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Effect of Flow Discharge on Sedimentation in Paneki River

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ABSTRACT

Introduction: Paneki River has the potential for sedimentation caused by flow discharge. The condition of the river is getting wider every day which will threaten the risk of flooding if there is heavy rain with high intensity. The purpose of this study is to determine the return time flood discharge and basic sediment transport discharge in the Paneki river which can be used as a reference in planning sediment control buildings. **Method**: This research method includes primary data collection and secondary data collection, data management including calculating width, slope, design rainfall, design flood discharge, sieve analysis, and specific gravity. Then proceed to calculate the return time flood discharge using the *Nakayasu* synthetic unit hydrograph method and basic sediment transport using the *Meyer-Peter and Muller* method. **Results and Discussion**: From this research, the result of the 2-year return time flood discharge is 121.306 m^3/det, for 5-year return time flood discharge is 185.069 m^3 /det, for 10-year return time flood discharge is 209.261 m^3 /det, for 25-year return time flood discharge is 312.359 m^3 /det, and for 50-year return time flood discharge is 373.566 m^3 /det. The results of basic sediment transport discharge per *cross-section* ranged from 0.0000861 m^3 /det to 0.005641775 m^3 /det. **Conclusion**: The study shows that sedimentation is influenced by flow discharge. The results of the calculation of flow discharge (Q) and bottom sediment transport (Qs) in Paneki River using the Meyer-Peter and Muller method resulted in Qs varying from 0.0000861 m^3/det to 0.016551197 m^3/det, according to the measured flow discharge. The greater the flow discharge, the greater the sediment transport, indicating a direct relationship between flow discharge and sedimentation.

1. Introduction

Indonesia has enormous potential in water investigation that can be utilized to fulfill the needs of the community. This is supported by the number of rivers and tributaries that are very large and spread throughout the archipelago. In addition to providing water sources for the community, rivers also play an important role in maintaining biodiversity, economic value, culture, transportation, and others. So it is not surprising that rivers are considered a natural element that is very important in shaping the pattern of life of a community that is around it [1]. The river is an open water flow that has a free water level and flows from upstream to downstream. Each river has different characteristics and shapes. This is caused by many factors such as climate, topography, and the process of river formation. Rivers that tend to be steep and due to the large amount of rainfall discharge result in a rapid rise in river levels and significantly erode the riverbed. Natural elements greatly affect the condition and stability of the river. Silting due to sedimentation in the river will have a major impact on the condition of the river flow so it will also affect human activities that depend on the river flow. The flow in the river, in general, carries a number of sediments, both *suspended sediments* *(suspended load)* and basic sediments *(bed load)* [2]. Research from Kamziah [3] entitled "Study of Basic Sediment Transport Rate in Paneki River after Earthquake". In this study, the authors used the *Meyer-Peter and Muller* method. So that the results of the calculation of the basic sediment transport rate (Qs) in the sampling can be obtained post-earthquake basic sediment transport rate, namely with a 5-year return flood discharge of 0.18177 m3 / sec, for a 10-year return flood discharge of 0.20883 m3 / sec, for a 25-year return flood discharge of 0.24320 m3 / sec, for a 50-year return flood discharge of 0.26857 m3 / sec, and for a 100-year return flood discharge of 0.29391 m3 / sec.

Research from Trias [4] entitled "Study of Basic Sediment Transport Rate in Paneki River". This research was chosen because the Paneki River has the potential for sedimentation caused by the scouring of the river cross-section. The research was calculated using the *Meyer-Peter and Muller* equation method. So as to get the results of river research with a 5-year return flood discharge of 0.63572 m3 / sec, for a 10-year return flood discharge of 0.71919 m3 / sec, for a 25-year return flood discharge of 0.82294 m3 / sec, for a 50-year return flood discharge of 0.89766 m3 / sec, and for a 100-year return flood discharge of 0.97134 m3 / sec. Paneki River has almost the same characteristics as rivers in Central Sulawesi in general, including topography and soil type. Paneki River crosses several villages, including Pombewe Village, Lolu Village, Jono Oge Village, and Langaselo Village. The river is located at a high altitude, while the villages it passes through are in the lowlands. Paneki River is the main support for the lives of the surrounding communities. The flow of the Paneki River is utilized for irrigation, clean water, and fisheries. Paneki River has the potential for sedimentation caused by the flow discharge so that the erosion process occurs. Sediments produced by the erosion process and carried by the flow of water will be deposited in a place where the flow speed slows down or stops. The condition of the Paneki River is getting wider every day, which will threaten the risk of flooding if there is heavy rain with high intensity.

2. Method

2.1 Data Collection

1. Primary Data

Primary data is data obtained directly from the research location. As for this research, the primary data that will be used are as follows:

a. Bottom sediment sample
Sampling of bottom sediments was carried out along 1000 m upstream of the Dam, each bottom sediment sampling point is 5 stakes where the distance between stakes is 200 m. Due to the limited tools available, sampling was carried out using sediment traps made of sack material.

b. Riverbed width measurement data
Riverbed width measurements were taken several times at each sediment sampling location.

c. Riverbed slope measurement data.
Measurement of riverbed slope was carried out using a Total Station (TS) tool along 1000 m with a distance between the main stakes of 200 m at a location that has been determined based on the difficulty level of the measurement field.

d. River depth data
River depth measurements were taken at the same point as the sediment sampling location, using a measuring board.

e. Flow velocity data
Flow velocity data collection is carried out at each cross-section point. The tool used is the current meter tool, then carried out at each point 10 times to get more accurate results.

2. Secondary Data

Secondary data is data obtained from related agencies or other reliable sources [5,6,7,8, 9]. The

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secondary data that will be used in this study are as follows:

a. Monthly rainfall data on the Paneki watershed obtained from Mutiara Meteorological Station.

b. Paneki watershed map obtained from the Palu-Poso Watershed and Protected Forest Management Center.

2.2 Data Management

Data obtained from field observations (primary data) and other sources (secondary data) are processed to obtain the parameters to be used:

1. Calculating the river flow velocity, using the Current Meter tool with 3 depth variations of 0.2 h, 0.6 h, and 0.8 h.
2. Calculating the average riverbed slope (S) of the surveyed river section based on previously obtained measurement data.
3. Determine and calculate the length of the main river (L) based on data on the topographic map of the Paneki watershed.
4. Calculate the average riverbed width (b), based on previously obtained measurement data.
5. Conduct hydrological analysis to obtain the value of the planned flood discharge using daily rainfall data obtained from the rainfall station closest to the research location. The steps in the hydrological analysis are as follows:
   a. Determine the watershed area at the bottom sediment sampling location
   b. Conduct rainfall frequency analysis using statistical parameters that aim to predict a rainfall amount.
   c. Test the validity of data from the *Log Pearson Type III Method* before it is used in the calculation of the planned flood discharge by conducting the *Chi-Square* Test and the *Sminor-Kolmogorov* Test.
6. Calculating the design flood discharge for return periods of 2, 5, 10, 25, and 50 years using the
   Nakayasu HSS Method based on previously processed data.
7. Calculate other river hydrological parameters including river wet cross-sectional area (A), river wet perimeter (P), river hydraulic radius (R), river flow depth (h), and river flow velocity (V).
8. Conducting sieve analysis tests at the Soil Mechanics Laboratory, Faculty of Engineering, Tadulako University.
9. Testing the specific gravity of the base sediment (**ϒ**s) at the Soil Mechanics Laboratory, Faculty of Engineering, Tadulako University.

2.3 Calculation of Bed Sediment Transport Discharge

Calculation of basic sediment transport discharge is done after data management [10, 11, 12]. The equation or method used in the calculation of basic sediment transport discharge in the Paneki River is the *Meyer-Peter and Muller* Method. The following are the calculation steps:

1. Determine the initial data or calculation parameters which include :
   a. Average riverbed width (b).
   b. Average riverbed slope (S).
   c. Main river length (L).
   d. Design flood discharge data (Q) for return periods of 2, 5, 10, 25, and 50 years.
   e. Earth's acceleration of gravity (g).
   f. Specific gravity of water (γw).
   g. The specific gravity of bottom sediment (γs).
   h. The grain diameter corresponds to 50% passing the sieve (d50).
   i. The grain diameter corresponds to 60% passing the sieve (d60).
   j. The grain diameter corresponds to 90% passing the sieve (d90).
2. Calculate the river flow depth (h) based on the design flood discharge value (Q).
3. Calculate the cross-sectional area of the river (A).
4. Calculating the wet perimeter of the river (P).

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5. Calculate the hydraulic radius (R).
6. Calculate the coefficient of roughness due to grain (Ks').
7. Calculate the value of Strickler's coefficient (Ks).
8. Calculating the bottom sediment transport discharge (Qs).

3. Results and Discussion

3.1. Research Location

Based on the elevation of the earth's surface, Kecematan Sigi Biromaru is generally located in the plains (65%), hills (25%), and mountains (10%) and is located at an altitude of 22-275 m above sea level.

Geographically, Sigi sub-district is located at 1° 11' 39" N and 119° 55' 53" E, while the location of the Paneki River is located at 0° 58' 28.20" N and 119° 57' 33.50" East.

Fig. 1. Map of Research Location Points
(Source: Palu-Poso Das and Protection Forest Management Center, 2023)

3.2 Hydrological Analysis

1. Maximum Rainfall Data
   Rainfall data used to calculate the design rainfall in the Paneki watershed is the rainfall measured at Paneki station.

Table 1. Maximum Daily Rainfall by Ranking

Ranking Data		
Ranking	Tahun	Curah Hujan (Xi) (mm)
1	2013	124.0
2	2015	119.0
3	2016	112.0
4	2021	81.1
5	2014	68.6
6	2019	62.7
7	2017	54.0
8	2020	46.9
9	2018	43.6
10	2022	21.0

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2. Abnormality Analysis
This analysis aims to determine abnormal rainfall data, which may be caused by *instrument sensitivity*, readings environmental changes, and so on. Rainfall data abnormality analysis can be performed as shown in Figure 2 below:

1	2013	124.0	2.093	101.593	2.007	4.028	
2	2015	119.0	2.076	113.398	2.055	4.221	
3	2016	112	2.049	106.398	2.027	4.108	
4	2021	81.1	1.909	75.498	1.878	3.527	
5	2014	68.6	1.836	62.998	1.799	3.238 3.086	0.552
6	2019	62.7	1.797	57.098	1.757		
7	2017	54.0	1.732	48.398	1.685	2.839	
8	2020	46.9	1.671	41.298	1.616	2.611	
9	2018	43.6	1.639	37.998	1.580	2.496	
10	2022	21.0	1.322	20.473	1.311	1.719	

3. Frequency Analysis
a. Gumbell Method

Table 3. Analytical Gumbell distribution calculation for monthly rainfall

No.	Tahun	Curah Hujan Xi (mm)	X Urut (mm)	(Xn - X)	(Xn - X)^2	(Xn - X)^3	(Xn - X)^4
1	2013	98	57.9	11.20	125.44	1,404.93	15,735.19
2	2014	80.4	60.0	9.10	82.81	753.57	6,857.50
3	2015	78.0	60.3	8.80	77.44	681.47	5,996.95
4	2016	88.0	60.5	8.60	73.96	636.06	5,470.08
5	2017	90.7	63.1	6.00	36.00	216.00	1,296.00
6	2018	78.8	72.0	-2.90	8.41	-24.39	70.73
7	2019	72.0	78.0	-8.90	79.21	-704.97	6,274.22
8	2020	98.0	78.8	-9.70	94.09	-912.67	8,852.93
9	2021	111.2	80.0	-10.90	118.81	-1,295.03	14,115.82
10	2022	95.5	80.4	-11.30	127.69	-1,442.90	16,304.74
	Total =	1703.3	691.0	0.0	8128.5	-117659.2	11766765.3
	Xn =	69.100	mm	Yn =	0.4592		
	Sx =	20.68	mm	Sn =	0.9496		
	CS =	0.3650		Cv =	0.2993		
	N =	10	tahun	CK =	91.4860		

From the results shown in Table 3, the calculation of parameters Cs, and Ck does not meet the requirements for frequency analysis of the *Gumbell* method, so the *Gumbell* method cannot be used as design rain, so the *Log Pearson III* method is used.

b. *Log Pearson III* Method

Calculation of frequency distribution selection using the Log Pearson Type III Method, first look for the value of $(Log\ Xi - Log\ X), (Log\ Xi - Log\ X)^2, (Log\ Xi - Log\ X)^3, dan\ (Log\ Xi - Log\ X)^4$.

Table 4. Recapitulation of design rainfall Log Pearson III Method

No.	Periode Ulang T (tahun)	Standar Deviasi (S Log Xi)	Log Xi (mm)	Log Xtr (mm)	Xtr (mm)
1	2	0,1032	1,9185	1,9160	82,41
2	5	0,1032	1,9185	2,0045	101,04
3	10	0,1032	1,9185	2,0523	112,80
4	20	0,1032	1,9185	2,0870	122,17
5	25	0,1032	1,9185	2,1043	127,15
6	50	0,1032	1,9185	2,1384	137,54
7	100	0,1032	1,9185	2,1696	147,789

$(Log\ Xi - Log\ X), (Log\ Xi - Log\ X)^2, (Log\ Xi - Log\ X)^3, dan\ (Log\ Xi - Log\ X)^4$.

From Table 4, the design rainfall values with a return period of 2, 5, 10, 20, 25, 50, and 100 years were obtained. Then the distribution suitability test was conducted [13, 14].

4. Frequency Distribution Conformity Test
   Chi-Square Test

The chi-squared test is intended to determine whether the odds distribution equation that has been selected can represent the statistical distribution of the data sample being analyzed.

Table 5. Crisis values for Chi-square distribution (One-sided test)

dk	a derajat kepercayaan							
	0.995	0.99	0.975	0.95	0.05	0.025	0.01	0.005
1	0.000039	0.000157	0.000982	0.000393	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	5.991	7.378	9.210	10.597
3	0.0717	0.115	0.216	0.352	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	11.070	12.832	15.086	16.750
6	0.676	0.872	1.237	1.635	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	15.507	17.533	20.090	21.955
9	1.735	2.088	2.700	3.325	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	18.307	20.483	23.209	25.188

Table 6. Chi-Square Test Calculation of annual maximum rainfall for Pearson III log distribution

No.	Nilai Batas Kelompok			Jumlah Data		(Fe - Ft)	(Fe - Ft)^2/Ft
				Fe	Ft		
1		<	1,692	2	4,00	-2,00	1,000
2	1,69	-	1,826	2	4,00	-2,00	1,000
3	1,83	-	1,946	4	4,00	0,00	0,000
4	1,95	-	2,007	5	4,00	1,00	0,250
5	2,01	>		7	4,00	3,00	2,250
			Total =	20	20		4,50

Judging from the above comparison as shown in Table 5 that X^2 h < X^2 Cr, the chi-square test distribution method is acceptable using Log Pearson III frequency analysis.

3.3 Rainfall Intensity Analysis

Rainfall intensity is the height or depth of rainwater per unit of time. The general nature of rainfall is that the shorter the time it lasts, the higher the intensity tends to be, and the greater the return period, the higher the intensity.

Table 7: Rainfall intensity

Lama Hujan	Intensitas Hujan It (mm/jam) Dengan Periode Ulang (Tr)						
t (jam)	2 tahun	5 Tahun	10 Tahun	20 tahun	25 tahun	50 tahun	100 tahun
1	28,569	35,029	39,105	42,354	44,079	47,681	51,236
2	17,997	22,067	24,634	26,681	27,768	30,037	32,277
3	13,735	16,840	18,800	20,362	21,191	22,923	24,632
4	11,338	13,901	15,519	16,808	17,493	18,922	20,333
5	9,770	11,980	13,374	14,485	15,075	16,307	17,522
6	8,652	10,609	11,843	12,827	13,349	14,441	15,517
7	7,807	9,573	10,686	11,574	12,046	13,030	14,001
8	7,142	8,757	9,776	10,589	11,020	11,920	12,809
9	6,603	8,096	9,038	9,789	10,187	11,020	11,842
10	6,155	7,547	8,425	9,125	9,496	10,273	11,038
11	5,776	7,082	7,906	8,563	8,912	9,640	10,359
12	5,451	6,683	7,461	8,081	8,410	9,097	9,775
13	5,167	6,336	7,073	7,661	7,973	8,624	9,267
14	4,918	6,030	6,732	7,291	7,588	8,209	8,820
15	4,697	5,759	6,429	6,964	7,247	7,840	8,424
16	4,499	5,517	6,159	6,670	6,942	7,509	8,069
17	4,321	5,298	5,915	6,406	6,667	7,212	7,750
18	4,160	5,100	5,694	6,167	6,418	6,942	7,460
19	4,012	4,920	5,492	5,948	6,191	6,696	7,196
20	3,877	4,754	5,307	5,748	5,982	6,471	6,954
21	3,753	4,602	5,137	5,564	5,791	6,264	6,731
22	3,639	4,461	4,981	5,394	5,614	6,073	6,526
23	3,532	4,331	4,835	5,237	5,450	5,896	6,335
24	3,434	4,210	4,700	5,090	5,298	5,731	6,158

3.4 Design Flood Discharge Analysis

The design flood discharge analysis was conducted using the HSS Nakayasu method [5,7,11].

Watershed Parameter Data:

Tuva River Watershed Area (A): 27.44 Km^2
River Length (L): 15.56 Km Nakayasu Synthetic Unit Hydrograph Parameters

1. Grace Period Concentration (tg)

$Jika\ L < 15\ km, tg = 0.21\ x\ L^{0.7}$

$Jika\ L > 15\ km, tg = 0.4 + 0.058\ L$

$$Tg = 0.4 + 0.058 \text{ x } L$$
$$= 0.4 \text{ x } 0.58\ x\ 15.56$$
$$Tg = 1.30 \text{ Hours}$$

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2. Time to Peak

$T_P = Tg + 0.8\, T_r$

$T_P = 1.30 + 0.8\, x\, 0.65$

$T_P = 1.30 + 0.8\, x\, 0.65$

$T_P = 1.823$ Jam

Table 9. Nakayusa HSS coordinates

t (Jam)	Qawal (m3/s)	Ket
0	0.000	Qa
1	0.430	Qa
1.82	**1.812**	**Qd1**
2	1.648	Qd2
3	0.938	Qd2
4	0.534	Qd3
5	0.304	Qd3
6	0.173	Qd3
7	0.098	Qd3
8	0.120	Qd3
9	0.082	Qd3
10	0.056	Qd3

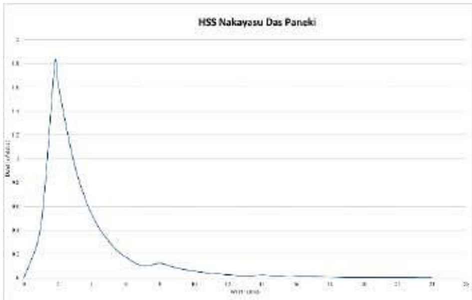

Fig 2. Nakayusa HSS Coordinate Chart

Recapitulation of Flood Discharge Calculation in Paneki River

t (jam)	Q2 (m^3/det)	Q5 (m^3/det)	Q10 (m^3/det)	Q25 (m^3/det)	Q50 (m^3/det)
0	0.000	0.000	0.000	0.000	0.000
1	28.821	43.971	49.718	74.213	88.756
1.82	**121.306**	**185.069**	**209.261**	**312.359**	**373.566**
2	110.323	168.312	190.315	284.077	339.743
3	62.795	95.802	108.326	161.695	193.380
4	35.742	54.530	61.658	92.036	110.070
5	20.344	31.038	35.096	52.386	62.651
6	11.580	17.667	19.976	29.818	35.661
7	6.591	10.056	11.370	16.972	20.298
8	8.013	12.225	13.824	20.634	24.677
9	5.504	8.397	9.494	14.172	16.949
10	3.780	5.767	6.521	9.733	11.641
11	2.596	3.961	4.479	6.685	7.995
12	1.783	2.720	3.076	4.591	5.491

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13	1.225	1.868	2.113	3.153	3.771
14	1.598	2.438	2.757	4.116	4.922
15	1.206	1.840	2.080	3.105	3.714
16	0.910	1.388	1.569	2.343	2.802
17	0.686	1.047	1.184	1.767	2.114
18	0.518	0.790	0.893	1.333	1.595
19	0.391	0.596	0.674	1.006	1.203
20	0.295	0.450	0.508	0.759	0.908
21	0.222	0.339	0.384	0.573	0.685
22	0.168	0.256	0.289	0.432	0.517
23	0.127	0.193	0.218	0.326	0.390
24	0.095	0.146	0.165	0.246	0.294

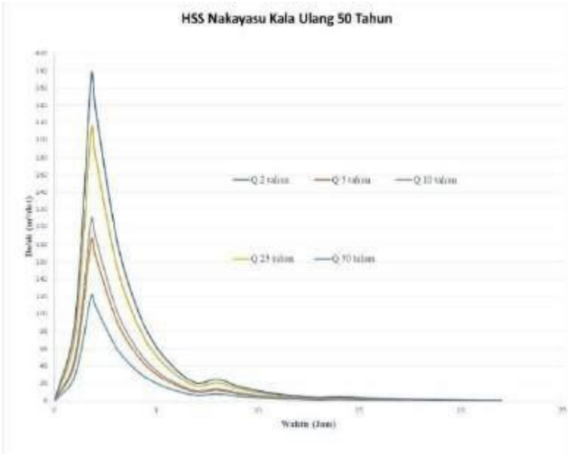

Fig 3. Design Flood Hydrograph of Paneki River

Table 11: Nakayasu HSS Recapitulation Table Paneki Watershed

Tabel Rekapitulasi HSS NAKAYASU DAS Paneki							
Kala Ulang					rata-rata	Max	Min
2 Tahun	5 Tahun	10 Tahun	25 Tahun	50 Tahun			
121.306	185.069	209.261	312.359	373.566	200.260	373.566	121.306

The results of the calculation of the design flood discharge as shown in Table 4.28 then get the size of the 2-year return time discharge, namely121.306 m^3/det, 5-year return time,

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namely185.069 m^3/det, 10-year return time, namely209.261 m^3/det, 25-year return time, namely312.359 m^3/det, 50-year return time, namely 373.566 m^3/det.

3.5 Riverbed Slope Calculation

Measurement of the slope of the riverbed was carried out using the TS (Total Station) tool along 1000 m. The following are the results of the measurements and calculations:

Table 12. Measurement and calculation results of riverbed slope

Patok (Pn)	Jarak Antar Patok (ΔX) (m)	Tinggi Titik (EL) (m)	Beda Tinggi (ΔH) (ΔH = EL.P(n+1) - EL.Pn) (m)	Kemiringan Dasar Sungai (S) (Sn = ΔH / ΔX)	Lebar Sungai (b) (m)
P0	200	172.99	3.78	0.01891	20.6
P1		176.78			16.0
	200		2.89	0.01447	
P2		179.67			10.0
	200		1.33	0.00666	
P3		181.00			14.5
	200		2.84	0.0142	
P4		183.84			10.0
	200		2.15	0.01076	
P5		185.99			8.0
Rata-rata				0.013000	11.3

3.6 River Hydraulics Calculation

In this study, river hydraulics is calculated based on the design flood discharge for the return period of 2 years, 5 years, 10 years, 25 years, and 50 years at each sampling point.

1. Determination of initial calculation parameters such as :

   a. River bed slope = 0.019 (PerCross*Section*)

   b. Average river bed width (b)=16.00 m (Per *Cross Section*)

   c. *Manning's* Coefficient (n) = 0.035 (From Manning's Coefficient Table)

2. Example of river hydraulics calculation in CS 1.1 at the time of 2-year return period flood discharge → QS = 121.306 m3/det (in the calculation of river hydraulics the river cross-section is assumed to be trapezoidal)

   a. Calculate the wet cross-sectional area of the river:
   $A = b + m \times h^2$
   $A = 4.356\ m^2$

   b. Calculating the wet perimeter of the river:
   $P = b + 2 \times h \times \sqrt{(1 + m^2)}$
   $P = 16.604\ m^2$

   c. Calculating the hydraulic radius of the river:
   $R = \frac{A}{P}$
   $R = 0.262\ m$

   d. Calculating river slope:
   $V = \frac{1}{n} x R^{\frac{2}{3}} x I^{\frac{1}{2}}$
   $V = 1.61$

   e. Calculating the flow velocity of the River:
   $V = \frac{Q}{A}$
   $V = 27.848\ m^3/sec$

   f. Calculating the 2-year return period design flood discharge:
   $Q_2 = A \times V$

121.306 = 4.356 × 27.848

121.306 = 121.306 m /sec^3

Table 13: Recapitulation of 2-year hydraulics calculation results for Per *cross-section*

Kala ulang (Q2)	**Lebar Sungai (b)**	**Tinggi Air (h)**	**Kemiringan Saluran (I)**	**Jari - Jari Hidrolis (R)**	**Kecepatan Aliran Sungai (V)**
	(m)	**(m)**		**(m)**	**(m/s)**
Cs 1.1	16	0.27	0.019	0.262	27.848
Cs 1.2	16	0.18	0.019	0.177	41.884
Cs 1.3	16	0.13	0.019	0.128	58.084
Cs 2.1	10	0.24	0.014	0.231	49.945
Cs 2.2	10	0.30	0.014	0.285	39.837
Cs 2.3	10	0.19	0.014	0.184	63.244
Cs 3.1	14.5	0.18	0.007	0.176	46.190
Cs 3.2	14.5	0.46	0.007	0.436	17.902
Cs 3.3	14.5	0.33	0.007	0.318	25.066
Cs 4.1	10	0.29	0.014	0.276	41.231
Cs 4.2	10	0.48	0.014	0.444	24.679
Cs 4.3	10	0.27	0.014	0.258	44.329
Cs 5.1	8	0.30	0.011	0.282	49.613
Cs 5.2	8	0.45	0.011	0.411	32.774
Cs 5.3	8	0.23	0.011	0.219	64.992

3.7 Calculation of Bed Sediment Sieve Analysis

The sieve analysis test aims to obtain the diameter size of the bottom sediment (D50, D60, D90). The basic sediment samples to be tested are taken from five different locations, namely Segment I (CS 1.1 - Cs 1.3), Segment II (CS 2.1 - Cs 2.3), Segment III (CS 3.1 - Cs 3.3), Segment IV (CS 4.1 - Cs 4.3) and Segment V (CS 5.1 - 5.3). The following is a table of Recapitulation of Sieve Analysis per Cross Section.

Table 14. Recapitulation of Sieve Analysis

Patok	D_{50}	D_{60}	D_{90}
	(mm)	(mm)	(mm)
CS 1.1	1.6	2.4	10
CS 1.2	1.4	2.4	10.2
Cs 1.3	1.8	2.5	10.2
CS2.1	1.7	2.5	10.2
CS 2.2	1.7	2.2	10.2
CS 2.3	1.7	2.5	10.2
CS 3.1	1.6	2.1	10.2
CS 3.2	1.8	2.8	10
CS 3.3	1.4	2.1	10.2
CS 4.1	1.4	2	10.2
CS 4.2	1.8	3.1	10.3
CS 4.3	1.6	2.4	10.2
CS 5.1	1.8	2.6	10.2
CS 5.2	1.8	3	10.2
CS 5.3	1.3	2	10.2

3.8 Calculation of Specific gravity of bottom sediment

After testing the sieve analysis of the basic sediment samples, the next test was carried out to determine the value of the specific gravity of the basic sediment.

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Table 15: Test results and calculation of CS 1 sediment specific gravity

Parameter Perhitungan	Satuan	Sample Sedimen Dasar					
		Kiri		Tengah		Kanan	
Piknometer (W1)	(gr)	181.61	178.06	181.31	179.07	181.96	181.27
Berat Piknometer + Contoh (W2)	(gr)	681.61	678.06	681.31	679.07	681.96	681.27
Berat Piknometer + Contoh + Air (W3)	(gr)	971.58	975.60	971.54	977.34	971.34	974.21
Berat Piknometer + Air pada t° (W4)	(gr)	659.68	665.44	659.12	675.34	658.21	671.29
Suhu Ruangan (t)	°C	28.00	28.00	28.00	28.00	28.00	28.00
Berat Contoh (WS = W2 – W1)	(gr)	500.00	500.00	500.00	500.00	500.00	500.00
(W5 = WS + W4)	(gr)	1159.68	1165.44	1159.12	1175.34	1158.21	1171.29
Berat air suling (Ww = W5 – W3)	(gr)	188.10	189.44	187.48	198.00	186.87	197.08
Berat Jenis Contoh, (γs = WS / Ww)	-	2.66	2.64	2.67	2.53	2.68	2.54
Berat Jenis Contoh rata-rata, ($\gamma_{srt} = (\gamma_{s1} + \gamma_{s2})/2$)	-	2.65		2.60		2.61	

3.9 Calculation of Base Sediment Transport Discharge with Mayer-Petter-Muller (MPM) Equation

In this study, the discharge of basic sediment transport was calculated using the *Meyer-Peter and Muller* Method. Calculation of basic sediment transport discharge (Qs) with instantaneous discharge for cross-section 1.1.

Unknown:
1. River Width (b) = 16 m
2. Water Level Height (h) = 0.27 m
3. Channel Slope (I) = 0.01891

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4. Flow Velocity (v) = 27.848 m/s
5. Gravitational acceleration (g) = 9.81 m/s
6. Specific gravity of water (γw) = 1 Ton/m^3
7. Sediment Specific gravity (γs) = 2.65
8. M.P.M Grain Diameter (D_{50}) = 1.8 mm = 0.0018 m
9. M.P.M Grain Diameter (D_{60}) = 2.8 mm = 0.0028 m
10. M.P.M Grain Diameter (D_{90}) = 10 mm = 0.010 m

a. Calculating cross-sectional area (A)
$= b \times h + m \times h^2$
$= 4{,}356\ m^2$

b. Calculating flow discharge (Q)
= A x V
= 1.394 m /dt^3

c. Calculating Wet Perimeter (P)
$= b + 2 \times h \times \sqrt{(1 + m^2)}$
$= 16 + 2 \times 0.27 \times \sqrt{(1 + 0{,}5^2}$
$= 16{,}604\ m^2$

d. Calculating Hydraulic Radius (R)
= A/P
= 0,262 m

e. Calculating the coefficient of roughness due to grain (Ks')
$= \frac{26}{d_{90}^{(\frac{1}{6})}}$

$= \frac{26}{0{,}010^{(\frac{1}{6})}}$

= 56,101 m

f. Calculating the value of Strickler's coefficient (KS)
$= \frac{V}{R^{(\frac{2}{3})} \times S^{(\frac{1}{2})}}$

$= \frac{0{,}32}{(\frac{2}{3}) \qquad (\frac{1}{2})}$

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0,262 x 0.01891

= 5.680 m/set

g. Calculating the base sediment transport rate per meter $(q\ )_B$

$$q_B = \sqrt{\left(\frac{\gamma_w \cdot R \cdot \left(\frac{Ks}{Ks}\right)^{\frac{3}{2}} \cdot s - 0{,}047 \cdot (\gamma_s - \gamma_w) \cdot d_{50}}{0{,}25 \cdot \left(\frac{\gamma_w}{g}\right)^{\frac{1}{3}}}\right)^3}$$

$$q_B = \sqrt{\left(\frac{1 \cdot 0{,}262 \cdot \left(\frac{5{,}680}{56{,}101}\right)^{\frac{3}{2}} \cdot 0{,}01891 - 0{,}047 \cdot (2{,}65 - 1) \cdot 0{,}0018}{0{,}25 \cdot \left(\frac{1}{9{,}81}\right)^{\frac{1}{3}}}\right)^3}$$

q_B = 0,00000538 m $/\text{det}^3$

h. Calculating the sediment transport rate for channel width k (Qs)
= (q_B) x b
= 0.00000538 x 16
= 0.0000861 m $/\text{det}^3$

Table 20: Recapitulation of Sediment Transport Calculation Results

Base Cs 1 to Cs 5 using the MPM equation

No	lebar sungai (b)	Tinggi Air (h)	Kecepatan Aliran (v)	Kemiringan sungai (s)	Percepatan Gravitasi (g)	Berat Jenis Air (γw)	Berat Jenis Sedimen (γs)	Diameter Butiran(D_{50})	Diameter Butiran(D_{60})	Diameter Butiran(D_{90})	Luas Penampang (A)	Debit Aliran (Q)	Keliling Basah (P)	Jari-Jari Hidrolis (R)	Nilai koefisien Kekasaran akibat butiran (Ks')	Nilai koefisien Stickler (Ks)	Laju Angkutan Sedimen dasar per meter (qb)	Laju Angkutan Sedimen dasar per saluran (Qs)
	(m)	(m)	(m/detik)		(m/detik)	Ton/m^3		(m)	(m)	(m)	(m^2)	(m^3/dt)	(m^2)	(m)	(m)	(m/detik)	(m^3/m.det)	(m^3/det)

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Cs 1.1		0.27	0.32		9.81	1	2.65	0.0016	0.0024	0.010	4.356	1.394	16.604	0.262	56.101	5.680	0.00000538	0.0000861
Cs 1.2	16	0.18	1.24	0.01891	9.81	1	2.60	0.0014	0.0024	0.010	2.896	3.591	16.402	0.177	56.101	28.667	0.000932	0.0149191
Cs 1.3		0.13	0.8		9.81	1	2.61	0.0018	0.0025	0.0102	2.088	1.671	16.291	0.128	55.916	22.897	0.00027960	0.0044737
Cs 2.1		0.24	0.73		9.81	1	2.66	0.0017	0.0025	0.010	2.429	1.773	10.537	0.231	56.101	16.150	0.00018719	0.0018719
Cs 2.2	10	0.3	1.38	0.01447	9.81	1	2.64	0.0017	0.0022	0.010	3.045	4.202	10.671	0.285	56.101	26.479	0.00105229	0.010522926
Cs 2.3		0.19	0.31		9.81	1	2.65	0.0017	0.0025	0.0102	1.918	0.595	10.425	0.184	55.916	7.971	0.000000998	0.00000998
Cs 3.1		0.18	0.43		9.81	1	2.61	0.0016	0.0021	0.0102	2.626	1.129	14.902	0.176	55.916	16.773	0.000015259	0.000221249
Cs 3.2	14.5	0.46	1.39	0.00666	9.81	1	2.62	0.0018	0.0028	0.010	6.776	9.418	15.529	0.436	56.101	29.615	0.000766261	0.011110777
Cs 3.3		0.33	1.6		9.81	1	2.64	0.0014	0.0021	0.0102	4.839	7.743	15.238	0.318	55.916	42.134	0.001141462	0.016551197
Cs 4.1		0.29	1.17		9.81	1	2.63	0.0013	0.0020	0.0102	2.942	3.442	10.648	0.276	55.916	23.155	0.000729068	0.007290675
Cs 4.2	10	0.48	1.53	0.0142	9.81	1	2.62	0.0018	0.0031	0.0103	4.915	7.520	11.073	0.444	55.825	22.071	0.001354714	0.01354714
Cs 4.3		0.27	1.01		9.81	1	2.66	0.0016	0.0024	0.0102	2.736	2.764	10.604	0.258	55.916	20.920	0.000478153	0.004781533
Cs 5.1		0.3	0.91		9.81	1	2.67	0.0018	0.0026	0.0102	2.445	2.225	8.671	0.282	55.916	20.410	0.000304075	0.002432599
Cs 5.2	8	0.45	1.21	0.01076	9.81	1	2.64	0.0018	0.0030	0.0102	3.701	4.479	9.006	0.411	55.916	21.109	0.000661849	0.005294795
Cs 5.3		0.23	1.21		9.81	1	2.65	0.0013	0.0020	0.0102	1.866	2.258	8.514	0.219	55.916	32.101	0.000705222	0.005641775

From the recapitulation in Table 3.20 obtained the results of sediment transport discharge from Cs 1 to Cs 5 for basic sediment transport discharge per cross-section (Qs) the resulting value varies with the highest value of basic sediment transport rate per cross-section at Cs 3.3 with a Qs value of 0.016551197 m^3 /det while the lowest value of basic sediment transport rate per cross-section is at CS 2.3 with a Qs value of 9.98 x 10^{-6} m^3 /det.

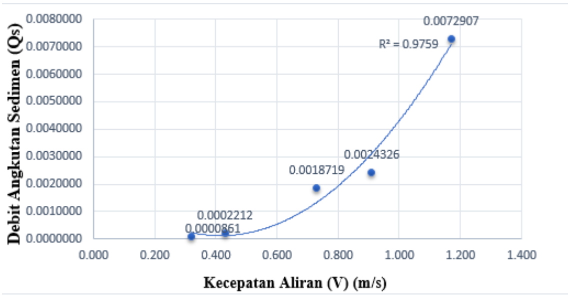

Fig 3. Relationship graph between bottom sediment transport discharge (Qs) with river flow velocity (V) Cs 1.1 to Cs 5.1

The results of the graph in Figure 3 show the relationship between sediment transport discharge (Qs) and flow velocity (V) where the greater the flow velocity, the greater the sediment transport discharge.

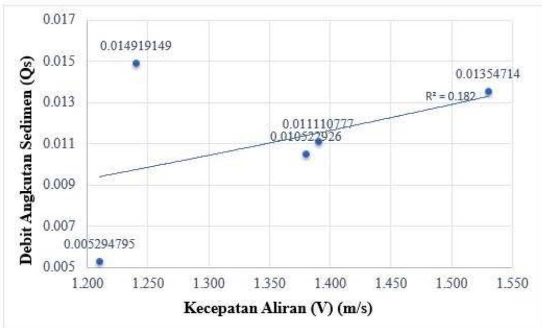

Fig 4. Relationship graph between bottom sediment transport discharge (Qs) With River Flow Velocity (V) Cs 1.2 to Cs 5.2

The results of the graph in Figure 4 show the relationship between sediment transport discharge (Qs) and flow velocity (V) in the middle cross-section which has not shown a certain trend.

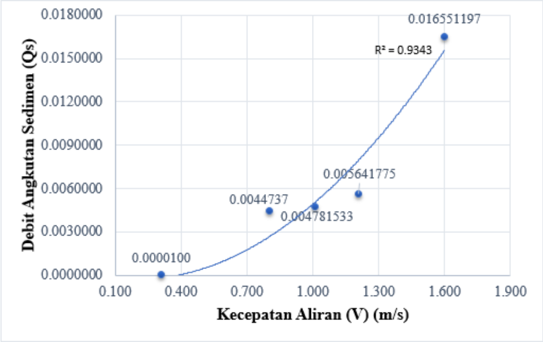

Fig 5. Relationship graph between bed sediment transport discharge (Qs) with river flow velocity (V) CS 1.3 to Cs 5.3

The results of the graph in Figure 5 show the relationship between sediment transport discharge (Qs) and flow velocity (V) where the greater the flow velocity, the greater the sediment transport discharge.

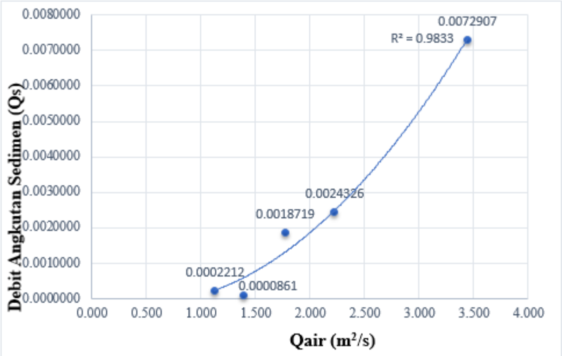

Fig 6. *Graph of the relationship between bed sediment transport discharge (Qs) with instantaneous discharge (Qair) CS 1.1 to Cs 5.1*

The results of the graph in Figure 6 show the relationship between sediment transport discharge (Qs) and instantaneous discharge (Qair) where the greater the flow velocity, the greater the sediment transport discharge.

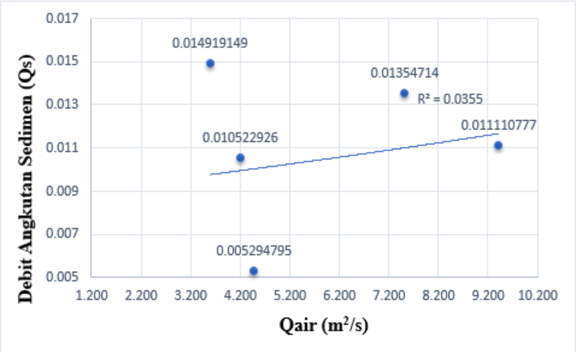

Fig 7. Graph of the relationship between bed sediment transport discharge (Qs) with instantaneous discharge (Qair) CS 1.2 to Cs 5.2

The results of the graph in Figure 3.8 In the center of all cross sections there is an increase in flow velocity. This increase in velocity is different from the velocity conditions on the left and right sides of the river. This causes an unusual trend in the center of the cross-section.

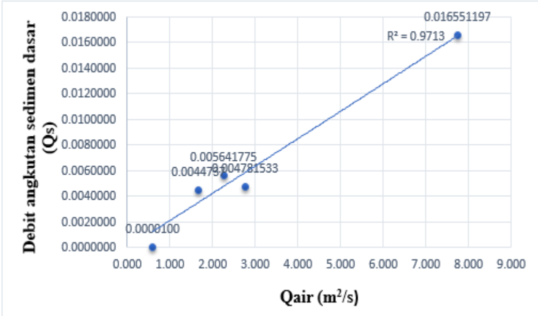

Fig 8. Graph of the relationship between bed sediment transport discharge (Qs) with instantaneous discharge (Qair) CS 1.3 to Cs 5.3

The results of the graph in Figure 3.9 show the relationship between sediment transport discharge (Qs) and instantaneous discharge (Qair) where the greater the flow velocity, the greater the sediment transport discharge.

4. Conclusion

This study examines the effect of flow discharge on sedimentation using the Meyer-Peter and Muller method in the Paneki river. The results showed that the value of flow discharge (Q) and bottom sediment transport (Qs) varied at various measurement points. For example, at point Cs 1.1, a discharge value of 1,394 m³/det was obtained with a bed sediment transport of 0.0000861 m³/det, while at point Cs 3.3, the discharge value reached 7,743 m³/det with a bed sediment transport of 0.016551197 m³/det. At point Cs 2.1, the flow discharge was recorded at 1,773 m³/det with bottom sediment transport of 0.0018719 m³/det, and at point Cs 2.2, the flow discharge increased to 4,202 m³/det with bottom sediment transport of 0.010522926 m³/det. These variations indicate that there is a direct relationship between flow discharge and the volume of sediment transported by the water flow in the Paneki River.

Furthermore, measurements at point Cs 4.2 showed a flow discharge of 7,520 m³/det with a bottom sediment transport of 0.01354714 m³/det, while at point Cs 5.1, a flow discharge of 2,225 m³/det resulted in a bottom sediment transport of 0.002432599 m³/det. These results are consistent with the observation that higher flow discharge tends to transport more sediment. Overall, the results of this study confirm that the greater the flow discharge in the Paneki River, the greater the sediment transport. These findings are important for river management and sedimentation mitigation, which can affect water quality and the surrounding environment.

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