Analysis of Sediment Characteristics and Sedimentation Rate of the Noling River, Luwu Regency

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Abstract

The Noling River plays an important role in the lives of the surrounding communities; however, it faces sedimentation problems that lead to riverbed aggradation, infrastructure disturbances, and reduced flow capacity. This study aims to determine the sediment characteristics and the rate of sedimentation in the Noling River, Luwu Regency. Sediment samples were collected from the midstream section of the river and analyzed in the laboratory to determine grain size distribution, specific gravity, and physical characteristics of the sediment. The results show that the Noling River sediment is dominated by sand (57.4%), gravel (31.8%), and silt/clay (10.9%), with a sediment classification of sandy clay. The sedimentation rate was calculated using both direct measurement and empirical approaches (Meyer-Peter and Duboys methods). The average suspended sediment load was found to be 5,251.97 tons/month, while the bed load reached 1,102.91 tons/month. The flow velocity, which exceeds the sediment fall velocity, indicates that sediment transport occurs actively. The findings of this study are expected to serve as a reference for better river management and future sedimentation mitigation efforts.

Keywords: Bed Load, Noling River, River Management, Sediment Characteristics, Sedimentation, suspended load

INTRODUCTION

A river is a natural stream of water above the earth's surface that holds rainwater while also draining it to lower areas such as lakes or seas. In addition to draining water, rivers also transport sediments found in the river water. So the sediment is washed away by the flow of river water, which can be distinguished as a bed *load* and a *suspended load* (Mansida, 2017). Meanwhile, according to Rivers, it is a network of channels that form naturally on the earth's surface. Therefore, rivers have the function of collecting rainwater and dumping it into the sea (Wardhana, 2015).

The problems that occur in rivers are complicated not as they seems. In addition to flowing water, the river also carries out sediment transportation activities. Sediment comes from an erosion or erosion event. The erosion series in the sediment will be deposited in places where the flow speed is slow or stopped. When sediment enters the river, sediment transportation occurs. Sediment is loose material produced from the weathering process of rocks and organisms, which are then transported by a medium such as water, wind, or ice, and deposited in a certain location such as a basin or valley (Sukandarrumidi, 2018). In addition, the large size of sediment in the water causes turbidity and can even harm the flora and fauna of the river/sea because it blocks the sun from photosynthesis (Hardjojo & Djokosetiyanto, 2005).

The sediment transport process occurs when sediment enters the river body. Two factors that affect the speed of transportation are the speed of the river flow and the size of the sediment particles. Flowing water can transport small sediment particles such as clay and silt in dissolved form (wash load). However, larger particles, such as sand, usually move by jumping (Asdak, 2023). Sediment transport is the displacement of *granular* (non-cohesive) material from sediment caused by the flow of water moving in the direction of the flow (Mardjikoen, 1987) . A very important property of sediment is the size of the sediment grains as it is used to indicate the resistance of the sediment to transport agents (Purbandono & Junarsyah 2005).

The Noling River area is a river area in South Sulawesi province located in Luwu Regency. The Noling River flows from the slopes of Mount Latimojong and the slopes of Mount Batu which crosses 3 sub-districts, namely: Bupon District, Ponrang District, South Ponrang District. The Noling River is one of the most valuable natural assets for the local community, not only as an important water source but also as a center of social and economic activities as well as a source of agricultural and plantation water in the 3 sub-districts. However, this river faces serious challenges in the form of increasing sedimentation, threatening the well-being of the surrounding communities.

The cases that occurred, namely:

1. River Siltation (2020). In 2020, siltation occurred at several points of the Noling River. Sediment accumulation reduces the capacity of water flow, this siltation results in waterlogging in several residential areas and agricultural land in Ponrang and South Ponrang Districts.
2. Irrigation Siltation (2020-2024). Since 2020, the irrigation system that depends on the Noling River has experienced significant siltation. Irrigation channels become shallow, reducing the efficiency of water flow.
3. Disruption to infrastructure (Bridges). In April 2024, there will be friction in the middle foundation of the bridge where the cause is erosion and sediment carried away. It resulted in an increase in maintenance costs and disruption of the community's economic activities because this bridge connects Noling village with Makating village.
4. The lip of the river collapsed (2022). In 2022, one part of the mouth of the Noling River collapsed due to excessive erosion. This event caused road damage and endangered nearby settlements and corn plantations.

Increased sedimentation in the Noling River has been a major concern for local authorities and the communities living along this river. However, a deep understanding of the characteristics of sediments carried by rivers and the rate of sedimentation that occurs is still lacking, complicating mitigation management efforts.

The presence of high sediments today is the result of high dynamic stability and the presence of sediments greatly affects the characteristics and causes dynamics related to human well-being. For example, the quality of flood water that needs to be considered and the subsidence of the soil level due to the influence of sedimentation. This situation causes the river to drain water less than optimally. In many cases, sedimentation on the banks of the Noling River increases due to the soil sediment that is quickly eroded.

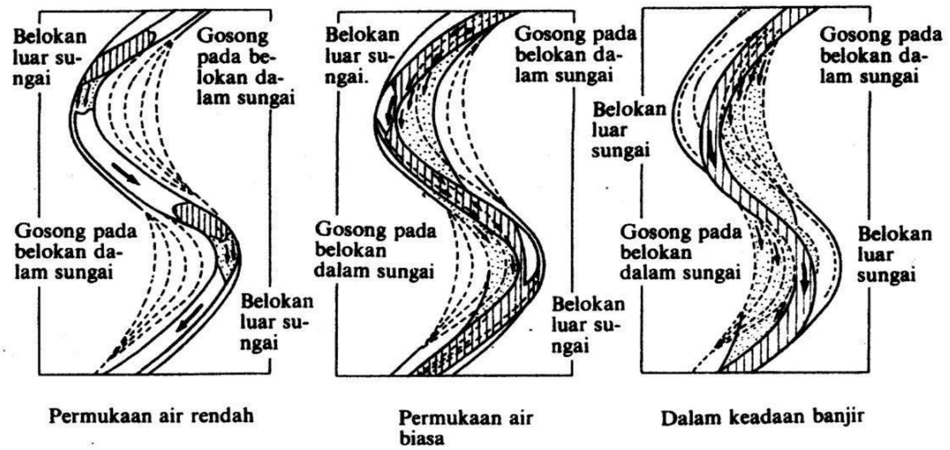

Figure 1. The progress of sediment movement and the displacement of sedimentation areas due to changes in the water level (Sosrodarsono and Tominaga 1994) .

Sedimentation is an event of deposition of rock material that is transported by hydropower or wind. When erosion occurs, water carries the rock flowing into rivers, lakes, and eventually reaches the sea. When its transport power is reduced or depleted, the rock is deposited in the watershed (Virlayani et al. 2024). As for specific gravity, it is the ratio between the weight of sediment particles and the volume of water (Ponce, 1989).

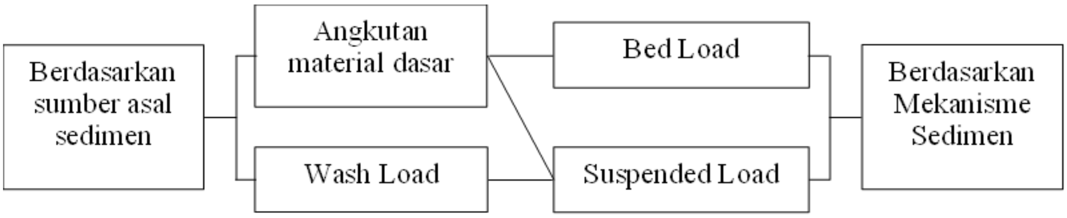

Figure 2. Chart of the mechanism and origin of sedimentary materials (Luka, 2014) **.**

The shape of the channel, the roughness of the walls, the free surface, and the discharge of the flow are some of the factors that affect the distribution of the flow speed through the open channel. The velocity distribution is uneven at each point on the transverse view as shown in the following figure:

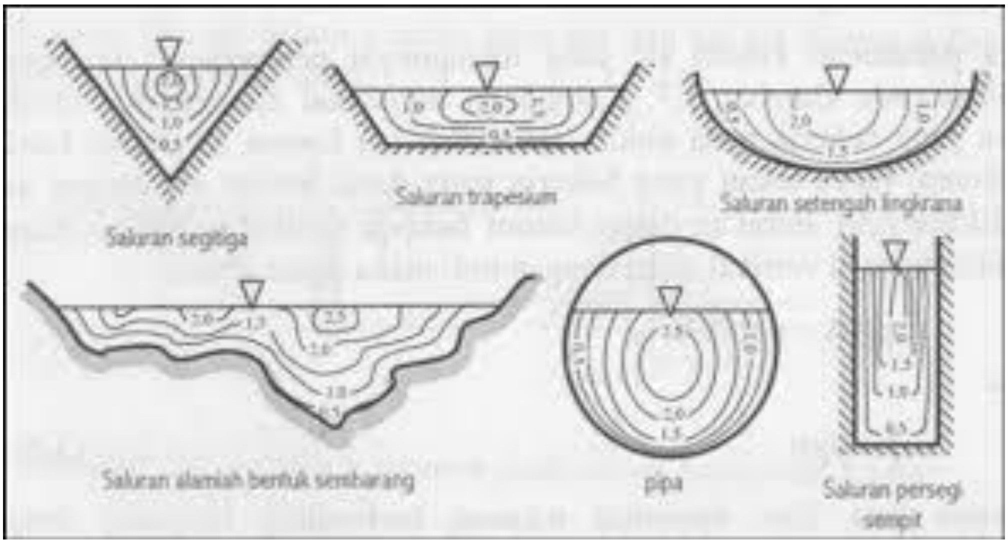

Figure 3. A wide variety of cross sections (Triatmodjo, 1996)

In this study, the goal is to find out the sediment characteristics of the Noling River and to analyze and determine the magnitude of the rate of basic sediment and sediment drifting on the Noling River.

METHODS

Research Location

This research was conducted in Padang Ma'bud Village, right in the middle of the Noling River. Where the Noling River headwaters on the slopes of Mount Latimojong and Mount Batu, then crosses Luwu Regency. Then this river flows east to Kamanre District and empties into Bone Bay. However, in the upstream area, this river is better known as the Paremang River.

Figure 4. Map of the research location on the Noling river *(Google earth)*

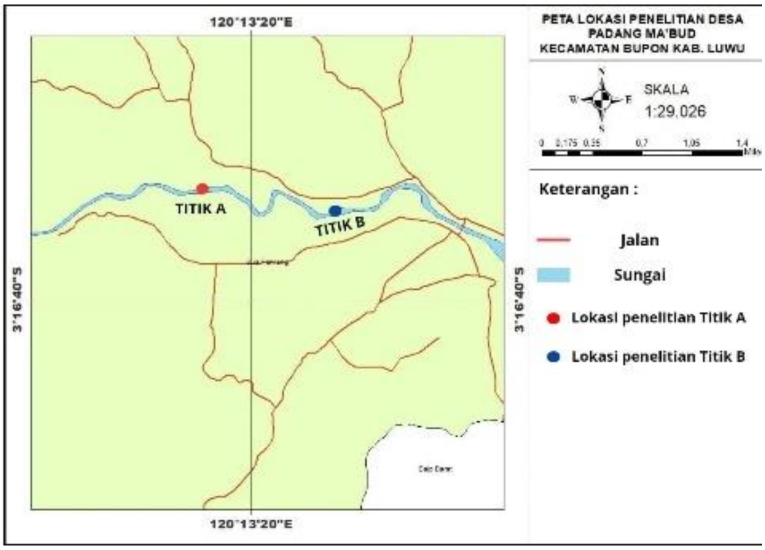

Figure 5. Map of the research location on the Noling river (ArcGIS)

Data Source

The two data sources of this study are as follows:

1. Primary data is data collected directly at the research site through observation and documentation of the condition of the Noling River
2. Secondary data collected from various institutions and literature studies are used as a complement and support to primary data.

Research Procedure

The research process is carried out by:

1. Sampling in a specific location, or rather in the middle of the Noling River
2. Samples are dried, sifted, and checked for specific gravity
3. Sieve analysis was carried out to determine the type of sediment material based on the granules
4. This test results in the distribution and size of sediment particles using a filter that complies with ASTM D 422.
5. Sediment specific gravity testing was carried out based on SNI 1964:2008. This International Standard specifies a test method for measuring the density of soil passing through a 0.425 mm diameter sieve (No. 40)
6. After the sample is taken with sieve no. 40, the dissolved sample is put in a pan (barrel) and put in the oven for 24 hours.
7. The sample is ready for data collection and specific gravity measurement after calcination for 24 hours.
8. Calculations of base sediment and floating sediment can be carried out using sediment content, based on laboratory data.

RESULTS AND DISCUSSION

Calculation of Sediment Characteristics

1. Filter Analysis

Sieve analysis was carried out to determine the distribution of sediment grain size in the analyzed sample and to determine the physical characteristics of the sediment. The results of the analysis carried out in the laboratory are as follows:

Table 1. Result of the percentage of sediment type

Types of Sediment	Point A	Point B
Gravel	32,7%	30,9%
Sand	58,1%	56,6%
Lanau / Clay	9,3%	12,5%

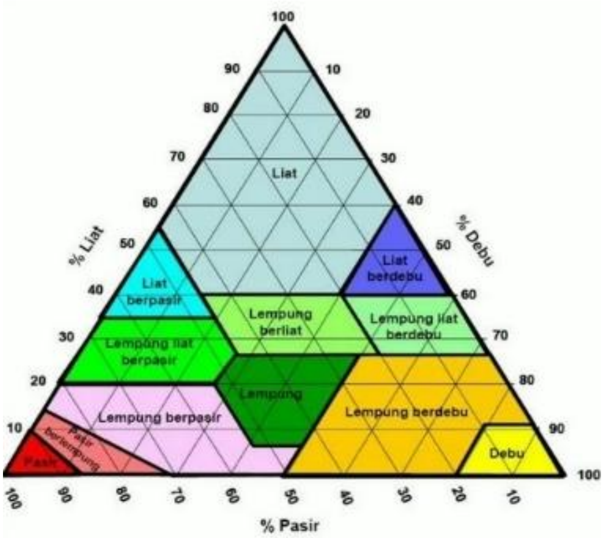

Figure 6. *USDA Textural Soil triangle*

Based on filter analysis data, the classification of sediment is based on the triangle of the USDA (*United States Department of Agriculture*) which is usually used based on sand, silt, and clay, not gravel. In this case we can ignore the gravel component because it is too large to be included in the USDA triangular classification and we only consider sand, silt and clay. So we position the sand (57.3%) on the bottom side and the silt (10.9%) on the left side, then we draw a line from the sand side according to the percentage up the left side, then we draw a straight line from the clay side to the dust side. Only then do we get the meeting of the two lines on sandy clay.

2. *Specific Gravity*

To find out the specific gravity of the basic sediment, sediment samples were first taken in the Noling River. Then, the sample is dried using an oven and weighed into 1500 grams, and the sampled sample is then weighed and separated based on a sieve. Once the sample is filtered, weigh and separate the retained amount based on the strain number. Then, 100 grams with the 3 finest samples are mixed with water and put in a cup and in the oven for 24 hours. After 24 hours in the oven, weigh the sample to compare wet and wet weight.

Table 2. Results of sediment specific gravity calculation

Point	Analysis Results
Point Specific Gravity A	2,68
Specific Gravity Point B	2,70
Average	2,69

Based on the specific gravity value above, it can be concluded that the sediment at the bottom of the Noling River is sandy (Nichols, 2009).

3. *Shear Stress (ʈ0) and Critical Shear Stress (ʈc)*

Known:

Specific Gravity of Water ()γw = 1000 Kg/m3

Channel Depth (h) = 0.5 m

Slope of the River Bed ()I = 0.01647 %

Specific Gravity of Basic Sediment ()γs = 2684 Kg/m3

to find the shear voltage value (ʈ0):

ʈ0 = $\gamma w \cdot h \cdot$ I

= $2686 \times 0{,}5 \times 0{,}01647$

= kg/m38,239

To find the value of the basic critical voltage (ʈc) the following calculations are used:

$$\tau c = \frac{\tau 0}{(ys-yw)h.s}$$
$$= \frac{8{,}239}{(2684-1000)0.5x0{,}016479}$$
$$= 0.594\ \frac{8{,}329}{13{,}8749}$$

4. *Fall Velocity*

When the falling velocity of the particles is spherical, the falling velocity can be represented as follows:

$$W = \left[\frac{4}{3} \cdot \frac{gd_s}{C_D} \cdot \frac{\rho_s - \rho_w}{\rho_w}\right] ½$$

Where:
w= Fall velocity (m/s)
g = gravitational acceleration (9.81 m/s2)
Ds = particle diameter (mm)
CD = solution coefficient /*drag coefficient* (dimensionless)
ρ_s = particle volume weight (g/cm3)
ρ_w = weight of water volume (1000 kg/m3)

The drag coefficient is a function of the Reynolds number () of a particle, which can be calculated as:R_e

$$R_e = \left[\frac{wd_{50}}{v}\right]$$

v is the kinematic viscosity of the liquid. For the Reynolds number, the particles are less than 0.1 so CD = 24/R. The rate of fall depends on temperature and viscosity, two particles of the same size, shape, and weight will not fall on the same liquid at different temperatures. Therefore to replace this CD value into equation 3.2 results in Stokes' law (Hambali & Apriyanti 2016):

$$w = \left[\frac{g{d_{50}}^2}{18_v}\right]\left(\frac{\rho_s - \rho_w}{\rho_w}\right)$$

So to calculate the rate of particle dropping:

Gravity Acceleration	(g)	= 9.81 m/s2
Grain Sieve Analysis	d_{50}	= 1.050 mm = 0.00105 m
Basic Sediment Specific Gravity	()ρ_s	= 2696 Kg/m3
Specific Gravity of Water	()ρ_w	= 1000 Kg/m3
Dynamic viscosity of water at 20°C (μ)		= 0.001002 kg/(m·s)

Finding value $V = \ = \frac{\mu}{\rho_w} \frac{0.001002}{1000} = 1{,}0x10^{-6}$ m2/s

$$w = \left[\frac{9{,}81.0{,}00105^2}{18x1{,}0x10^{-6}}\right]\left(\frac{2696-1000}{1000}\right)$$
$$= (0{,}6008625)(1{,}696)$$
$$= 1{,}019\ m/s$$

Basic Sediment Analysis

1. Field Measurements

Calculation of the basic sediment with direct measurements at the observation location did not obtain the discharge of the basic sediment load, so it is recommended to use the calculation. In this study, 20% of the floating sediment load is taken. As for the calculations: (Soewarno. 1991)

Calculation of basic sediment discharge (Qsd) per day:
$Qsd\ = Qsm\ x\ 20\%$
$Qsd\ = 12{,}811\ x\ 20\%$
$Qsd\ = 2{,}562$ tons/day

Calculation of the basic sediment discharge (Qsd) per month:
$Qsd\ = Qsm\ x\ 20\%$
$Qsd\ = \ 384{,}328\ x\ 20\%$
$Qsd\ = 78{,}866$ tons/month

Calculation of basic sediment discharge (Qsd) per year:
$Qsd\ = Qsm\ x\ 20\%$
$Qsd\ = 4675{,}996\ x\ 20\%$

$Qsd = 935{,}199$ tons/year

2. Analysis of Basic Sediments Using Peter's Meyer Method
Based on Peter's Mayer equation, the first step in calculating the coefficient of roughness, or *bed load*, is to calculate the average flow velocity.

Table 3. Results of basic sediment calculation using the Mayer peter method

Point	B(m)	A (m2)	Q (m3/sec)	V(m)	I (%)	N	n`	Ψ	Φ	QB (kg/sec)	Qb (tons/year)
A	30	14,10	43,44	3,08	0,01647	0,0148	0,0158	0,2071	83,708	0,0129	406,20
B	30	17,90	42,48	2,37	0,00678	0,01647	0,0158	0,51188	21,0658	0,00582	183,40

3. Basic Sediment Analysis Using the Duboys Method
For the calculation of the base sediment using the Duboys method, the first step is to find the shear stress value (Ʈ0) and the critical shear stress value at the bottom (Ʈc).

Table 4. The results of the calculation of the basic sediment using the duboys method

Point	B (m)	A (m2)	Q (m3/sec)	I (%)	ʈ0 (kg/m)	Ʈc	QB (kg/sec)	Qb (tons/year)
A	30	14,10	43,44	0,01647	8,239	0,594	0,01416	446,559
B	30	17,90	42,48	0,00678	2,786	0,590	0,01045	329,744

4. Basic sediment analysis uses the Shields approach to determine the condition of the river bed.
According to the shield approach, if the >frictional force applied by the water flow is large enough, in other words, the sediment will move and the water flow conditions are very strong to move the sediment significantly. For the condition of the channel base showing a value much greater than the value, then the channel base consists of coarse sediment that can be displaced or eroded by the existing water flow.$\tau_p \tau_c \tau_p \tau_c$

Table 5. Recapitulation of the calculation of the basic sediment

Bottom Sediment Size (Qb)	Based on Direct Measurements	Based on the Mayer-Peter Approach	Based on Duboys' Approach	Based on the Shield Approach
Qb Ton/year	935,199 ton	294.80 tons	388,152 tons	5771,015 tons

Based on the table above, the shield approach produces greater value than the other approaches while the Mayer-Peter and Duboys approaches are closer to each other. This suggests the possibility that the parameters used in the theoretical approach need to be further calibrated to match the real conditions at the research site.

CONCLUSION

Based on the findings and discussions in the previous chapter, we can come to the following conclusions:
From the data from the sediment sample test, the particle gradation and characteristics of the basic sediment in the Noling River are gravel (31.9%), sand (57.3%), and silt/clay (10.9%). For the size of the sediment grains is 1,050 mm and for uniform (homogeneous) sediment gradation. Based on the results of the sediment type weight, sand sediment was obtained, and the fall velocity was 1,019 m/s.

Based on the results of the calculation analysis, the sedimentation rate in the Noling River varies, with the direct measurement method producing a value of (935,199 tons/year), while the Meyer Peter and Duboys method gives lower and consistent results (294.80–388,152 tons/year). The Shields method shows the highest estimate (5771,015 tons/year), indicating the need to calibrate theoretical parameters to suit field conditions.

REFERENCE

Asdak, C. 2023. *Hydrology and watershed management*. Yogyakarta: Gadjah Mada University Press.

Hambali, R., and Y. Apriyanti. 2016. "Study of Sediment Characteristics and Sedimentation Rate of Daeng River-West Bangka Regency." *Journal of Civil Engineering, Faculty of Engineering, University of Bangka Belitung* 4(2):165–74.

Hardjojo, B., and Djokosetiyanto. 2005. *Water Quality Measurement and Analysis (1st ed.)*. Jakarta: Open University.

Luke, T. 2014. "Sediment and erosion control."

Mansida, A. 2017. *River Morphology Teaching Material.* . Makassar: University of Muhammadiyah Makassar.

Mardjikoen, P. 1987. *Sediment Transportation*. Inter-University Center for Engineering Sciences.

Nichols, G. 2009. *Sedimentology and Stratigraphy (2nd ed.).* . New Jersey: John Wiley & Sons.

Ponce, V. M. 1989. *Engineering Hydrology: Principles and Practices.* New Jersey: Prentice-Hall Inc.

Purbandono, and E. Junarsyah. 2005. *Hydrographic Surveys.* . Bandung: Refika Aditama.

Soewarno. 1991. *Hydrology: Measurement and Processing of River Flow Data (Hydrometry).* Bandung: Nova.

Sosrodarsono, S., and M. Tominaga. 1994. *Improvement and regulation of rivers*. Jakarta: Pradnya Paramita.

Sukandarrumidi. 2018. *Geology of Metallic Minerals*. Yogyakarta: Gadjah Mada University Press.

Triatmodjo, B. 1996. *Hydraulics I*. Yogyakarta: Beta Offset.

Virlayani, A., N. T. Karim, M. I. Munafri, M. I. Amir, and M. A. Zainuddin. 2024. "Analysis of Sediment Characteristics and Sedimentation Rate of the Tino River, Jeneponto Regency." *Hydro* Engineering 17(1):8–13.

Wardhana, P. N. 2015. "Analysis of Opak River Sediment Transport Using the HEC-RAS 4.1 Program. 0. ." *Technician* 20(1):22–31.