A study of water distribution near Taman Seri Wang, Arau, Perlis

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Abstract. The water distribution system consists of a network of pipelines of different sizes with control valves for transporting water to all streets and providing water to consumers through the water distribution system. The water distribution system may either be continuous or intermittent. Water is available 24 hours a day and seven days a week throughout the continuous water distribution network. This study was conducted to access the water distribution near Taman Seri Wang (TSW) in Arau, Perlis. Research had been outlined to access the existing water distribution at RPA ARAU, to identify the head loss of water distribution at TSW ARAU and to determine the relationship between node demand and pressure of water distribution system at TSW ARAU. A quantitative method was used in this study, which gathers the data parameter from Syarikat Air Perlis (SAP) generated using EPANET software to calculate the head loss inside the pipe Hazen – William equation. The flow rate shows a declining value at nodes 42, 34, 54 and 46 after an analysis of 0700 hours. Simultaneously, a higher proportion of head loss is found in mainly link 1 of the water intake point and link 15 in the water tank near the study area.

1. Introduction
The choice of the distribution system depends on its topography, position and extent, and the altitude and site conditions. According to some literature review research [1], a water distribution system is a hydraulic infrastructure that transmits water to consumers from the source. The system consists of elements such as junctions, pipes, dams, reservoirs and pumps. Then a water distribution network's shared purpose which is to provide customers with water-based on demand levels and required pressures. The water distribution system begins from the behaviours of its factors beneath particular circumstances. From this point, understanding the critical components in any Water Distribution System (WDS) will improve the capacity of giving robust solutions to overcome WDS related challenges [1].

The need for water includes the water supplied to the facilities to meet the needs of the consumer, the supply of water for fire and flushing systems and the water required to properly operate the treatment facilities [2]. The most commonly used head loss equation in the US is the Hazen-Williams equation. It cannot be used for fluids other than water and, as it was, was originally developed for the turbulent
stream [3]. The software used in this research is EPANET software that can help evaluate alternative management strategies throughout a system to improve water quality. Operating under Windows, EPANET provides an integrated environment for editing network input data, running hydraulic and water quality simulations and viewing results in a variety of formats [3]. The distribution of head loss of water and the relationship between node demand and pressure are therefore particularly identified in this study.

2. Material and methods

2.1. Study area
The purpose of this research is to determine the distribution of water at Taman Seri Wang (TSW), near Arau Perlis. Together with Rancangan Perumahan Arau (RPA), which is located opposite Taman Seri Wang, this research will take place in the residential area of Taman Seri Wang.

2.2. EPANET software
This study is using the EPANET software, which is all the data parameter provides from the Syarikat Air Perlis (SAP). EPANET is a worldwide software application for modelling water distribution systems that has been developed as a method for understanding the movement and purpose of components of drinking water within distribution systems and can be used for many different types of applications in the study of distribution systems. These hydraulic parameters, particularly the initial pressure value, are essential. This value is used as resourceful data and information to run the EPANET software.

2.3. Water demand
In order to avoid incorrect conclusions, a substantial distinction should always be made between measurements at several points of the method. It is generally agreed that \( Q_d (\text{water demand}) = Q_{wc} (\text{water consumption}) + Q_{wl} (\text{water leakage}) \). In addition, when the supply is calculated without interim storage of water, such water goes directly to the distribution network: \( Q_{wd} (\text{water supply}) = Q_d (\text{water demand}) \), otherwise: \( Q_{wd} (\text{water supply}) = Q_{wp} (\text{water generation}) \). The equation of total demand for the study area is presented as shown in equation (1).

\[ W_{Dn} = (P_n \times C \times F) + D_a \]  

(1)

where,

\( W_{Dn} \) = total demand for water at year-end \( n \)
\( P_n \) = population at year-end planned \( n \)
\( C \) = consumption per capita at year-end \( n \)
\( F \) = service factor at the end of year \( n \)
\( D_a \) = supplementary request at year-end

2.4. Hazen – William equation
The equation between Hazen and Williams has the advantage that the coefficient \( C \) is not a function of the number of Reynolds, but is only valid for water. It also does not make up for the water’s temperature or viscosity. Hazen-Williams coefficients are used to calculate friction loss in ducts and pipes in the Hazen-Williams equation. Equation (2), \( H_L (\text{head loss}) \) used to depend on the data and situation of the pipe.

\[ H_L = L \left( \frac{Q}{0.85 A C h R} \right)^{0.63} \]  

(2)

where,

\( Q \) = Flowrate (m³/s)
\( A \) = Area (m²)
\( C_h = 100 \) (Hazen – William coefficient)
R = Hydraulic Radius of flow conduit
L = Length (m)

3. Results and discussion
The Piping Skeleton Sketch for the research area is illustrated in figure 1. The line in the figure shows the layout of the pipe from the place of water intake to the water treatment plan to the area of research.

Figure 1. Water Intake Research Area.

3.1. Pattern of the water demand
The demand for water was connected to the trends of water usage and the position of the point of use — the maximum daily water in one hour per litre. Distribution networks should be designed to satisfy the demand for a maximum hourly or full day plus an increased flow of fire. Storage tanks provide space for high-time flows above normal daily capacity. The pattern of demand for water, as shown in figure 2, is 18 hours of total demand for water used within the TSW with an average of one. The demand for water is higher at 17 to 18 hours because it has limited usage for one day due to the operation carried out by the resident.

Figure 2. Pattern of the water demand for Taman Seri Wang.
3.2. Head loss
The value of head loss versus time is shown in figure 3. The head loss unit is in m / km, and the time unit is in hour. This graph shows the time of the EPANET software running analysis for 24 hours. The link is chosen with different lengths to look at the different head loss value for the different pipe. The maximum head loss is 1, 4, 7, 24, 26, 28, 31, 37, 48, 13.25 m / km, 18.64 m / km, 9.46 m / km, 0.12 m / km, 0.03 m / km, 0.01 m / km, 0.09 m / km, 0.05 m / km, 0.01 m / km. Flow rate plays a more important role than the diameter in determining the head loss in pipes that are closer to the water source, and this diameter appears to be more important than the flow rate in pipes on the periphery. In addition, aging process, sagacious and subsequent reduction of the effective diameter may have a more critical effect on the loss of head at the periphery of the system in smaller pipes. Finally, as far as head losses are concerned, the water conservation and pump scheduling effects at different locations in the network may be more apparent on larger pipes closer to the source of water and, in some cases, on smaller peripheral pipes [5].

![Figure 3. Head Loss Value versus Time.](image)

3.3. Relationship between flow and pressure
Figure 4 shows the Piping Skeleton Sketch for the area of research. The figure also shows the pipeline pressure value and the water flow value generated for this area of study. The figure shows the result at 0700. In the legend box, the colour is shown to explain the parameter value for the pipe layout. The result is that lower flow leads to higher stress values. Based on the results, the colour blue indicates a flow value ranging from 0 to 25 lps, whereas the pressure in red for each single node is greater than 100 m.
3.4. Relationship between head loss against velocity

Head loss estimation of the energy diffused in a device by friction. For total energy losses, the length of the pipe and the operation of the fittings, valves and other device structures are determined. Velocity is a calculation of how something moves efficiently in a specific way. It requires to set both size and direction. This was partly due to the tank pipe that flowed through to deliver the water to the study area. The pipe velocity depends on the head loss, and higher velocity contributes to higher head loss, as the velocity is 0.74 m/s for pipe 35. The velocity of pipe 64 is 0.02 m/s and the velocity of pipes 65, 66, 67, 15, 16 and 19 is 0.01 m/s. The remaining pipe has zero speed which indicates no loss of head. The head loss graph against speed is shown in figure 5.
5. would also increase.

There is a way to minimise head loss in the pipe by reducing the pipe system's surface roughness, increasing the pipe system's pipe diameter, and decreasing the pipe system's length. The relation between node demand and pressure is also measured. This relationship indicates that water pressure depends on the demand for water use in the residential area. If there is more demand for water use, the pressure inside the pipe will also increase.

3.5. Pressure against nodes demand

As shown in Figure 6, the pressure at the connexion will decrease on demand for the nodes. Links chosen for this case are 4, 5, 6, 7, 13, 8, 31, 32, 51, 52 and 33. The first relation includes connexion 4 with a pressure of 0.41 m, 1.95 m and 3.67 m, respectively for 0 hours, 9 hours and 19 hours with a node demand of 22.9 l/s. This first connexion appears to be located at the first junction between the tank and the residential area.

![Figure 5](image1.png)

**Figure 5.** The graph of head loss against velocity at 0hour, 9hour and 19 hours.

![Figure 6](image2.png)

**Figure 6.** The graph of pressure against nodes demand for 0hour, 9hour and 19 hours.

The demand for the nodes remains the same as shown in Figure 6 for 0 hours, 9 hours and 19 hours. Meanwhile, for 0 hours, 9 hours, and 19 hours, because the pressure inside the pipe depends on the daily routine demand for water use, the level of pressure is different.

4. Conclusions

Head loss analysis against velocity and flow indicates that head loss affects the velocity and flow of the pipe. There is a way to minimise head loss in the pipe by reducing the pipe system's surface roughness, increasing the pipe system's pipe diameter, and decreasing the pipe system's length. The relation between node demand and pressure is also measured. This relationship indicates that water pressure depends on the demand for water usage in the residential area. If there is more demand for water use, the pressure would also increase.

5. References

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