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APPLICATION OF THE NTU-18 TURBIDITY DEVICE FOR REAL-TIME RIVER SEDIMENTATION MONITORING

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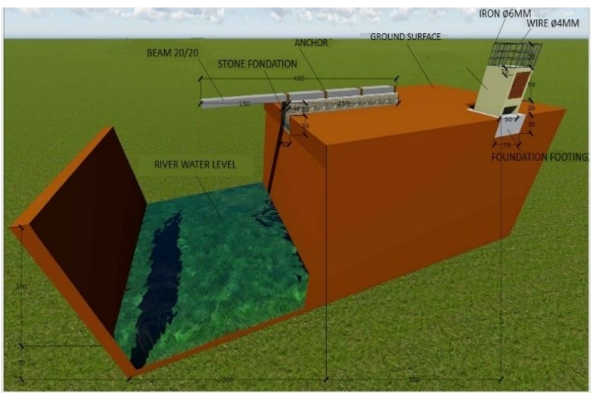
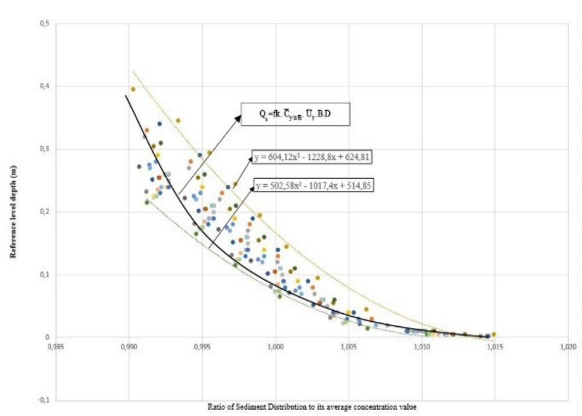
Graphic abstract





Abstract

The NTU-18 turbidity sensor tool is used for sediment measurement so that the process can be done more easily and practically. The purpose of this study is to analyze and calculate the distribution of sediment using the Rouse equation based on the measurement results with the NTU-18 turbidity sensor tool at a certain point in the Way Khilau watershed. The method used is the Rouse equation. Measurement data is used to calculate particle fall velocity and Rouse parameters. Sediment concentration was calculated with the depth of the reference surface increased by 0.05 m until it approached the depth of the riverbed. The sediment distribution ratio is calculated at each depth and the result is a graph of the relationship between the sediment distribution ratio and the average concentration value at the reference surface depth. Then the amount of sediment in the Way Khilau watershed can be approximated by the equation $y = 502.58 X^2 – 1017.4 X + 514.85$ to $y = 604.12 X^2 – 1228.8 X + 624.81$. The sediment distribution graph shows that sediments in the Way Khilau watershed tend to be bed load. This occurs because of the relatively low flow velocity in the Way Khilau watershed. The conclusion is that the amount of sedimentation in the Way Khilau watershed can be estimated using the Rouse equation, although only with certain point and amount of data and sediment at all river depths can be calculated.

Keywords: Suspended sediment, sediment estimator, NTU-18, sediment distribution, rouse

1.0 INTRODUCTION

Sediment is a common problem in natural rivers that can cause river siltation and reduce water clarity [1]. Erosion processes in the upper reaches of rivers carry sediment downstream causing the riverbed to become shallow [2, 3, 4]. Suspended sediment transport can reduce water quality in rivers due to silt and clay particles [5]. Therefore, sediment measurement is important. However, until now there is no more effective measurement technique to ascertain the amount of suspended sediment flow or concentration in a river suspended in a river.

Currently, sediment measurements require many time-consuming procedures, operations and analysis [1, 6, 7] because many sediment distributions are not uniform [8, 9, 10] thus affecting the quality and quantity of data obtained [11] such as tools made by Kelley [12] and SGZ-200 which require sampling for measurement. Recording measurement data is at risk of being lost or recorded incorrectly. Therefore, a system is needed so that the recording process could be easier. Many studies have designed sediment measuring devices using a type of turbidity sensor and their use has become popular [13, 14] such as the NTU-18 designed by Yuda Romdania *et al.* [15]. This design has proven to be able to overcome the problems that have been encountered in the field because the amount of sediment is influenced by the physical characteristics of the river area [16, 17, 18]. Therefore, in managing stored aquatic sediment data, probabilistic comparison can be used [19, 20].

Perhaps, indirect sampling of suspended sediments in the field is still relied upon. But the use of the NTU-18 turbidity sensor [15] as a measurement tool is a breakthrough that has not yet been implemented. Datas can be generated directly in the field and sediment estimation can be done more easily and practically.

The purpose of the study is to analyze and calculate the distribution of sediment using the Rouse equation based on the measurement results with the NTU-18 turbidity sensor tool only at certain points in the Khilau watershed. The sediment distribution ratio graph will be obtained from the calculation so that the equation obtained represents the graph. This equation can be used to estimate the amount of sediment at all depths of the river cross section.

2.0 METHODOLOGY

2.1 Research Location

Data collection was carried out in the downstream of the Khilau watershed for 30 days. Data obtained were in the form of velocity, depth, water turbidity level and tool height data using turbidity sensor NTU-18 at the research site. See Figure 1.

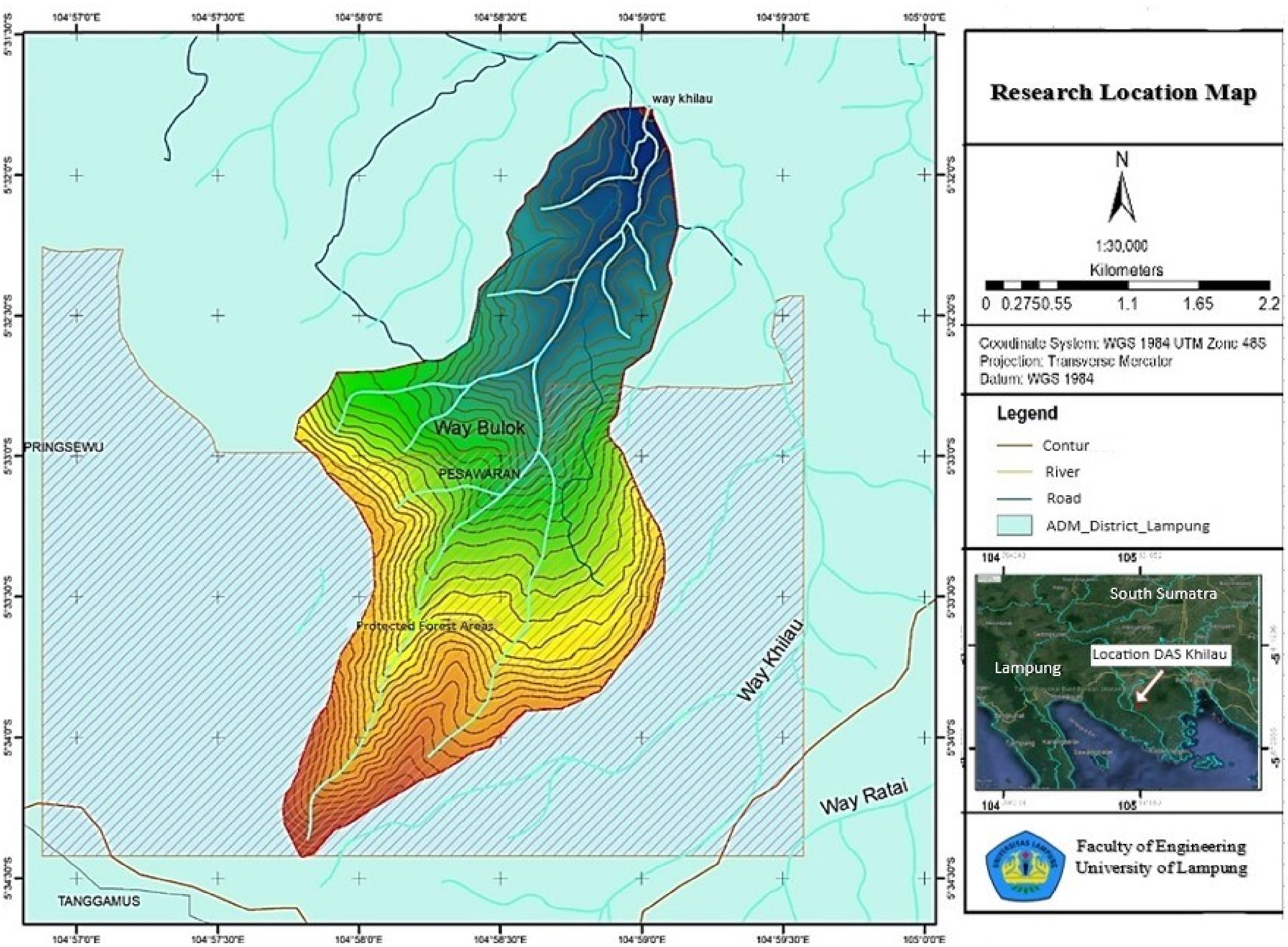


Figure 1 Research locatio

2.2 Research Instruments

The measurement used the NTU-18 turbidity sensor tool, see Figure 2. The tool has been previously calibrated with the SGZ-200 tool based on the equation y = 1.1038X - 13.323 and has been converted from NTU to PPM with the equation y = 1.718X - 1037.2 [15].

Figure 2 NTU-18 Sediment Estimator

2.3 Data Retrieval

The data collection process with the NTU-18 was carried out once per day based on the following steps:

1. Connect the system to the power supply to turn on the device.
2. Check the SD card LED light to check whether it is on and ready for operation to save the data then wait until the light turns off.
3. Place the sediment detector outdoors for approximately 2-3 minutes until the GPS light comes on (GPS has locked the position).
4. The turbidity sensor is then inserted into the clear water sample for calibration. The point where the turbidity value is zero NTU will be used as the clear water turbidity measurement point.
5. Measurements are taken on the river to be tested.
6. Data was collected for at least 5 minutes at one location, before moving on to another location.
7. Dry and clean the tool after use.
8. The data obtained from the tools are:
    - Flow velocity in cm/sec
    - River turbidity (Suspended Solution) in NTU
    - Data collection location (Latitude-Longitude)
    - Time of data collection (year, month, date, hour, minute, second)
9. Other data for calculations that need to be measured directly using a meter are:
    - Tool height (m)
    - Water depth (m)

The data collection process is shown in Figure 3 and Figure 4. The measurement data is shown in Table 1.

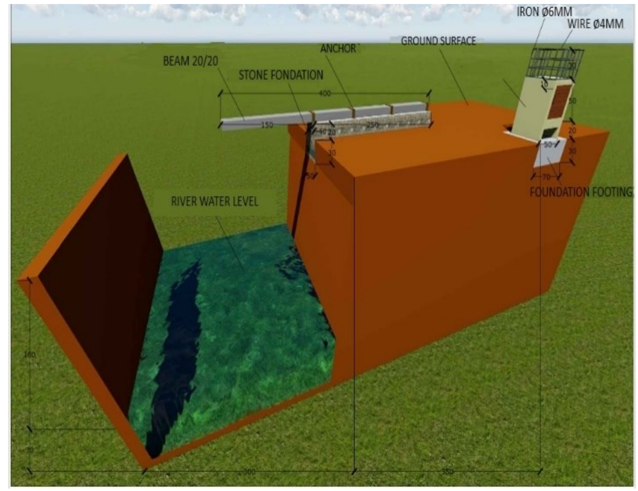


Figure 3 Placement of elevation detection device

Figure 4 Data collection with NTU-18 at Way Khilau

2.4 Rouse Equation

To calculate the sediment distribution requires an understanding of the Rouse equation [21], which is based on a logarithmic velocity distribution. Assuming that the sediment diffusion coefficient is equal to the momentum transfer coefficient, the following equation is used:

$$\frac{C_s}{C_a} = \left[\frac{D-y}{y} \quad \frac{a}{D-a}\right]^Z \text{ with } Z = \frac{W_s}{k\,U^*} \quad \ldots\ldots(1)$$

Where:

C_s = Sediment concentration (g/L)
C_a = Reference concentration that is a distance away from the reference point (g/L)
D = Depth of flow (m)
y = Vertical measurement point measured to the surface from the bottom (m)
a = Reference level (m)
Z = Rouse Parameters (*Rouse Number*)

W_s = Suspended sediment particle fall/settling velocity (m/ sec)
U* = Shear velocity (m/sec)
k = Von Karman Constant (k ≈ 0,4)

Then, the formula for finding the fall velocity of suspended sediment particles (W_s) can be estimated by the formula [22] as follows:

$$W_s = -4e^{-7}C_s^2 + 1{,}93e^{-5}C_s - 0{,}0001314 \quad (2)$$

where:
W_s = Sediment falls velocity (m/sec)
C_s = Sediment concentration (kg/m³)

Table 1 Sediment measurement results with NTU-18 in Way Khilau watershed for 30 days

No.	Retrieval	Turbidity (NTU)	D (m)	v (m/s)	A (m²)	y' (m)	y (m)	Q (m³/s)	B (m)	B/D	Fr	D90 (m)	z/z0	K	U*
1	Day 1	200.1	0.38	0.05	0.93	0.13	0.25	0.049	3.5	9.21	0.027	0.008	32.05	0.4	0.0061
2	Day 2	198.5	0.37	0.05	0.88	0.14	0.23	0.045	3.5	9.46	0.027	0.008	29.49	0.4	0.0061
3	Day 3	195.4	0.34	0.05	0.76	0.12	0.22	0.036	3.5	10.29	0.026	0.008	28.21	0.4	0.0057
4	Day 4	195	0.33	0.05	0.72	0.15	0.18	0.033	3.5	10.61	0.025	0.008	23.08	0.4	0.0058
5	Day 5	196.1	0.31	0.04	0.64	0.12	0.19	0.027	3.5	11.29	0.025	0.008	24.36	0.4	0.0054
6	Day 6	198.3	0.31	0.04	0.62	0.13	0.175	0.026	3.5	11.48	0.025	0.008	22.44	0.4	0.0055
7	Day 7	193.6	0.31	0.04	0.64	0.11	0.2	0.027	3.5	11.29	0.025	0.008	25.64	0.4	0.0053
8	Day 8	197.8	0.32	0.04	0.68	0.1	0.222	0.031	3.5	10.87	0.025	0.008	28.46	0.4	0.0053
9	Day 9	197.8	0.36	0.05	0.82	0.09	0.265	0.040	3.5	9.86	0.026	0.008	33.97	0.4	0.0056
10	Day 10	185.8	0.39	0.05	0.97	0.11	0.28	0.053	3.5	8.97	0.028	0.008	35.90	0.4	0.0061
11	Day 11	196.3	0.36	0.05	0.84	0.12	0.24	0.042	3.5	9.72	0.027	0.008	30.77	0.4	0.0058
12	Day 12	194.6	0.33	0.05	0.70	0.09	0.235	0.031	3.5	10.77	0.025	0.008	30.13	0.4	0.0053
13	Day 13	194	0.31	0.04	0.64	0.14	0.17	0.027	3.5	11.29	0.025	0.008	21.79	0.4	0.0056
14	Day 14	191.5	0.30	0.04	0.60	0.09	0.21	0.025	3.5	11.67	0.024	0.008	26.92	0.4	0.0051
15	Day 15	191.2	0.29	0.04	0.56	0.09	0.2	0.022	3.5	12.07	0.024	0.008	25.64	0.4	0.0050
16	Day 16	198.1	0.32	0.04	0.68	0.12	0.2	0.030	3.5	10.94	0.025	0.008	25.64	0.4	0.0055
17	Day 17	198.8	0.31	0.04	0.64	0.11	0.2	0.027	3.5	11.29	0.025	0.008	25.64	0.4	0.0053
18	Day 18	195.4	0.30	0.04	0.60	0.13	0.172	0.025	3.5	11.59	0.024	0.008	22.05	0.4	0.0054
19	Day 19	197.2	0.31	0.04	0.62	0.15	0.155	0.026	3.5	11.48	0.025	0.008	19.87	0.4	0.0057
20	Day 20	198.2	0.28	0.04	0.53	0.14	0.142	0.021	3.5	12.41	0.024	0.008	18.21	0.4	0.0054
21	Day 21	210.5	0.45	0.06	1.22	0.11	0.335	0.075	3.5	7.87	0.030	0.008	42.95	0.4	0.0066
22	Day 22	197.4	0.28	0.04	0.52	0.07	0.21	0.020	3.5	12.50	0.023	0.008	26.92	0.4	0.0047
23	Day 23	199.5	0.27	0.04	0.48	0.15	0.115	0.018	3.5	13.21	0.023	0.008	14.74	0.4	0.0055
24	Day 24	199.9	0.29	0.04	0.56	0.1	0.19	0.022	3.5	12.07	0.024	0.008	24.36	0.4	0.0051
25	Day 25	194.4	0.29	0.04	0.54	0.15	0.135	0.021	3.5	12.28	0.024	0.008	17.31	0.4	0.0056
26	Day 26	189.9	0.27	0.04	0.50	0.15	0.123	0.019	3.5	12.82	0.023	0.008	15.77	0.4	0.0055
27	Day 27	196.1	0.28	0.04	0.51	0.15	0.125	0.019	3.5	12.73	0.023	0.008	16.03	0.4	0.0055
28	Day 28	195.2	0.31	0.04	0.64	0.07	0.24	0.027	3.5	11.29	0.025	0.008	30.77	0.4	0.0050
29	Day 29	192.6	0.28	0.04	0.51	0.15	0.125	0.019	3.5	12.73	0.023	0.008	16.03	0.4	0.0055
30	Day 30	188.4	0.29	0.04	0.56	0.07	0.22	0.022	3.5	12.07	0.024	0.008	28.21	0.4	0.0048

2.5 Data Analysis

Data analysis was conducted using the following steps:

1. The data used are data on velocity (W_s), depth (D), water turbidity (C) and tool height.
2. Convert the C value into PPM units with a conversion value of 200.1 NTU = 66.70 ppm = 0.067 Kg/m³.
3. Find the value of the falling velocity of suspended sediment particles (W_s) based on Equation 2.

4. Calculation of Rouse parameters (Z) based on equation 1.
5. Calculating the sediment concentration value (C_s) with the Rouse equation.
6. Created a comparison graph between the depth of the reference level and the ratio of sediment distribution to its mean value.
7. Based on the graph, an equation will be obtained to estimate the amount of sediment at all depths.

3.0 RESULTS AND DISCUSSION

3.1 Particle Falling Velocity

The suspended sediment particle fall velocity (W_s) is a fixed velocity achieved by allowing particles to fall freely through liquid and gaseous media [23]. Several factors affect this velocity including particle shape, size, mass, temperature, density, and viscosity. For W_s values, see Table 2.

3.2 Rouse Parameters

The Rouse parameter (Z) is a parameter used in sediment science to describe the relationship between fluid flow velocity and sediment particle size [22]. This parameter is commonly used to characterize the behavior of sediment particles in the flow as well as determine whether sediment particles will settle, remain floating or suspended in the flow. Rouse parameter values are smaller than one indicates that particles tend to settle, while values greater than one indicate that particles tend to remain suspended in the flow. Z values can be seen Table 2.

Table 2 Calculation of Ws and Z values

No.	Retrieval	Turbidity			Depth		W_s	U*	K	Z
		(NTU)	(PPM)	(Kg/M³)	D (cm)	D (m)	g/L	m/s		
1	Day 1	200.1	66.70	0.067	38	0.38	0.0007	0.006	0.4	0.002
2	Day 2	198.5	66.17	0.066	37	0.37	0.0007	0.006	0.4	0.002
3	Day 3	195.4	65.13	0.065	34	0.34	0.0007	0.006	0.4	0.002
4	Day 4	195	65.00	0.065	33	0.33	0.0007	0.006	0.4	0.002
5	Day 5	196.1	65.37	0.065	31	0.31	0.0007	0.005	0.4	0.002
6	Day 6	198.3	66.10	0.066	30.5	0.305	0.0007	0.005	0.4	0.002
7	Day 7	193.6	64.53	0.065	31	0.31	0.0007	0.005	0.4	0.002
8	Day 8	197.8	65.93	0.066	32.2	0.322	0.0007	0.005	0.4	0.002
9	Day 9	197.8	65.93	0.066	35.5	0.355	0.0007	0.006	0.4	0.002
10	Day 10	185.8	61.93	0.062	39	0.39	0.0007	0.006	0.4	0.002
11	Day 11	196.3	65.43	0.065	36	0.36	0.0007	0.006	0.4	0.002
12	Day 12	194.6	64.87	0.065	32.5	0.325	0.0007	0.005	0.4	0.002
13	Day 13	194	64.67	0.065	31	0.31	0.0007	0.006	0.4	0.002
14	Day 14	191.5	63.83	0.064	30	0.3	0.0007	0.005	0.4	0.002
15	Day 15	191.2	63.73	0.064	29	0.29	0.0007	0.005	0.4	0.002
16	Day 16	198.1	66.03	0.066	32	0.32	0.0007	0.005	0.4	0.002
17	Day 17	198.8	66.27	0.066	31	0.31	0.0007	0.005	0.4	0.002
18	Day 18	195.4	65.13	0.065	30.2	0.302	0.0007	0.005	0.4	0.002
19	Day 19	197.2	65.73	0.066	30.5	0.305	0.0007	0.006	0.4	0.002
20	Day 20	198.2	66.07	0.066	28.2	0.282	0.0007	0.005	0.4	0.002
21	Day 21	210.5	70.17	0.070	44.5	0.445	0.0008	0.007	0.4	0.002
22	Day 22	197.4	65.80	0.066	28	0.28	0.0007	0.005	0.4	0.002
23	Day 23	199.5	66.50	0.067	26.5	0.265	0.0007	0.005	0.4	0.002
24	Day 24	199.9	66.63	0.067	29	0.29	0.0007	0.005	0.4	0.002
25	Day 25	194.4	64.80	0.065	28.5	0.285	0.0007	0.006	0.4	0.002
26	Day 26	189.9	63.30	0.063	27.3	0.273	0.0007	0.006	0.4	0.002
27	Day 27	196.1	65.37	0.065	27.5	0.275	0.0007	0.006	0.4	0.002
28	Day 28	195.2	65.07	0.065	31	0.31	0.0007	0.005	0.4	0.002
29	Day 29	192.6	64.20	0.064	27.5	0.275	0.0007	0.006	0.4	0.002
30	Day 30	188.4	62.80	0.063	29	0.29	0.0007	0.005	0.4	0.002

3.3 Sediment Concentration

Sediment concentration (C_s) refers to the mass amount of sediment contained in a given volume of water or liquid [24]. Factors that affect Cs are flow velocity, substrate type, human activity and hydrological conditions. Sediment concentration (C_s) values were calculated based on the Rouse equation at each data collection time with the reference level depth increasing by 0.05 m to the riverbed. The C_s values from day 1 to day 5 are shown in Tables 3, 4, 5, 6 and 7.

3.4 Sediment Distribution Ratio

Sediment distribution ratio is a parameter that describes the particle size distribution in a sediment sample [24]. Particle size distribution can vary from fine to coarse particles. One way to describe the sediment size distribution is to use the sediment distribution ratio.

In the calculation, after obtaining C_s at each depth, the values are averaged. After that, the ratio of sediment distribution to the average concentration value is calculated so that the amount of Khilau watershed sediment at each depth is obtained. The calculation results can be seen in Tables 3, 4, 5, 6 and 7.

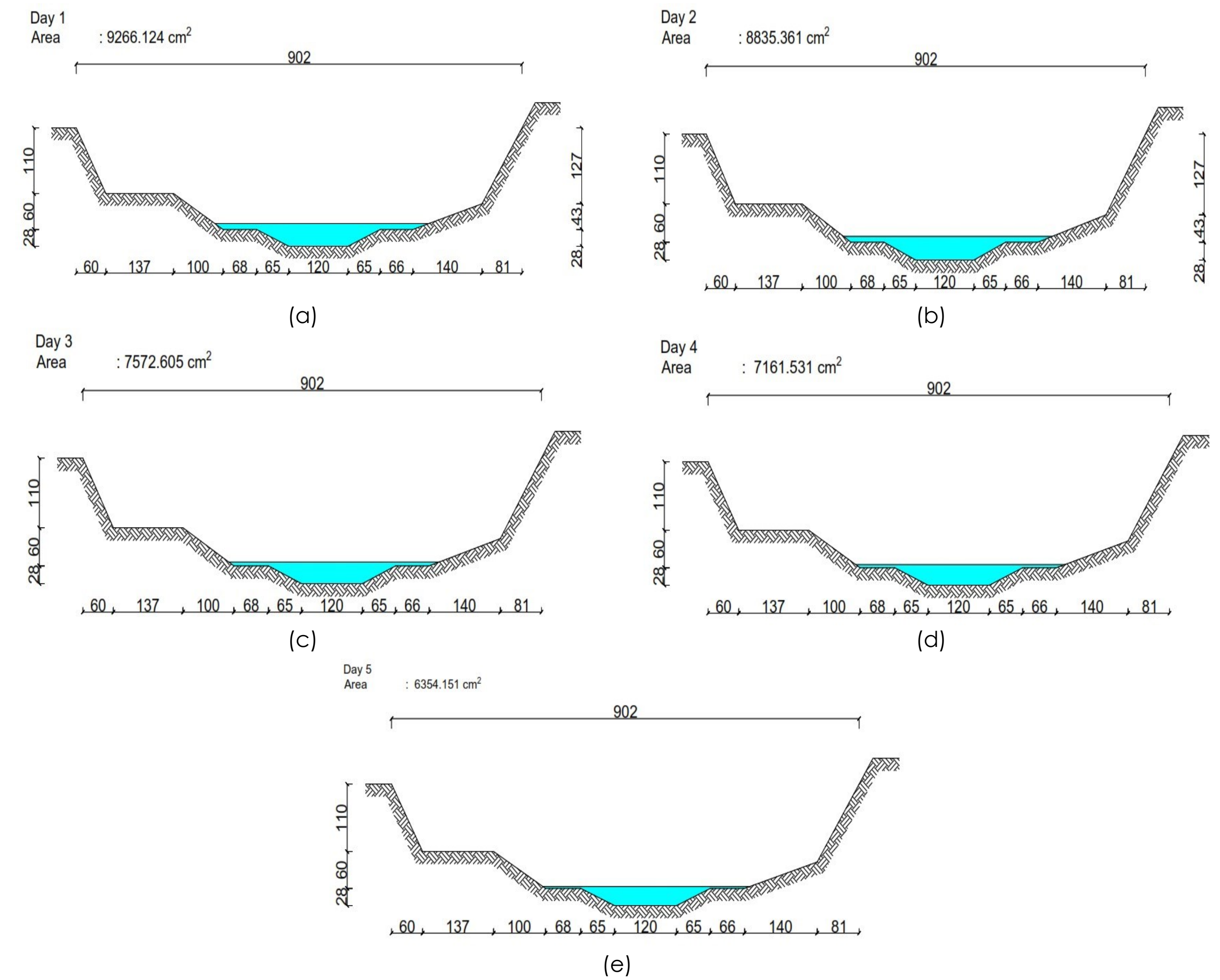


Figure 5 Cross section of way khilau river day 1 to 5 (in cm units)

Table 3 Calculation results of sediment distribution of day 1

Reference Level Depth (a)	Reference Concentration (C_a)	Flow Depth (D)	Retrieval height (y)	Z	Sediment Distribution (C_s)		Ratio
(m)	(ppm)	(m)	(m)		ppm	g/L	
0.05	66.70	0.38	0.33	0.002	66.255	0.066	0.991
0.10	66.70	0.38	0.28	0.002	66.457	0.066	0.994
0.15	66.70	0.38	0.23	0.002	66.599	0.067	0.996
0.20	66.70	0.38	0.18	0.002	66.725	0.067	0.998
0.25	66.70	0.38	0.13	0.002	66.855	0.067	1.000
0.30	66.70	0.38	0.08	0.002	67.013	0.067	1.003
0.35	66.70	0.38	0.03	0.002	67.283	0.067	1.007
0.37	66.70	0.38	0.01	0.002	67.559	0.068	1.011
Average						0.067	

Table 4 Calculation results of sediment distribution of day 2

Reference Level Depth (a)	Reference Concentration (C_a)	Flow Depth (D)	Retrieval height (y)	Z	Sediment Distribution (C_s)		Ratio
(m)	(ppm)	(m)	(m)		ppm	g/L	
0.05	66.17	0.37	0.32	0.002	65.737	0.066	0.991
0.10	66.17	0.37	0.27	0.002	65.936	0.066	0.994
0.15	66.17	0.37	0.22	0.002	66.078	0.066	0.996
0.20	66.17	0.37	0.17	0.002	66.204	0.066	0.998
0.25	66.17	0.37	0.12	0.002	66.337	0.066	1.000
0.30	66.17	0.37	0.07	0.002	66.506	0.067	1.003
0.35	66.17	0.37	0.02	0.002	66.835	0.067	1.008
0.36	66.17	0.37	0.01	0.002	67.005	0.067	1.010
Average						0.066	

Table 5 Calculation results of sediment distribution of day 3

Reference Level Depth (a)	Reference Concentration (C_a)	Flow Depth (D)	Retrieval height (y)	Z	Sediment Distribution (C_s)		Ratio
(m)	(ppm)	(m)	(m)		ppm	g/L	
0.05	65.13	0.34	0.29	0.002	64.739	0.065	0.992
0.10	65.13	0.34	0.24	0.002	64.937	0.065	0.995
0.15	65.13	0.34	0.19	0.002	65.080	0.065	0.997
0.20	65.13	0.34	0.14	0.002	65.214	0.065	0.999
0.25	65.13	0.34	0.09	0.002	65.363	0.065	1.002
0.30	65.13	0.34	0.04	0.002	65.588	0.066	1.005
0.33	65.13	0.34	0.01	0.002	65.924	0.066	1.010
Average						0.065	

Table 6 Calculation results of sediment distribution of day 4

Reference Level Depth (a)	Reference Concentration (C_a)	Flow Depth (D)	Retrieval height (y)	Z	Sediment Distribution (C_s)		Ratio
(m)	(ppm)	(m)	(m)		ppm	g/L	
0.05	65.00	0.33	0.28	0.002	64.616	0.065	0.992
0.10	65.00	0.33	0.23	0.002	64.814	0.065	0.995
0.15	65.00	0.33	0.18	0.002	64.959	0.065	0.997
0.20	65.00	0.33	0.13	0.002	65.096	0.065	0.999
0.25	65.00	0.33	0.08	0.002	65.255	0.065	1.002
0.30	65.00	0.33	0.03	0.002	65.517	0.066	1.006
0.32	65.00	0.33	0.01	0.002	65.780	0.066	1.010
Average						0.065	

Table 7 Calculation results of sediment distribution of day 5

Reference Level Depth (a)	Reference Concentration (C_a)	Flow Depth (D)	Retrieval height (y)	Z	Sediment Distribution (C_s)		Ratio
(m)	(ppm)	(m)	(m)		ppm	g/L	
0.05	65.37	0.31	0.26	0.002	64.994	0.065	0.993
0.10	65.37	0.31	0.21	0.002	65.199	0.065	0.996
0.15	65.37	0.31	0.16	0.002	65.352	0.065	0.998
0.20	65.37	0.31	0.11	0.002	65.502	0.066	1.000
0.25	65.37	0.31	0.06	0.002	65.691	0.066	1.003
0.30	65.37	0.31	0.01	0.002	66.142	0.066	1.010
Average						0.065	

Based on Table 3, 4, 5, 6 and 7, a graph of the relationship between depth from the bottom (retrieval height) and the sediment distribution ratio was made, see Figure 6.

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The amount of sediment distribution is then averaged at each retrieval time to obtain the sediment concentration (C_s) for 30 days. See Table 7.

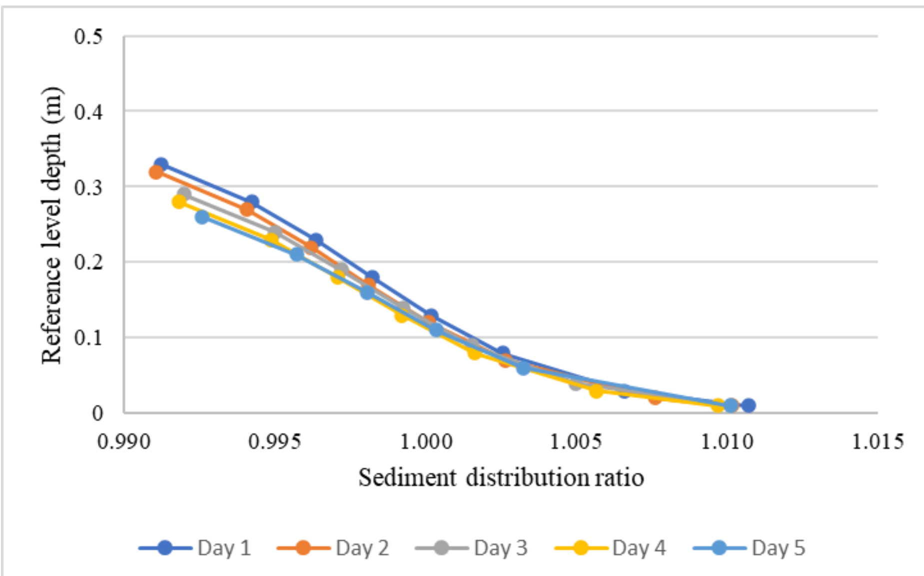

Figure 6 Sediment distribution graph from day 1 to day 5

Table 8 30-day sediment concentration results

No	Retrieval	Depth (D) m	Sediment Concentration (C_s) gr/L	No	Retrieval	Depth (D) m	Sediment Concentration (C_s) gr/L
1	Day 1	0.380	0.067	16	Day 16	0.320	0.066
2	Day 2	0.370	0.066	17	Day 17	0.310	0.066
3	Day 3	0.340	0.065	18	Day 18	0.302	0.065
4	Day 4	0.330	0.065	19	Day 19	0.305	0.066
5	Day 5	0.310	0.065	20	Day 20	0.282	0.066
6	Day 6	0.305	0.066	21	Day 21	0.445	0.070
7	Day 7	0.310	0.065	22	Day 22	0.280	0.066
8	Day 8	0.322	0.066	23	Day 23	0.265	0.067
9	Day 9	0.355	0.066	24	Day 24	0.290	0.067
10	Day 10	0.390	0.062	25	Day 25	0.285	0.065
11	Day 11	0.360	0.066	26	Day 26	0.273	0.064
12	Day 12	0.325	0.065	27	Day 27	0.275	0.066
13	Day 13	0.310	0.065	28	Day 28	0.310	0.065
14	Day 14	0.300	0.064	29	Day 29	0.275	0.064
15	Day 15	0.290	0.064	30	Day 30	0.290	0.063

3.5 Sediment Distribution Analysis

Based on all the data from the measurement of sediment using turbidity sensor NTU-18 in table 1 and the calculation of the distribution ratio in table 3, 4, 5, 6, 7 and 8, sediment distribution graphs for 30 days were made, see Figure 7. The x-axis represents the ratio of sediment distribution to the average concentration value, while the y-axis represents the depth of retrieval from the bottom/depth of the reference level in meters. There are three sediment distribution lines calculated using the Rouse equation (green and yellow) and sediment distribution lines from previous research using the Rouse equation and the Tanaka and Sugimoto equation (black) [2].

The equation obtained can be used to estimate the amount of sediment because the resulting graph shows similarities in shape. However, the line in [2] is a little different, where the ratio of 0.995 to the ratio of 0.990 the line is more uphill when compared with the results of the calculation but still in the range. Then the amount of sediment in Khilau watershed can be estimated by the equation $y = 502.58 X^2 - 1017.4 X + 514.85$ and the equation $y = 604.12 X^2 - 1228.8 X + 624.81$. The graph shows that the sediment in the Khilau watershed tends to be bed load because of the relatively low flow velocity conditions, especially on the riverbed.

The flow velocity will get smaller when approaching the bottom of the channel because of the friction between the water flow and the bottom of the channel, causing the flow velocity to decrease and the sediment concentration at the bottom of the river to increase. Based on the value of the Rouse parameter, it can also be concluded that the value obtained is smaller than one, which indicates that particles tend to settle to the bottom of the channel.

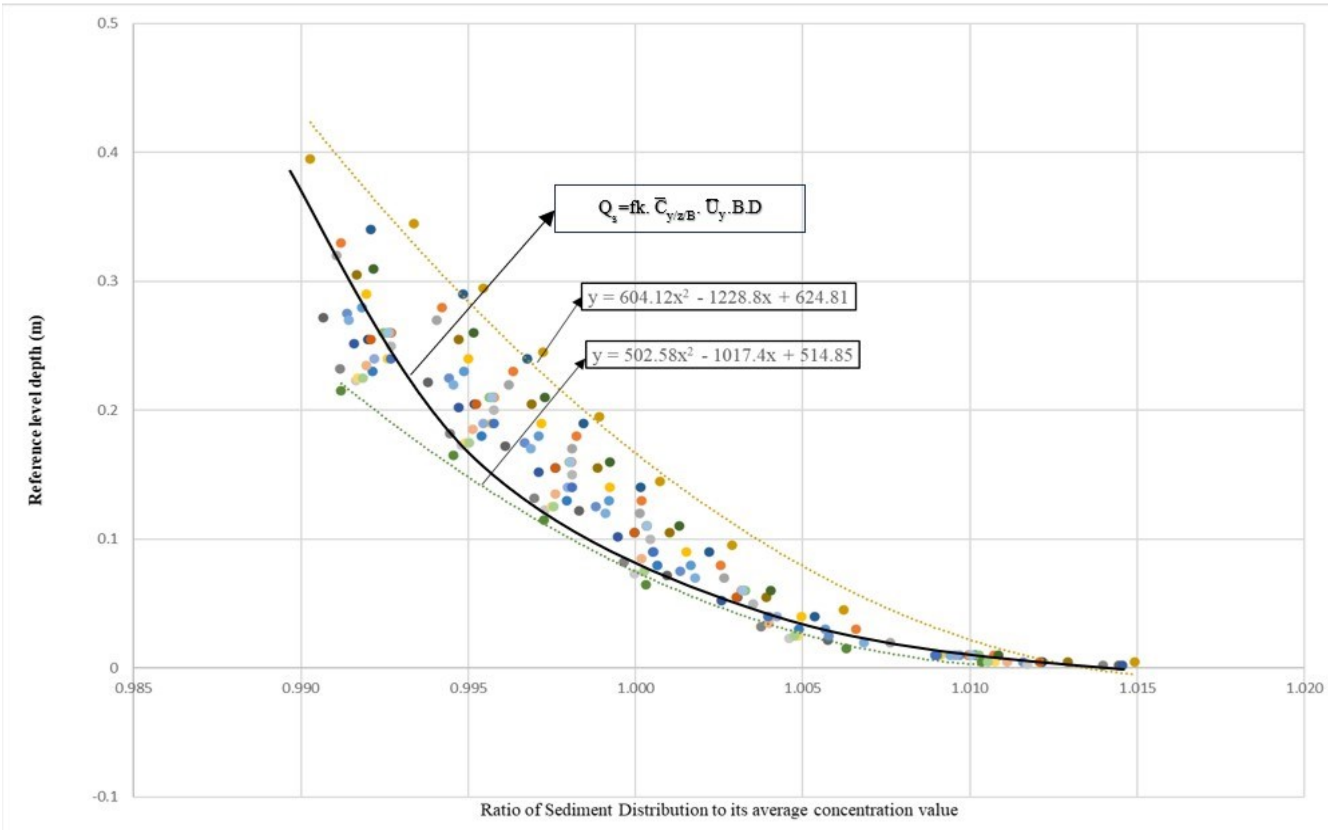

Figure 7 Sediment distribution graph for 30 days

4.0 CONCLUSION

The conclusion is that the amount of sedimentation in the Way Khilau watershed can be estimated using the Rouse equation, although only with certain points and amount of data and sediment at all river depths can be calculated. Thus, the use of the NTU-18 tool for sediment estimation can be easier even in real time at the research site.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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