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Evaluation of the Relationship between Water Discharge and Flow Speed on the Volume of Open Channel Sediment in the UKI Campus Area, Jakarta

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Friction, discharge, current meter, simulation

ABSTRACT

Open channels are a common type of channel and require special attention because they often undergo erosion and sedimentation processes. The erosion that occurs in open channels is affected by water discharge as well as flow speed. This study aims to determine the volume of eroded sediment in open channels within the Christian University of Indonesia. The research method uses a simulation approach to obtain an overview of conditions through a small-scale system. Observations were made on a 25-meter-long channel divided into five pias, resulting in six measurement points. The water discharge and flow speed are measured at each point using a current meter. Furthermore, at the sixth point, sediment is added to measure the volume of sediment that has eroded in a certain time span. The observation results show that the flow discharge (Qp) increases as the water level (h) in the channel increases. The larger the discharge that occurs, the greater the volume of sediment erosion that is formed.

1. INTRODUCTION

The flow of water in the pipe can be in the form of an open channel flow, which is a flow that has a free surface. Open channels are closely related to daily human activities. Common examples of open channels include sewers, rivers, and culverts. Sewers, for example, play an important role in supporting people's lives because they function to distribute wastewater or rainwater to the disposal site so that they do not cause environmental and health problems. Usually sewers are located on the side of the road and are designed to drain rainwater or surface runoff from areas such as highways, parking lots, as well as building roofs.

Water itself is an essential natural resource for humans, animals, and plants, so its use must be optimized. One example of a water resource is a river. Flows in open channels are dynamic and difficult to predict because they are influenced by many factors, including flow speed and sediment volume. An increase in river surface sediment has an impact on discharge changes, while the accumulation of sediment in the riverbed can decrease its flow capacity (1). Excessive sediment buildup risks reducing the capacity of the river, (2–4).

Flow discharge is used to describe the hydrological parameters of the field. The ability to measure discharge is very important in knowing the potential of water resources in watersheds. Stream discharge data can be leveraged to monitor and evaluate water balance through a surface water potential approach. One of the tools used in measuring current discharge and velocity is the current meter. Information about river discharge is needed in the design of flood control buildings, including consideration of peak discharge during flooding and minimum discharge required for water utilization in the dry season.

Open Channel Flow (OCF) is a flow that is related to free air, for example, rivers, sewers, reservoirs, etc (5). A pipe with the presence of the smallest air gap is still included in the OCF, open channels have various shapes as shown in Figure 1.

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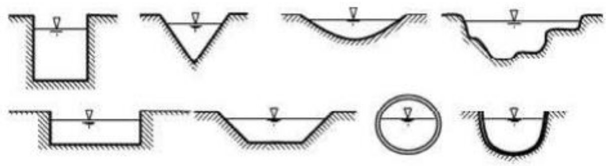


Figure 1. Variations of Open Channel Cross-Section Geometry

Open channels are more complicated than pipeline flows, this is based on the fact that the position of the free surfaces that tend to change depends on time and space, the depth of flow, the discharge, the slope of the flow base, as well as the free surfaces that depend on each other. In addition, the physical condition of open channels that vary compared to pipes and the cross-section of the transverse flow of various open channels is not only circular like pipe flows, it also causes open flows to be more complicated than pipe flows. The flow of water occurs in an open channel because there is a difference in height between 2 places (Δy) meters, so the influence of gravity will cause a flow speed of V (m/s). So the factor that affects the open channel is V (Flow Velocity) will be directly proportional to the longitudinal slope S (Slope). S big then big V, small S then small V small. Flows in rivers generally carry a number of sediments, both suspended load and bed load.

There will be a change in the basic sediment transportation (bed load) will be accompanied by a change in the concentration of suspension sediment. The suspension sediment concentration and velocity distribution are known to change from the center towards the edge of the channel. Coleman (1981) and Zainuddin and Kironoto (2003) in Kironoto (2007), reported that the presence of suspension sediments can affect the shape of the velocity distribution, which will affect the magnitude of the frictional velocity it causes. The presence of bed loads that are known to affect the concentration content of suspension sediments, and also affect the shape of the speed distribution, is thought to also affect the magnitude of the friction velocity. Sediment is a fragment of material fragments generally consisting of the physical and chemical breakdown of rocks. Such particles range in size from large (boulder) to very fine (colloids), and range in shape from spherical to square (6,7). As a result of the flow of water, forces that act on sedimentary materials arise. Such forces have a tendency to move or drag the details of sedimentary material. When the forces acting on the sediment grains reach a certain price, so that if a little force is added it causes the sediment grains to move, this condition is called the critical condition. This event shows that the shear voltage in the line is greater than its critical value or theoretically $\tau o > \tau c$ (8).

Discharge is referred to as the amount of water flow (volume) flowing through a cross-section in a given time, generally expressed in units of volume/time (m3/second) (9–11). Discharge measurements at certain times can be used as analytical material. Discharge measurement can be divided into two types, namely measurements are carried out directly and indirectly. Direct discharge measurement is a measurement carried out using equipment in the form of current meters, buoys, and dyestuffs. The discharge of the measurement results can be calculated as soon as the measurement is completed. Indirect discharge measurement is a discharge measurement carried out using a hydraulic formula such as the Manning or Chezy formula. Measurements are carried out by measuring the hydraulic parameters of the river, namely the cross-sectional area of the river, the wet circumference, and the slope of the energy line.

With the availability of discharge data, water management in conditions of excess and deficiency can be calculated more accurately to minimize the impact of floods and droughts. Therefore, in this study, discharge and flow speed measurements were carried out to obtain data on the volume of water flowing at a certain time. The research entitled Evaluation of the Relationship between Water Discharge and Flow Speed to the Volume of Open Channel Sediment in the UKI Campus Area, Jakarta aims to determine the flow discharge, flow speed, and volume of eroded sediment in the open channel. The formulation of this research problem includes the effect of water discharge and flow speed on the amount of sediment transported. The limitations of the research are focused on trapezoidal open channels in the environment of the Indonesian

Christian University with dimensions of 1 meter high and 2.5 meters wide. Discharge calculations are carried out using a current meter, with measurements limited to open channel flow discharge and sediment discharge.

2. METHOD

This research on open channels was carried out on open water channels (Open Channel Flow) located within the Indonesian Christian University (UKI). Data collection was carried out for approximately two months. The research method used is in the form of field testing. The simulation approach in this study aims to obtain an image through a small-scale system or a simple model, where the model is manipulated or controlled to observe the influence of certain variables. This research has similarities to experimental research, but the difference lies in the need to create conditions that are close to the actual system. Based on the objectives described in the previous chapter, the variables studied include flow velocity (v), water level (h), and sediment erosion volume. The research diagram as shown in Figure 2.

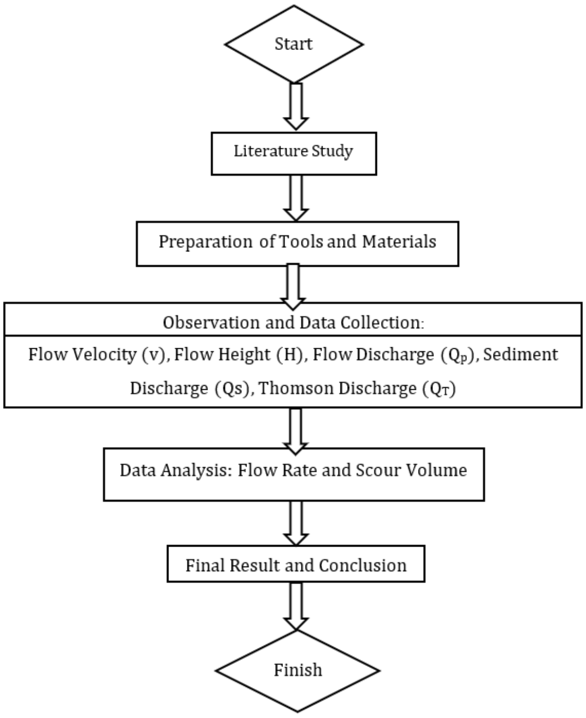


Figure 2. Research Flow Diagram

3. RESULT AND DISCUSSION

Sediment Discharge Calculation (Qs) of UKI Open Channel Flow (OCF)

From the results of tests and calculations carried out in the field, the analysis data of the Sediment Discharge (Qs) of the UKI Open Channel Flow (OCF) as in Table 1 was obtained.

No	t (second)	Thickness beginning (d) (m)	Thickness (d1) from base after irrigation (m)	d2 Eroded (d - d1) (m)	A (1,9 x 0,5) (m^2)	Volume sedimen Eroded (A x d2) (m^3)	Qs (Vol / t) (m^3/second)
1	120	0,035	0,030	0,005	0,950	4,75 x 10^{-3}	3,958 x 10^{-5}
2	180	0,035	0,027	0,008	0,950	7,60 x 10^{-3}	4,222 x 10^{-5}
3	240	0,035	0,025	0,010	0,950	9,50 x 10^{-3}	3,958 x 10^{-5}
4	300	0,035	0,025	0,010	0,950	9,50 x 10^{-3}	3,166 x 10^{-5}
5	360	0,035	0,025	0,010	0,950	9,50 x 10^{-3}	2,638 x 10^{-5}
						Qs rata rata =	3,588 x 10^{-5}

Graph of the relationship between sediment discharge and water flow measurement discharge

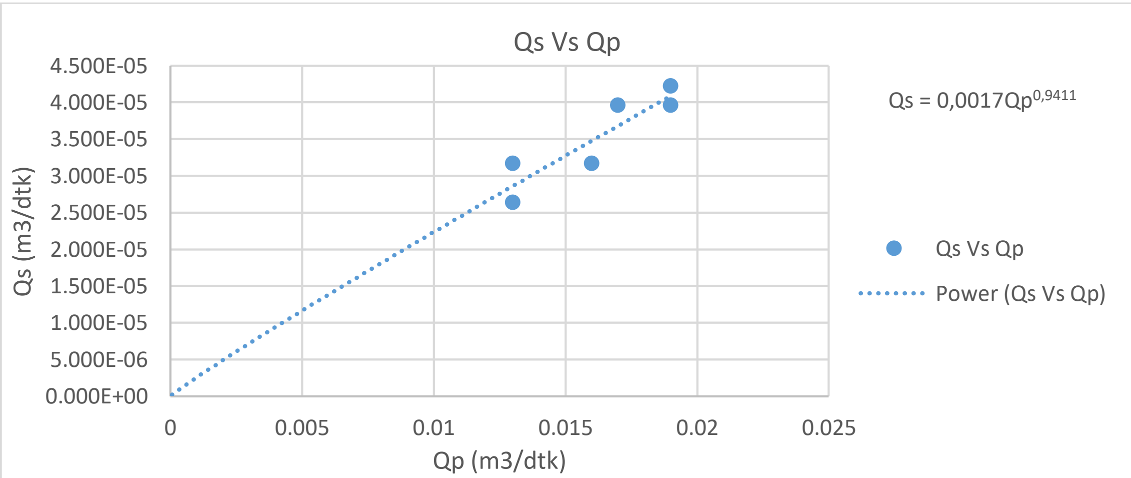


Figure 3. Graph of the relationship of sediment discharge (m^3/sec) to water flow measurement discharge (m^3/sec)

Chart of the Discharge Relationship of Water Flow Measurement to Flow Height

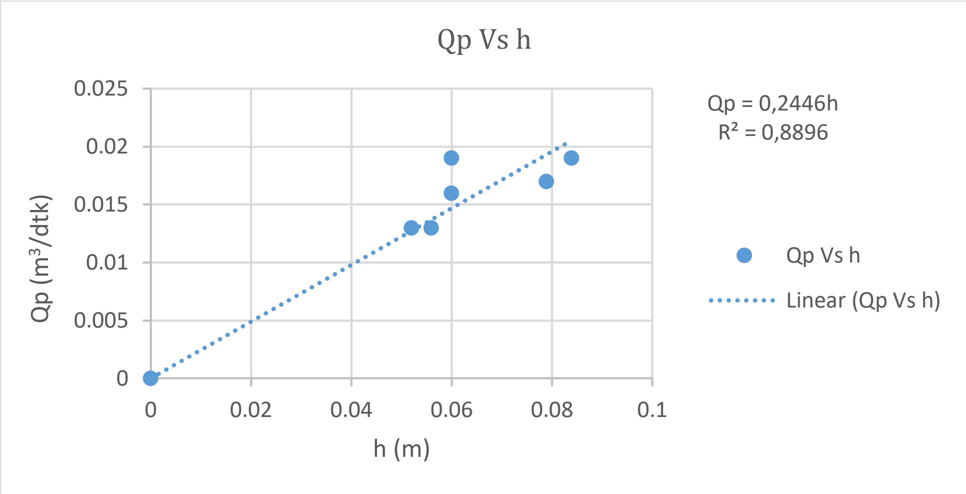


Figure 4. Graph of the relationship between the discharge of water flow measurement (m^3/sec) to the flow height (m/sec)

Thompson Discharge Chart Against Flow Height

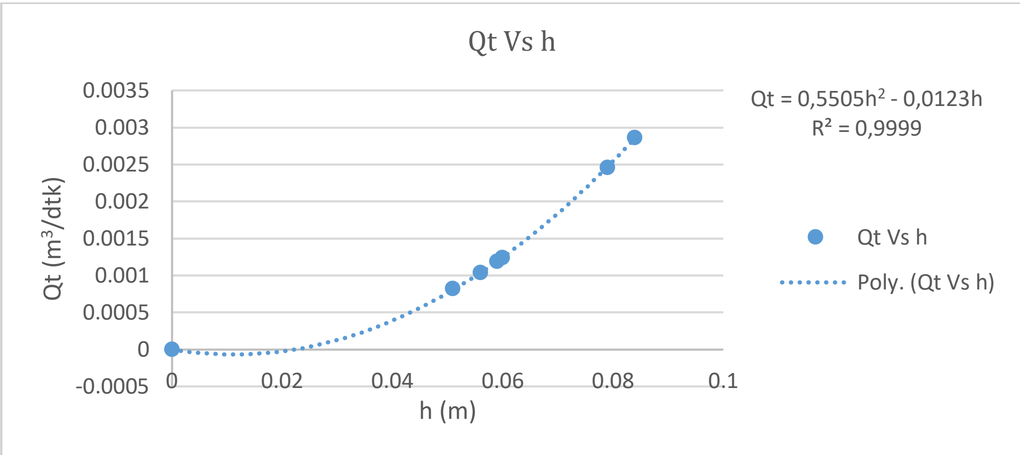
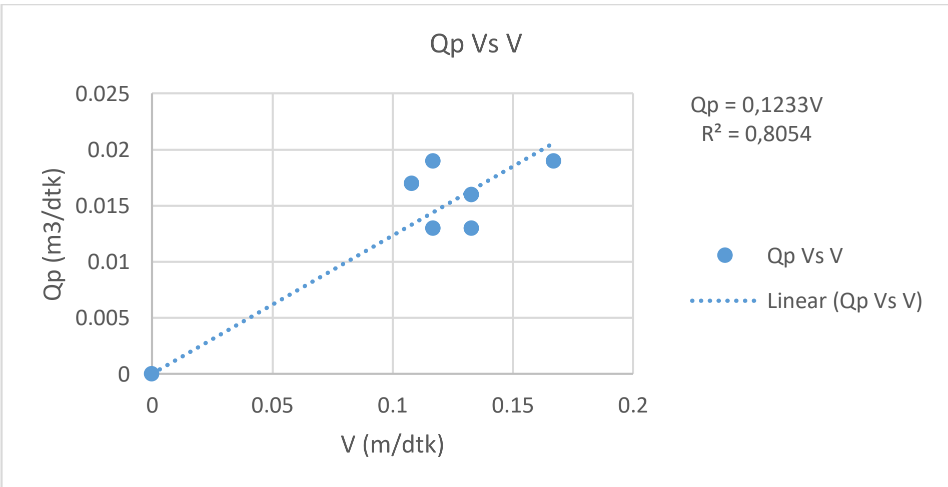


Figure 5. Graph of the relationship between Thompson discharge (m^3/ sec) to flow height (m/ sec)

Graph of the Discharge Relationship of Water Flow Measurement to Velocity



Gambar 5. Grafik hubungan debit pengukuran aliran air (m^3/detik) terhadap kecepatan (m/detik)

4. CONCLUSION

Based on the results of the research conducted, a conclusion was obtained where there is a positive relationship between measured water flow discharge (Qp) and sediment discharge (Qs), where an increase in Qp will cause an increase in Qs. This relationship can be represented through the regression equation Qs = 0.0017 Qp0.9411. The water flow discharge (Qp) shows a tendency to increase as the water level (h) in the channel increases, and vice versa. The linear relationship between the two is expressed in Qp = 0.2446 h. The relationship between Thompson Discharge (QT) and water height (h) shows that QT increases as h increases. This relationship follows the form of the quadratic equation QT = 0.5505 h2 –0.0123 h. The measured flow discharge (Qp) is also affected by the flow velocity (v), where a decrease in velocity leads to a decrease in discharge. The relationship is shown by the linear equation Qp = 0.1233 V

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