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Analysis of Water Flow Rate in the Kemiri River, Jayapura District

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ABSTRACT

Kali Kemiri Sentani frequently experiences flooding, particularly during periods of intense rainfall. Given the critical importance of flood risk mitigation, this study aims to analyze the water flow rate in Kali Kemiri and investigate the key factors influencing its dynamics. The research was conducted within the Kali Kemiri watershed in Jayapura Regency, focusing on a watershed area with a total study area of 1,640 m², mapped at a small scale across two measurement points. Flow rate measurements were performed at two locations along Kali Kemiri using the float method. The study recorded key hydrological parameters, including water depth, river width, and flow velocity. These data were utilized to calculate the volumetric flow rate at the designated measurement sites. This methodology provides a comprehensive understanding of the hydrodynamic factors affecting water flow, which is essential for assessing flood hazards in the region. The results indicate that the highest discharge rate was observed at the first measurement point, with an average flow discharge of 0.188 m³/s and a velocity of 0.52 m/s. In contrast, the second measurement point recorded a discharge of 0.115 m³/s with a flow velocity of 0.29 m/s. These findings suggest a direct correlation between flow velocity and discharge, wherein an increase in velocity corresponds to an increase in discharge. Furthermore, the study highlights that the flow rate is influenced by watershed area, watershed volume, and watershed slope, which collectively govern the hydrological behavior of the river system.

Keywords: Flow Discharge; Flow Velocity; Float Method; Hydrodynamics; Flood Risk Assessment

1. Introduction

Water flow rate analysis is an effort to measure and analyze the speed and volume of water flowing in a channel or river [1][2]. This information is crucial because flow rate data helps effectively plan and manage water resources. This includes irrigation regulation, flood control, hydroelectric power generation, and clean water supply.

The flow rate in the river basin (DAS) influences the potential for flooding [3]. Kali Kemiri, which is located in Jayapura Regency, is one of the times that supplies clean water for the survival of the people in Jayapura Regency. Seeing that the potential for flash floods frequently occur in Jayapura Regency, namely in 2007 and 2019, and the opportunity for flash floods to happen more regularly due to the high intensity of rainfall, information about flow rates is significant in early warning of flood disasters. Knowing that the flow rate has increased significantly, we can take evacuation and mitigation actions. So, this makes researchers interested in analyzing the water flow rate in the Kemiri Sentani watershed.

Fundamentals are needed to present research results on the water flow rate in the Kali Kemiri watershed, which include hydrology, continuity, and water flow rate measurement techniques. Hydrology covers various aspects, including surface water, groundwater, and the interactions between the two. Hydrology is the science that studies the system of water occurrence on and in the ground. This includes analysis of the hydrological and meteorological characteristics of the watershed to understand rainfall patterns and water discharge [4][5].

The hydrological cycle is a continuous process in which water moves from the atmosphere to the earth and back again. This process includes evaporation of water from the surface, condensation into clouds, precipitation in the form of rain or snow, infiltration into the soil, and surface flow towards rivers and the sea. This process is critical to maintaining ecosystem balance and water availability on earth [4][5][6]. Several factors influence water flow rates, including land slope, soil type, vegetation cover, and rainfall intensity. Impervious surfaces such as asphalt can increase surface runoff, while porous land allows water infiltration [4][5].

The product of the flow area and the flow velocity $(A\vec{v})$ is the volume flow rate or discharge (Q); the discharge along the flow line is constant, so it satisfies the continuity equation. Assuming the fluid is incompressible, the fluid volume at the first point must be the same as at the second. Following is the continuity equation [7].

$$A_1\vec{v}_1 = A_2\vec{v}_2$$
$$Q_1 = Q_2$$

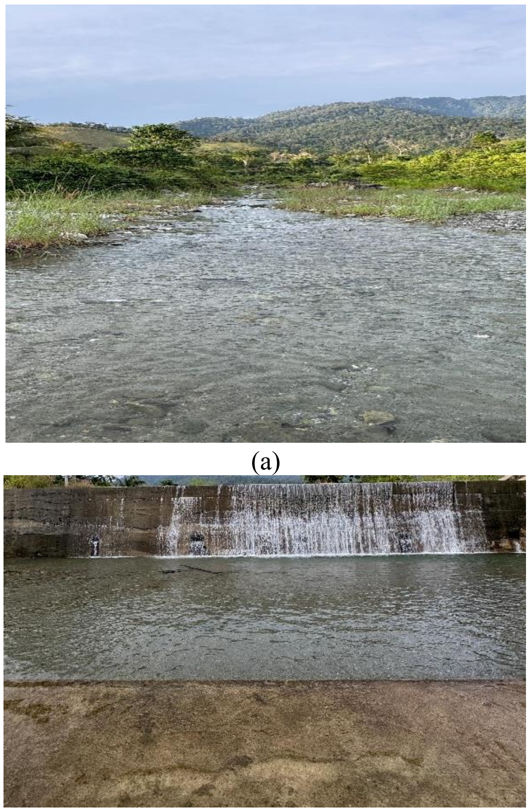
This research analyzes the water flow rate in Kali Kemiri, Jayapura Regency, which often experiences flooding, especially during high rainfall. Research on floods and flood risk management has developed rapidly in recent decades, providing essential insights that can be applied to local contexts such as the Kali Kemiri Watershed. Presentation of a compilation of flash flood data in Europe, providing a relevant global context for understanding flood risk in various regions [8]. Research on the flash flood early warning system through the HYDRATE project, which is very applicable for mitigating flood risk in the Kali Kemiri watershed [9]. Analyzes the economic impact of floods, emphasizing the importance of water flow rate studies in disaster mitigation [10]. A comprehensive review of flood modeling methods, which can be applied in risk analysis in Kali Kemiri [11]. Discusses progress in flash flood forecasting, relevant for risk mitigation efforts in watersheds, applied in risk analysis in Kali Kemiri [12]. Analyzes the impact of climate change on river flooding in Europe, providing insight into the factors influencing water flow rates globally [13].

Research on the increasing risk of major floods and the frequency of river flooding due to climate change and global warming provides a broader context for research on Kali Kemiri [14][15]. It presents international and regional perspectives on flood risk and climate change and analyzes global factors influencing future river flood risk [16]. Overall, this research provides a strong theoretical and methodological foundation for understanding, analyzing, and managing flood risk in the Kali Kemiri watershed, considering the local context within the framework of global climate change and current flood risk management practices [17].

This research was conducted because the Kemiri River in Jayapura Regency often experiences flooding, especially during high rainfall, as in the flash floods of 2007 and 2019. The increasing potential for flooding due to high rainfall intensity requires understanding water flow rates to mitigate flood risk. Information about water flow rates is needed to provide early warning and support mitigation actions, such as evacuation. In addition, this research answers the need for specific hydrological data, especially the influence of watershed area, watershed volume, and watershed slope on water discharge, which has not been widely analyzed in the Kali Kemiri watershed previously.

The novelty of the research in this article lies in its specific focus on analyzing water flow rates in Kali Kemiri, Jayapura Regency, using a simple but effective float method to map the linear relationship between water flow speed and water discharge. This research was uniquely conducted at two locations with different characteristics—before the dam and at the dam—which allows comparison of the influence of topography, watershed slope, and the presence of the dam on flow rates. In addition, this research provides important initial data for assessing flood risk in Kali Kemiri, an area that has a history of flash floods. This is important because previous research has not specifically mapped the hydrological dynamics in the Kali Kemiri watershed using a local approach or in the context of flood risk mitigation.

2. Method



(a)

(b)

Figure 1. Research locations: (a) first location before the dam and (b) second location at the dam.

A preliminary survey in February 2024 directly observed that the geological conditions of the research area had a height difference between the first location and the second location, which was measured as high as 5 meters; there was a slope along the watershed, and it was dominated by granite, diorite and gabbro rocks. Data collection activities were carried out in July 2024. Equipment was used to support measurement activities in data collection, such as a roll meter, stopwatch, cork box, geological compass, and GPS. The location chosen for research activities is the Kemiri Sentani watershed in Jayapura Regency with a measurement center around the dam area with a research area of 1640 m² and mapped on a small scale for data collection activities, which is divided into two measurement points, namely the first point along the 25-meter water path before the dam and the second point in the dam area 11 meters long. Data collection time is 06.00 am to 12.00 noon. The method used is a direct measurement method using the buoy or floating method to determine the surface water flow rate of the Kemiri Sentani watershed.

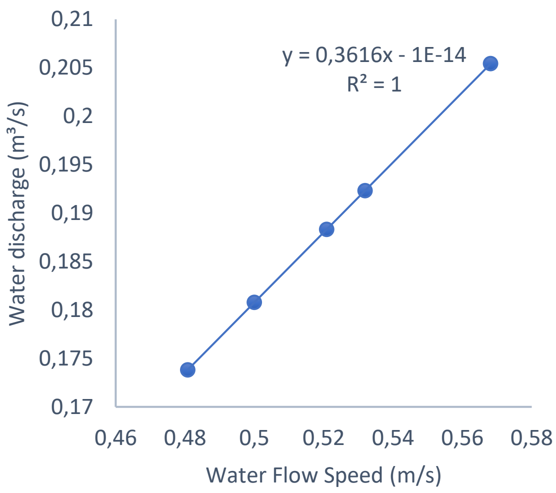
The following are data acquisition parameters for measurement activities, which are presented in table form.

Table 1. Data Acquisition Parameters

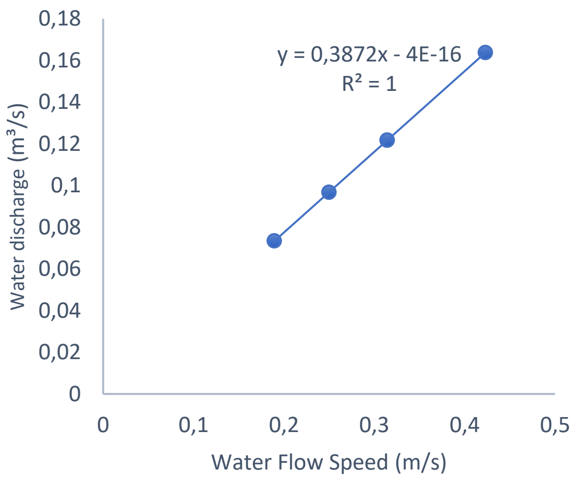
Number of measurement areas	1 Area
Number of observation points	2 Point
Number of paths per point	1 track along the Kemiri watershed with the length, width, and average depth of each point being: Point 1: Long 25 m, wide 3,5 m, depth 0,103 m Point 2: Long 11 m, wide 4,4 m, depth 0,088 m
Number of measurement repetitions	5 repetitions
Data obtained	Water flow speed

Data processing stages: After the measurement, the data obtained during the measurement will be input into the laptop. The data obtained cannot be selected, but all the data is typed into Ms. Excel for the initial synthetic data. The data is operated using mathematical equations to calculate flow velocity and discharge.

3. Result and Discussion



(a)



(b)

Figure 2. (a) Graph of the relationship between water flow velocity and water discharge at the first location point, and (b) Graph of the relationship between water flow velocity and water discharge at the second location point.

Figure 2 (a) explains that the water flow rate in the Kemiri watershed mapped in the research at the first location has a linear relationship with the water discharge. This can be seen from the line equation and the correlation value, namely one (1), which means 100% forms a linear line on the graph, so it can be stated that the greater the water flow speed, the greater the water discharge. In collecting data, it was found that the time values varied in 1 pass in repeated measurements, but the variations in the water flow speed values did not differ significantly. So at t, the first location, it can be calculated that the average value of the water flow velocity and water discharge is 0.52 m/s with a water discharge of 0.188 m³/s.

Figure 2 (b) explains the relationship between water flow speed and water discharge at the second location, the main dam in the Kemiri watershed, which was created after the flash flood on March 16, 2019, in Jayapura Regency. Based on the form of the line equation and the correlation value in the graphic image above, it can be explained that the water flow velocity has a linear relationship with the water discharge; that is, the water flow rate depends on the water discharge, the greater the water flow velocity, the water discharge also increases. In repeated data collection five times, there were variations in the water flow velocity values , which did not have a significant difference. In the 3rd and 4th measurements, the same water flow velocity values were obtained. This is due to the reasonably stable current conditions in the dammed pool of water.

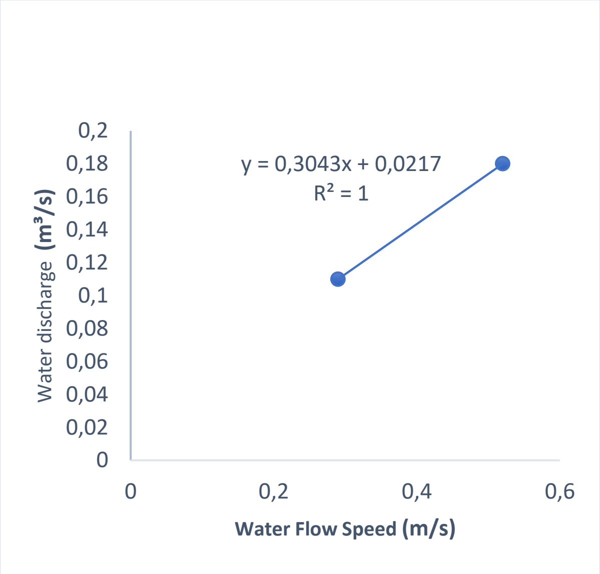


Figure 3. Comparison graph of the average speed of water flow and the average water discharge from the two research location points

Figure 3 compares the average speed of water flow with the average water discharge from two measurement location points. For the first location, the average speed of water flow is 0.52 m/s with a water discharge of 0.188 m^3/s, while at the second location in the dam area, the average speed of water flow is 0.29 m/s with a water discharge of 0.115 m^3/s. The two locations where this research was conducted were shallow river locations.

So, the first location point has a faster water flow rate than the water flow rate at the second location point. This is because the first location is a pure water flow from a spring on a mountain that is not dammed, so there are no puddles, and it has a slope compared to the second location, which is flat. The tip of the first location point is 5 meters from the dam, the second location point. The second location, the dam location, has a pool of water with a more minor water discharge than the first location. So, the speed of water flow will flow faster if the water discharge is also significant.

4. Conclusion

Based on the results of research on the analysis of water flow rates in the Kemiri River at two research points, it can be concluded that:

1. The water discharge before the dam is significantly different from the water discharge at the dam, namely 0.188 m^3/s before the dam (first location point), which is greater than the water discharge at the dam (second location point), namely 0.115 m^3/s.
2. Water flow speed has a linear relationship with water discharge; the greater the water flow speed, the greater the water discharge.
3. Water flow rate is influenced by the area of the watershed, the volume of the watershed, and the slope of the watershed

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