STUDY OF SEDIMENT DISTRIBUTION FOR HANDLING SEDIMENTATION IN JENEBERANG ESTUARY MAKASSAR SOUTH SULAWESI PROVINCE

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ABSTRACT

Jeneberang river has an important role to control flood in Makassar and Gowa. The estuary is an area of expenditure river water, especially during flood discharges it is a result of a great number of sediment transportation from upstream that will undergo a huge deposition, so the function is not able to performed optimally, especially during flood discharge and partly transported to the beach around the estuary such as, Tanjung Bunga beach and Barombong beach. This study aimed to analyze the type of sediments based on diameter 50 (D50) and the distribution of sediments and how to handle it. The methodology of sediment sampling was conducted directly in the field based on the point of the review that had been determined as data acquisition. Furthermore, sediment samples were analyzed in the laboratory to determine the type of sediments and the distribution. The type of sediments obtained with the number of the review point 6 (six) location of the material, there were 7.56% gravel material, 73.43% sand, 3.47% clay, and 18.05% silt. Based on those sediment types, Jeneberang estuary categorized in the form of a sand beach and distribution of the size sand grain is equal because the average value (So) is 1.286 located between 1.0 and 1.5 (1.0 ≤ So ≤ 1.5). The alternative treatment is divided into two ways, there are short-term and long-term treatment whereas in the short-term ways is done by doing dredged and for long-term treatment is done by making jetty that pointed out.

Keywords: estuary, sediment type, sediment distribution, dredging, jetty.

INTRODUCTION

Jeneberang River is a large river which is located in the western part in the administrative area of Makassar city, a capital city of South Sulawesi. This river originates and flows from the eastern part of Mount Bawakaraeng (2,833 m above of the sea level) and Mount Lom彼得battang (2,876 m above of the sea level) and then headed to its downstream in the Makassar Strait. Based on the source of Coordinating Survey Agency and National Mapping (BAKOSURTANAL), the location of region Jeneberang estuary located geographically at coordinates 119° 23'50” EL. - 119° 56'10” EL, and 05° 10'00” SL - 05° 26'00” SL with the length of main river of 78.75 kilometers [1].

Revitalization of the coastal area of Makassar, especially at the estuary of Jeneberang is one of the government program that require a sustainable arrangement, of course by taking into various factors such as wind, the flow of sea water, the tide of estuary, erosion, abrasion, sedimentation, etc. One of the areas that need attention is the existence of Jeneberang River which is disemboquetu Makassar. Jeneberang river has an important role to control flood in Makassar and Gowa. The estuary is an area of expenditure river water, especially during flood discharges it is a result of a great number of sediment transportation from upstream that will undergo a huge deposition, so that the function is not able performed optimally, especially during flood discharge and partly transported to the beach around the estuary such as, Tanjung Bunga beach and Barombong beach [2].

Coastal sediments can be derived from the erosion of the coast line itself, from the land that be carried by the river and from the sea in the drifted to the coast.

The properties of coastal sediments may affect the rate of sediment transportation along the coast. The factors that affect the rate of sediment, among others;

a) The characteristic of sediment material (distribution and grain gradation, cohesiveness, form factor, size, density, and so on).

b) The characteristic of waves and currents (wind speed and direction, the position of wave generation, tidal and coastal topography is concerned).

The most important of sediment characteristic is the distribution of grain size after that the sedimentation velocity of sediment, etc [3].

Coastal sediment is classified based on grain size becomes clay, silt, sand, gravel, coral (pebble), cobble, and rock (bolder). Classificationis widely apply in the field of coastal engineering isa classification according to Wentworth (CERC, 1984). Based on the classification, sand that has diameter between 0, 063 and 2.0 mm is distinguished into five classes. The smoothest material such as silt and clay have diameter under 0, 063 mm which is cohesive sediments. The distribution of grain size usually analyzed by sieve and presented in the form of cumulative weight percentage curve [4].
Due to the moonson season, the disposal of river discharge into the sea will be disrupted. The disfluencies may cause flooding in the area upstream of the estuary. Another result like when low tide, the ships utilize the estuary area as a conector with the flow upstream areas will have problems [5].

Based on the above, we tried to do research on the distribution of sediments in the Jeneberang estuary in order to determine the type of sediment based on diameter 50 ($D_{50}$) and sediment distribution with its handling. Methodology sediment sampling conducted directly in the field based on the point of the review that had been determined as the data retrieval. Furthermore, sediment samples were analyzed in the laboratory to determine the type and size of the grain.

**LITERATURE REVIEW**

**The morphology of Estuary**

The Estuary can be distinguish into three groups, which is depend in the dominant factors that influence them. The three of dominant factors are the wave of sea, river flow, and tidal [5]. In estuary, these three factors are working simultaneously, but usually one of them has a more dominant influence than others. Ocean waves provide the most dominant influence in the small river that empties into the open sea (wide). Preferably big rivers that empty into the calm sea will be dominated by stream flow.

**Estuary is dominated by flood discharge or river**

Estuary occurs in the river with discharge during the year is quite large, which is disambogue into the sea with wave that relative small. The river carries a greater of sediment transport. The Sediment that reach estuary is a sediment suspension with a small particle diameter, such as within a few microns. The characteristic of cohesive sediments is more dependent in the forces on the surface rather than the gravity, in the form of attractive forces and repulsive-rejected force.

**Estuary is dominated by tidal**

In case of a large tidal, the volume of tide water enters the river is very large. The water will accumulate in water from upstream rivers. When the water down, a great number of water volume within certain time period which depends on the type of tide. Thus, the current speed during low tide is huge which has enough potential to form the estuary.

**The characteristic of the sediment**

According to [5], that material can derive from erosion of the coast line itself, from the land is brought by the river, and from the deepest sea is brought by flow to coastal area or estuary. The properties of the sediment is very important in order to study the process of erosion and sedimentation. The characteristics are the size of grains (grain diameter) and sediment grain distribution, density, shape, creep speed, resistance to erosion, and so on. In some of these properties, grain size (diameter) and sediment grain distribution are the most important in studying the processes of erosion and sedimentation.

**The grain size (grain diameter) of sediment**

The sediment of material is classified based on the grain size becomes clay, mud, gravel, coral (pebble), cobble and stone (Boulder). Table-1 shows the classification in Wentworth sediment grain size, which is widely used in the coastal or the estuary engineering [4].

The classification is based on sand having diameters 0.062 and 2.0 mm furthermore, divided into five classes. Materials which is very smooth for example, silt and clay that has diameter under 0.063 mm which is cohesive sediments [4].
Table-1. Classification of particle size and sediments [4].

<table>
<thead>
<tr>
<th>Unified Soils Classification</th>
<th>ASTM Mesh Size</th>
<th>mm Value</th>
<th>Phi Value</th>
<th>Wentworth Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>COBBLE</td>
<td>256.0</td>
<td>3.0</td>
<td>0.0</td>
<td>BOULDER</td>
</tr>
<tr>
<td>COARSE GRAVEL</td>
<td>190.0</td>
<td>4.75</td>
<td>-2.25</td>
<td>PEBBLE</td>
</tr>
<tr>
<td>FINE GRAVEL</td>
<td>4.0</td>
<td></td>
<td></td>
<td>GRAVEL</td>
</tr>
</tbody>
</table>

The distribution of grain sediment

Grain size distribution has been analyzed by using sieve and presented in the form of a cumulative weight percentage curve.

In general, the size distribution of grains of sand approaching a log normal distribution, so it is often using phi scale units, which are defined as follows [6].

$$\Phi = \log_2 D$$  

(1)

with $D = \text{grain diameter in mm}$

Sediment grain size ($D_m$) as shown in Table-1 is the most widely used for sand grain size. Based on the log normal distribution proficiency level, the average grain size ($D_m$) and standard deviation ($\sigma D$). It can be calculated in the following way [4];

$$D_m = \sqrt{D16 \cdot D84}$$  

(2)

And

$$\sigma D = \sqrt{\frac{D84}{D16}}$$  

(3)

By the notation $D_p$ is a grain size whereas $p\%$ of the weight sample is more smooth than the grain diameter. For measuring the degree of grain size distribution to the mean value, it is often using coefficient ($So$) which is defined as follows:

$$So = \sqrt{\frac{D75}{D25}}$$  

(4)

If $1.0 \leq 1.5 \leq$ the sand grain size is equal, for $1.5 < So \leq 2.0$ spreading of sand grain size distribution is medium, whereas for $2.0 \leq So = 2.0$ the sand gradation of sand size is diverse.

Mechanical analysis

Mechanical analysis of the soil is the determination of the variation of the size of the particles that exist on the ground. The variation is expressed as a percentage of the total dry weight. There are two common ways to obtain the distribution of soil particle sizes, namely; sieve analysis, for the size of particles of diameter greater than 0, 075 mm, and a hydrometer analysis, for the size of the particles of diameter smaller than 0, 075 mm [7]. Based on the mechanical analysis performed in this study was obtained the size distribution of the particles diameter greater than 0, 075. Therefore in this study, only using sieve analysis to obtain sediment particle size.
Sieve analysis is sifting through the soil and is moving example of a set sieve sieve where the holes are smaller in sequence. For the US standard sieve, sieve number and size of the holes are given in Table-2 [4], the following:

Table-2. Size standard sieve size in the United States [4].

<table>
<thead>
<tr>
<th>Sieve number</th>
<th>Hole sieve (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4.750</td>
</tr>
<tr>
<td>6</td>
<td>3.350</td>
</tr>
<tr>
<td>8</td>
<td>2.360</td>
</tr>
<tr>
<td>10</td>
<td>2.000</td>
</tr>
<tr>
<td>12</td>
<td>1.680</td>
</tr>
<tr>
<td>16</td>
<td>1.180</td>
</tr>
<tr>
<td>20</td>
<td>0.850</td>
</tr>
<tr>
<td>30</td>
<td>0.600</td>
</tr>
<tr>
<td>40</td>
<td>0.425</td>
</tr>
<tr>
<td>50</td>
<td>0.300</td>
</tr>
<tr>
<td>60</td>
<td>0.250</td>
</tr>
<tr>
<td>80</td>
<td>0.180</td>
</tr>
<tr>
<td>100</td>
<td>0.150</td>
</tr>
<tr>
<td>140</td>
<td>0.106</td>
</tr>
<tr>
<td>200</td>
<td>0.075</td>
</tr>
<tr>
<td>270</td>
<td>0.053</td>
</tr>
</tbody>
</table>

At first instance drained soil first, then all clumps are broken down into particles that are smaller and new sifted in laboratory experiments. After enough time to sifting by means of vibration, land mass retained on each sieve is weighed. To analyze cohesive soils, perhaps somewhat difficult to break up clumps of soil into loose particles that stands alone. To that end, the land needs to be mixed with water until it becomes a watery slurry and then washed entirely passed through the sieve-sieve. The solid part retained on each sieve is collected separately. Then, each sieve along with the soil dried in an oven, and then the weight of the dry soil was weighed. After enough time to sifting by means of vibration, land mass retained on each sieve is weighed. To analyze cohesive soils, perhaps somewhat difficult to break up clumps of soil into loose particles that stands alone. To that end, the land needs to be mixed with water until it becomes a watery slurry and then washed entirely passed through the sieve. The solid part retained on each sieve is collected separately. Then, each sieve along with the soil dried in an oven, and then the weight of the dry soil was weighed.

**RESEARCH METHODS**

**Locations and timing of research**

The research location at estuary of the Jeneberang River and Soil Mechanics Laboratory of Civil Engineering Department of the Polytechnic Ujung Pandang.

Preparation and implementation of the study lasted for eight (8) months, in the beginning of February 2015 to the beginning of October 2015. Implementation of the survey location and retrieval of sedimentary material and secondary data from relevant agencies, conducted during 7 (seven) weeks, in mid February 2015 until in early April 2015. While testing in Soil Mechanics Laboratory such us, sieve analysis test, conducted over two (2) weeks, in the beginning of May 2015. Data compilation, processing and analysis of data, evaluation and presentation of data, both are obtained from test results obtained from the relevant agencies, held for 3 (three) months, the beginning of June 2015 until the end of August 2015.

**Tools and materials research**

The equipment is a motor boat; it was used for sampling sediment material based on a predetermined point of the review, as shows in Figure-1. Once the determined point of the review, then the material sediments samples were taken at each point of the review with a dive at the bottom of estuary of with using shovels and other tools.

Figure-1. Sediment sampling locations.

The research materials that use in this study were a form of primary data and secondary data. For primary data sedimentary material had been taken directly at estuary of the Jeneberang River, while for secondary data the condition of Jeneberang estuary on topographic maps obtained from Google Maps.

**Preparation of testing**

Sediment material obtained from the field, ready to be tested in Soil Mechanics Laboratorium the sieve analysis test. The purpose of the sieve analysis test is to determine the grain size (grain diameter) of a sample of sedimentary material.
Implementation of research

Implementation of the sieve analysis test which has conducted at the Laboratory of Soil Mechanics are as follows:

A. The tools and materials used
1. Sieve size No. 4, No. 10, No. 30, No. 40, No. 60, No. 100, No. 200, and Pan
2. Scales with accuracy 0.1 gram
3. Steel brushes
4. Machine colander
5. Oven
6. Desiccator
7. Chamfer
8. Brush, spoon, and etc.

B. Work steps
a) The specimens were dried in an oven.
b) Strain the test specimen through the filter arrangement with the largest sieve size is at the top
c) The filter was rocked by hand or by machine colander for ±15 minutes

d) Specimens retained on each sieve was weighed.

C. Calculation
a) Heavy soil stuck = (Weight Sieve + Land Suspended) - Weight Filter
b) The amount of soil weight = Total weight of the soil stuck to each sieve size cumulatively
c) The cumulative percent retained = Total weight divided by the total number of land retained land is filtered and multiplied by 100%.

The cumulative percent pass = 100% - percent cumulative.

RESULTS AND DISCUSSIONS

Research result

Based on the test sieve sediment grain size of the material obtained from the estuary Jeneberang can be seen in Table-3, below:

Table-3. Sieving grain size (diameter sediment) at the point of the review.

<table>
<thead>
<tr>
<th>Sieve number</th>
<th>Diameters (mm)</th>
<th>Detained weight (gram)</th>
<th>Cumulative weight (gram)</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Detained</td>
</tr>
<tr>
<td>4</td>
<td>4,75</td>
<td>0,00</td>
<td>0</td>
<td>0,00</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>18,48</td>
<td>18,48</td>
<td>3,70</td>
</tr>
<tr>
<td>30</td>
<td>0,84</td>
<td>134,43</td>
<td>152,9</td>
<td>30,6</td>
</tr>
<tr>
<td>40</td>
<td>0,425</td>
<td>92,37</td>
<td>245,3</td>
<td>49,1</td>
</tr>
<tr>
<td>60</td>
<td>0,25</td>
<td>121,12</td>
<td>366,4</td>
<td>73,3</td>
</tr>
<tr>
<td>100</td>
<td>0,15</td>
<td>82,62</td>
<td>449,0</td>
<td>89,8</td>
</tr>
<tr>
<td>200</td>
<td>0,075</td>
<td>23,67</td>
<td>472,7</td>
<td>94,5</td>
</tr>
<tr>
<td>Pan</td>
<td>-</td>
<td>27,27</td>
<td>499,9</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure-2. Curved gradation at the point of the review.
Based on Figure-2, the curved gradation of each dot location of sedimentary material was obtained as shown in Table-4, as follows:

**Table-4. Recapitulation of sedimentary material at point locations to be reviewed.**

<table>
<thead>
<tr>
<th>Sedimentary materials</th>
<th>The point of review 1 (%)</th>
<th>The point of review 2 (%)</th>
<th>The point of review 3 (%)</th>
<th>The point of review 4 (%)</th>
<th>The point of review 5 (%)</th>
<th>The point of review 8 (%)</th>
<th>Average Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>0.00</td>
<td>7.56</td>
<td>7.56</td>
<td>7.56</td>
<td>7.56</td>
<td>0.00</td>
<td>7.56</td>
</tr>
<tr>
<td>Sand</td>
<td>94.55</td>
<td>85.48</td>
<td>85.48</td>
<td>85.48</td>
<td>85.48</td>
<td>4.13</td>
<td>73.43</td>
</tr>
<tr>
<td>Clay</td>
<td>0.00</td>
<td>4.99</td>
<td>4.99</td>
<td>4.99</td>
<td>4.99</td>
<td>0.88</td>
<td>3.47</td>
</tr>
<tr>
<td>Silt</td>
<td>5.45</td>
<td>1.97</td>
<td>1.97</td>
<td>1.97</td>
<td>1.97</td>
<td>95.0</td>
<td>18.05</td>
</tr>
</tbody>
</table>

Based on the equation (2), (.3), and (4) with refer to Figure-3, the sediment grain size distribution, then obtained as in Table-5, as follows:
Discussion of the results

Based on the 6 (six) points review the sampling site at the estuary of river sediment material Jeneberang were summarized in Table-4, obtained an average amount of material, the material of 7.56% gravel, sand 73.43%, 3.47% clay, and 18.05% silt. This suggests that the estuary Jeneberang categorized in the form including the type of sandy beaches. Sand grain size distribution is equal, because the average value (So) of Table-5 is 1.286 lies between 1.0 and 1.5 (1.0 ≤ So ≤ 1.5).

Precipitation occurs as a result of sediment transported by a wave moves into the estuary of the river in the area has been calm wave conditions. The amount of sludge depends on the wave and availability (sand) from the beach. The bigger the bigger waves and sediment transport more sediment that settles in the estuary.

At Jeneberang river small river discharge and flow velocity was not be able to erode, such deposition so estuaries possibilities covered by sediment. At the time of the rainy season, where the flood discharge is not smoothly discharged into the sea because of the closure of the estuary. Due to flooding may occur in the upstream estuary of Jeneberang River.

To handle this alternative estuary management Jeneberang is;

a) Short-term program; which is held dredging sediment at the mouth of the river which is an alternative to handling the most simple and cheap. The dredging is carried out both mutual assistance by the local population or with heavy equipment and done at the beginning of the rainy season. Dredging is done especially if the function is to skip Jeneberang River flood discharge at the river mouth of the river mouth is always open or closed at certain times.

b) Long-Term Program; which made long jetty that juts into the sea until beyond the breaking waves. The utilization of the river mouth in this case as ship traffic particularly large ships.

Table-5. Recapitulation of total sedimentary material at point locations to be reviewed.

<table>
<thead>
<tr>
<th>Grain size parameters</th>
<th>The point of review 1 (%)</th>
<th>The point of review 2 (%)</th>
<th>The point of review 3 (%)</th>
<th>The point of review 4 (%)</th>
<th>The point of review 5 (%)</th>
<th>The point of review 8 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D16</td>
<td>2.15</td>
<td>1.52</td>
<td>2.21</td>
<td>1.02</td>
<td>0.93</td>
<td>2.05</td>
</tr>
<tr>
<td>D50</td>
<td>2.36</td>
<td>1.76</td>
<td>2.50</td>
<td>1.35</td>
<td>1.25</td>
<td>2.38</td>
</tr>
<tr>
<td>D75</td>
<td>2.95</td>
<td>2.35</td>
<td>3.08</td>
<td>2.12</td>
<td>1.95</td>
<td>3.0</td>
</tr>
<tr>
<td>D84</td>
<td>3.55</td>
<td>2.85</td>
<td>3.65</td>
<td>2.85</td>
<td>2.65</td>
<td>3.60</td>
</tr>
<tr>
<td>Dm</td>
<td>3.75</td>
<td>3.10</td>
<td>3.92</td>
<td>3.25</td>
<td>2.95</td>
<td>3.95</td>
</tr>
<tr>
<td>σn</td>
<td>2.84</td>
<td>2.17</td>
<td>2.94</td>
<td>1.82</td>
<td>1.66</td>
<td>2.85</td>
</tr>
<tr>
<td>Sn</td>
<td>1.32</td>
<td>1.43</td>
<td>1.33</td>
<td>1.79</td>
<td>1.78</td>
<td>1.39</td>
</tr>
</tbody>
</table>

CONCLUSIONS AND SUGGESTION

Conclusions

Based on the results were obtained as described in the discussion, it can be in the following conclusion:

1) The average amount of sediment material and the results obtained in the laboratory test of the number of the review point 6 (six) ie 7.56% of material gravel, sand 73.43%, 3.47% clay, and silt 18.05%. Based on the results of a material amount of gravel, sand, clay and silt, the river estuary Jeneberang categorized in the form of beaches and sandy beaches types based on grain size distribution including uniformed sand, because the average value namely 1.286 (So), which lies between 1.0 and 1.5 (1.0 ≤ So ≤ 1.5).

2) Alternative handling of the sedimentation in the estuary of the Jeneberang river namely for short-term dredged while the long term made jetty that juts far out.

Suggestion

Things that can be suggested of the results of this study are:

a) Handling estuary of the Jeneberangriver was required accuracy careful particularly the cost of building work and the impact on the environment.

b) Further research is needed particularly research on the characteristics of estuarine and coastal estuary of the Jeneberang River.

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