Analysis of domestic and smallholder farm water demand in Kaajhu Village Baitussalam Sub-district Aceh Besar District

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Abstract. The pipeline system of clean water providers is a very important part because it functions to deliver clean water to every home so that water can flow continuously and meet the needs of the community. This research was to analyze the domestic and smallholder farm water demand in Village Kajhu Baitussalam Sub-district, Aceh Besar District using EPANET 2.0. Pipeline network information obtained from PDAM Tirta Mountala. The data obtained are water supply, water demand, flow, velocity, pipe diameter, pipe length, pipe type and pipe elevation. The results of the EPANET 2.0 analysis were interpreted in the form of pipeline network maps. The maps shows the water flow received by pipelines, pressure, pressure loss and velocity. Based on research, water needs for smallholder farm has been sufficient. Water required for smallholder farm is 658 m$^3$ a day while average debit through irrigation channel is 135.648 m$^3$ a day. Domestic water requirement of 0.499 dm$^3$/sec, while the average discharge based on the simulation result is 0.422 dm$^3$/sec. Water Distribution to the research location is still not functioning optimally because there are several criteria of pipeline network that has not been fulfilled such as the water debit in the channel is not sufficient, here is a pipe with speed less than 0.6 m / s, node with low pressure pipe length, pipe diameters and the distribution is still uneven.

1. Introduction

As a result of population growth, the competition to get water for various kinds of interests also increased. The availability of water is an essential factor for people's to live in a certain area, therefore, it should be managed properly to make sure the availability of water is adequate. Based on the regulation number 121 of 2015 Article 8 concerning water resources, it is stated that in case of limited amounts of water, the allocation of water to fulfill basic daily needs is prioritized over water for smallholder agriculture.

Analysis of pipelines is very necessary because of the various problems in the pipeline network such as lack of production capacity, high leakage rates, customers have not yet gotten water and potential customers who have not been reached by the pipeline network [1]. Epanet is a hydraulik model approach that is more appropriate in solving cases of pipelines, water discharge and user demand values to analyze the behavior of the distribution network by allocating water demand based on the value of the pressure head [2].
has studied and designed a water distribution network based on the amount of water demand between blocks, height of node location, pipe length, roughness coefficient and pipe diameter. Results obtained there is no shortage of water and excess water is stored in standing water, which can be useful during rush hour.

System hydraulic reliability (based on pressure head at the request node, pipe roughness can be calculated using EPANET [4]. System hydraulic reliability (based on pressure head at the request node, pipe roughness can be calculated using EPANET [4], [5], researching to make EPANET 2.0 work faster with optimization applications that utilize modern multicore processors in code implementation. The results obtained are not from the solver which tested its performance faster than the original solver.

The research focused on the needs of clean water in Kajhu Village which consists of 6,125 residents with 1,808 families. The geographical location of Kajhu Village is in coastal area has caused the scarcity of clean water availability, so that the supply from water company which is located around 20 km is the main source of clean water for the community. This study observed the domestic water needs and water needs for smallholder agriculture on the coast of Kajhu. Moreover, analysis of pipelines needs to be done in order to make sure that clean water can be supplied from water company to the housing area without any obstacle.

2. Methodology

2.1 Research Location

The research was carried out in PDAM Tirta Mountala and in Kajhu Village, Baitussalam Sub-District, Aceh Besar District, Aceh. (figure 1)

![Figure 1. Research Location (Source : Google Satellite, 2019).](image)

2.2 Tools and Materials

The tools and materials used in this study were GPS (Global Positioning System), printer, scanner, Current meter, meter, EPANET 2.0 software, QGIS 2.16 software and Google Earth.

EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time steps. The data taken in this study are as follows (a) Primary data obtained for clean water distribution are water source coordinates, elevation, pipeline network data. The data required for agricultural water needs are area sample and water debit. (b) Secondary data needed are data on clean water distribution pipeline network and map of pipeline network in Baitussalam District, spatial map and population data, as well as regional facilities and infrastructure.
2.3 Data Analysis

Based on the observations, the agricultural land in Kajhu Village consists only of fishponds. When the measurements made on the calculation of water for smallholder agriculture are measuring the size of the pond area, making a map of the pond airways, measuring the dimensions of the channel and measuring the flow with the current meter. Water requirements and patterns of water use for fisheries vary according to the type of fish farming. The water that is replaced is approximately one third the height of the pond or 7 mm / day / ha. Pond water requirements are calculated based on the 2002 Indonesian National Standard (SNI) provisions.

Evaluation of Clean Water Distribution Pipes with EPANET use parameters. Parameters reviewed are pressure, discharge, pressure loss, speeds and water requirements at peak hours of use. Data input includes: daily debit data, pipeline data, pump data and pipe connection data. The analysis was carried out using the single period simulation method. The stages of processing clean water needs analysis using EPANET 2.0 are the creation of new projects and program settings, depiction of the scheme of clean water distribution networks, data input components of clean water distribution networks, program simulations and interpretation of simulation results. In this study, to determine head loss between the starting point and end point, Hazen-Williams formula is used [6]:

\[ Q = 0.2785 \times C \times d^{2.63} \times S^{0.54} \]  
\[ (1) \]

Information:

\( Q \) = flow rate (m\(^3\)/sec)
\( C \) = Coefficient of roughness
\( d \) = Pipe diameter (m)
\( S \) = Pipe slope = difference in height / length of pipe (m/m)

Major pressure losses can be calculated by equations [6]:

\[ H_f = 10.654 \left( \frac{Q}{CHW} \right)^{1/0.54} \left( \frac{1}{d} \right)^{4.87} L \]  
\[ (2) \]

Information:

\( H_f \) = loss of Pressure (m)
\( C \) = CHW roughness coefficient
\( L \) = pipe length (m)
\( d \) = diameter

Minor losses are calculated using formulas [7]:

\[ HL = K \times V^2 / 2 \]  
\[ (3) \]

Information:

\( H_L \) = Minor loss (m)
\( K \) = minor loss coefficient
\( V \) = Flow velocity (m / s)
\( g \) = Earth's gravity 9.81 (m / s\(^2\))

The simulations obtained are pressure, discharge, pressure loss, speeds and water requirements of each pipe during peak hours of use. The results of the simulation are compared with the criteria set by American Water Work Association (AWWA) 2005, while the criteria assessed are speed, pressure, pipe size and pressure loss.

3. Results and Discussion
3.1. Research Location
Kajhu Village is located on the coast of Baitussalam District. The main livelihoods of the Kajhu community are fishermen and aquaculture. The people's agricultural land found in the research location is only a pond with an area of about 9.41 ha. Water sources for ponds come from tides. The main domestic water source of the Kajhu Village is the supply from PDAM Tirta Mountala. Only the 213 houses in the research location, 190 houses or 99.18% of them use supplies from PDAM Tirta Mountala, and the other 0.89% still use well water. In the dry season, well water is still available but is limited, because the coastal area of the well's surface is not too deep. The observations show that the average well depth is 3-4 m. Wells cannot meet water needs during peak water use because well water is only able to meet the needs of 3-4 people. If well water runs out, it takes a long time to be filled again, especially in the dry season.

3.2. Pond Water Needs
Available water discharge is measured in the water channel located at the research location, the channel has a surface width of 8 m and the width of the inner channel is 7.2 m and a depth of 2.5 m. the channel delivers water from the sea to the pond area. The average discharge at the measurement is 1.25 m³/second. The average discharge at the time of tide is 2.44 m³/sec and the average discharge at low tide is 0.07 m³/sec. Then the discharge channeled to the farm is 135,648 m³/day.

Table 1. Average Debit Measurement Results

| Measurement Time | Average Q (m³/sec) |
|------------------|-------------------|
| Monday, 07.20 WIB | 0.05              |
| Monday, 11.35 WIB | 2.01              |
| Tuesday, 06.30 WIB| 0.06              |
| Tuesday, 12.35 WIB| 2.92              |
| Wednesday, WIB   | 0.09              |
| Wednesday, 12.35 WIB | 2.37         |

Source: Analysis Results, 23rd-25th October 2017

The requirement of exchange of water level per pond is 7 mm a day for 1 hectare area or approximately one third the height of ponds. The pond area is 9.41 hectares, the pond water needs are 658 m³/day while the discharge is 135,648 mm³/day. The discharged debit is sufficient for the operation of the pond in Kajhu.

3.3. Domestic Water Needs
The Kajhu village is classified into small village groups. Per-person water needs of 60 l dm³/person/day. The population in the simulated research area is 719 people. Water requirements per day are 43,140 dm³/day or 0.499 dm³/second.

Pipeline of PDAM Tirta Mountala in Kajhu Village, Baitussalam Sub district is included in the Zone V (Ingin Jaya) service area. The Zone V Drinking Water Service System (SPAM) takes raw water from the Krueng Aceh River and then processes it with a Water Treatment Plant (IPA) distributed through the 300 mm HDPE (High Density Poly Ethylene) main distribution pipeline to the reservoir at Village Neuheun with a capacity of 1000 m³ along 20,000 m using a centrifugal pump with a capacity of 20 liters/sec as many as 3 units with a pump head of 60 m each. The average age of the pump ranges from 3-5 years.

The pipes used for the main pipe are 13 inch PE, PVC dividing pipes 4 inches, 1.5 inches, 2 inches, and 3 inches with a total of 92 pipes. The length of the main pipe is 18.6 km along Laksamana Malahayati road. Pipes to housing are adjusted to the location of the house connection. The pipe length range is 12 - 1,645 ft or 3.6 -501 m.

Pipes used by PDAM Tirta Mountala to distribute clean water to the coast of the Kajhu Village are PVC and HDPE pipes with a diameter of <24 inches aged 3-6 years. Based on the conditions and
types, the pipe has a coefficient of friction of 140. The criteria for evaluating the pipe coefficient of friction are in accordance with the provisions of Hazen-William.

Measurement of elevation or altitude is carried out at several points according to the junction in the pipe network. The pipeline network at the study location has junction elevations ranging from 0-6 masl, pump elevation of 14 masl and reservoir elevation of 20 masl.

At the location of research demand is the water needs that must be supplied by the PDAM in order to meet the needs of the community. Demand of 0.28 gpm is the amount of water supplied by the PDAM, in the condition that all taps are open. So the demand in the simulation is based on data obtained from the PDAM, which is 0.28 gpm.

3.4 Simulation Result Using EPANET 2.0

Analysis of the clean water distribution network system with EPANET 2.0 in this study used the single period simulation method. Data processed using EPANET 2.0 in this study requires several assumptions a) Network conditions and water quality are considered good b) All pipes use a type of PVC and the pipe roughness number is calculated according to the Hazen-Williams equation; c) Reservoirs in the field are modeled as reservoirs with unlimited water storage conditions and can meet any need for 24 hours.

Simulation results in figure 2 (a) shows that the biggest discharge is found in pipe 1, which is 54.32 gpm or 3.42 lps and the smallest on pipe 31 is 0.24 gpm or 0.015 lps. The average discharge distributed is 6.692 gpm or 0.422 l/sec. Simulation results in figure 2 (b) shows the highest speed is found in pipe 1 which is 1.39 fps or 0.42 m/s and the lowest is in pipes 32, 38 and 91 which are 0.1 fps or 0.03 m/s.

![Figure 2](image)

**Figure 2.** Discharge (a) and Velocity (b) Simulation Results.

Simulation results in figure 3 (a) shows that the biggest pressure loss occurs in pipe 1 which is equal to 3.95 ft / kft (ft of water / 100 ft of pipe) and the smallest pressure loss occurs in pipes 38, 60 and 80 which is equal to 0 ft / kft. Simulation results in figure 3 (b) shows that the greatest pressure occurs at junction 78, 83 and 84 which is equal to 14.38 psi or 10.11 mH2O and the lowest pressure occurs in pipe 63 which is equal to 5.73 psi or 4.03 mH2O.
Simulation results in figure 4 shows that the highest water requirements are at Junction 19, which is 2.8 gpm or 0.17 lps and the lowest water needs occur at Junction 5, 24, 27 and 21 which are 0.28 gpm or 0.018 lps. Overall, the simulation using the EPANET 2.0 can be done properly. Even so, there are still obstacles, such as inadequate data, so that the water demand simulation cannot be carried out for 24 hours and there are still several criteria and standards for pipelines that must be met if they refer to the criteria set by American Water Work Association (AWWA 2005). The criteria set are speed, pressure, pipe size and pressure loss.

EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time steps. EPANET can help assess alternative management strategies for improving water quality throughout a system. [8] examined the design of the water supply system for the KATHGARH India area with the help of "EPANET" software. The design of the water supply scheme for the right water supply was efficient to meet the daily water needs in the area. [9] worked on generation of satellite based thematic layers, town and ward boundary maps and Geospatial Information System (GIS) based census data to estimate water demand, design of transmission lines and main pipe lines to meet the requirement of future demand for the case study area of Alnavar, Karnataka, India.

A network consists of pipes, nodes (pipe connections), pumps, valves and storage tanks or reservoirs. EPANET can track the flow of water in each pipe, pressure at each node, water level in each tank, across the network during the simulation period consists of several time steps. EPANET is designed for to increase understanding about movement and sustainability in the distribution of drinking water. Distribution process can be known and carried out repairs, so that the water supply can meet the needs of the community. In smallholder agriculture for aquaculture, it requires a lot of water to use the cultivation pond. Aspects observed in pond culture are water requirements for cultivation, water requirements for rinsing in pond areas. [10] states quantitatively that water must be able to irrigate all areas of soil and water discharge that are good for ponds not less than 10-15 liters / second / ha.
The dominant factor to implement the clean water supply strategy is to establish services for water treatment plants, allocate funds for improving clean water infrastructure, increase the flow of clean water sources related to water needs in each village. Research on clean water distribution can be distributed by placing divider tank and pipe specifications with pipe sizes varied for secondary pipes and dividing pipes.

The simulation results using EPANET 2.0 software show that there are several AWWA 2005 criteria that have not been fulfilled, including there are still pipes that have speeds of less than 0.6 m/s and junction with a pressure of less than 25 m water, while for the pipe diameter and length criteria, there was no 4 inch pipe with a length of more than 400 m (dead-ended) or 600 m which was connected to the system. Pipes with a diameter of 2-3 inches in low population areas, there was one pipe with a length of more than 100 m (dead ended) and there are no pipes more than 200 m connected to the system. There is no area with a high population in the study area and the main pipeline network has met the criteria of 12 inches. The criteria for pressure loss are still appropriate, in the range 1-4 m/km.

4. Conclusions

Water needs for smallholder agriculture on the coast of Kajhu Village are sufficient. The required discharge is 658 m³/day while the available average discharge is 135,648 m³/day. The use of water for smallholder agriculture does not interfere with domestic needs. More than 99% of the population of Kajhu have used water supply from the PDAM (190 of 213 families). The average water debit needed by the Kajhu Village pipeline network at peak hours of use is 0.499 dm³/sec, while the average discharge supplied by PDAM is 0.422 dm³/sec. The distribution of clean water in the Kajhu Village is

Figure 4. Water Requirements for Each Connection.
still not functioning optimally because there are still pipes with speeds less than 0.6 m/s, nodes with a pressure of less than 25 m of water and less uniform distribution. The suggestions that can be given based on the results of research are for further research on water supply for smallholder agriculture in this case farmland, debit data should be used for one year so that results are more accurate, for clean water distribution pipelines, so that maximum supply needs to be planned re-pipe network, there are still long and diameter pipes that are not in accordance with AWWA 2005 standards and we recommend that the water supply at peak hours be added to meet the needs and reduce when the usage hours are low so as not to damage the pipes.

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