

Water supply system in Titab village and Telaga village, Busungbiu district, Buleleng regency

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Abstract. The rate of population growth in Titab and Telaga Village, Busungbiu District, Buleleng Regency in 2007-2010 reaches 0.75%, which affects the level of water demand needed for daily needs. One of the efforts to meet the needs of raw water for drinking water, among others, by the development of a potable water supply system infrastructure. Based on the facts, it is necessary to design Water Supply System (SPAM) in Titab and Telaga Village with Titab Reservoir spring with 350 l/dt of debit which is expected to give standard of quantity, quality, continuity of service for Titab and Telaga Village which is 5 km from the dam. In order to maximize the service to the community in Titab and Telaga Village, it is necessary to know the use of drinking water for each household. The next analysis is the calculation of projected drinking water needs over the next 20 years. Planning and calculation of water distribution using WaterCad i8 Software. From the result of projection analysis, the drinking water requirement in Titab and Telaga Village based on the fact of household drinking water usage in 2037 is 5,568 lt/sec. While the effort to maximize water supply network services is by projecting drinking water needs in Titab and Telaga Village based on the fact of household drinking water usage. With the help of WaterNet Software, it will simplify the distribution network planning of drinking water in order to produce integrated drinking water network system to meet the needs of clean water in Titab and Telaga Village.

1 Introduction

Titab and Telaga Village are administrative areas located in Busungbiu district, Buleleng Regency in which the area of both villages reaches 819,355 Ha. The distance from Titab and Telaga village government to the district is 5 km, while the distance from the village government to the regency government is 37 km and the distance from the village government to the provincial capital is 80 km. The natural appearance, in the form of the topography of Titab and Telaga Village, categorized as hilly area where the population of both villages reaches 3,240 people, including 640 families. The main livelihoods of the population are as farmers and breeders, with agricultural commodities such as rice, pulses,

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cloves, and cocoa, also for livestock products which are generally developed including cattle, goats, and pigs.

The field survey result found that the utilization of raw water resources for the fulfillment of clean water in Titab and Telaga Village was managed by the villager who came from four spring sources including Tinggih spring, Batu Prigi, Pangkung Biu and Hutan Telaga with a distance of ± 5 km from both villages. The condition of these four springs is quite clean but clogged up, it can be seen from the small discharge. These four spring sources have been used to the maximum with the number of families served is about 235 families, this number is still 33% of 100% families in Titab and Telaga Village. The potable water supply system that is available still conventional and not yet owned in an integrated and still partial way causing clean water cannot be distributed equally.

The provision of potable water is one of the basic needs and socio-economic rights of the society that must be fulfilled by the government, both by the Regional and Central Government. The availability of potable water is one of the determinants in improving society welfare, which is expected with the availability of potable water can improve public health and can encourage increased productivity of the society. One of the efforts to meet the needs of raw water for potable water equally is to build infrastructure in the form of potable water supply systems in Titab and Telaga Village. The development of a potable water supply system for Titab and Telaga Village is expected to be able to overcome the limitations of potable water services for society. Furthermore, the potential for economic growth in these areas can grow even faster with the availability of potable water services.

The infrastructure development of the potable water supply system is one of the efforts to improve the service of water distribution systems to serve the needs of clean water for society in Titab and Telaga village. Planning for a clean water distribution network must consider several aspects including a review of technical implementation and preparation. Intact planning is needed to produce an integrated water distribution network system. Therefore, it is necessary to design Water Supply System (SPAM) in Titab and Telaga Village, Busungbiu District, Buleleng Regency with a spring source of Titab Reservoir with an effective storage volume of 10.08 million m³.

2 Literature review

2.1 Design of water supply system

Water Supply System (SPAM) is a physical (technical) and non-physical unit of potable water infrastructure and facilities. The development of SPAM is in the form of activities aimed at developing, expanding and/ or improving physical (technical) and non-physical systems (institutional, management, financial, community, and legal roles) in a unified whole to carry out potable water supply for society towards a better condition.

2.2 Clean water needs

All beings need water in their lives. Therefore, without water, there is no life. Every year, clean water needs are increased, but the availability of clean water is limited [1]. The availability of water in each location is affected by the water cycle [2].

2.3 Hydraulics analysis on piping

The flow in the pipeline of the water transmission network in potable water supply system is the flow in the pipe or pressurized flow in which the flow where the entire cross section

of the pipe is filled with water. If there is a free water surface in the flow of the pipe, then the flow is not included in the definition of pipe flow [3].

2.3.1 Energy equation

In the pipeline flow, the energy equation (Bernoulli equation) and continuity equation are known. Bernoulli's equation is written as follows [4].

$$Z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = Z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + hf \quad (1)$$

2.3.2 Pressure loss in pipes

According to Triatmadja [4], there are two types of pressure loss in the distribution pipe network, they are 1) Major energy loss and 2) Minor energy loss. Major energy losses are caused by friction or friction with the pipe wall. The loss by friction is caused by fluid or fluid having the viscosity, and the pipe wall is not perfectly slippery. According to Darcy Weisbach equation (Eq. 2) and Hazen Williams equation (Eq. 3):

$$hf = 8f \frac{L}{D^5} \frac{Q^2}{\pi^2 g} \quad (2)$$

or

$$hf = 8f \frac{L}{D} \frac{v^2}{2g} \quad (3)$$

This energy loss equation is slightly simpler than Darcy Weisbach because of the energy loss coefficient (CHW) does not change with the Reynold number. This equation can be written as follows:

$$Q = C_u C_{HW} d^{2.63} i^{0.54} \quad (4)$$

with $C_u = 0.2875$, then the equation can be written as follows:

$$Q = 0.2875 C_{HW} d^{2.63} i^{0.54} \quad (5)$$

In addition to energy loss due to friction with the pipe wall during drainage, water loss energy must turn thus turbulence occurs. Likewise, if there is water, it must go through a sudden narrowing and enlargement. Energy loss will also occur if water must go through a valve (the valve interrupts the flow so that it can reduce or even stop the flow altogether). Energy loss in these places is called minor energy loss. It can be formulated as follows [4]:

$$hf = k \frac{Q^2}{2A^2 g} \quad (6)$$

$$\text{or } hf = k \frac{v^2}{2g} \quad (7)$$

2.4 Use of the water net application

According to Triatmdja [6], the WaterNet program is designed to simulate the flow of water or other fluids (not gas) in a pipe, either with a closed network system (loop), open network system (branched) or mixed network system between loops and branches.

3 Methodology

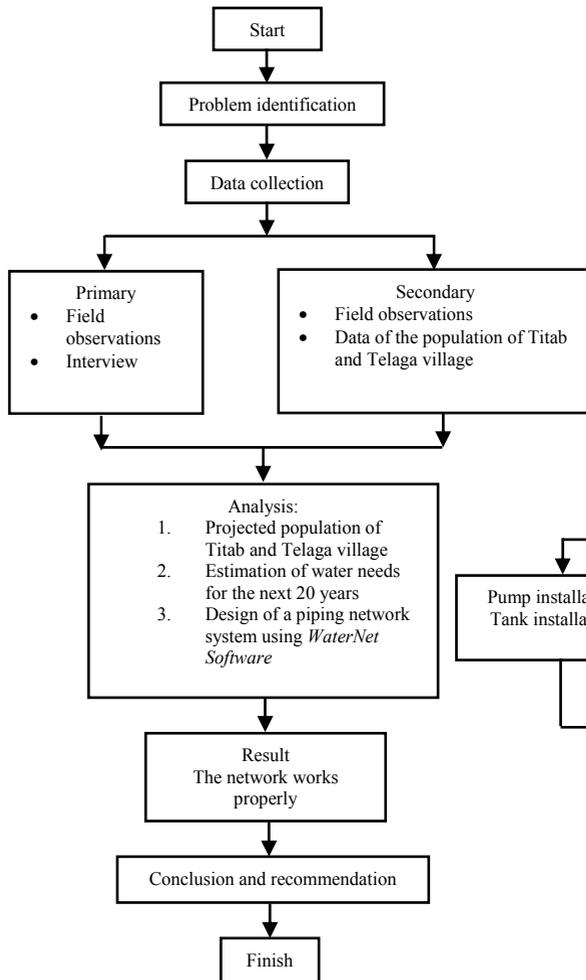


Fig. 1. Methodology of soils test.

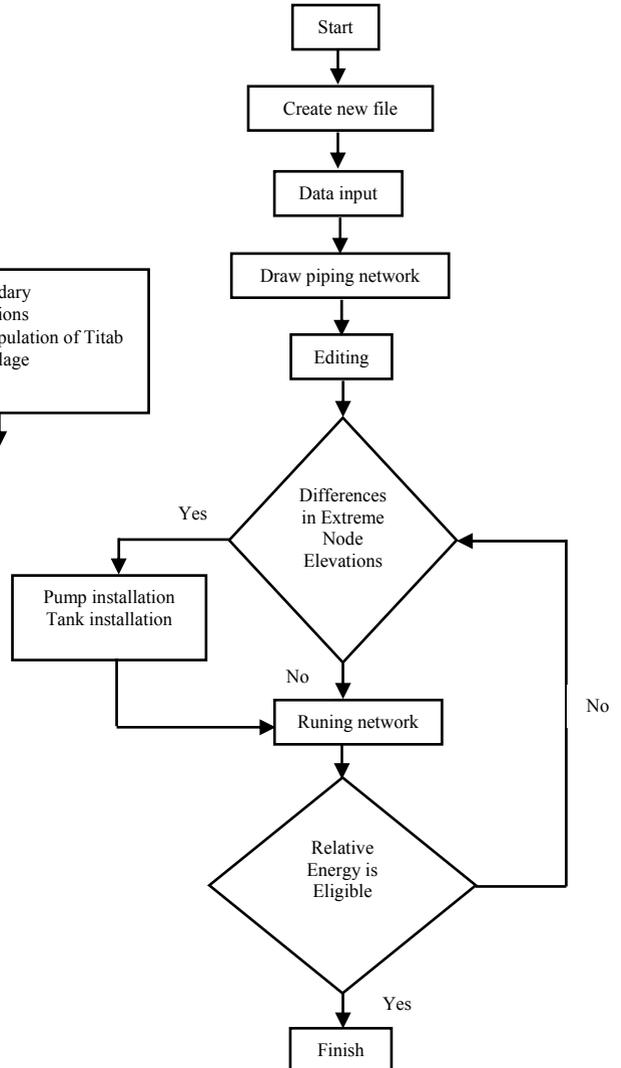


Fig. 2. WaterNet application flow chart.

Figure 1 shows flow chart of soils tests. Two types of data, i.e. primary and secondary were collected in this stage. In Figure 2, water flow simulation using WaterNet application is presented. The data taken was relative energy to minimize energy loss.

4 Results and discussion

4.1 Neighborhood and community unit (RTRW) of Buleleng regency

4.1.1 Physical conditions of Titab village

The area of Titab Village is 253 Ha. Titab Village has the following limits: North: Kekeran Village, East: Pucaksari Village, South: Subuk Village, West: Telaga Village. The population of Titab Village is 1,234 people, and there are 340 families. The main livelihoods of the villagers are as farmers. Rice is a developed agricultural commodity. Meanwhile, the plantation commodities in this village are cloves and chocolate. Farming commodities developed are cattle and goats. In Titab Village, there is only one kindergarten and one elementary school. Therefore, Titab Village needs an increase in human resources, both through socialization and providing training for villagers, especially for those who are still in school age and productive age groups, with the aim to balance the quality and quantity of human resources.

4.1.2 Physical condition of Telaga village

The area of Telaga Village is 566,355 ha with the following limits: North: Ularan Village, East: Titab Village, South: Puncaksari Village, West: Unggahan Village. From a distance, Telaga Village is close to district town but quite far from the center of Regency Government, because the location is a bit west and goes inland. For more details, the distance to Government centers is as follows: to the district capital: (hours (5 km), to the regency capital: 1 hour (37 km), to the provincial capital: 2.5 hours (84 km). From the landform, Telaga Village area consists of land that is mostly mountainous, but there are only a few plains thus it does not affect the climatic conditions in this area. Meanwhile, from the geographical location, Telaga Village is located at an altitude of 300-500masl, with rainfall of 14.022 mm/year and an average air temperature of 32°C.

4.2 Potable water supply system in Buleleng regency

Based on the reports from Nyoman Suwirta, technical director of drinking water facilities and infrastructure of Regional Water Supply Company (PDAM) Buleleng Regency on February 20th 2018 state that total population in Buleleng regency is 646,200 people were served with a house connection (1 SR = 6 people) of 48,847 (293,082 people) and served with KU/HU (1 KU = 100 people) 177 connections (17,700 people). Thus, the number of people who have been served through PDAM's drinking water connection is 310,782 with a percentage of the population served for administrative coverage (over the population of Buleleng Regency) is 48.09%, and the technical coverage (of the PDAM Service Area Population) is 90.23%.

4.2.1 Clean water service system in Titab and Telaga Village

Titab and Telaga Village are located in Busungbiu district of Buleleng regency. The village has not been served by PDAM Buleleng, and the drinking water supply system in the area is managed by the village. Rural Water Supply System (SPAMDES) in Titab and Telaga Village using four springs that are ±5 km away including Tinggih, Batu Prigi, Pangkung Biu and Hutan Telaga springs. These four springs' sources have been maximally utilized with the number of households served ±235 households. However, this number is only 1/3

of the total village population in the village and lake villages in which the percentage of service coverage is still below the national minimum service standard of 60%.

4.3 Regional service plan

The source of raw water used in potable/drinking water supply system of Titab and Telaga village is water from Titab reservoir. Titab Reservoir is located in Busungbiu district, Buleleng regency has an effective storage volume of 10.08 million m³. Regional service plan to be served using 2 stage pumps is Titab (± 308) and Telaga (± 310) village. The scheme for installing the 2 stage pumps as seen in Fig. 3.

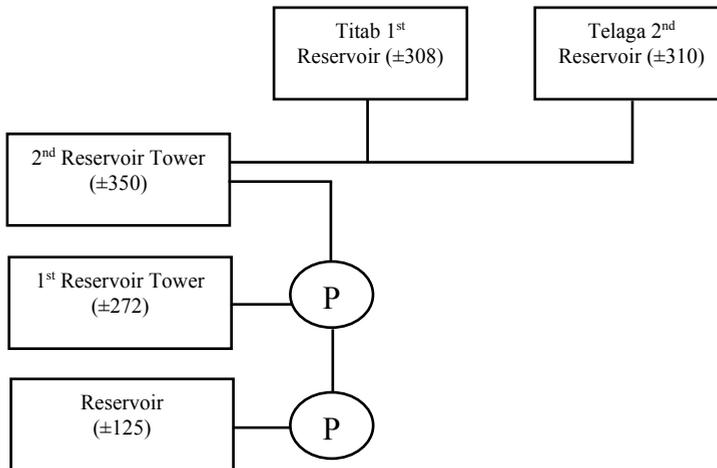


Fig. 3. Service plan flowchart.

Table 1. Projected population result of Titab and Telaga village.

Year	Population	Year	Population
2017	2877	2027	3100
2018	2899	2028	3123
2019	2920	2029	3147
2020	2942	2030	3170
2021	2964	2031	3194
2022	2987	2032	3218
2023	3009	2033	3242
2024	3031	2034	3267
2025	3054	2035	3291
2026	3077	2036	3316

Table 2. Clean water needs in Titab dan Telaga village.

No	Description	Unit	Titab village	Telaga village
			2037	2037
1	Population according to year	people	1433	1908
2	Service level	%	75	75
3	Served population in 2016	people	1075	1431
4	Domestic Service Consumption Level			
	SR	l/o/h	120	120
	HU	l/o/h	60	60
5	Comparison of SR : HU		100 : 0	100 : 0
6	The amount of water needs for SR	l/day	129,000	171,720
7	The amount of water needs for HU	l/day	0	0
8	Total water needs for Domestic	l/day	129,000	171,720
9	Percentage of non-Domestic needs	%	20	20
10	Total water needs for Non Domestic	l/day	25,800	34,344
11	Total Domestic + Non Domestic Water needs	l/day	154,800	206,064
	or	l/sec	1.8	2.4
12	Leakage rate	%	20	20
13	Number of Leaks	l/sec	0.36	0.48
14	Average Water needs	l/sec	2.16	2.88
15	Maximum Day Factor		1.15	1.15
16	Maximum Day Capacity	l/sec	2.5	3.312
17	Peak hour factor		1.75	1.75
18	Peak hour capacity	l/sec	3.78	5.04

Table 3. Reservoir capacity.

Reservoir	Capacity
1 st main reservoir	100.43 m ³
2 nd main reservoir	100.43 m ³
1 st Reservoir (Titab village)	43.2 m ³
2 nd Reservoir (Telaga village)	57.23 m ³

4.4 Water needs analysis

4.4.1 Projected population

Projected population is used as a first step in calculating clean water needs. Calculation of projected population in this study uses Arithmetic, Geometry, and Least Square methods. The projected population formula used in this study is the Geometric Method because it has the smallest standard deviation. The projected population of Titab and Telaga Village is presented in Table 1 and 2.

4.4.2 Clean water needs

The amount of production capacity is presented in Table 3.

4.4.3 Water treatment plant

Titab reservoir water testing that has been carried out refers to the Standard Quality of the Regulation of the Ministry of Health of Republic of Indonesia No. 32 the year 2017 [7] with the following results in Table 4.

Table 4. Characteristics of Titab water reservoir.

No.	Parameter	Method	Unit	Result	Quality standard [8]
1	pH	pH Meter	-	7.88	6.5 – 8.5
2	Temperature	Thermometer	C	27	Water temperature ±3
3	TDS	Gravimetric	mg/l	320	1000
4	Turbidity	Spectrophotometry	mg/l	11.118	25
5	Color	Spectrophotometry	Unit PT-Co	9.875	50
6	Nitrate NO ₃ -	Spectrophotometry	mg/l	1.230	10
7	Nitrite NO ₂ -	Spectrophotometry	mg/l	ttd	1
8	Hardness	Titrimetric	mg/l	113.95	500
9	Detergent	Spectrophotometry	mg/l	Ttd	0.05
10	Cyanide	Titrimetric	mg/l	Ttd	0.1
11	Iron (Fe)	Emission Spectrometry	mg/l	0.087	1
12	Manganese (Mn)	Emission Spectrometry	mg/l	0.023	0.5
13	<i>E. Coli</i>	MPN	MPN/100 ml	0	0
14	<i>Coliforms</i>	MPN	MPN/100 ml	460	50

From Table 4, it can be seen that the Titab reservoir raw water is not feasible as raw water because it does not pass the biological compulsory quality standard (coliforms > 50) thus it is necessary to conduct a Water Treatment Plant which refers to the Government Regulation of the Republic of Indonesia No. 82 the year 2001 concerning Water Quality Processing and Water Pollution Control [8] which consists of the process of coagulation, flocculation, sedimentation, filtration, and disinfection.

3 Conclusions

The raw water needs available for Titab and Telaga Village are 150 l/sec where the raw water is sourced from Titab Dam. The collection of potable water for Titab and Telaga Village are from Titab Dam to the 1st Reservoir is carried out with a pump system. The water demand needed in Titab and Telaga Village for the year 2037 is 5.812 l/sec. This shows that the raw water available is sufficient to meet drinking water needs during the planning year.

Planning of Potable Water Supply System (SPAM) in Titab and Telaga village carried out by a combination system where the flow from the raw water source to the 1st reservoir plan uses a pump and from 1st reservoir is pumped again to the 2nd reservoir, then drainage from 2nd reservoir to the service area using a gravity system. Pump use is done due to the source elevation is lower than the 1st reservoir and 2nd reservoir plans. Based on the results of measurements that have been done, obtained the elevation of the source is +102 m-asl and the base elevation of the 1st reservoir is +270 m-asl, and the 2nd reservoir is +352 m-asl. The pump used with debit (Q) 5.9 l/d for 1st and 2nd pump, the head pump used is 150 m for the 1st pump and 90m for a 2nd pump according to the calculation results. Based on the calculation and simulation results of WaterNet application use, it was found that the gravity flowing can be done where it is shown from the relative amount of energy calculated.

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