Evaluation of Raw Water Availability Kaliboyo River in the Effort for Drinking Water Meeting in the District Batang and the City Pekalongan

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Abstract. One form of delivery of SPAM which is currently running is the Drinking Water Sector Development in Central Java province. One construction site is located in the city of Pekalongan and Batang. With limited sources of raw water through a breakthrough in the region Pekalongan potential utilization of raw water in Boyo Sungai Batang located in the region to meet the needs of drinking water services for the city of Pekalongan and some regional areas in Batang. The purpose of this study is to describe and analyze the fulfillment of raw water for the construction of Pekalongan and Batang, check the availability of raw water in the river Boyo, knowing how much discharge that could be used to help meet the needs of drinking water services in Pekalongan and some regional areas in Batang. The effort - upaya for the fulfillment of the raw water continuously in an effort to help meet the drinking water. To check the availability of water in this study FJ Mock method is used to simulate the discharge Q90 for 17 years for irrigation and drinking water needs. Needs Batang and Pekalongan is equal to 450 liters / sec with the distribution of discharge 200 liters / sec for Batang and 250 liters / sec to Pekalongan. there is still a deficit of 1.5 months for raw water supply. In fulfillment of the necessary raw water so that continuous pitcher / reservoir.

1. Introduction

1.1 Background

In line with the Central Government's role as a facilitator in the era of regional autonomy through the Government Regulation (PP) No. 122 2015 on Water Supply System (SPAM). Have the authority and responsibility in the implementation of the development of Water Supply System (SPAM) covers:

a. Establish national policies and strategies
b. Regulating norms, standards, guidelines and manuals (NSPM)

c. Facilitating the raw water supply.
Provision of drinking water infrastructure is a prerequisite for a sustainable community life. The availability of drinking water systems are very influential on regional economic growth, and improving quality of life and the environment.

The government's efforts to achieve national targets by the end of 2019 the program targeting 10 million household connections. The target is quite high and indicates the enormity of the challenges ahead SPAM development. To achieve the target of the drinking water service coverage in the national government through the Regional SPAM development program that has the objective to improve the efficiency and operational effectiveness, increase utilization of raw water in the province.

One form of delivery of SPAM which is currently running ie Drinking Water Sector Development in Central Java province. One of the construction site located in the region Pekalongan and Batang. Pekalongan city that currently rely on the potential of raw water with deep wells to meet the needs of drinking water services. With limited sources of raw water through a breakthrough in the region Pekalongan potential utilization of raw water in the river Boyo Batang located in the region to meet the needs of drinking water services for the city of Pekalongan and some regional areas in Batang. This study will reviewing the raw water supply in the watershed Boyo in Batang Central Java province's regional development plan SPAM Pekalongan and Batang. It is expected that with the implementation of the review of raw water supply may increase water service followed by significant economic development.

1.2 Goals and objectives research
a. Research purposes
1. Analyzing the raw water supply for the construction of the Regional SPAM Pekalongan and Batang.
2. Knowing the availability of raw water in the river Boyo.
3. Knowing how much discharge that could be used to help meet the needs of drinking water services in Pekalongan and Batang.
b. Research Goals
The objective of this study is on the water balance data collection of Boyoriver in Batang which can be used as a reference in the extraction of water for SPAM in Batang and Pekalongan. In addition, the results of this study are expected to provide a picture of the availability of water in the fields of printing new location in the future so do efforts to maintain the availability of water in the future.

1.3 Literature review
1.3.1 Understanding water. Raw water for household drinking water, hereinafter referred to as raw water is water that comes from surface water, ground water basins and / or rain that meet certain quality standards as raw water for drinking water [4]

Based on the Decree of the Minister of Health of the Republic of Indonesia Number 1405 / Menkes / SK / IX / 2002 on Health Requirements for Work Environment Office and Industrial, clean water is the water that is used for everyday purposes and quality meet the health requirements of clean water as legislation in force and can be drunk when cooked [6]. According to the Ministry of Health of the Republic of Indonesia No. 492 / Menkes / PER / IV / 2010 on Drinking Water Quality Requirements, drinking water is water that through the processing or without processing that meets the health requirements and can be drunk directly.
1.3.2 Water sources. Basically the amount of water on the earth is fixed and followed a cycle (recycling) is called the hydrologic cycle. With the sun shines, the water undergoes evaporation or evaporation and will form water vapor. The water vapor is then fused in high places, which is known as the cloud. By winds, this cloud will carry higher so as to achieve a low temperature, which causes water droplets fall to earth as rain. Rainwater in part will flow into the ground, if the water is out on the surface of the earth or ground water springs will be called. While the rain water that falls to the earth or ground and then flows into the low places (concave), then the water will form a lake or pond. But many of them flowing to the sea back. Based on the source,

a. Atmospheric water
Air atmosphere occurs from surface water evaporation and evapotranspiration from plants by the aid of sunlight through a process of condensation and then fall to earth as rain, snow or dew. Atmospheric water has properties of soil (soft water) because it contains less salts and mineral substances that feels less fresh and will also be wasteful to use soap. In addition, atmospheric water has an aggressive nature, especially in pipes and tanks dealer reservoir so that it will accelerate corrosion.

b. Sea water
Salty sea water has the properties because it contains NaCl. Levels of salt in sea water approximately 3%. With this situation, the sea water is not eligible to drinking water if not yet processed first. The sea water is rarely used as raw water for drinking water for processing to eliminate the salt content requires a considerable cost.

c. Surface water
Surface water is rain water flowing on the surface of the earth. In general, the water will go through contamination during up streaming. This fouling load for each surface water will be dependent surface water drainage areas. Various kinds of surface water, among others:
1. River water
   In the consumer as drinking water must undergo a perfect processing, given that the water has a high degree of soiling. The river water is a reservoir of various types of waste that are surrounding both the domestic waste and industrial waste. River that has been polluted by industrial waste that weight will be difficult to process and it requires a more complex process.

2. water Swamp
   In general, colored swamp water, because the organic substances that have rotted. With the abundance of organic matter increases the amount of O2 dissolved in a little water so that the content of Fe and Mn are dissolved in water becomes high. On the surface this water to grow algae (moss) because of the sunshine and O2, to take this water should be at the center so that deposits of Fe and Mn and moss do not get carried away.

d. Groundwater
According to the Law of the Republic of Indonesia Number 7 of 2004 on Water Resources, ground water is the water contained in the soil or rock layers below the soil surface. Groundwater comes from rain water that falls to the earth's surface and then sink into the ground and experience the natural filtration process. The processes that have been experienced by the rain water, on the way to the underground, making groundwater becomes better and purer than surface water. Groundwater is divided into:
1. Shallow Groundwater
   Shallow groundwater occurs because of the process of water infiltration from the ground surface. Mud will be captured, as well as most of the bacteria so that the ground water will be crystal clear but many contain chemicals because through soil layers that have certain chemical elements for each layer of soil. Fouling also continues to take place mainly at the surface of the water near the soil surface. The shallow ground water used for drinking water sources through the shallow wells.
2. Groundwater In
The ground water in the water there after meeting the first layer. This water is required to take the drill because of its depth ranges from antara100-300 meters. If the water pressure is great soil and water will gush to the surface of the well. The well is called the deep well. If water is not coming outside by itself would require a pump.

3. Water springs
The spring water is ground water that comes out by itself the soil surface. Eyes water from the ground, barely affected by season and quantity and has the same quality as in the ground water.

1.3.3 The principle of Clean Water Source. In planning for water supply must meet the 3K concept is the quality, quantity, and continuity. Quality is concerning water quality, both raw water and water treatment results are ready to be distributed. The quantity that is concerning the amount and availability of water to be treated on the provision of clean water required in accordance with the number of consumers who will be served. Continuity is regarding ongoing water needs. This means that the raw water source is able to supply water continuously, especially during the dry season.

1.3.4 Watershed (DAS). Watershed (Watershed) is defined as an area of land that receives rainwater, accommodating and running it through the major rivers to the sea or lake. One DAS, usually separated from other areas in the vicinity (watersheds etc.) by dividing the natural topography (such as ridges and mountains). A watershed is divided into sub-basins that are part of watershed that receives rainwater and divert it through a tributary to the river [2].

Asdak [1] suggests the notion of watershed as an area of land that is bounded by the topographic ridges that accommodate and store rainwater for later channeled to the sea through the main river. The land area is called Watershed (DTA) or the Water Catchment Area which is an ecosystem with its main element consists of natural resources (land, water, and vegetation) and human resources as utilizing natural resources. DAS is a particular area is a natural form and nature of the ecosystem, including hydrology with the river and its tributaries which serves as a receiver, and a water storage reservoir from rain and other sources. Rivers or streams as the main component of the watershed is defined as an amount of water that flows along the track on land towards the sea so that the river is a track where the water coming from upstream merge heading in one direction, namely downstream (estuary). The river is part of the hydrological cycle that consists of several processes, namely the evaporation or water evaporation, condensation and precipitation [3].

Watershed (DAS) has several characteristics that can describe the specific conditions of the watershed with each other watershed. Characteristics that are characterized by parameters consisting of:

a. Morphometry watershed that includes relief DAS, DAS shape, drainage density, stream gradient, width DAS and others.
b. Hydrological, includes rainfall, discharge and sediment.
c. Soil.
d. Geology and geomorphology.
e. Land use.
f. Socioeconomic conditions in the basin.

In studying the watershed ecosystem, usually divided into the upstream, midstream and downstream. In biophysical, the upstream, midstream and downstream is characterized by the following matters (200) in:

a. Upstream areas characterized as a conservation area, has a high drainage density, slope is large (> 15%), not a flood area, water consumption is determined by the pattern of drainage and vegetation types is generally a forest stand.
b. Downstream area is characterized as an area of utilization, has a density of small drainage, slope is very small (<8%), in some places are flooded areas (inundation), water consumption
is determined by building irrigation, vegetation type dominated by agricultural crops except estuaries dominated by mangrove forests or peat.

c. Central area is an area of transition of both biophysical characteristics of the different watersheds between upstream and downstream.

2. Material and methods

2.1 Research sites
Research was conducted in the watershed area of Boyo, which is administratively included in the administrative area, Batang, Central Java Province. Das Boyo is located at coordinates 7° 9'40.48" S 109° 50'7.45" N and 6° 54'26.12" S 109° 50'30.02" E with a total area of 139.3 km.

2.2 Tools and materials
Equipment and Materials Equipment used includes a set of computers that are equipped with the Map application Source. Includes field measurement equipment, GPS, Currentmeter, measuring tape, ring samples and rope. The data collection of research include climate data and daily rainfall in the watershed Boyo last 10 years, discharge and water level Boyo River, the water needs of agriculture in the basin Boyo.

2.3 Method of collecting data
The study used quantitative research methods with positivistic approach that is deductive. According Sugiyono (2008) deductive research process in which to answer the problem formulation used concept or theory. Data collection method used is the method of collecting primary data and secondary data. Methods of primary data collection is done by observation and and interview. Interviews were conducted to determine the respondent's perception related to the availability of raw water Kaliboyo river for drinking water compliance. Secondary data collection methods performed by a document review and literature review of books, law journals and articles related thesis.

2.4 Data analysis method
Data processing is done by analyzing the results of the data collected. Calculating and analyzing the total water needs, calculate the availability of water in the watershed Kaliboyo by calculating the availability of discharge on existing buildings. Dr. FJ Mock (1973) introduced a simple model for the monthly water balance simulation that includes data stream rainfall, evaporation and hydrological characteristics of the area. calculations and assumptions criteria used in this analysis are as follows (Mock, 1973; Sri Harto, 1993; and Montarchi 2010).

Infiltration coefficient is estimated based on porosity of the soil conditions and the slope drainage area. For example porous land that has fine sand infiltration was higher than heavy clay soil. Rugged land where water infiltration into the soil did not get the coefficient of infiltration will be small. Limitation of infiltration coefficient is 0 - 1.0. At the beginning of the simulation must be specified initial deposit (initial storage) which depends on the local geological conditions and time. For example: in a small drainage area in which geological conditions the bottom layer is impermeable to water and perhaps there is no water in the river during the dry season, the soil water storage to zero.

The formula is used:

\[ V_n = K \cdot V_{n-1} + \frac{1}{2} (1 + k) \cdot in \]
\[ DVN = V_n - V_{n-1} \]

with:

\[ V_n = \text{Volume of groundwater months } n \]
\[ V_{n-1} = \text{Volume of groundwater months } (n - 1) \]
\[ k = \frac{qt}{qo} = \text{groundwater flow recession factor (catchment area recession factor)} \]
\[ qt = \text{Groundwater flow at time } t \text{ (month } t) \]
\[ qo = \text{Groundwater flow at baseline (month } 0) \]
\[ in = \text{Infiltration months to } n \]
DVN-1 = Change in volume of groundwater flow

Groundwater recession factor (k) is 0 to 1.0. K high prices will provide a slow recession as the bottom layer of the geological conditions were very pass water (permeable).

- base flow: infiltration is reduced by changes in the volume of water flow in the soil,
- direct runoff: Excess water (water surplus) - infiltration
- runoff: Basic + direct runoff flow

Mainstay discharge: Stream flow expressed in m³/month

3. Results and Discussion

3.1 Identification location DAS Boyo

From upstream to downstream watershed Boyo there are 5 technical weir, 2nd weir semi-technical, temporary weir 26, and 2 free retrieval. Meeting propeller Kali, Kali and Kali Terju Tinap hereinafter Tinap time. At the time there were 2 weirs Tinap while that dam and weir Kedungserut Kedunglanggar. Meeting Tinap Kali, Kali Kaligebang and supplementation called Kali Boyo. The most downstream dam watershed Kenconorejo Boyo namely weir. For more details can be seen in the scheme of figure 1.

![Figure 1. DAS scheme Boyo](image)
Table 1. Technical weir in DAS Boyo

| No. | Technical weir          | DI Size (Ha) | Q (L / Sec) |
|-----|-------------------------|--------------|-------------|
| 1   | Bendung Siwuni          | 331          | 550.28      |
| 2   | Bendung Sidayu          | 227          | 377.39      |
| 3   | Bendung Siuji           | 246          | 327.18      |
| 4   | Bendung Siwuluh         | 20           | 26.60       |
| 5   | Bendung Simbang Jati    | 115          | 152.95      |
| 6   | Bendung Kenconorejo     | 853          | 1134.49     |

Source: Kupang Korpokla Pekalongan, 2019

Table 2. Half weir Technical Inventory at Boyo Watershed

| No. | Half weir technical | DI Size (Ha) | Q (L / Sec) |
|-----|---------------------|--------------|-------------|
| 1   | Bendung Siambat     | 246          | 327.18      |
| 2   | Bendung Jolo Sekti  | 68           | 90.44       |

Source: Kupang Korpokla Pekalongan, 2019

Table 3. Inventory weir While on Boyo Watershed

| No. | While weir          | DI Size (Ha) | Q (L / Sec) |
|-----|---------------------|--------------|-------------|
| 1   | Bendung Sigogik     | 45           | 59.85       |
| 2   | Bendung Siambat     | 49           | 65.17       |
| 3   | Bendung Siantap     | 46           | 61.18       |
| 4   | Bendung Warakas     | 24           | 31.92       |
| 5   | Bendung Sikebo      | 18           | 29.92       |
| 6   | Bendung Bajong      | 16           | 26.60       |
| 7   | Bendung Murogo      | 24           | 39.90       |
| 8   | Bendung Sijambean   | 15           | 23.94       |
| 9   | Bendung Sutri       | 30           | 47.88       |
| 10  | Bendung Sipontang   | 20           | 31.92       |
| 11  | Bendung Kemijing    | 10           | 15.96       |
| 12  | Bendung Bancet      | 62           | 82.46       |
| 13  | Bendung Sikuwang    | 40           | 53.20       |
| 14  | Bendung Gembongan   | 69           | 91.77       |
| 15  | Bendung Siayam      | 252          | 335.16      |
| 16  | Bendung Gebyak      | 22           | 29.26       |
| 17  | Bendung Pangilingan | 26           | 34.58       |
| 18  | Bendung Cempeh      | 15           | 19.95       |
| 19  | Bendung Blado       | 15           | 19.95       |
| 20  | Bendung Kemarongan  | 18           | 23.94       |
| 21  | Bendung Susukan     | 30           | 39.90       |
| 22  | Bendung Wadas Atas  | 20           | 26.60       |
| 23  | Bendung Kendil      | 17           | 22.61       |
| 24  | Bendung Kelilingan  | 53           | 70.49       |
| 25  | Bendung Siwarek     | 15           | 19.95       |
| 26  | Bendung Jamban      | 10           | 13.30       |
| 27  | Bendung Jleagong    | 57           | 75.81       |
| 28  | Bendung Posong      | 40           | 66.50       |
| 29  | Bendung Cenggereng  | 19           | 25.27       |
| 30  | Bendung Kedung Langgar | 61   | 81.13       |
| 31  | Bendung Poko        | 32           | 42.56       |
| 32  | Bendung Kedung Serut| 93           | 123.69      |

Source: Kupang Korpokla Pekalongan, 2019
| No. | While weir       | DI Size (Ha) | Q (L / Sec) |
|-----|------------------|--------------|-------------|
| 33  | Bendung Glangsing| 32           | 42.56       |
| 34  | Bendung Cempoko  | 28           | 37.24       |
| 35  | Bendung Blewah   | 169          | 224.177     |
| 36  | Bendung Sogo     | 15           | 19.95       |
| 37  | Bendung Wareng   | 10           | 13.30       |
| 38  | Bendung Gintung Siguci | 14       | 18.62  |
| 39  | Bendung Sikendil | 12           | 15.96       |
| 40  | Bendung Cekluk   | 35           | 46.55       |

Source: Kupang Korpokla Pekalongan, 2019

Table 4. Taking Inventory Free At Boyo Watershed

| No. | Free | DI Size (Ha) | Q (L / Sec) |
|-----|------|--------------|-------------|
| 1   | PB. Tropong A | 68          | 90.44       |
| 2   | PB. Tropong B | 22          | 29.26       |

Source: Kupang Korpokla Pekalongan, 2019

Table 5. Inventory Springs at Boyo Watershed

| No. | Water springs | DI Size (Ha) | Q (L / Sec) |
|-----|---------------|--------------|-------------|
| 1   | MA. Siu       | 14           | 18.62       |
| 2   | MA. Siguci    | 14           | 18.62       |
| 3   | MA. Gepret    | 16           | 21.28       |
| 4   | MA. Randu     | 22           | 29.26       |
| 5   | MA. prime minister | 22    | 29.26 |
| 6   | MA. Sijambe   | 11           | 14.63       |
| 7   | MA. Sijoho    | 62           | 82.46       |
| 8   | MA. Jambe     | 23           | 30.59       |

Source: Kupang Korpokla Pekalongan, 2019

3.2 River discharge Kaliboyo

Measurement of water balance for the river Kaliboyo perform calculations on the study of the river or the dam Kenconorejo. Which weir Kenconorejo a Control Point in the study of the water balance calculation. Discharge data was recorded (AWLR) is Boyo river flow data recorded at the weir Kenconorejo semimonthly from year 2001 to 2018 (17 years old). Below is a graph of average discharge semimonthly Boyo River.

![Figure 2. Half Debit graph Monthly Averages Boyo River](image-url)
3.3 Raw Water needs for Batang and Pekalongan

Table 6. DAS air balance Kaliboyo

|     | DEBIET PERIODE (L/DT) |
|-----|----------------------|
|     |                       |
|     |                       |

Based on table 6 Balance of River Basin Boyo seen that the availability of water in November - August and October I (10.5 months) had a surplus of 165 385 l/s. While the availability of water deficit for 1.5 months or experiencing a dry month in September and October II amounted to -1 812 l/sec. From the results of the analysis show that water availability can still meet the water needs of irrigation and raw water requirements for Batang and Pekalongan of 450 l/s if the planned building in the form of water storage reservoirs. In addition to the construction of water reservoirs is also worth noting the existing soil structure and cropping patterns in the surrounding areas. Reservoir volume necessary to meet the needs of water in a watershed Boyo amounted to 2,357,309 m³, with details as follows:

Volume catchment reservoirs = 2,357,309 m³

H = 25 m

A = 94 292 m² = 9 ha

4. Conclusion

Based on the calculations have been done in this discussion we obtain some results Q90 of the water balance analysis in November to August and October I have a surplus and a deficit in the period of September and October. From the calculation of the water balance is the highest surplus amounted to 23.96 m³/sec and minimum amounts to 0.029 m³/sec. Drinking water discharge requirement of 450 liters/sec for Batang and Pekalongan City can be filled continuously with a capacity of 2,357,309 m³ pitcher simulation.
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