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STUDY OF THE POTENTIAL AND STRATEGY OF RAW WATER RESOURCE MANAGEMENT TO MEET THE NEED FOR SUSTAINABLE CLEAN WATER IN TANJUNGBALAI CITY

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Abstract

Fulfillment of clean water needs in Tanjungbalai City still faces various challenges, although the potential of raw water sources from the Silau River and drilled wells is quite large. The current clean water distribution system is not optimal in meeting the needs of the community, with a high level of water leakage and inadequate infrastructure. This study aims to analyze the potential of available raw water sources, factors that affect water quality and quantity, and the effectiveness of the clean water distribution system in Tanjungbalai City. The results of the study indicate that high water leakage and old infrastructure conditions are the main problems in clean water distribution. Therefore, the suggested solutions include infrastructure improvements, the application of advanced technology in water treatment and distribution, and diversification of raw water sources to ensure the availability of sustainable clean water for the community. This study is expected to contribute to the management of water resources in Tanjungbalai City.

Keywords: ***Potential sources of raw water, Clean water distribution system, Water leaks, Clean water infrastructure and PDAM Tirta Kualo***

INTRODUCTION

Clean water is a basic need that is vital for human life, both for consumption, household activities, and social and economic activities.(Lubis & Sugiarto, 2024). Along with population growth, regional development, and increased economic activity in Tanjungbalai City, the need for clean water continues to increase from year to year. However, the availability of adequate and quality clean water in this area still faces various challenges, such as limited raw water sources, environmental pollution, and suboptimal water management infrastructure. Tanjungbalai City, located on the east coast of North Sumatra, has potential water resources from rivers, lakes, and groundwater. However, this potential has not been fully utilized to meet the community's clean water needs. This condition is exacerbated by climate change, degradation of water quality due to industrial and domestic activities, and limitations in the water management and distribution system. As a result, some people still have difficulty in accessing clean water, both in terms of quantity and quality.

Seeing these problems, it is important to conduct an in-depth study of the potential of raw water sources in Tanjungbalai City, including the identification of water sources, their quality and quantity, and sustainable utilization strategies. By understanding the potential of available raw water, it is hoped that a more effective clean water management program can be designed, in order to support the fulfillment of community needs and encourage improvements in the quality of life and sustainable development in Tanjungbalai City.(Akus Harmoko et al., 2024). In recent years, the need for clean water in Tanjungbalai City has continued to increase along with population growth, development of residential areas, and industrial and trade sector activities. However, the availability of clean water has not been able to fully meet these needs. Many people still rely on shallow groundwater sources or buy water from third parties to meet their daily needs, while others face obstacles in obtaining clean water that is suitable for consumption, especially in densely populated areas and residential areas that are far from the distribution network.

One of the striking phenomena is the decreasing quality of surface water due to domestic and industrial waste pollution, thus reducing the potential of raw water sources that can be processed into clean water. In addition, the long dry season also causes a decrease in the availability of raw water, while in the rainy season, pollution due to surface runoff also worsens water quality. The clean water management infrastructure currently available is also considered suboptimal, both in terms of processing capacity and service distribution coverage. This condition shows a gap between the potential of available raw water sources and the real needs of the community for clean water. If this phenomenon is not immediately addressed by efforts to identify the potential of appropriate raw water sources and sustainable management, it is feared that it will have an impact on the decline in the quality of public health and hinder the pace of development in Tanjungbalai City.

The potential for raw water in Tanjungbalai to meet clean water needs includes rivers and drilled wells. PDAM Tirta Kualo, which serves Tanjungbalai City, utilizes 2 locations on the Silau River and 6 drilled well locations as sources of raw water. However, the city has not been fully able to meet the community's clean water needs, with a still high level of water leakage. Meeting clean water needs is an important factor in supporting quality of life, public health, and regional development. Tanjungbalai City, despite having raw water potential from the Silau River and a number of drilled wells managed by PDAM Tirta Kualo, still faces serious obstacles in providing clean water evenly and sustainably. The high level of water leakage in the distribution system, as well as the limited capacity of existing raw water sources, means that some people have not received optimal clean water services.

This situation shows that the management of potential raw water sources in Tanjungbalai City needs to be reviewed and developed further.(Akus Harmoko et al., 2024). This research is very important to examine the extent of the availability and quality of existing raw water sources, analyze the factors causing suboptimal utilization, and formulate more effective and efficient management strategies. With this research, it is expected to provide recommendations based on strong data and analysis to improve clean water services, reduce leakage rates, and ensure the sustainability of water availability for all levels of society in Tanjungbalai City. This research also supports efforts to realize the sustainable development targets (SDGs), especially the sixth goal, namely ensuring the availability and management of clean water and sustainable sanitation for all. Therefore, the existence of this research is not only important for improving clean water services in Tanjungbalai, but also to support the development of a healthier, more inclusive, and more competitive city in the future.

Research on the potential of raw water sources and the fulfillment of clean water needs has been widely conducted in various regions in Indonesia. For example, according to research conducted by Sulistyowati (2018), analysis of the potential of raw water from rivers and wells in urban areas shows that the main obstacle in fulfilling clean water needs is not only limited to the availability of water sources, but also to the quality of polluted water and the high level of distribution leakage. This research is in line with the conditions in Tanjungbalai City, where water sources from the Silau River and wells have been utilized, but have not been able to optimally meet the needs of the community due to technical and quality problems. Meanwhile, according to Suryono and Kusuma (2020), in a study on clean water management in coastal cities, it was found that a major challenge comes from river water pollution due to domestic and industrial activities. This study emphasizes the importance of integrated and sustainable management of raw water sources to maintain the quality and quantity of clean water. This is relevant to the phenomenon that occurs in Tanjungbalai, where the potential for river pollution is a threat to the sustainability of clean water provision.

On the other hand, research conducted by Pranata (2019) shows that strengthening infrastructure, improving distribution systems, and reducing the level of water loss (non-revenue water) are the keys to improving the performance of clean water services by PDAM. This provides a basis for this study to not only examine the potential of raw water, but also evaluate the efficiency of the clean water management and distribution system in Tanjungbalai City. Thus, this study has relevance and important contributions to enrich the study of raw water potential management, with a special focus on the actual conditions of Tanjungbalai City which has its own geographical characteristics and challenges. This study is expected to be able to provide a more contextual and applicable approach compared to previous studies, especially in formulating solutions that are appropriate to local conditions.

Identification of problems

Tanjungbalai City faces serious challenges in meeting the clean water needs of its citizens, despite having a large potential source of raw water from water sources such as the Silau River and drilled wells. Although PDAM Tirta Kualo has utilized two locations in the Silau River and six drilled well locations as sources of raw water, real conditions in the field show that the clean water needs in this city have not been fully met. This is due to several factors, such as limited processing capacity, pollution that occurs in raw water sources, and a distribution system that

is not yet optimal. In addition, the high level of water leakage in the distribution network worsens the situation, causing an imbalance between the amount of water available and the water that actually reaches consumers.

This phenomenon shows that although the potential of raw water sources exists, the major challenge in managing and utilizing this potential effectively is still a major problem. Therefore, it is important to conduct further research to identify factors that affect the availability and quality of raw water in Tanjungbalai City and to develop appropriate solutions to optimize water resource management.

Formulation of the problem

Based on the identification of existing problems, the problem formulation that can be proposed in this research is as follows:

1. What is the potential of raw water sources from the Silau River and drilled wells in Tanjungbalai City to meet the community's clean water needs?
2. What are the factors that influence the quality and quantity of raw water used by PDAM Tirta Kualo in providing clean water?
3. To what extent is the effectiveness of the clean water distribution system in Tanjungbalai City in meeting community needs and reducing the level of water leakage?
4. What solutions and strategies can be implemented to optimize the utilization of potential raw water sources and improve sustainable clean water management systems in Tanjungbalai City?

LITERATURE REVIEW

2.1 Raw Water

Raw water is water obtained from natural resources, such as rivers, lakes, or wells, which is used as a raw material in the process of providing clean water. Before raw water is used for consumption purposes, the water must go through a processing process to ensure its quality is suitable. According to Setiawan et al. (2022), raw water plays an important role in providing clean water for the community, especially in urban areas that have high demand for water.

2.2 Fulfillment of Clean Water Needs

Fulfillment of clean water needs refers to efforts to provide safe, sufficient, and affordable water for the community. This includes all stages, from taking raw water, processing, to distribution to consumers. According to Rahayu and Suryadi (2022), fulfilling clean water needs is a major challenge, especially in areas experiencing rapid urbanization, such as Tanjungbalai City.

2.3 Water Resources Potential

Water resource potential is the capacity of an area to provide sufficient water, both from surface water and groundwater sources. This potential is influenced by natural factors such as rainfall, topography, and geological conditions. Research by Hidayat et al. (2022) explains that mapping the potential of water resources available in Tanjungbalai City is very important for planning sustainable use of raw water.

2.4 Raw Water Quality

Raw water quality refers to the level of suitability of water for further processing into clean water. This quality is influenced by various factors, such as contamination levels, pH, temperature, and chemical content. Poor raw water quality can have an impact on public health. Fitriani and Wibowo (2022) stated that the importance of monitoring raw water quality is very necessary to ensure that the processed water meets health standards.

2.5 Climate Change and Its Impact on Water Resources

Climate change can affect rainfall and temperature patterns, which in turn affect the availability of water resources. Research by Rizal et al. (2022) shows that climate change can cause an imbalance in water availability, which has the potential to reduce the potential of raw water that can be used for clean water needs.

2.6 Framework of Thought

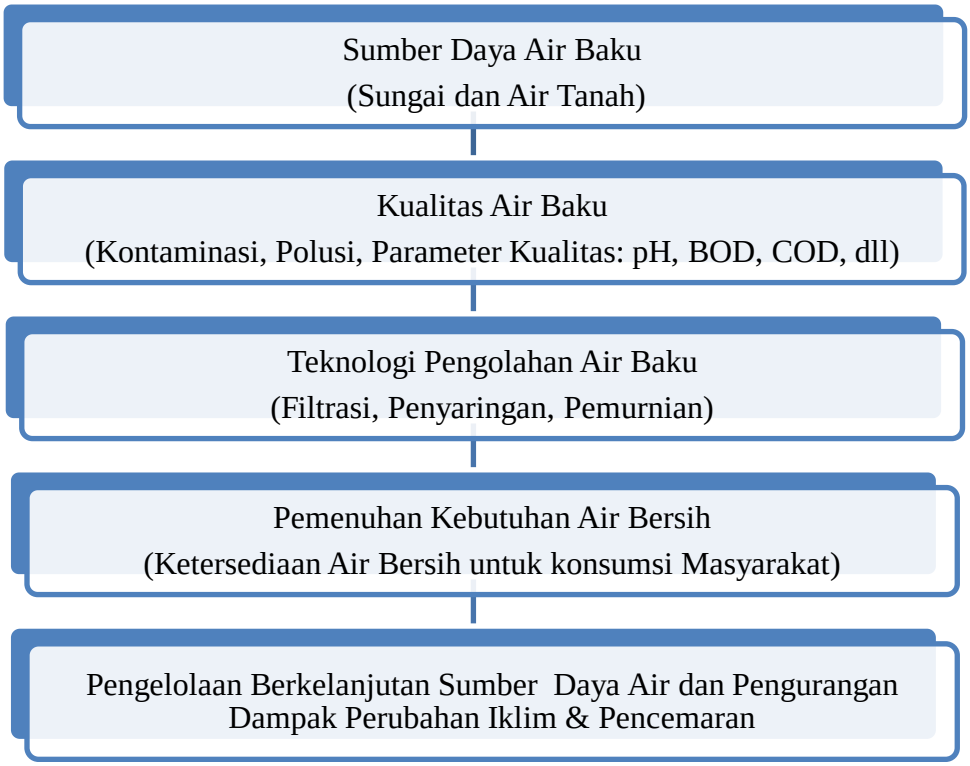

Figure 2.1 Framework of Thought
(Source: Author's Thoughts, 2025)

1. Raw Water Resources: Describes the origin of water used for clean water needs (originating from rivers and drilled wells).
2. Raw Water Quality: Taking into account various factors that affect raw water quality, such as pollution, contamination, and physical chemical parameters.
3. Raw Water Treatment Technology: Refers to the methods and technologies used to process raw water into clean water that is safe for consumption.
4. Fulfillment of Clean Water Needs: Shows the final results of raw water processing to fulfill the community's clean water needs.
5. Sustainable Management: Involves long-term planning and management to maintain the availability of raw water while taking into account environmental aspects, climate change and pollution.

RESEARCH METHODS

3.1 Research Methods

Research methods are ways or procedures used to collect, analyze, and interpret data related to a research topic. According to Sugiyono (2022), research methods can be divided into two main types: qualitative and quantitative, depending on the type of data used and the purpose of the research.(Sugiarto et al., 2024). In the context of this research, the approach used is a qualitative method, which combines both approaches to obtain a more comprehensive picture of the potential of raw water and its management in Tanjungbalai City.

3.2 Qualitative Approach

The qualitative approach is an approach used to explore descriptive and in-depth data, such as perceptions, experiences, and views of the community on the quality and availability of raw water. In this study, qualitative methods were used to conduct in-depth interviews with stakeholders in Tanjungbalai City, such as related agencies, water managers, and affected communities. According to Creswell (2022), a qualitative approach allows researchers to gain a deeper understanding of the phenomenon being studied, which in this case is the challenge of meeting clean water needs.

3.3 Quantitative Approach

The quantitative approach is used to measure and analyze numerical data related to the quality and quantity of raw water available in Tanjungbalai City. This technique involves the use of measuring instruments, such as water quality monitoring devices, to obtain objective data that can be analyzed statistically. According to Sekaran and Bougie (2022), the quantitative approach provides data that can be measured and tested for validity, allowing researchers to make comparisons between variables and produce more accurate findings.

3.4 Data Collection Techniques

In this study, data collection techniques involve two main methods: in-depth interviews and direct observation. In-depth interviews are used to obtain information from various related parties, while direct observation is carried out to examine field conditions related to existing water resources. According to Nasution (2022), proper data collection is very important to ensure the validity of research results.

3.5 Data Analysis

Data collected through qualitative and quantitative approaches will be analyzed using analysis techniques appropriate to the type of data. For qualitative data, the analysis was carried out using thematic analysis which aims to identify important themes that emerged in the interview. For quantitative data, the analysis was carried out using descriptive statistics to describe the condition of water resources and regression analysis to assess the influence of certain factors on the availability of raw water. According to Tesch (2022), the combination of qualitative and quantitative analysis provides more comprehensive results in social research.

RESULTS AND DISCUSSION

What is the potential for raw water sources from the Silau River and drilled wells in Tanjungbalai City to meet the clean water needs of the community?

The potential of raw water sources in Tanjungbalai City is highly dependent on two main sources, namely the Silau River and drilled wells. The Silau River, which flows through the middle of the city, has great potential as a source of raw water, because it can provide sufficient water volume to meet most of the clean water needs. PDAM Tirta Kualo utilizes two locations on this river to take water, which is then processed and distributed to households and industries in the city. However, the use of river water is not free from the challenge of water quality which is often polluted by domestic and industrial waste entering the river. In addition, problems with sedimentation control and poorly managed water flow management can reduce the quality of the raw water source.

Silau River and b) Drilled Well.
(Source: Author's Documentation, 2025)

On the other hand, drilled wells are also an important source of raw water in Tanjungbalai City. PDAM Tirta Kualo relies on eight drilled well locations spread across various strategic points to obtain groundwater used to meet clean water needs. Although groundwater tends to be more stable in quality, the use of drilled wells faces its own challenges, especially in terms of quantity and sustainability of supply. Excessive groundwater extraction without proper management can cause a decrease in the groundwater level, which has an impact on the sustainability of water sources. In addition, groundwater quality can be affected by pollution from industrial activities, domestic waste, and infiltration from poorly controlled surfaces. The combination of water utilization from the Silau River and drilled wells shows that although Tanjungbalai City has sufficient raw water source potential, its utilization is still limited and requires more efficient management. The Silau River, which can provide a large volume of water, must be better managed to reduce the risk of pollution and ensure the quality of water that is suitable for consumption. Meanwhile, drilled wells need to be closely monitored to maintain sustainable groundwater availability, considering that excessive utilization can threaten the sustainability of water supply in the long term. Overall, the potential of raw water sources in Tanjungbalai City can meet most of the community's clean water needs, but it needs to be supported by a better

management system. Integrated and sustainable management between these two water sources is very important to ensure the availability of sufficient and quality clean water for all levels of society in Tanjungbalai City(Rahmadhani et al., 2023).

What are the factors that influence the quality and quantity of raw water used by PDAM Tirta Kualo in providing clean water?

The quality and quantity of raw water used by PDAM Tirta Kualo to provide clean water to the community in Tanjungbalai City is influenced by various factors, both those originating from natural factors and those caused by human activities. Some of the main factors that influence the quality and quantity of raw water are:

1. Condition of Water Sources (Silau River and Boreholes)
   The first factor that affects the quality and quantity of raw water is the condition of the water source itself. The Silau River, as one of the main sources, can experience a decrease in water quality due to pollution from industrial waste, domestic waste, and garbage dumped into the river. In addition, sedimentation factors and fluctuations in water discharge due to the rainy and dry seasons also affect the availability of raw water. In the dry season, river flow tends to decrease, which has an impact on the quantity of water that can be taken. Conversely, during the rainy season, sedimentation and contaminated surface runoff can worsen water quality. The drilled wells used by PDAM Tirta Kualo also face challenges related to the depth and sustainability of groundwater supplies. The decrease in groundwater levels caused by excessive groundwater utilization, as well as the potential for infiltration of contaminated water from human activities around the drilled well area, can reduce the quality of available groundwater. Therefore, the sustainability and proper management of drilled wells are key to maintaining the quantity and quality of raw water.
2. PDAM Processing and Infrastructure Quality
   The quality of water treatment is also an important factor in ensuring that raw water obtained from the Silau River and drilled wells can meet health standards for consumption. The treatment system at PDAM Tirta Kualo must be able to handle the levels of pollutants such as heavy metals, pathogenic microorganisms, and particles and turbidity contained in raw water. This factor is highly dependent on the conditions and technology used in the water treatment process, including the ability of the water treatment plant (IPA) to overcome various water quality challenges. In addition, the distribution infrastructure owned by PDAM also plays a major role in ensuring that the treated water reaches consumers with good quality. Poorly maintained or leaking pipe networks can cause contamination and loss of water in large quantities.
   significantly, which in turn reduces the quantity of clean water reaching the community.

Figure 4.2 Water Treatment Plant (IPA) WTP 2 Tanjungbalai City
(Source: Documentation of the PUTR Service of Tanjungbalai City, 2025)

3. Environmental pollution
   Environmental pollution, whether from industrial, agricultural, or domestic activities, is one of the main factors affecting the quality of raw water. Disposal of industrial waste that is not managed properly into rivers or groundwater sources can contaminate raw water with hazardous materials such as heavy metals, chemicals, and pesticides. In addition, domestic waste, garbage, and the use of chemical fertilizers in agriculture can also increase the content of pollutants in water, which has the potential to reduce the quality of raw water used for clean water treatment.
4. Climate Change and Rainfall Patterns

No	Month	Rainy day	Rainfall (mm3)
1	January	11	146.00
2	February	8	41.50
3	March	10	91.00
4	April	9	114.50
5	May	9	82.00
6	June	7	71.00
7	July	8	48.00
8	August	11	195.50
9	September	17	462.50
10	October	17	231.00
11	November	19	291.50
12	December	17	151.50
	Total	**143**	**1,884.50**

Table 4.1 Number of days and rainfall in Tanjungbalai City
(Source: Tanjungbalai City Food and Agriculture Service, 2024)

Global climate change that affects rainfall patterns is also an important factor in the availability and quality of raw water. Significant variations in rainfall can cause imbalances in the amount of water available, especially during prolonged dry seasons. This can result in reduced river discharge and lowering of groundwater levels, which have a direct impact on the quantity of raw water that can be processed by PDAM. In addition, increasing temperatures due to climate change can worsen water quality by increasing evaporation and contamination.

5. Natural Resource Management and Government Policy
   Good management of natural resources, including raw water, is also very important to ensure the quality and quantity of clean water available.(Ramadhani & Nuraini, 2024). Government policies on water resource management, pollution control, and groundwater use regulations can affect the availability and quality of raw water. Without clear regulations and strict supervision, environmentally damaging practices, such as illegal mining or deforestation in upstream rivers, can reduce nature's ability to provide water suitable for consumption.

Overall, the quality and quantity of raw water used by PDAM Tirta Kualo are highly dependent on natural, technical, and sustainable management factors. Therefore, collaborative efforts are needed between PDAM, local governments, and the community to maintain the sustainability of water sources and improve the efficiency of the clean water treatment and distribution system in Tanjungbalai City.

To what extent is the effectiveness of the clean water distribution system in Tanjungbalai City in meeting community needs and reducing the level of water leakage?

Year	Number of Customers	Water distribution volume (m3)
2023	27,641	480,287
2022	22,601	491,117
2021	22,838	478,677

Table 4.2 Data on the Number of Customers and Water Distribution in Tanjungbalai City
(Source: PDAM Tirta Kualo, 2025)

The clean water distribution system in Tanjungbalai City, managed by PDAM Tirta Kualo, plays a crucial role in meeting the clean water needs of the community. Although the potential for raw water from the Silau River and drilled wells is quite large, the effectiveness of this water distribution system is greatly influenced by various technical and managerial factors. One of the main challenges in clean water distribution is the still quite high level of water leakage, which causes waste of resources and inadequate water supply for some communities.

1. Water Leakage Rate (Non-Revenue Water - NRW)
   One indicator of the effectiveness of the distribution system is the level of water leakage or better known as Non-Revenue Water (NRW). NRW includes water that is produced and distributed but cannot generate revenue for PDAM, which is caused by leaks in the pipe network, water theft, or meter reading errors. In Tanjungbalai City, the level of water leakage is still a significant problem, with several reports showing high NRW figures. This is due to the condition of the distribution infrastructure which is quite old and vulnerable to damage, as well as suboptimal maintenance. These leaks reduce the amount of clean water that is actually available to the community, causing a gap between the existing water supply and the community's needs.
2. Infrastructure Condition and Maintenance of Pipeline Networks

Figure 4.3 Condition of Water Treatment Plant Infrastructure and Pipe Network
(Source: Documentation of the PUTR Service of Tanjungbalai City, 2025)

   The effectiveness of the distribution system is highly dependent on the condition of the existing pipe network infrastructure. In Tanjungbalai City, most of the pipe networks are quite old, making them prone to damage such as cracks, leaks, or blockages. Old pipes are often the source of undetected leaks, which cause large amounts of water loss. Although PDAM Tirta Kualo has carried out routine maintenance efforts, the limited budget and resources to repair or replace old pipes mean that leaks remain a major problem. Therefore, greater investment is needed to renew and strengthen the distribution infrastructure to make it more efficient and durable.
3. Service Coverage and Distribution Reliability
   Although the water distribution system has reached most areas in Tanjungbalai City, some areas, especially those located on the outskirts of the city or areas with low population density, still often experience water shortages. This is due to limited distribution capacity in certain areas and an imbalance between existing water sources and increasing demand. People in these areas often rely on private wells or buy water from third parties. The reliability of the distribution system in some of these areas is also affected by technical disruptions that occur, such as power outages that hamper the operation of distribution pumps or technical damage to the main pipes that affect the flow of water to consumers.
4. Leak Monitoring and Management System
   To improve distribution effectiveness, PDAM Tirta Kualo has attempted to implement a more sophisticated leak monitoring system, such as the use of sensor-based leak detection technology or a digital monitoring system to identify leaks more quickly. Although these efforts have shown positive results, their implementation is still limited to certain areas. A broader and more efficient monitoring system needs to be introduced so that leaks can be detected and repaired immediately, thereby reducing uncontrolled water loss.
5. Distribution System Improvement to Reduce Leakage
   One of the important steps to improve the effectiveness of water distribution is to reduce the level of water leakage. Further research and analysis of the most significant leakage points are needed to focus on repairing and replacing old and damaged pipes. In addition, the application of new technologies in the distribution network that are more efficient and durable, such as HDPE (High-Density Polyethylene) pipes, can reduce the possibility of leakage and increase a more stable water flow to customers.

Overall, the effectiveness of the clean water distribution system in Tanjungbalai City still faces significant challenges, especially related to water leakage, infrastructure quality, and uneven supply in various regions. To improve water distribution performance, serious attention needs to be paid to improving infrastructure, improving monitoring systems, and more efficient management in order to meet the clean water needs of the community evenly and reduce water waste.

What solutions and strategies can be implemented to optimize the utilization of potential raw water sources and improve sustainable clean water management systems in Tanjungbalai City?

Optimizing the utilization of raw water source potential and improving the clean water management system in Tanjungbalai City requires a comprehensive and sustainable approach, involving various technical, managerial, and policy aspects. Some solutions that can be implemented to achieve these goals include:

1. Infrastructure Repair and Replacement of Old Pipes
   One of the main steps in optimizing water distribution is to repair and replace old and damaged pipe network infrastructure. Old pipes are often the main cause of water leakage (Non-Revenue Water). Therefore, replacing old pipes with more durable and leak-proof materials, such as HDPE (High-Density Polyethylene) pipes or fiber pipes, can reduce leakage and increase water distribution efficiency. In addition, a more modern distribution system equipped with sensor-based monitoring technology can help detect leaks faster and reduce water loss.
2. Strengthening the Management of Raw Water Resources
   To ensure a sustainable supply of raw water, water source management must be carried out more efficiently. In this case, the management of the Silau River and drilled wells must be considered carefully. For the Silau River, efforts to control pollution and conserve water resources are very important. PDAM Tirta Kualo can collaborate with the government and the community to reduce the discharge of domestic and industrial waste into the river and implement a reforestation program in the upstream to maintain water quality. In addition, regular monitoring of water quality is essential to ensure that the raw water taken meets health standards. On the other hand, for drilled wells, groundwater management must be carried out wisely. PDAM Tirta Kualo needs to develop a management system that regulates the sustainable use of groundwater, avoiding over-extraction which can cause a decrease in the groundwater level. A recharge or well recovery system can also be applied to maintain the balance of groundwater resources.
3. Implementation of More Efficient Water Treatment Technology
   To improve the quality of raw water used, the application of more sophisticated water treatment technology is essential. Technologies such as filtration membranes, reverse osmosis, or UV technology can be used to overcome contamination in raw water, be it chemical, biological, or particle contamination. With more effective technology in processing water, PDAM Tirta Kualo can provide cleaner and safer water for consumption. The use of the right technology can speed up the processing process, reduce operational costs, and improve the quality of the water produced.

Figure 4.3 Water Management Technology
(Source:https://www.mediasulsel.com/sulsel-akan-adoption-teknologi-pengolahan-air-tercanggih-di-jerman/)

4. Improvement of Clean Water Monitoring and Management System
   Digital monitoring systems integrated with the distribution network are essential to improve the efficiency and effectiveness of water management. Technologies such as smart metering, which allows real-time monitoring of water usage, and leak sensors installed in pipe networks, can help detect problems quickly and make repairs before further damage occurs. In addition, data-driven water management systems can help PDAMs plan water distribution more precisely, identify areas that need the most supply, and minimize water waste due to leaks or irregular distribution.
5. Education and Community Participation
   Public education about the importance of water conservation and wise water use is essential in supporting sustainable water management.(Saputra & Sugiarto, 2024). Educational programs that target all levels of

society, especially in areas that often experience water crises, can help raise awareness about the importance of water conservation. In addition, communities can be involved in infrastructure maintenance programs such as cleaning drainage channels, maintaining wells, and managing waste to reduce pollution of water sources.

6. Diversification of Raw Water Sources
   Given the high dependence on the Silau River and boreholes, diversifying raw water sources is an important step to reduce pressure on existing resources. PDAM Tirta Kualo can explore the use of alternative water sources, such as rainwater harvesting or developing desalination in coastal areas. In addition, the use of water recycling technology or recycling wastewater for non-consumption activities can also help reduce pressure on the main water source.
7. Government Policy and Support
   Local governments have an important role to play in supporting efforts to improve water management. Policies that support integrated water resource management must be implemented, including strict regulations on water source pollution, groundwater use, and regulations related to fair and transparent water tariffs. In addition, budget allocations to improve PDAM infrastructure and fund projects to increase water treatment and distribution capacity also need to be a priority.

Optimizing the utilization of raw water potential and improving the clean water management system in Tanjungbalai City requires a holistic and collaborative approach between PDAM, the government, and the community. The solutions mentioned above, such as improving infrastructure, implementing advanced technology in water treatment and distribution, and increasing public awareness, can be strategic steps to overcome the challenges faced in providing clean water. The successful implementation of these solutions will have a positive impact in increasing access to more quality and sustainable clean water for the entire community of Tanjungbalai City.

CLOSING

Conclusion

Based on the analysis conducted, it can be concluded that Tanjungbalai City has a large potential source of raw water, both from the Silau River and drilled wells. However, the fulfillment of clean water needs for the community still faces major challenges, especially related to the high level of water leakage and old distribution infrastructure. The existing raw water potential has not been fully utilized optimally, and the distribution of clean water is still not evenly distributed throughout the city. Therefore, the effectiveness of clean water management in Tanjungbalai City needs to be improved through infrastructure improvements, the use of the latest technology in water treatment and distribution, and wiser and more sustainable management of water resources.

Suggestion

1. Water Distribution Infrastructure Improvement
   It would be better for PDAM Tirta Kualo to immediately replace old pipes that are damaged and prone to leaks with more durable materials, and to carry out routine maintenance on the distribution network to reduce the level of water leakage.
2. Application of Advanced Technology in Water Treatment
   To improve the quality of raw water, the use of more efficient water treatment technologies, such as reverse osmosis and membrane filtration, can be considered. This will ensure that the water distributed to the community is safer and meets health standards.
3. Diversification of Raw Water Sources
   Given the high dependence on the Silau River and boreholes, PDAM Tirta Kualo needs to explore alternative water sources, such as rainwater treatment and wastewater treatment for non-consumption activities, to reduce pressure on primary resources.
4. Improvement of Monitoring and Management System
   Using digital technology for real-time monitoring of water distribution and leak detection can improve the efficiency of clean water management. Smart metering systems and leak sensors need to be expanded in their implementation.
5. Public Education
   Public education about the importance of water conservation and water infrastructure maintenance needs to be strengthened through programs that target various levels of society.

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