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Water Supply for Lawas Community: Investigating Demand and Enhancing Distribution Efficiency

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Abstract. The Lawas community in Sarawak, especially in the town area, heavily depends on treated water from the Trusan Regional Water Treatment Plant (WTP) for daily water needs. However, the hilly and remote areas face several challenges, such as deteriorated water distribution, inadequate supply, and low water pressure. These issues are worsened by the increasing number of new water meter connections each year and the difficulties in supplying water to remote areas. As a result, there have been more complaints to water authorities from the community due to the impact on their essential survival needs. This study aims to comprehensively investigate, analyse, and assess water demand and residual water pressure to determine if the current water supply is sufficient for the population in Lawas. By utilising population data from the 2022 Lawas District Office and recent water pressure measurements obtained using a Pressure Gauge and Prime Log, along with water flow data collected using a Portable Ultrasonic Flow Meter (PT900), Electromagnetic Flow Meter, and Insertion Flow Meter, this research identifies the factors contributing to the inadequacy of water demand. The recommended solutions optimise water pressure and flow to ensure reliable data for future operations and maintenance. These findings provide a reference for designing an efficient water distribution system and promoting optimised water usage tailored to specific areas based on their needs.

Introduction

Water distribution networks (WDN) are vital hydraulic infrastructures for providing consumers with sufficient water of appropriate quality [1]. WDN transmits water to consumers after physical and chemical treatment, an essential part of water supply systems [2]. This water grid system refers to the part of the water supply network that distributes portable water from a centralized treatment plant or a storage system for residential, commercial, industrial, and firefighting purposes [3]. Water distribution systems (WDS) connect consumers to water sources using hydraulic components such as pipes, valves, and reservoirs. Choosing operational components that can provide adequate pressure is essential when meeting demands. [4]. A change in one path affects the flow of other paths in the network [5]. A portable water hydraulic analysis constrains pipe diameter and nodal pressure [6]. The transmission of water from a WTP transmits treated water from the WTP which directly pumps into the Ground Tank Reservoir capacity of 7 million Liter located at 113m height from sea level. Treated water is distributed by gravity from the reservoir toward the Lawas.

The water agency in Lawas is the Rural Water Supply Department Limbang Division also known as Jabatan Bekalan Air Luar Bandar (JBALB) Bahagian Limbang [7]. As of May 2023, the data from the JBALB Water Billing System, reveals 6864 active water meters for consumers in the Lawas Community. However, only 72% of these active meters are connected to the treated water, serving approximately 24,560 consumers. The rapid population growth in Lawas, accompanied by the expansion of new developments and houses, has affected the water supply for the community. This deficiency mainly affects the far-end areas of the gridline and poses a significant challenge for residents residing in hilly regions. Immediate action is required to address these concerns and minimize the affected areas.

Residents in hilly regions rely on alternative sources such as gravity-fed systems and rainwater harvesting for their clean water needs. However, during the dry season, these alternative sources cannot meet the water demands, resulting in severe difficulties for the villagers in their daily activities. To address this issue, the water agency has resorted to supplying treated water through tanker trucks. Moreover, this reliance on tanker deliveries has increased transportation costs, adding a financial burden to the annual Operation and Maintenance budget. It is anticipated that this study holds great significance as it aims to assess the adequacy of water demand fulfillment from the Trusan Regional WTP supply grid. The treated water is pumped to a reservoir at a higher altitude that provides water to the entire population. However, an elevated tank or reservoir is constructed if this is not feasible. The pumping mechanism fills the tank in such systems, and gravity regulates the water supply [8]. The reservoir height is crucial in generating water head pressure, enabling water to flow by gravity. The reservoir outlet releases water with significant pressure, necessitating the selection of an appropriate pipe size capable of handling high pressure.
The water pressure is also known as a force that makes a water flow strong or weak. Water pressure is the force that pushes water through the pipes and is typically created by the altitude and elevation measured in pounds per square inch (psi) and is essentially the force at which the water exits the faucets [9]. Higher range water pressure could damage the plumbing system. Meanwhile, low water pressure leads to several house cores being disrupted. The longer the distance of the conveyance of fluids, the less the water pressure due to water loss occurrence.

1. Methodology

1.1. Background analysis of the case study area

This paper focused on analyzing the sufficiency of water demand from the Trusan Regional WTP water supply system. Water demand data could be tracked from the data given by the Lawas District Department. The primary occupations of the Lawas population revolve around agriculture, livestock rearing, and river fishing. The Malays and Kedayan communities residing along the river primarily engage in agricultural and fishing activities. In contrast, the Lun Bawang indigenous people residing in the upstream areas are predominantly involved in agriculture [10]. Rapid population growth in Lawas, it is anticipated that the population will continue to rise in the coming decade [11].
The population of Lawas has been steadily increasing over the years, with a few fluctuations. From the department of statistic Malaysia [12]; in 1970, the population was 16,979; by 1980, it had increased to 19,777, with an average annual growth rate of 1.5%. The population grew, reaching 29,276 in 1991 and 32,726 in 2000, with average annual growth rates of 3.9% and 1.1%, respectively. By 2010, the population had reached 37,212, with an average annual growth rate of 1.3%. However, in 2020, the population slightly decreased to 36,604, with an average annual growth rate of -0.2%. Despite the slight decrease in 2020, this steady growth trend highlights the need to address the water supply needs in Lawas. Whereby according to official records from the Lawas District Department dated 19th November 2020, the population in 2020 was reported to be 42,010, indicating a 1.1% increase over the past decade since 2010. The projected population in Lawas for the next ten years is estimated to be approximately 42,619, reflecting a 1.45% increase from 2020.
Given the projected population growth, the current water supply capacity needs to be increased. The data indicates a need for a water supply of about 53MLD. This underscores the immediate need to enhance the current water capacity to meet future demands.

1.2. Zero Pressure Test

Zero Pressure Test (ZPT) is a conventional way to check on the source of the water supply in the areas. It is a methodology to identify if the zone or area is completely tight or if there are no water escapes or feeding through any boundary valve. The supply valves are closed for a period and the pressure is monitored. A sudden drop to zero pressure means the boundaries of that area are watertight. The first step of the ZPT is to pre-configure the pressure logger to record each 1-minute interval inside and outside of the zone. The ZPT conducted during the night at 11 pm started and ended at 2 am is an ideal time to close the supply valve at that sub-main area for checking purposes. For example, a few kampungs at Sundar junction were tested and the graph profile from the pressure logger was used to identify which area is inside the coverage supply area from the inlet valve. The same method was carried out for each of the zones for reference and record.

1.3. Water Pressure Gauge and Prime Log

A gauge pressure logger is a measurement instrument that indicates the water pressure in a system. It is a calibrated pressure indicator that is connected to a water pipe or tank and converts the force exerted on it into units such as Pascal, bar, psi, and Torr. Water pressure gauges provide real-time pressure measurements in domestic, commercial, and industrial applications. They are easy to use, durable, and require little maintenance. A system's water pressure can be static or dynamic. Static pressure is the pressure of water when it is not moving. Conversely, dynamic pressure is the pressure of flowing water. Static water pressure can help ensure that the plumbing system's design can handle the pressure of supply water. If the pressure is too high, it can cause damage to fixtures and pipes. Otherwise, if the pressure is too low, getting enough water flow to certain areas of the system can be challenging. Dynamic water pressure determines the flow rate through the system. Dynamic water pressure can ensure that the plumbing system can handle the anticipated demand for water in the home or building. [13].

The model analysis in this study is based on static hydrostatic pressure based on each zone's water demand and compared with the actual reading of water pressure at each zone junction and the residual pressure at the end of the pipelines. To control water pressure, a Pressure Release Valve (PRV) were installed at the designated zones with recommended supply pressure within 2.5 bar to 3 bars. The other basic way to avoid further damage to fixtures and pipes is for the workers need gently turn off or on the Sluice Valve (SV) in situations where the shutdown of the water supply for repairs works to avoid water hammer occurring in the pipe. The installation of Air Valves (AV) is important to release air traps in the pipes after SV are closed.

1.4. Ultrasonic Water Flow Meter PT900 (UFM)

The pipeline is segmented by the installation of a clamp-on UFM across the targeted area. Each flow meter measures the flow rate of the commodity at its location. This transPort PT900 measures the velocity, volume, mass, totalizer, and energy flow rate. It is suitable for most pipe sizes and materials, both lined and unlined, and suitable for many fluids including portable water. Firstly, this Ultrasonic Water Flow Meter PT900 installs the clamping fixture with minimal confusion and repositioning. After that, connect the transmitter and transducer cables correctly, turn on the tablet, and pair it via Bluetooth with the transmitter. The appearance reading is recorded. The PT900 apps can be installed from the Play Store apps and paired with a mobile phone.

1.5. Electromagnetic Flow Meter (EFM)

Electromagnetic Flow Meter (EFM) has been researched and the subject of analysis for over 180 years with indisputable advantages earned on the flow measurement, especially with regards to measurements taken in pipelines [14]. The velocity profile from measured potential differences can be measured within the electromagnetic flow meter [15]. EFM requires the installation of the short pieces upstream (minimum 5 x pipe diameter) and downstream (minimum 3 x pipe diameter) to ensure constant flow record by the logger and to avoid turbulence of water inside the pipe. The installation of EFM was chosen because of its high-value, precision solution for remote water metering applications. It also has a built-in multi-sampling rate, pressure, and flow data logger. Data could be accessed and all logged data remotely via wireless communication via a built-in Global-System-Mobile-Communication (GSM) modem. This could reduce the requirement for costly and time-consuming site visits.

1.6. Insertion Flow Meter (IFM)

The Insertion Flow Meter (IFM) is one of the additional equipment that has been installed on the ground for measuring water flow in a pipe. IFM is installed together with a Gauging Rod, a tool to measure internal pipe diameter at 700mm Nominal-Diameter of Mild Steel Concrete Lining Pipe of distribution main pipe from Trusan. To produce ideal, fully developed flow requires either a minimum of 100D of straight pipe or the use of a flow conditioner, therefore, in many situations, particularly if the pipeline has a larger diameter or space is limited, insertions flowmeters are installed in non-ideal flow conditions. In a fully developed flow, the velocity at D/2 in the center of the pipe is equal to the maximum velocity [16].

2. Results

2.1. Residual Pressure

The data of residual pressure from the initial point and endpoint at each network zone (refer Fig. 1). The data at the initial water pressure point was manually recorded using a pressure gauge and UFM. From the graph, most of the network zones received enough residual pressure at the initial point. However, at the endpoint, most of the residual pressure was recorded below 10m, below the minimum requirements, except for the zone of Jalan Trusan, which is slightly above the active meter demand. Minimum requirements related to the essential minimum pressure requirements for some home appliances, such as washing machines, require 10m and above water pressure. Residual pressure of less than 10m could be considered insufficient because of appliance requirements in residential areas [17]. Hence, the following criteria were set up under the Guidelines and Requirements of the Sarawak State Water Authority. The baseline water pressure was set at 10m for each zone highlighted in red on the graph.

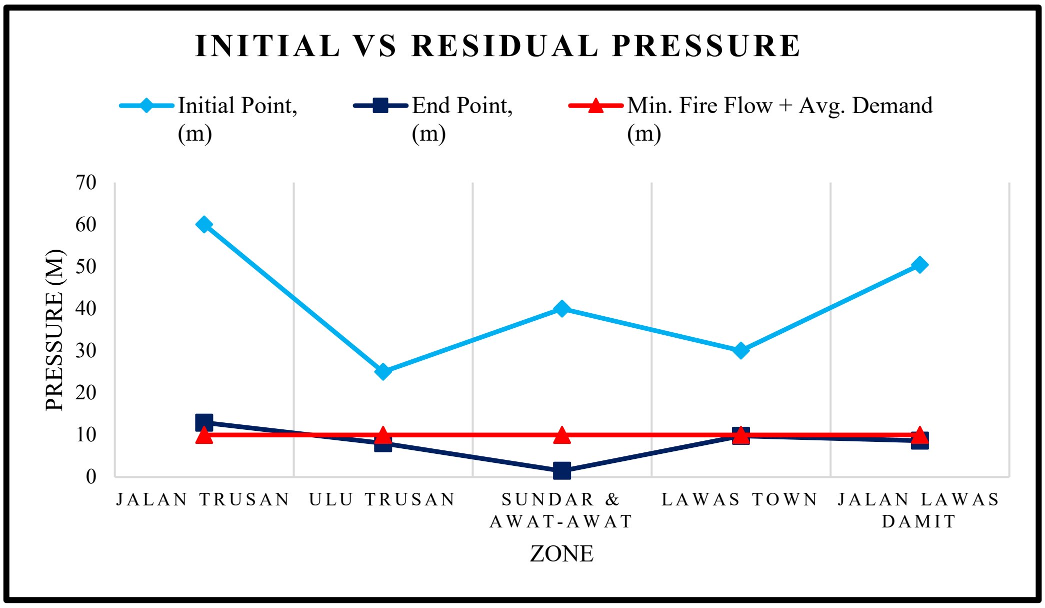

Fig. 1. Initial vs. Residual Pressure

2.2. Water Demand

After analyzing the demand, it has been determined that the actual demand profile of each zone (refer with: Fig. 2), indicates that the starting point of water flow at each main junction has sufficient flow to cater to the demand of all zones. Unfortunately, the endpoint of all five zones found inadequate water flow. These results reflect the actual situation that is currently happening in the Lawas community.

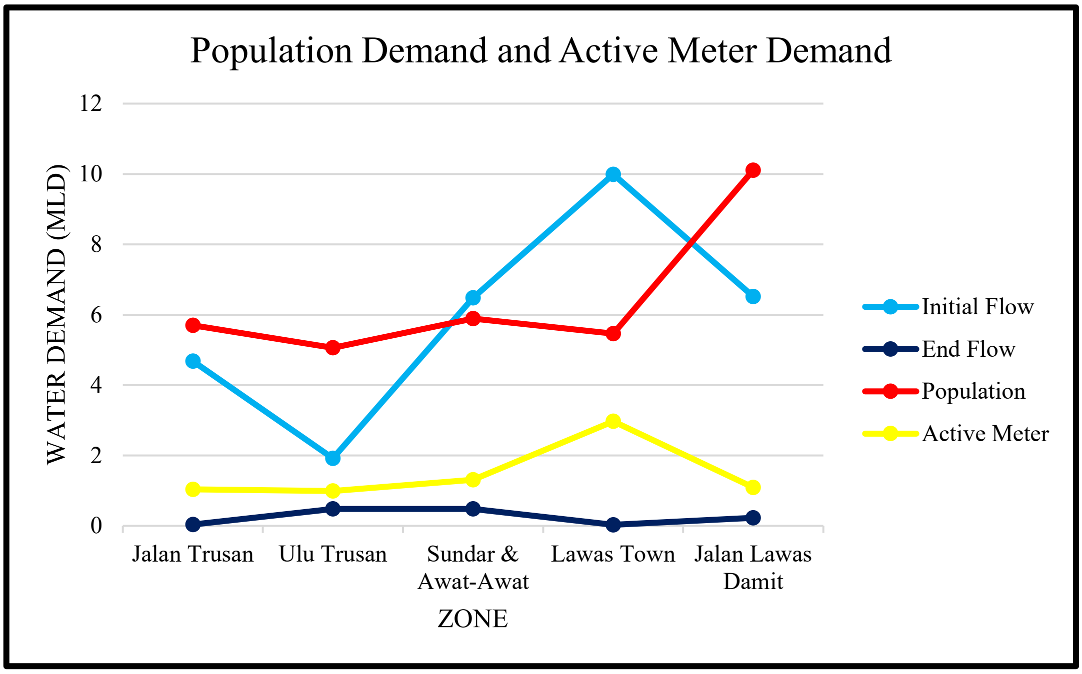

Fig. 2. Population Demand correlation to the Active Meter Demand

3. Discussion

In 2016, studies recommended establishing dedicated District Metering Areas (DMA) for Awat-Awat. By establishing the DMA, proper monitoring, and improvements in pressure and supply issues of the Awat-Awat area can be done. Another DMA was needed because the current DMAs cover a large area and are difficult to maintain and monitor [18]. In the current study, the mentioned DMAs are currently established and are still under installation stages. Establishing a dedicated District Metered Area (DMA) not only for the Sundar and Awat-Awat areas but for all zones can help compile data. Additionally, installing Prime log and i2O loggers at the DMAs and IFM can provide further insights on the real-time data monitoring.
Based on the results, the water pressure is below 10m in all areas except Jalan Trusan, indicating low pressure. This could lead to water shortages and affect daily laundry and toilet use in hilly areas. The main factor affecting pressure is the elevation of the ground. While the supply from Trusan Regional WTP should be enough, the study shows that end flow demand in some areas needs improvement. Lawas town has high demand due to its proximity to essential establishments. Addressing factors like pipe leaks, illegal tapping, and rapid development affecting water flow is crucial. To improve water flow, consider increasing the sub-main pipe diameter to reduce friction, installing pumps to boost flow during low pressure, and using pressure break tanks in hilly areas.

4. Conclusion

In conclusion, this study has investigated the water supply challenges faced by the Lawas community, particularly in hilly and remote areas. By analysing water demand and residual water pressure, the study has revealed significant issues with water distribution, inadequate supply, and low pressure. These issues are further exacerbated by increasing consumer demand and the complexity of supplying remote areas. The study, by utilising population data and advanced measurement tools, has identified key factors contributing to the insufficiency of the current water supply, underlining the critical need for immediate action. The recommended temporary solution for areas with water supply issues is to use individual water pumps and provide a one-day storage tank to meet the total water demand at the end of the water supply grid. This approach could reduce reliance on the water tank and decrease operational costs. To minimize pressure losses, installing an Air Valve (AV) at the highest elevation is recommended to release airlocks. It is also suggested that additional booster pumps be constructed to increase water flow. An analysis of ground elevation will help determine the location and design of the pump head. Calculating the height difference between the initial point and the highest elevation is essential to ensure the pump head design can elevate the water past the highest height. The pump location could be positioned before the highest elevation to boost the water pass-through. In addition, a new water treatment plant (WTP) is recommended at the endpoint of Lawas Town, especially in Pengalih, to meet the surrounding demand. The water authority has proposed rehabilitating the old Lawas town storage tank as a secondary storage tank for the town area. These suggestions are highly recommended to address the water supply issues in the Lawas community. A detailed study of the overall system, incorporating detailed hydraulic calculations of the new booster pump head and appropriate location, is recommended. These factors should be considered for the future water grid system design. Specific locations require a booster pump station to enhance the pressure for continuous and stable water pressure. Secondary or high-level storage tanks are also necessary to create water head pressure.

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