Sediment material potential of Bone River as a prevention of silting and flood of Bone River estuary, Gorontalo

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Abstract: Bone River Estuary acts as a connecting lane between the three rivers (Bolango River, Bone River, and Tamalate River) with Tomini Bay. There is a port activity of goods located right on the river estuary, which is potentially disrupted due to the silting and can cause flood. This situation will undoubtedly disrupt port transportation routes and affect the economic condition of Gorontalo. The aim of this research is to identify the potential of sediment utilization at the downstream of the Bone River as an effort to prevent siltation at the estuary of river Bone, Gorontalo and to prevent flood. The method used in this research is field observation which includes observation of the morphological condition of research location and sampling. Samples will then be processed by means of sieving, separation, and classification of Sphericity sediment material by referring to zoning classification and Sneed and Folk classification. The result of histogram data showed that the sediment material was dominated by coarse sand size and grain size distribution dominated by coarse sand with size of phi is 0, on sediment data showed generally very leptokurtic with skewed skill or highly skewed.

1. Introduction
Transport of sediment or sediment transport is a component of the stream that has an important factor in the change or morphology of an estuary. If the river sediment transport is very high at the junction between the river to sea and the deposition process occurs due to the low flow velocity then transported material will be deposited the encounter area. Buildup of material in estuary will form a dry area that is classified as delta [1].

The sedimentation process and flood in the Gorontalo area is a very serious problem [2], especially in the Bone River. The Bone River upstream ecosystem has a function as a protection and the downstream part is a utilization area [3].

Bone Watershed is the largest in the Gorontalo area compared to the Limboto watershed and the Bolango watershed as well as many sediment contributors [4]. Erosional processes and heavy rainfall generated resulted in large amounts of sediment or sediment yield of Bone River an average of 10.6 million tons. This amount makes a great contribution in the process of silting in the river mouth Bone, Gorontalo province.

Bone River estuary is a meeting place of three rivers, namely Bolango River, Bone River, and the River Tamalate. This estuary acts as a connecting path between the three rivers with Tomini Bay. In
addition, there is an activity of port goods located right on the river which has the potential to be disrupted due to situations [5]. This situation will certainly disrupt the port transportation route and have an impact on the regional economic conditions of Gorontalo.

Seeing these conditions, it is necessary to anticipate the silting of the Bone River, which is by utilizing sediment in the lower reaches of the Bone River. This action can handle silting of river mouths Bone by identifying the potential use of sediment in the river downstream Bone.

The purpose of this study is to identify the potential for sediment utilization in the lower reaches of the Bone River as an effort to prevent silting and flood on the Bone estuary, Gorontalo. This research is expected to provide a solution to the government, relevant agencies, and the public related to the problem of sedimentation, silting and flood of the Bone River estuary. The expected outcome of this research is classification of Bone River sediment material and type of utilization of Bone River sediment material, Gorontalo.

2. Data and Method

The research location is located along the Bone River, Bone Bolango Regency, Gorontalo. Based on geographical conditions, the location of the study is in the coordinates 0°29'0" - 0°33'30" N and 123°9'30" - 123°4'0" E (Fig. 1).

2.1 Preparation

The preparation phase consists of preparing tools and materials needed in the form of Brunton type geology compass, Point tip type geological hammer, Garmin OREGON 550 GPS, Loupe, magnet, Roll meter, camera, stationery, 0.1 M HCl solution sample bag, handling administration related research, and preliminary studies related to the research location.

Figure 1. Location of research area
2.2 Field Data Collection
Field data collection phase includes a description of field conditions, sampling and documentation. The data obtained in the field will then be processed and analyzed in the laboratory.

2.3 Data Processing and Analyzing
Processing phase and data analysis Sample processing consists of sieving, separation, namely the separation of metal and non-metallic minerals, classification of shape and size of grain of sediment material. Sphericity classification of sediment material refers to the classification of Zingg [6] and Sneed and Folk [7]. The analysis carried out consisted of analysis of sediment transport process, the material content of the sediment, and the potential utilization of river sediment Bone material.

3. Result and Discussion
The histogram data show that sedimentary material is dominated by coarse sand - medium. Histogram calculations obtained the average value of Bone River material ranged from 32.80 - 60.41% or in the wenworth scale ranging from 1/16 mm - 2 mm. This indicates that the sedimentation process is generally located in the lower reaches of the river where the current is weak. Grain size distribution predominantly coarse sand with size phi is 0 as shown in the frequency curve is generated for each station. It supports the statement of depositional environments associated sedimentary material that has a weak flow velocity. Sorting of sedimentary is classified as poorly sorted. This shows that size distribution of sedimentary material lengthwise following the watershed. Sediment data shows that generally very leptokurtic with skewness is positive, namely fine skewed to very fine skewed, (Fig. 2).

![Figure 2. Histogram data of sedimentary material of Bone River.](image)

Measurement data size and shape of the grain shows a sample dominated by a spheroid shape using Zingg classification. This indicates that the sediment transfer process that occurs at a location very far from weathering rocks. Seeing the condition of the Bone River which has a high water discharge, supports the transfer of sediments with a distance away from the weathering rock.

Meanwhile, based on Sneed and Folk classification shows the dominant sample in the form of Compact Bladed - Compact Elongated. Based on the analysis of provenance, can be observed predominantly metallic minerals and mineral quartz. This indicates that the rocks of sedimentary origin, derived from rock weathering are rich in elements of metal and silica. The geological conditions in the
area are composed of igneous rocks and volcanic rocks (pyroclastic), which can support provenance analysis of sediment material.

**Table 1.** Grain size of sedimentary material at station 1 and station 2 using Zingg classification.

| Grain size | Station 1 | Station 2 |
|------------|-----------|-----------|
| Disc       | 32        | 30        |
| Rod        | 13        | 13        |
| Blade      | 8         | 4         |
| Spheroid   | 66        | 48        |
| Total      | 119       | 95        |

**Table 2.** Grain size of sedimentary material at station 3 and station 4 using Zingg classification.

| Grain size | Station 3 | Station 4 |
|------------|-----------|-----------|
| Disc       | 30        | 33        |
| Rod        | 13        | 27        |
| Blade      | 4         | 5         |
| Spheroid   | 48        | 63        |
| Total      | 95        | 128       |

**Table 3.** Grain size of sedimentary material at station 5 and station 6 using Zingg classification.

| Grain size | Station 5 | Station 6 |
|------------|-----------|-----------|
| Disc       | 16        | 19        |
| Rod        | 3         | 6         |
| Blade      | 0         | 3         |
| Spheroid   | 37        | 24        |
| Total      | 56        | 52        |

**Table 4.** Grain size of sedimentary material at station 7 and station 8 using Zingg classification.

| Grain size | Station 7 | Station 8 |
|------------|-----------|-----------|
| Disc       | 7         | 6         |
| Rod        | 22        | 27        |
| Blade      | 1         | 1         |
| Spheroid   | 32        | 54        |
| Total      | 62        | 88        |

**Table 5.** Grain size of sedimentary material at station 9 and station 10 using Zingg classification.

| Grain size | Station 9 | Station 10 |
|------------|-----------|------------|
| Disc       | 12        | 24         |
| Rod        | 12        | 10         |
| Blade      | 0         | 3          |
| Spheroid   | 37        | 30         |
| Total      | 61        | 67         |
Related to the study of sediment utilization, the data from the histogram calculation can show a variety of material sizes in the river bone, especially on sand-sized material or quartz sand which is the most dominant. The types of utilization, among others, can be used as filler materials for carpet making, while in the field of industrial sand material is used as a material in the glass industry, cement industry and the foundry industry. In addition, the granulated materials can also be used as the added material for road construction, construction of concrete and red brick raw materials.

In the manufacture of carpets, the affect the strengthening of the finished goods are rubber particle size. Quartz sand is filler added to the rubber compound in large enough quantities for the purpose of improving the physical properties, improving particular processing characteristics and reduce the cost of production [8].

In the glass industry, quartz sand is used as a glass-forming oxide and is the main raw material besides soda and salt. Factors that affect the quality of quartz sand are oxides of impurities. With appropriate processing technology, it will produce the characteristics of quartz sand in accordance with the specifications of the glass industry is needed [9].

Table 6. Grain size of sedimentary material at station 1 and station 2 using Sneed & Folk classification.

| Grain size        | Station 1 | Station 2 |
|-------------------|-----------|-----------|
| Very Platy        | 0         | 0         |
| Very Bladed       | 0         | 0         |
| Very Elongated    | 3         | 0         |
| Platy             | 12        | 6         |
| Bladed            | 16        | 18        |
| Elongated         | 4         | 8         |
| Compact Platy     | 14        | 10        |
| Compact Bladed    | 30        | 28        |
| Compact Elongated | 15        | 10        |
| Compact           | 25        | 15        |

Table 7. Grain size of sedimentary material at station 3 and station 4 using Sneed & Folk classification.

| Grain size        | Station 3 | Station 4 |
|-------------------|-----------|-----------|
| Very Platy        | 0         | 0         |
| Very Bladed       | 0         | 0         |
| Very Elongated    | 0         | 1         |
| Platy             | 3         | 8         |
| Bladed            | 9         | 17        |
| Elongated         | 5         | 18        |
| Compact Platy     | 2         | 15        |
| Compact Bladed    | 16        | 26        |
| Compact Elongated | 11        | 22        |
| Compact           | 6         | 21        |
Table 8. Grain size of sedimentary material at station 5 and station 6 using Sneed & Folk classification.

| Grain size   | Station 5 | Station 6 |
|--------------|-----------|-----------|
| Very Platy   | 0         | 0         |
| Very Bladed  | 0         | 0         |
| Very Elongated | 0       | 0         |
| Platy        | 3         | 4         |
| Bladed       | 7         | 13        |
| Elongated    | 1         | 7         |
| Compact Platy| 7         | 8         |
| Compact Bladed| 16       | 12        |
| Compact Elongated | 13    | 2         |
| Compact      | 9         | 6         |

Table 9. Grain size of sedimentary material at station 7 and station 8 using Sneed & Folk classification.

| Grain size   | Station 7 | Station 8 |
|--------------|-----------|-----------|
| Very Platy   | 0         | 0         |
| Very Bladed  | 0         | 0         |
| Very Elongated | 2       | 2         |
| Platy        | 5         | 2         |
| Bladed       | 15        | 3         |
| Elongated    | 7         | 10        |
| Compact Platy| 6         | 2         |
| Compact Bladed| 19       | 15        |
| Compact Elongated | 8     | 18        |
| Compact      | 5         | 10        |

Table 10. Grain size of sedimentary material at station 9 and station 10 using Sneed & Folk classification.

| Grain size   | Station 9 | Station 10 |
|--------------|-----------|------------|
| Very Platy   | 0         | 0          |
| Very Bladed  | 0         | 0          |
| Very Elongated | 1       | 1          |
| Platy        | 5         | 0          |
| Bladed       | 2         | 7          |
| Elongated    | 5         | 10         |
| Compact Platy| 8         | 6          |
| Compact Bladed| 16       | 28         |
| Compact Elongated | 17   | 29        |
| Compact      | 7         | 21         |

In the Portland cement industry, quartz sand is needed as controlling the content of silica in the cement. The content of silica in the quartz sand will determine the number and composition of the
cement mixture. In general, the composition of quartz sand is 66.5 kg to 1 ton of Portland cement products [9].

In the foundry industries, quartz sand used as molding sand (sand casting). Implied SiO\(_2\) content is a minimum of 90% with a maximum of 1.5% Fe\(_2\)O\(_3\). Quartz sandstone processing is generally a washing process to remove impurity compounds and refining processes and grain size uniformity to obtain the required specifications [9].

For basic materials for asphalt construction, sand material is used as a material for adding fine aggregate to the Hot Rolled Sheet Base (HRS-Base) surface layer mixture. However, the fine aggregate material has several requirements which refer to the 2010 general revision specification 3.2015. As for the congregation which consists of [10].

### Table 11. Common specification requirements of sand

| Examination              | Specification |
|--------------------------|---------------|
| Sand Equivalent (%)      | 60            |
| Bulk Density (gr/cm\(^3\)) | Min, 2,5     |
| SSD Density (gr/cm\(^3\)) | Min, 2,5     |
| Apparent Density (gr/cm\(^3\)) | Min, 2,5   |
| Permeation               | Max , 3       |
| Sieve material No, 200 (%) | Max,10       |

For use as a concrete construction, sand material is used for the concrete-making mixture, but the sand used must go through further research to find out the sludge content in accordance with the reference rules for the concrete-making mixture.

In addition the use of sand also affect the compressive strength and flexural strength of concrete where the compressive strength of concrete using river sand has been treated increased 45.85 kg/cm\(^2\) or by 22.35%. The increase in compressive strength is very high due to the content of the sludge that is well deflected.

For utilization as raw material for red bricks, existing sediment material is tested for physical characteristics consisting of specific gravity test and sieve analysis test where the sediment values that can be printed into bricks are sediments with values the percentage of sand reaches 40% while for sediments with sand values above 40% cannot be printed into bricks [11].

### 4. Conclusions

Based on the results of histogram calculations obtained the average value of Bone River material ranged from 32.80 - 60.41% or in the wenworth scale ranging from 1/16 mm - 2 mm.

The type of material in the Bone River is dominated by sediments measuring coarse sand to fine sand with compact bladed shapes using Sneed and Folk classification and Spheroid using Zingg classification.

The mechanism of the sedimentation process that works on Bone River deposits in the form of coarse sand material with suspended transportation processes and deposition dynamics are affected by weak currents. Sand sediment depositional environments affect the distribution of the size and shape of the Bone River material.

The estimated area that can be utilized is 1.12 km\(^2\) as quarrying material in various industrial fields and in the construction sector.
5. References

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