Characteristics of Sediment Material at Bengkalis River Bengkalis Regency, Riau

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Abstract: One of the causes of decreasing river capacity is silting and/or narrowing by sedimentation, this is what happened in the Bengkalis River, another impact due to siltation is the occurrence of overflowing water from the river which can threaten the area on the riverbank, so research is carried out on the characteristics of sediment samples, especially the Bengkalis river with the aim to obtaining information about the characteristics of river sediments. The method used in this research is field observation by measuring the river profile and flow velocity, then taking soil samples at the riverbed and carrying out laboratory tests such as specific gravity, filter analysis, and hydrometer. The results of BJ sediments from three sediment samples at the estuary, middle and upstream locations of STA 0+000, STA 0+925, and STA 1+922 were 2.46; 2.26; and 2.37. Based on the results of laboratory tests, the results of the specific gravity show that the farther from the sea, the smaller the density of the sediment. The types of sedimentary material from the results of the sieve analysis and hydrometer test are silt (silt) and clay, respectively STA 0+000 37.84%, 19.81%, STA 0+925 42.46%, 31.01%, and STA 1 +922 50.07%, 28.82%.

1 INTRODUCTION

A river is a natural and/or artificial water channel or container in the form of a water drainage network and the water in it, starting from the upstream to the estuary, bordered on the right and left by border lines (PP No. 38, 2011).

The river is a flow of water that flows from upstream to downstream and this river flow moves from a high place to the lowest or shallow place. River water always flows in one direction because the river is located on the lower part of the earth's surface than the surrounding land, which comes from mountain water which then empties into one place, namely the sea (Andini and Nisye, 2017).

The river consists of a river trough and a river border. The space for flowing water is located in the riverbed and as a place for the life of the river ecosystem to take place, so that in essence rivers and their tributaries play an important role in accommodating, storing, and draining water that comes from rainfall to the sea naturally. The success of rivers in carrying out their functions minimizes the risk of flooding, especially in urban areas (PP No. 38, 2011).

The river has its own capacity to be able to ward off flooding. One of the causes of decreasing river capacity is due to silting and/or narrowing by sedimentation.

Sedimentation is a process of entering sediment loads into a certain aquatic environment through water media and being deposited in that environment. Sedimentation that occurs in coastal and river environments becomes a problem if it occurs in locations where there are human activities that require clean water conditions (Triatmodjo, 1999).

There are several causes of sedimentation, including the deposition of river water, sea water deposition. This deposition process will result in sediment consisting of several materials with various sizes of soil particles depending on the parent material that composes them. Some materials that often become sediment, including: sand and clay. The type of sediment according to the particle size can be found dissolved in the river or what is called the suspended load and the sediment that creeps on the riverbed is called the bed load (Triatmodjo, 1999).

The difference between sediment load and creeping sediment can be seen by looking at the movement of the sediment particles. The movement

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of these particles is influenced by flow velocity, river morphology, riverbed roughness and river slope. These parameters interact with each other so that it will determine the amount and type of sediment and the speed of sediment transport, this causes the results of the sedimentation process in one place to another, even though it is in one coastal area, as well as for the Bengkalis island area which is on the coast of the Malacca strait.

The source of origin of sediment is one of the factors that cause differences in characteristics. Waikelo Beach and Melolo are beaches facing the Sumba Strait and facing the surrounding islands (Flores Island and Sumbawa Island) so that the coastal sediments have a major influence on the sediment supply from the mainland. Meanwhile, the Laboya beach is directly related to the Indian Ocean which causes the size of the coastal sediment to be smoother. The same thing was expressed by Nugroho and Putra (2017), who conducted research on the grain size of sediments in the Sumba Strait and to the south and west of the Indian Ocean, that sediments that are directly related to the Indian Ocean have a smoother character than those in the Sumba strait.

The results of the calculation of the sediment fraction of the waters of the Silandak River (Table 2) sedimentary classification is dominated by sand (sand) and clay (clay). Sand is found at points 1,2, and 3 where point 1 is upstream, points 2 and 3 are part of the middle river, where the three points are areas with a depth of < 30 cm and a low river current speed of 0.04 seconds. The condition around the river is in the form of densely populated settlements, around the river rocks and sand are found, so that the sediment that is deposited in the form of sand, other fine materials is carried by currents into lower waters to the sea. Points 4 and 5 are dominated by clay with an average clay percentage of 60%, this is because points 4 and 5 are parts close to the coast where fine particles carried from upstream will enter downstream (Dominig and Muskananfola, 2019).

Analysis of sedimentation characteristics has been carried out in the New Straits port area at the mouth of the Bengkalis Liong River, where the Liong River estuary is located on the north coast of Bengkalis Island which is directly connected to the Malacca Strait. Analysis of sediment characteristics was carried out at 2 station points in the New Straits port. From the results of the sedimentation analysis, it was found that there were three sediment fractions, namely sand, silt and clay with various diameters. The percentage of sand at station 1 is 75.87% which is located in the port dock area, while the percentage of sand at station 2 is 53.9%, precisely at the end of the river mouth. The percentage of silt at station 1 is 20.85%, while at station 2 is 43.86%. The percentage of clay at station 1 is 3.28%, while at station 2 is 3.24% (Khabib et all, 2013).

Research on sediment characteristics was also carried out on the Selatbaru beach with a location distance of +1 km (Khabib et all, 2013), where the results obtained that the sediment characteristics of the beach bottom surface were grouped into three sedimentary fractions, namely gravel, sand and mud. The sand sediment fraction is found at each station and is the most common sedimentary sediment found when compared to the gravel and mud fractions. The type of sediment in the research location can be grouped into 2 types of sediment, namely sand and muddy sand. Sediment with sand type is found in every sub-station, except for sub-station 1B which has a muddy sand fraction type (Putra et all, 2017).

Study of sediment characteristics on the west coast of Bengkalis Island, the study was carried out by taking test samples using the Eckman Grab from 7 station points (Figure 1) then analyzed to determine the composition and content of organic matter in the sediment, where the results of the analysis of the sediment fraction in the waters The Bengkalis Strait shows that these waters consist of three types of fractions, namely gravel, sand, and mud. However, the dominant fraction in each station is the sand fraction (Putri and Rifardi, 2012).

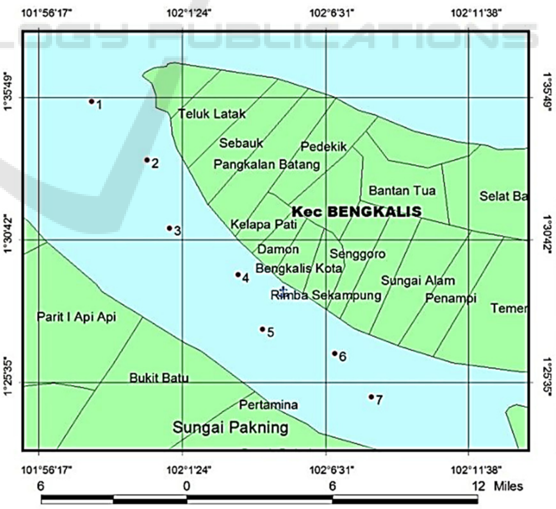

Figure 1: Sample station of Putri and Rifardi research, 2012.

The percentage of gravel fraction ranges from 0-17.84% where the lowest percentage is at Stations 2, 3, and 5 while the highest percentage is at Station 4 with a percentage of 17.84%. The percentage of sand fraction ranges from 80-96.72% where the highest percentage is at Station 2 and the lowest is at Station 4. While the percentage of mud fraction is around 2,1618.42% where Station 4 is the lowest percentage and Station 3 is the highest percentage. The type of sediment fraction in these waters is dominated by sand at each station (Putri and Rifardi, 2012).

Bengkalis River is one of the rivers in the Bengkalis District with a total length of 3.81 km from upstream to downstream. The location of the Bengkalis river is in the coastal area so that the condition of the river water level is strongly influenced by the conditions of the tides and the ebb and flow of sea water. Visual observation of several sea segments of the Malacca Strait sedimentation occurs (Figure 1).

The occurrence of sedimentation is strongly supported by the condition of the river which has a water flow at high tide that is greater than the flow at low tide, so that the material carried by water upstream during high tide will experience sedimentation.

Over time, sedimentation that occurs in the Bengkalis river results in greater siltation and causes a reduction in the capacity of the river so that it has the impact of overflowing water that threatens the area on the outskirts of the river from the danger of flooding, so it is necessary to do research on the characteristics of sediment samples, especially the Bengkalis river. Based on the description above, research was conducted with the aim of obtaining information about the characteristics of sediments in the Bengkalis river, the results of this study can be used as an initial reference in handling river sediments, especially the Bengkalis river.

Besides that, the results of this test must include SNI 3423:2008:

a. Percentage of grain greater than 2.00 mm;
b. The percentage of coarse sand 2.0 mm to 0.42 mm;
c. Percentage of fine sand, 0.42 mm to 0.074 mm;
d. Percentage of silt 0.074 mm to 0.002 mm;
e. The percentage of clay is less than 0.002 mm and;

Colloidal percentage is smaller than 0.001 mm.

2 METHOD

The method implemented in this study is a field observation method in the form of a field survey to obtain input data needed in analyzing sediment characteristics and by conducting tests at the Soil Testing Laboratory of the Civil Engineering Department of the Bengkalis State Polytechnic. The stages of research implementation are as follows:

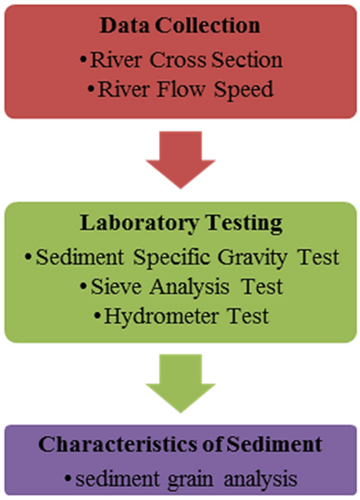

Figure 2: Research Flowchart.

To determine the characteristics of the Bengkalis river sediment, a test sample is needed, the sediment test sample used is the test material (sediment) which represents the sediment that occurs in the Bengkalis river, namely the test sample from STA 0+000, STA 0 +925 and 1 + 922. Location of position each point of sediment sampling can be seen in Table 1 and Figure 3, Figure 4, Figure 5 and Figure6. For each STA 3 representative sediment samples were taken.

Table 1: Coordinate Sampling Points.

No	STA	River Basin	Coordinate
1	0 + 000	Downstream/ Estuary	102^{0}7’10,299” E 1^{0}27’37,772” N
2	0 + 925	Middle	102^{0}7’18,327” E 1^{0}28’2,051” N
3	1 + 922	Upstrem	102^{0}7’17,888” E 1^{0}28’30,434” N

The stages of this research include the following activities:

2.1 Data Collection Stage

Data collection includes measurement of river cross-section, river flow velocity and sediment sampling. Measuring the cross section of the river to determine the dimensions of the river using the Theodolite measuring instrument and drawing using AutoCad software. Measurement of the speed of river currents in a cross-sectional area of the river by using a measuring instrument Currentmeter.

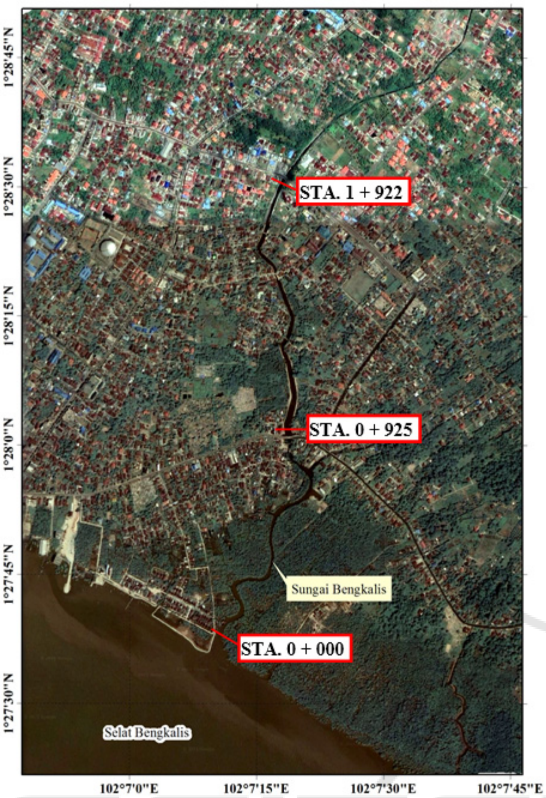

Figure 3: Research locations and sampling points in the estuary, middle and upstream of the river in Bengkalis Island.

Figure 4: Research locations STA 0+000.

Figure 5: Research locations STA 0+925.

Figure 6: Research locations STA 1+922.

Sediment Sampling was taken at several points, namely at STA. 0 + 000, STA. 0 + 925 and STA. 1 + 922 by using a sediment sampler which will then be tested for its characteristics at the Soil Testing Laboratory.

Figure 7: Sampling of riverbed sediment.

2.2 Laboratory Testing Stage

This stage includes the activities of several sediment sample testing to determine the characteristics of the sediment. There are several tests carried out:

2.2.1 Sediment Specific Gravity Test (GS)

Specific gravity is the ratio between the density of soil grains and the density of distilled water at the same temperature and volume. The test uses a pycnometer and a test object that passes the No. sieve. 40 (SNI 1964, 2008).

The sequence of processes in the specific gravity test is as follows:

1. Preparation of tools including pycnometer (in clean condition) and test sample
2. Weigh the pycnometer (W1)
3. Fill the pycnometer with water up to the specified limit and then weigh the pycnometer + water (W4)

4. Enter the test sample into the pycnometer to a predetermined limit, then weigh the pycnometer + soil weight (W2)
5. Fill the pycnometer with water and gently shake the pycnometer so that there are no more water pores. Heat the water until it boils and put the pycnometer in the pot, then the air bubbles will evaporate until the air bubbles disappear. Lift the pycnometer if the air bubbles are no longer there, add water to the pycnometer to the specified limit and let the pycnometer stand for 24 hours.
6. Weigh the pycnometer + water + the sample that has been set aside (W3)
7. Analysis of sediment density calculation
   Calculating the density of sediment using the formulation

$$Gs = (W_2-W_1)/(W_4-W_1)-(W_3-W_2) \qquad (1)$$

Where:

Gs = Density of soil
W1 = Weight of pycnometer (grams)
W2 = Weight of pycnometer and dry sample (grams)
W3 = Weight of pycnometer, sample and water (grams)
W4 = Weight of pycnometer and water (grams)

Figure 8: Specific Gravity Test of Sediment Samples.

2.2.2 Sieve Analysis Test

This test was carried out to obtain the grain size distribution of the soil using sieve analysis. The test object used was an oven-dried sediment sample. The process in testing sieve analysis is as follows:

1. The test object is dried in an oven at a temperature of (110 + 5 C).
2. Weigh the sieve used in an empty state.
3. Take a sample weighing 2000 grams.
4. Put the sample into the plastic and soak for + 1 hour.
5. After 1 hour, wash the sample above 1 set of filters until the color of the water entering the filter is the same as the water coming out of the filter.
6. Put the sample retained on each sieve into different containers and code according to the sieve number.
7. Oven sample in container for 24 hours
8. Weigh and record the weight of the oven dry sample.

The filter analysis test with the following sieve size (SNI 3423, 2008):

Table 2: Sieve Size.

# Sieve	ø (mm)
2,5"	63,5
1,5"	38,1
1"	25,4
3/4"	19,05
3/8"	9,525
No. 4	4,75
No. 10	2,000
No. 20	0,850
No. 40	0,425
No. 100	0,150
No. 200	0,075

Figure 9: Wet method sieve analysis (washing).

2.2.3 Hydrometer Test

The hydrometer test is a test carried out to calculate the grain size distribution of a fine-grained soil or the fine-grained portion of a coarse-grained soil based on the sedimentation of the soil in water, sometimes also called the sedimentation test.

In the hydrometer test, the tested soil sample is dissolved in water in a dispersed state, the soil grains will drop freely to the bottom of the vessel. The settling speed of the soil grains varies depending on the size of the soil grains. The largest soil particles will settle first with a greater settling velocity. The process in testing the hydrometer analysis is as follows SNI 3423, 2008 :

1. Prepare tools and test samples that pass the No. sieve. 200 which has been oven-dried weighing 50gr.
2. Weigh the kalgon to be used weighing 15 grams.
3. So that the soil settles Pour a little water on the sample and leave it for 10 minutes.
4. Fill 30 ml of water into the first measuring cup, put kalgon into the water and stir until dissolved. After dissolving add water until the volume of water becomes 1000 ml.
5. Fill 1000 ml of water in the second measuring cup.
6. Fill 1000 ml of water in the third measuring cup
7. Close the second measuring cup and shake for 60 times
8. Place the first, second and third measuring cups in a parallel position, turn on the stopwatch for 2 minutes, take the hydrometer and temperature readings on the 2nd measuring cup.
9. Lift the hydrometer and thermometer and clean it, calculate the hydrometer and temperature in the first measuring cup
10. Do the same steps at a time of 5 minutes, 15 minutes, 30 minutes, 60 minutes, 240 minutes and 1440 minutes.

Figure 10: Hydrometer Test.

3 RESULTS AND DISCUSSION

In this study, researchers conducted an examination of the specific gravity of the sediment obtained by the test results as shown in Table 3 and Figure 11.

From table 4, it is known that the speed and discharge of water at low tide decreases from downstream to upstream. Likewise, the speed and discharge of water at high tide decreases from downstream to upstream. However, the speed of the water at low tide is higher than the speed of the water at high tide. however, the water discharge at low tide that occurs at STA 0+925 and STA 1+922 is greater than at high tide.

Table 3: Specific Gravity of Bengkalis River Sediment.

Description	STA		
	0 + 000	0 + 925	1 + 922
Empty pycnometer weight (M_1) (gr)	88.10	96.90	172.53
Weight of pycnometer + dry soil (M_2) (gr)	151.10	157.13	299.50
Weight of pycnometer + soil + water (M_3) (gr)	371.37	380.63	741.90
Weight of pycnometer + water (M_4) (gr)	336.23	344.87	668.50
Temperature t °c (degrees)	29.17	29.00	29.17
Dry soil weight ($A = M_2 - M_1$) (gr)	63.00	60.23	126.97
Weight of soil in water ($B = M_3 - M_4$) (gr)	35.13	35.77	73.40
C = A- B	27.87	24.47	53.57
Specific gravity Gs = A / C	2.26	2.46	2.37
G for 27.5 °c = Gs * (Bj. Water t °c/Bj. Water 27.5 °c)	1923.41	2069.67	2017.30

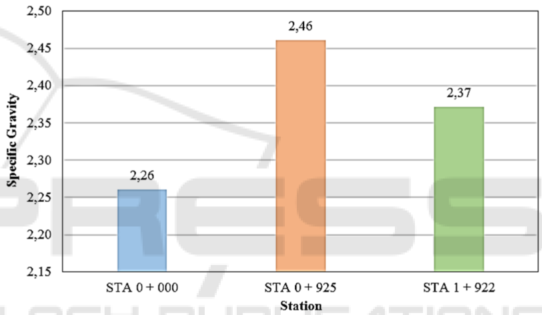

Figure 11: Specific Gravity of Sediment at 3 observation stations.

Table 4: Specific gravity, velocity and river discharge.

Description	Unit	STA		
		0 + 000	0 + 925	1 + 922
Specific Gravity Gs		2.26	2.46	2.37
Average speed of low tide	m/s	0,133	0,039	0,036
Average Discharge of Low tide	m^3/s	3,137	1,254	0,194
The average speed of the tide	m/s	0,088	0,037	0,030
Average High Water Discharge	m^3/s	4,27	1,143	0,162

According Table 3 and Figure 11, it can be seen that there are differences in the density of sediment in each STA, where the density of sediment at STA 0+925 is greater than the density of sediment at STA 0+000 and STA 1+922. This difference is influenced by the position of the STA. Sampling at STA 0+000 is in the estuary area, STA 0 + 925 is in the middle of the length of the river and is in the area after the bridge, while STA 1+922 is in the upper part of the river. The deposition at the end of the river mouth (STA 0+000) is smaller due to ship wave activity and the influence of tidal currents is greater than in the areas of STA 0 + 925 and STA 1+922.

Different results were also obtained a study for one of the rivers on the island of Bengkalis (Liong River) (Khatib et all, 2013), the density of sediment at station one (2,551) and station two (2,569), where the density of sediment at station two was greater than that at station two. with the sediment density of station one. This difference is influenced by the position of the station. Sampling at station one is in the port dock area, while station two is at the end of the river mouth. The deposition at the end of the river mouth is caused by ship waves and the influence of tidal currents is greater than in the area near the harbor pier. That even though the rivers are in the same island, the specific gravity of the sediment deposits has different characteristics.

Table 5: Analysis of sediment grains.

Sieve Analysis					
ø (mm)	% Pass				
	0 + 000	0 + 925		1 + 922	
63,5	100,00	100,00		100,00	
38,1	100,00	100,00		100,00	
25,4	99,37	100,00		100,00	
19,05	98,45	95,01		99,15	
9,525	97,98	92,68		98,48	
4,75	97,41	91,90		98,10	
2,000	96,15	91,53		97,49	
0,850	94,24	90,95		96,20	
0,425	87,74	89,86		94,95	
0,150	79,92	85,84		91,55	
0,075	65,14	83,23		90,55	
Hydrometer Analysis					
0 + 000		0 + 925		1 + 922	
Diameter (mm)	% Pass	Diameter (mm)	% Pass	Diameter (mm)	% Pass
0,0307	35,33	0,0289	49,38	0,0300	47,83
0,0203	27,30	0,0190	40,77	0,0195	40,47
0,0121	18,74	0,0114	32,73	0,0116	34,34
0,0087	14,99	0,0082	29,29	0,0083	30,05
0,0062	16,06	0,0059	24,69	0,0060	26,37
0,0031	11,51	0,0030	18,95	0,0030	19,62
0,0013	7,49	0,0013	9,76	0,0013	11,65

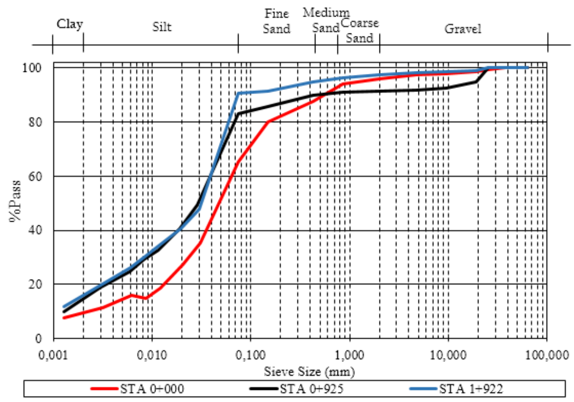

Figure 12: Grain size distribution of Bengkalis river sediment.

For testing the grain size distribution analyzed by hydrometer analysis and sieve analysis and presented in the form of a cumulative weight percentage curve. The test results can be seen in table 5 and Figure 12 below.

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Table 6: Grouping of Bengkalis river sediment grain size.

Sediment Grain Size	STA 0+000	STA 0+925	STA 1+922
Gravel	3,853	8,467	2,510
Coarse Sand	8,403	1,677	2,540
Fine Sand	22,60	6,63	4,40
Silt	37,84	42,46	50,07
Clay	19,81	31,01	28,82
Colloids	7,49	9,76	11,65

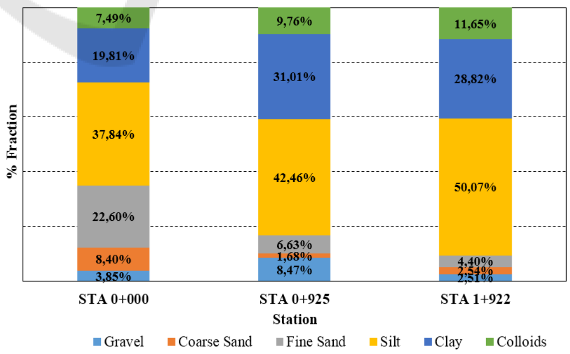

Figure 13: Bengkalis river sediment grain size grouping.

From table 6 and figure 13 it is known that the dominant types of sedimentary material in the Bengkalis river are silt (silt) and clay, respectively STA 0+000 37.84% and 19.81%, STA 0+925 42.46% and 31 0.01% and STA 1+922 50.07% and 28.82%.

The percentage of silt has increased from downstream to upstream. In contrast to the sediment content of the Liong Bengkalis river (Khatib et all, 2013), which is dominated by 75.87% sand (station 1) and 53.9% (station 2) while silt is 20.85% (station 1) and 43.86% (station 2). The results of this study are also very different from the results of research on sediment deposits in the Bengkalis strait (Putri and Rifardi, 2012), the percentage of sand fraction and gravel fraction dominates the type of sedimentary material ranging from 80-96.72% and 0-17.84%, so it can be concluded it is stated that the type of sedimentary material between the river and the sea where the river empties has different materials.

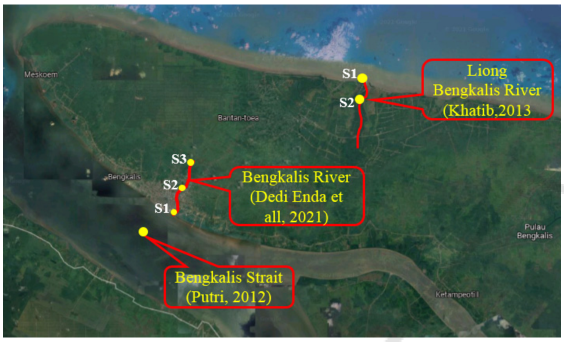

Figure 14: Location Research of Sediment.

4 CONCLUSIONS

Based on the results of data analysis that has been carried out, conclusions can be drawn including Density of sediment from the dominant sedimentary material, respectively STA 0+000 2,26, STA 0+925 2,46 and STA 1+922 2,37.

The type of sedimentary material that dominates the Bengkalis river sediment deposits are silt (silt) and clay, respectively STA 0+000 37.84% and 19.81%, STA 0+925 42.46% and 31.01% and STA 1+922 50.07% and 28.82%.

The type of sedimentary material that dominates the sediment in the Bengkalis river is different from the type of sedimentary material in the Bengkalis strait where the Bengkalis river estuary.

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