electricity flow, and the presence of bacteria, Perumda Air Minum Tugu Tirta can identify and address corrosion and scale formation issues that can affect the quality of pipes and accessories.

Overall, the implementation of optimization strategies carried out by Perumda Air Minum Tugu Tirta Kota Malang shows good steps in reducing the level of water loss, improving management efficiency, and ensuring accurate, efficient, and sustainable drinking water supply. With the installation of water meters, pipe rehabilitation, pressure management, DMA monitoring, and water quality monitoring, it is expected that the water supply system in the of City Malang can run better and provide better services to customers.

4.4 Benefits of Water Supply System Optimization

Optimizing water supply systems and reducing water loss have many significant benefits for sustainable development. By optimizing water supply systems, the level of clean water availability can be increased. This means more people will have access to adequate water supply for their daily needs, including drinking, hygiene, sanitation, and agricultural irrigation. This increased availability of clean water will have a positive impact on public health and improve quality of life.

Increased community access to safe drinking water ensures that the quality of water delivered is safe to drink. Improved water treatment processes, strict monitoring of water quality, and better monitoring of the distribution system will ensure that the water reaching customers' homes meets health and safety standards. This will reduce the risk of illness caused by contaminated water.

Efficient use of water resources can reduce the level of water loss in the water supply system. High water losses, such as through pipe leaks and uncontrolled use, lead to a waste of precious water resources. By optimizing the system and reducing water losses, more water can be delivered to consumers and used efficiently, reducing natural resource losses. By optimizing the system, water utilities can improve their operational effectiveness. The use of more advanced technology, regular monitoring, and improved risk management will help water utilities manage the supply system more efficiently and effectively. This includes better financial management, more precise planning, tighter oversight of infrastructure, and improved customer service.

Optimization of water supply systems also has a positive impact on the environment. By reducing water loss, withdrawal of water resources from the environment can be reduced, reducing pressure on natural ecosystems. In addition, the reduction in energy requirements for pumping and processing water can also reduce greenhouse gas emissions and negative impacts on climate change.

By implementing strategies to optimize water supply systems and reduce water loss, it is possible to achieve sustainable development that involves increasing the availability of clean water, improving public access to safe drinking water, allowing efficient use of water resources, and improving the operational effectiveness of water utilities.

4.5 Challenges and Constraints

In implementing the strategy to optimize the water supply system, there are several challenges and constraints that need to be overcome. One of the main challenges is budget constraints. Adequate financing is required to make the necessary infrastructure repairs and upgrades. However, sometimes the available financial resources are limited, thus affecting the ability to make the necessary investments. In addition, the need for infrastructure improvements is also a constraint. Existing water supply systems may require repair or replacement of damaged components. This requires significant time, effort, and cost. Technical challenges can also arise in detecting leaks in extensive pipeline networks. The process of identifying and repairing leaks can be complex, and this requires specialized technology and expertise. Changes in water use behavior by the community are also an obstacle in optimizing the water supply system. Education and awareness on the importance of efficient water use needs to be increased. Changing inefficient water consumption habits and encouraging sustainable water-saving practices can be a complex challenge. In addition, another challenge is climate change and uncertainty in water resources. Changing rainfall patterns, increasing temperatures, and other climate change phenomena can affect water availability and distribution. In optimizing water supply systems, it is necessary to consider these factors and develop appropriate adaptation strategies. In the face of these challenges and constraints, cooperation between the government, relevant agencies, and communities is essential. There needs to be good coordination, effective resource allocation, innovative technology development, and shared awareness in overcoming challenges and realizing sustainable optimization of water supply systems.

5 Conclusions

Based on the presentation of the research results in the previous section, the following conclusions can be made:

1. Optimizing and controlling the level of water loss in the Drinking Water Supply System of Perumda Air Minum Tugu Tirta Kota Malang as a sustainable development effort is a crucial step. By implementing concrete strategies to reduce water loss in the water supply system, it is possible for Perumda Air Minum Tugu Tirta Kota Malang to achieve more efficient use of water resources, environmental sustainability, community welfare, and financial sustainability.
2. Overall, the implementation of optimization strategies carried out by Perumda Air Minum Tugu Tirta Kota Malang shows good steps in reducing the level of water loss, improving management efficiency, and ensuring accurate, efficient, and sustainable drinking water supply. With water meter installation, pipe rehabilitation, pressure management, DMA monitoring, and water quality monitoring, it is expected that the water supply system in the City of Malang can run better and provide better services to customers.
3. Improved water treatment processes, close monitoring of water quality, and better monitoring of the distribution system will allow the water reaching customers' homes to continue to meet health and safety standards. By optimizing the system and reducing water losses, more water can be delivered to consumers and used efficiently, reducing natural resource losses. By implementing strategies to optimize water supply systems and reduce water losses, it is possible to achieve sustainable development that involves increasing the availability of clean water, improving people's access to safe drinking water, allowing efficient use of water resources, and improving the operational effectiveness of water utilities.
4. In implementing the water supply system optimization strategy, there are several challenges and constraints that need to be overcome. Changing inefficient water consumption habits and encouraging sustainable water-saving practices can be a complex challenge. There needs to be good coordination, effective resource allocation, innovative technology development, and shared awareness in overcoming challenges and realizing sustainable water supply system optimization.

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