

Analysis of Sediment Dynamics in the Waters Perancak and Pengambengan Beaches, Jembrana - Bali

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Abstract

Perancak and Pengambengan Beaches located in Jembrana District, Bali. This research was conducted at Perancak and Pengambengan Beaches, which are areas with high community activity especially in fisheries sector. This study aims to analyze sediment dynamics in Perancak and Pengambengan Beaches waters, Jembrana, Bali. Sediment grab was used to carry sediment bottom, nansen bottles was used to collect water samples and ADCP was used to measure current direction and velocity. Analysis of sediment transport used modelling system by software MIKE 21. The result had shown that TSS concentrations at low tide smaller than high tide. TSS value at high tide is 1333,33 *mg/l* and at low tide it is 409,09 *mg/l*, therefore bottom sediment was dominated by medium sand. The result of modeling shown that sediment transport at high tide is $4,65 \times 10^{-3}$ *gr/s* with current direction 310° and dominant movement to the northwest, therefore at low tide it is $3,96 \times 10^{-3}$ *gr/s* with current direction 353° dominant movement to the northwest.

Keywords: Grain size, sediment characteristics, modelling, sediment transport

INTRODUCTION

Coastal regions are highly dynamic and continuously vulnerable due to natural and artificial disturbances by humans (To and Thao, 2008; Saranathan *et al.*, 2011; Mahapatra *et al.*, 2014; Jayakumar, 2014; Poornima *et al.*, 2015). This causes them getting pressed from various activities and phenomena occurring on the land or the sea. These natural phenomena occurred on the sea, i.e. tides, currents and waves, can make some impacts towards coastal ecosystem (Dahuri *et al.*, 2001). Hydro-oceanography is one of influential aspects in the process occurring on the coasts and seas. The distribution of sediment in waters is one of the coastal processes depending on hydro-oceanographic conditions such as currents, waves and tides (Dijkstra, 2008).

Seawater circulation such as currents and waves are effective in generating sedimentary materials. Coarse or fine sedimentary materials depend on the currents and waves in the area. Waters with large currents and waves generally have coarse materials. In contrast to waters with small currents and waves, they tend to have fine-sized ones (Hendromi *et al.*, 2015).

Perancak and Pengambangan Beaches located in Jembrana District are areas with coastal lines which have undergone a big change, either sedimentation or erosion. According to the results of satellite image recording in 2009, which was issued by the Bali-Penida River Basin Centre of the Directorate General of Water Resources of the Ministry of Public Works in 2010 and used by the Bali Provincial Public Works Office, shows that the length of the coast in Bali that experienced erosion was 181,7 km or 41,5 %. Then from the 181,7 km of eroded beaches, about 81,5 km have been handled. It was found that there are still about 100,2 km of beaches which have undergone erosion and have not been handled, including the beaches in Perancak and Pengambangan villages.

Coastal areas are large-scaled complexed ecosystem and cannot be explained entirely with short-term study, as it involves the connection between various variables or parameters. Thus, the purpose of this research is to analyse sediment dynamics in Perancak and Pengambangan Beaches Waters, Jembrana - Bali.

RESEARCH METHOD

Research Site

This research was conducted in November 2018 at Perancak and Pengambangan Beaches, Jembrana, Bali. Research materials included the data of sediments and currents. Bottom sediment sampling used sediment grabs in 16 point. Determination of measuring location employed Purposive Sampling Method, i.e. determining sampling location based on consideration of representative research locations. The locations are presented in Figure 1.

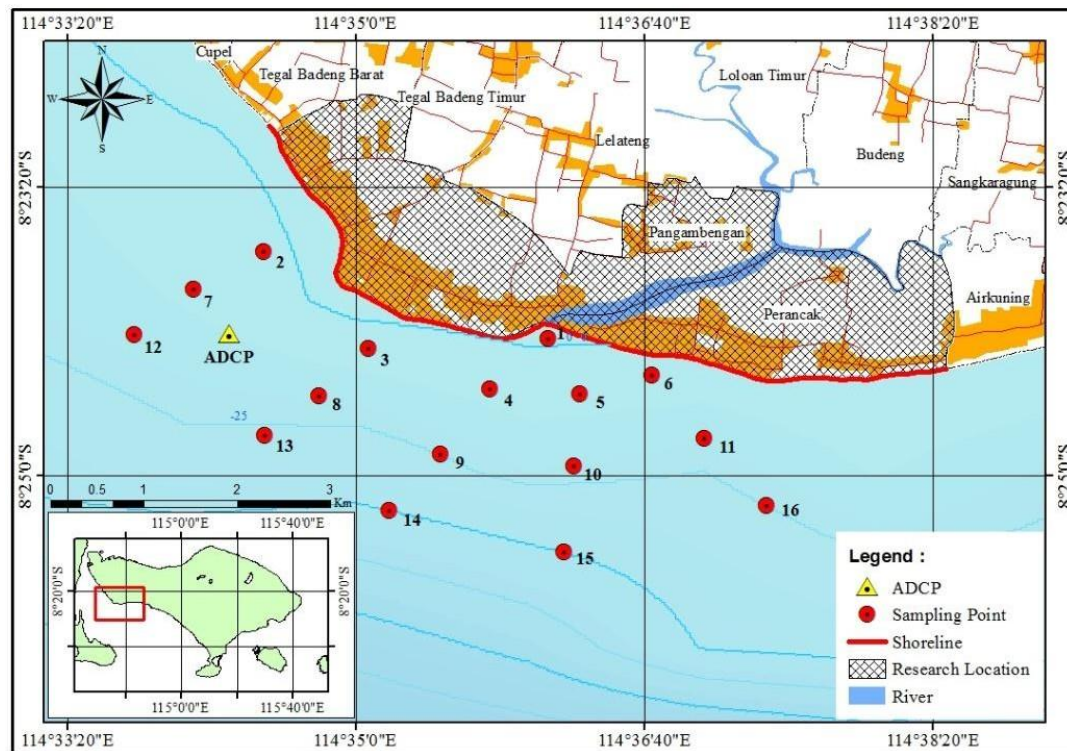


Figure 1. Map of Research Location in Perancak and Pengambangan Beaches

Sampling Technique

Bottom Sediment Sampling

Sediment was collected using sediment grab. Then the sediment trapped was put into a plastic bag which was then labelled using label paper to mark the samples taken at each point. The sampling location was divided into several points, where they were considered to have represented the characteristics of these waters.

Water Sampling for TSS (*Total Suspended Solid*)

Water was taken using a nansen bottles and put in a 1000 ml polyethylene bottle which was then labelled using label paper to mark the samples taken at each point. The sampling location was divided into several points, where one of the points was in the estuary area. Water sampling at the river estuary was carried out as much as once in 24 hours during spring tide. For the other points, the sample was taken only once.

Current Data Measurement

Data measurement of current direction and velocity used ADCP instrument (Acoustic Doppler Current Profiler). It started by determining location point of ADCP placement

at a depth of ± 10 meters. Then, preparation for devices and materials that would be used was done. Measurement of current direction and velocity data was done by installing ADCP into waters. It was left idle for seven days for data recording in accordance with time series. Apart from being installed as mooring at the surface or seabed, ADCP also could be installed permanently or temporarily to take the data of current profiles, depending on its configuration.

Data Analysis and Processing

Sediment Data Processing

The granulometric analysis of sediment included several things that are commonly done such as calculating the mean value, sorting, skewness, and kurtosis. Each of these calculations has different formulas and limitations to describe the state of the sediment grains taken and analysed. The following is an equation formula for calculating sortation, skewness and kurtosis:

Mean

$$M = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$$

Sortasi

$$S = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_5}{6.6}$$

Skewness

$$Sk = \frac{\phi_{84} + \phi_{16} - (2 \cdot \phi_{50})}{2(\phi_{84} - \phi_{16})} + \frac{\phi_{95} + \phi_5 - (2 \cdot \phi_{50})}{2(\phi_{95} - \phi_5)}$$

Kurtosis

$$K = \frac{\phi_{95} - \phi_5}{2.44(\phi_{75} - \phi_{25})}$$

TSS (Total Suspended Solid) Data Processing

The water sample obtained was then analyze in the laboratory to check its TSS (Total Suspended Solid) contents in the waters. The first step is to prepare the samples and filter paper for water sample filtration. The paper was dampened with *aquades* which was then put into a filtering tool. Water samples were stirred to obtain homogenous results. Those samples were then filtered with a vacuum pump for approximately 3 minutes. Next, the filter paper was weighed and recorded as wet weight. It was then

drained with an oven for an hour at a temperature of 103-105° C. After that, the paper was weighed once more and recorded as dry weight. After all processes were finished, the next thing to do was calculating TSS concentration by applying a formula as follows:

$$TSS = \frac{(BKS(k)R - BKS) \times 1.000}{\text{Test Sample Volume, mL}}$$

Where:

- BKS : Filter Paper Weight (mg)
- BKS(b)R : Wet Filter Paper Weight + Residue (mg)
- BKS(k)R : Dry Filter Paper Weight + Residue (mg)
- BAF : Aluminum Foil Weight (g)

Model Simulation

The collected primary and secondary data were then simulated with MIKE 21 programme. It is necessary to determine simulation time to start the process. It required 14 days for modelling simulation in this research. Then the determination of the boundary conditions would define the boundaries of the area to be modelled. There were six boundary conditions employed for running programme MIKE 21. They consisted of three sea boundaries which would be opened. Two boundary conditions for the lands according to coastline tracking using GPS, and the other one for the river to be opened for flow rates originating from the river.

RESULTS AND DISCUSSION

Sediment Characteristics and Grains Size

The measurement of sediment characteristics and grains is divided into two, that is according to tide condition. Where at one point the sampling was repeated three times both at high and at low tide, to obtain the average value of the type and size of the sediment grains. Based on the results, the sediment grain size using a sieve shaker and analysing the type of sediment grains with the Wentworth scale, the average value during tide conditions is described in Table 1 as follows.

Table 1. Characteristics and Diameter of Sediment Grain Size in High Tide

Stations	Result			
	%Sediment Characteristics	%Soil Retained	Diameter (mm)	Description
1	99,37	57,86	0,5	Medium Sand
2	100, 00	59,07	0,5	Medium Sand
3	99,65	73,35	0,5	Medium Sand
4	99,99	76,58	0,5	Medium Sand
5	100,00	62,77	0,5	Medium Sand
6	99,84	76,71	0,5	Medium Sand
7	96,52	84,78	0,5	Medium Sand
8	97,68	50,83	0,5	Medium Sand
9	96,82	58,11	0,5	Medium Sand
10	96,74	85,08	0,5	Medium Sand
11	93,44	73,22	0,5	Medium Sand
12	91,43	53,86	0,5	Medium Sand
13	95,84	45,46	0,5	Medium Sand
14	99,06	91,43	0,5	Medium Sand
15	98,79	88,08	0,5	Medium Sand
16	97,45	85,11	0,5	Medium Sand

Based on the calculation results table, it is gained that during high tide, the sediment characteristics in all points of sample taking are dominated with medium sand with the diameter of 0,5 mm. Then the results of the measurement of the sediment grain size using a sieve shaker and analysis of the type of sediment grains using the Wentworth scale are obtained, the average value at low tide is in Table 2 as follows.

Table 2. Characteristics and Diameter of Sediment Grain Size in Low Tide

Stations	Result			
	% Sediment Characteristics	%Soil Retained	Diameter (mm)	Description
1	99,71	58,36	0,3	Medium Sand
2	100,00	76,51	0,5	Medium Sand
3	99,74	63,80	0,5	Medium Sand
4	99,97	67,67	0,5	Medium Sand
5	99,96	74,06	0,3	Medium Sand
6	99,92	47,43	0,5	Medium Sand
7	93,56	45,53	0,5	Medium Sand
8	97,29	60,80	0,5	Medium Sand
9	97,41	69,16	0,5	Medium Sand
10	94,29	79,97	0,5	Medium Sand
11	98,11	74,69	0,5	Medium Sand
12	85,85	48,42	0,5	Medium Sand
13	99,11	48,85	0,3	Medium Sand
14	97,81	70,19	0,5	Medium Sand
15	95,41	53,65	0,3	Medium Sand
16	98,38	58,03	0,3	Medium Sand

It is discovered that at low tide the sediment characteristics at all sampling points are dominated by medium sand with a diameter of 0,5 mm. However, at several sampling points, medium sand types were found with a diameter of 0,3 mm.

After obtaining the results, interpolation was then carried out to obtain a map of the distribution of the basic sediment at Perancak and Pengambangan Beach both at high and at low tide. The following is a map of the distribution of basic sediment at high tide and at low tide in Figures 2 and 3.

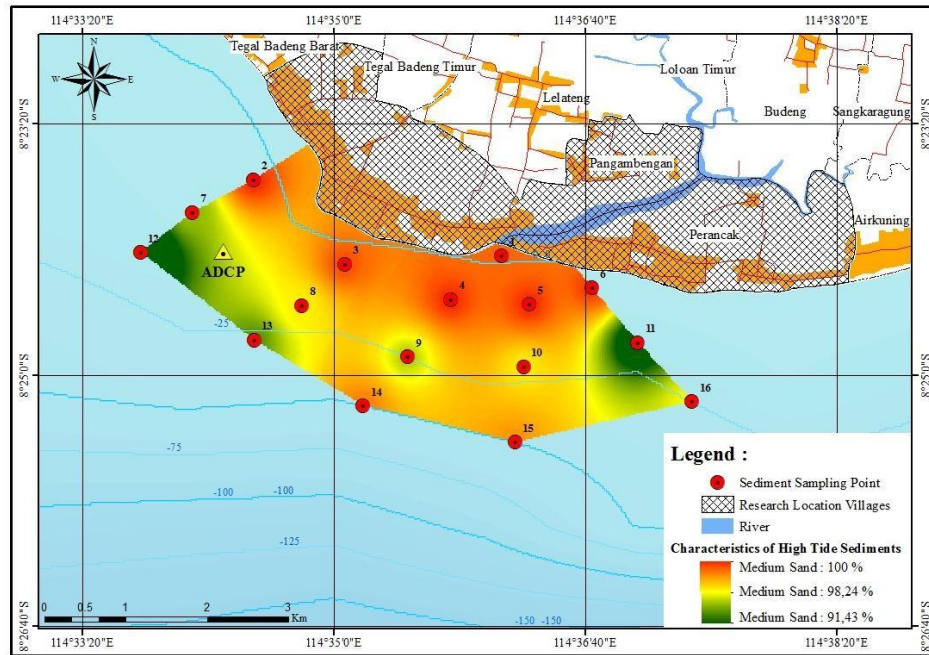


Figure 2. Map of The Distribution of Baseline Sediments at High Tide

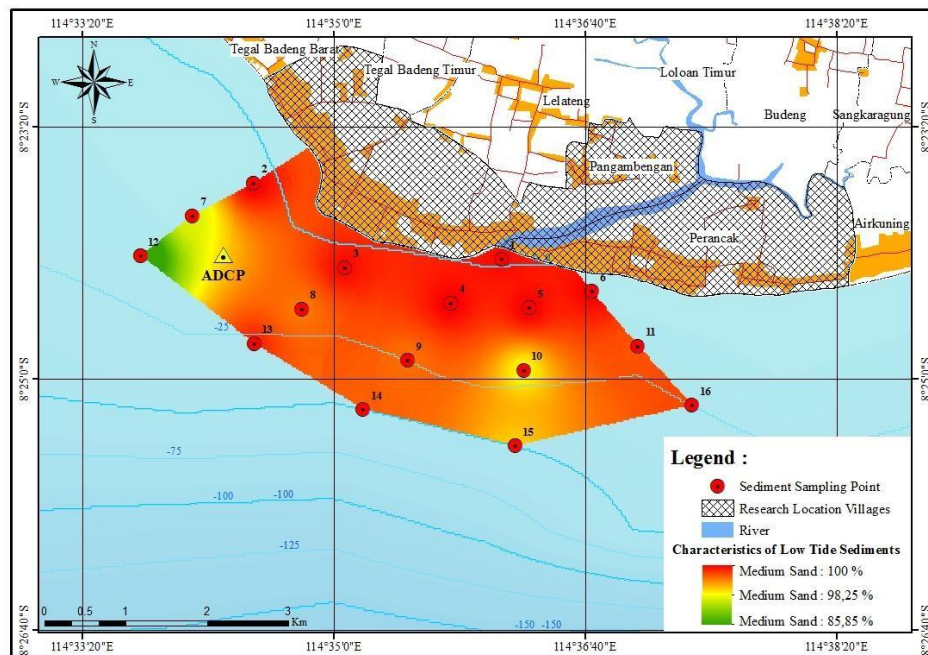


Figure 3. Map of The Distribution of Bottom Sediments at Low Tide

Based on the interpolation results, it is discovered a map of the distribution of basic sediments during high tide conditions in the beach waters is dominated by medium sand. Where the highest percentage by 100% is at stations 2 and 5, while the lowest percentage is by 91,43% at station 12. While the distribution map of basic sediments at low tide in the waters is dominated by medium sand. Where the highest percentage is by 100% at station 2, and the lowest percentage by 85,85% is at station 12.

The distribution of sediment grains is strongly influenced by the type and presence of sediment source materials such as landslides, erosion of walls and riverbeds and from the sea that is carried by currents to the estuary area. So that the distribution of sediment along the flow in the upstream, middle and downstream of the river is dominated by sand. Sand sediment in the upper reaches of the river is then then brought out to sea and settle at the estuary mouth. This process occurs due to the influence of tides, where at high tide the volume of water entering the river is very large. This water will accumulate with another one flowing from the upstream of the river, so that the current velocity is close to zero. It causes the sediment carried from the upstream of the river to settle into bottom sediment and some of the sediment will be carried to the sea and the coast around the river mouth.

During low tide, the large water volume entering the river, flows out carrying sand sediment for a certain period of time depending on the type of tide. Hence at low tide, the sediment movement spreads towards the coast and offshore waters. Therefore, the sediment characteristics both in river estuaries, coastlines and offshore waters are dominated by sand types, where the distribution of the sediment is very likely influenced by oceanographic factors. This condition is in line with Triatmodjo's statement (1999) that a beach experiences erosion, sedimentation or remains stable depending on the sediment which enters (supply) and leaves the beach. Grain size analysis is not only done to identify the type of seafloor sediment and its distribution, but also used to determine the dynamics and energy conditions of the depositional environment (Stewart, 1958; Passega, 1964; Carranza-Edwards et al. 2005; Opreanu et al. 2007).

Granulometry calculation on bottom sediment in the waters of Perancak and Pengambangan Beaches consists of Sorting (Sorting Coefficient), Skewness (Inclination), and Kurtosis (Sharpness), each of which is calculated based on tide condition. It requires phi to gain its results. Phi value determination is obtained from the sediment distribution graphic. The following Table 3 and 4 presents phi value at high tide and at low tide.

Table 3. Phi Value Calculation at High Tide

Stations	phi	Sorting	phi	Skewness	phi	Kurtosis
1A	-0,95	<i>very well sorted</i>	0,30	<i>positively skewed</i>	0,72	<i>platykurtic</i>
1B	-0,86	<i>very well sorted</i>	-0,02	<i>nearly symmetrical</i>	0,79	<i>Platykurtic</i>
1C	-0,91	<i>very well sorted</i>	0,23	<i>positively skewed</i>	0,74	<i>Platykurtic</i>
2A	-0,87	<i>very well sorted</i>	0,32	<i>very positively skewed</i>	0,71	<i>Platykurtic</i>
2B	-0,83	<i>very well sorted</i>	0,16	<i>positively skewed</i>	0,73	<i>Platykurtic</i>
2C	-0,84	<i>very well sorted</i>	0,04	<i>nearly symmetrical</i>	0,82	<i>Platykurtic</i>
3A	-0,91	<i>very well sorted</i>	0,02	<i>nearly symmetrical</i>	0,79	<i>Platykurtic</i>
3B	-0,80	<i>very well sorted</i>	-0,09	<i>nearly symmetrical</i>	0,85	<i>Platykurtic</i>
3C	-0,78	<i>very well sorted</i>	-0,06	<i>nearly symmetrical</i>	0,93	<i>Mesokurtic</i>
4A	-0,77	<i>very well sorted</i>	-0,05	<i>nearly symmetrical</i>	0,79	<i>Platykurtic</i>
4B	-0,75	<i>very well sorted</i>	-0,02	<i>nearly symmetrical</i>	0,79	<i>Platykurtic</i>
4C	-0,77	<i>very well sorted</i>	-0,05	<i>nearly symmetrical</i>	0,79	<i>Platykurtic</i>
5A	-0,76	<i>very well sorted</i>	0,60	<i>very positively skewed</i>	0,89	<i>Platykurtic</i>
5B	-0,81	<i>very well sorted</i>	0,14	<i>positively skewed</i>	0,70	<i>Platykurtic</i>
5C	-0,79	<i>very well sorted</i>	-0,03	<i>nearly symmetrical</i>	0,82	<i>Platykurtic</i>
6A	-0,85	<i>very well sorted</i>	-0,05	<i>nearly symmetrical</i>	0,85	<i>Platykurtic</i>
6B	-0,80	<i>very well sorted</i>	0,01	<i>nearly symmetrical</i>	0,93	<i>Mesokurtic</i>
6C	-0,69	<i>very well sorted</i>	-0,06	<i>nearly symmetrical</i>	0,78	<i>Platykurtic</i>
7A	-1,00	<i>very well sorted</i>	0,22	<i>positively skewed</i>	0,72	<i>Platykurtic</i>
7B	-0,87	<i>very well sorted</i>	0,32	<i>very positively skewed</i>	0,76	<i>Platykurtic</i>
7C	-1,00	<i>very well sorted</i>	0,22	<i>positively skewed</i>	0,77	<i>Platykurtic</i>
8A	-1,00	<i>very well sorted</i>	0,22	<i>positively skewed</i>	0,72	<i>Platykurtic</i>
8B	-0,87	<i>very well sorted</i>	0,32	<i>very positively skewed</i>	0,76	<i>Platykurtic</i>
8C	-1,00	<i>very well sorted</i>	0,22	<i>positively skewed</i>	0,77	<i>Platykurtic</i>
9A	-0,98	<i>very well sorted</i>	0,12	<i>positively skewed</i>	0,82	<i>Platykurtic</i>
9B	-0,91	<i>very well sorted</i>	0,14	<i>positively skewed</i>	0,74	<i>Platykurtic</i>
9C	-0,93	<i>very well sorted</i>	0,08	<i>nearly symmetrical</i>	0,74	<i>Platykurtic</i>
10A	-0,72	<i>very well sorted</i>	0,06	<i>nearly symmetrical</i>	0,94	<i>Mesokurtic</i>
10B	-0,68	<i>very well sorted</i>	0,08	<i>nearly symmetrical</i>	0,82	<i>Platykurtic</i>

Stations	phi	Sorting	phi	Skewness	phi	Kurtosis
10C	-0,69	<i>very well sorted</i>	0,22	<i>positively skewed</i>	0,86	<i>Platykurtic</i>
11A	-0,97	<i>very well sorted</i>	0,21	<i>positively skewed</i>	0,91	<i>Mesokurtic</i>
11B	-0,94	<i>very well sorted</i>	0,42	<i>very positively skewed</i>	0,98	<i>Mesokurtic</i>
11C	-0,90	<i>very well sorted</i>	0,10	<i>nearly symmetrical</i>	0,95	<i>Mesokurtic</i>
12A	-0,74	<i>very well sorted</i>	-0,97	<i>very negatively skewed</i>	0,22	<i>very platikurtic</i>
12B	-0,74	<i>very well sorted</i>	-0,97	<i>very negatively skewed</i>	0,25	<i>very platikurtic</i>
12C	-0,74	<i>very well sorted</i>	-0,97	<i>very negatively skewed</i>	0,23	<i>very platikurtic</i>
13A	-1,17	<i>very well sorted</i>	0,46	<i>very positively skewed</i>	1,00	<i>Mesokurtic</i>
13B	-1,18	<i>very well sorted</i>	0,40	<i>very positively skewed</i>	0,92	<i>Mesokurtic</i>
13C	-1,18	<i>very well sorted</i>	0,40	<i>very positively skewed</i>	0,92	<i>mesokurtic</i>
14A	-0,64	<i>very well sorted</i>	0,03	<i>nearly symmetrical</i>	0,78	<i>platykurtic</i>
14B	-0,64	<i>very well sorted</i>	0,03	<i>nearly symmetrical</i>	0,78	<i>platykurtic</i>
14C	-0,64	<i>very well sorted</i>	0,03	<i>nearly symmetrical</i>	0,78	<i>platykurtic</i>
15A	-0,68	<i>very well sorted</i>	0,08	<i>nearly symmetrical</i>	0,82	<i>platykurtic</i>
15B	-0,68	<i>very well sorted</i>	0,08	<i>nearly symmetrical</i>	0,82	<i>platykurtic</i>
15C	-0,68	<i>very well sorted</i>	0,08	<i>nearly symmetrical</i>	0,82	<i>platykurtic</i>
16A	-0,69	<i>very well sorted</i>	0,10	<i>positively skewed</i>	0,78	<i>platykurtic</i>
16B	-0,71	<i>very well sorted</i>	0,08	<i>nearly symmetrical</i>	0,90	<i>mesokurtic</i>
16C	-0,71	<i>very well sorted</i>	0,08	<i>nearly symmetrical</i>	0,82	<i>platykurtic</i>
Average	-0,83	<i>very well sorted</i>	0,06	<i>nearly symmetrical</i>	0,78	<i>platykurtic</i>

Table 4. Phi Value Calculation at Low Tide

Stations	phi	Sorting	phi	Skewness	phi	Kurtosis
1A	-0.87	<i>very well sorted</i>	0.65	<i>very positively skewed</i>	1.04	<i>mesokurtic</i>
1B	-0.91	<i>very well sorted</i>	0.67	<i>very positively skewed</i>	1.08	<i>mesokurtic</i>
1C	-0.92	<i>very well sorted</i>	0.70	<i>very positively skewed</i>	1.81	<i>leptokurtic</i>
2A	-0.29	<i>very well sorted</i>	0.33	<i>very positively skewed</i>	1.50	<i>very leptokurtic</i>
2B	-0.36	<i>very well sorted</i>	0.38	<i>very positively skewed</i>	1.91	<i>very leptokurtic</i>
2C	-0.50	<i>very well sorted</i>	0.60	<i>very positively skewed</i>	1.07	<i>mesokurtic</i>

Stations	phi	Sorting	phi	Skewness	phi	Kurtosis
3A	-0.87	<i>very well sorted</i>	0.41	<i>very positively skewed</i>	0.76	<i>platykurtic</i>
3B	-0.85	<i>very well sorted</i>	0.05	<i>nearly symmetrical</i>	0.60	<i>platykurtic</i>
3C	-0.76	<i>very well sorted</i>	-0.10	<i>negatively skewed</i>	0.82	<i>platykurtic</i>
4A	-0.81	<i>very well sorted</i>	0.14	<i>positively skewed</i>	0.76	<i>platykurtic</i>
4B	-0.81	<i>very well sorted</i>	0.14	<i>positively skewed</i>	0.76	<i>platykurtic</i>
4C	-0.75	<i>very well sorted</i>	-0.02	<i>nearly symmetrical</i>	0.79	<i>platykurtic</i>
5A	-0.77	<i>very well sorted</i>	-0.05	<i>nearly symmetrical</i>	0.86	<i>platykurtic</i>
5B	-0.39	<i>very well sorted</i>	0.42	<i>very positively skewed</i>	1.64	<i>very leptokurtic</i>
5C	-0.62	<i>very well sorted</i>	0.69	<i>very positively skewed</i>	1.89	<i>very leptokurtic</i>
6A	-0.67	<i>very well sorted</i>	0.19	<i>positively skewed</i>	0.76	<i>platykurtic</i>
6B	-0.63	<i>very well sorted</i>	0.04	<i>nearly symmetrical</i>	0.74	<i>platykurtic</i>
6C	-0.62	<i>very well sorted</i>	0.03	<i>nearly symmetrical</i>	0.71	<i>platykurtic</i>
7A	-1.08	<i>very well sorted</i>	0.12	<i>positively skewed</i>	0.87	<i>platykurtic</i>
7B	-1.11	<i>very well sorted</i>	0.06	<i>nearly symmetrical</i>	0.90	<i>platykurtic</i>
7C	-1.09	<i>very well sorted</i>	0.07	<i>nearly symmetrical</i>	0.85	<i>platykurtic</i>
8A	-1.09	<i>very well sorted</i>	0.12	<i>positively skewed</i>	0.87	<i>platykurtic</i>
8B	-1.11	<i>very well sorted</i>	0.06	<i>nearly symmetrical</i>	0.90	<i>platykurtic</i>
8C	-1.08	<i>very well sorted</i>	0.07	<i>nearly symmetrical</i>	0.85	<i>platykurtic</i>
9A	-0.83	<i>very well sorted</i>	-0.08	<i>nearly symmetrical</i>	0.79	<i>platykurtic</i>
9B	-0.88	<i>very well sorted</i>	0.08	<i>nearly symmetrical</i>	0.79	<i>platykurtic</i>
9C	-0.86	<i>very well sorted</i>	0.02	<i>nearly symmetrical</i>	0.92	<i>mesokurtic</i>
10A	-0.37	<i>very well sorted</i>	8.54	<i>very positively skewed</i>	0.89	<i>platykurtic</i>
10B	-0.34	<i>very well sorted</i>	7.58	<i>very positively skewed</i>	0.89	<i>platykurtic</i>
10C	-0.31	<i>very well sorted</i>	4.08	<i>very positively skewed</i>	0.89	<i>platykurtic</i>

Stations	phi	Sorting	phi	Skewness	phi	Kurtosis
11A	-0.36	<i>very well sorted</i>	4.13	<i>very positively skewed</i>	0.92	<i>mesokurtic</i>
11B	-0.35	<i>very well sorted</i>	7.60	<i>very positively skewed</i>	0.85	<i>platykurtic</i>
11C	-0.56	<i>very well sorted</i>	-1.04	<i>very negatively skewed</i>	0.76	<i>platykurtic</i>
12A	-0.83	<i>very well sorted</i>	-1.04	<i>very negatively skewed</i>	0.22	<i>very platykurtic</i>
12B	-0.90	<i>very well sorted</i>	-0.93	<i>very negatively skewed</i>	0.48	<i>very platykurtic</i>
12C	-1.16	<i>very well sorted</i>	0.10	<i>positively skewed</i>	0.22	<i>very platykurtic</i>
13A	-1.16	<i>very well sorted</i>	0.60	<i>very positively skewed</i>	0.80	<i>Platykurtic</i>
13B	-1.16	<i>very well sorted</i>	0.74	<i>very positively skewed</i>	0.96	<i>Mesokurtic</i>
13C	-1.12	<i>very well sorted</i>	0.51	<i>very positively skewed</i>	0.77	<i>Platykurtic</i>
14A	-0.92	<i>very well sorted</i>	0.16	<i>very positively skewed</i>	0.77	<i>Platykurtic</i>
14B	-0.80	<i>very well sorted</i>	-0.05	<i>nearly symmetrical</i>	0.79	<i>Platykurtic</i>
14C	-0.76	<i>very well sorted</i>	-0.04	<i>nearly symmetrical</i>	0.82	<i>Platykurtic</i>
15A	-0.98	<i>very well sorted</i>	0.77	<i>very positively skewed</i>	1.59	<i>very leptokurtic</i>
15B	-1.02	<i>very well sorted</i>	0.42	<i>very positively skewed</i>	0.79	<i>platykurtic</i>
15C	-1.02	<i>very well sorted</i>	0.24	<i>positively skewed</i>	0.79	<i>platykurtic</i>
16A	-0.89	<i>very well sorted</i>	0.70	<i>very positively skewed</i>	1.49	<i>leptokurtic</i>
16B	-0.89	<i>very well sorted</i>	0.70	<i>very positively skewed</i>	1.49	<i>leptokurtic</i>
16C	-0.96	<i>very well sorted</i>	0.36	<i>very positively skewed</i>	0.74	<i>platykurtic</i>
Average	-0.78	<i>very well sorted</i>	0.88	<i>very positively skewed</i>	0.95	<i>mesokurtic</i>

Based on the high tide calculation, the mean value is obtained for sorting, skewness, and kurtosis respectively are -0.83 categorised as very well sorted, 0.06 as nearly symmetrical, and 0.78 as platykurtic or flat. While the calculation at low tide, the mean value obtained for the three categories respectively are -0.78 categorised as very well sorted, 0.88 as very positively skewed (tending to coarse sand), and 0.78 as mesokurtic or normal.

TTS (Total Suspended Solid) Distribution

The calculation of the total value of suspended solids is divided into two conditions, namely at high and low tide. It can be seen when the waters are at high tide the suspended solids concentration is higher than at low tide. The following Table 5 presents the results of the calculation of total suspended solids.

Table 5. Calculation of TSS Value at High Tide and Low Tide

Stations	High Tide (<i>mg/l</i>)	Low Tide (<i>mg/l</i>)
1	442,86	409,09
2	866,6	133,3
3	1333,3	366,6
4	1266,6	266,6
5	333,3	266,6
6	666,6	266,6
7	1266,6	233,3
8	1000	266,6
9	266,6	200
10	1066,6	200
11	800	166,6
12	500	266,6
13	200	100
14	566,6	100
15	466,6	100
16	500	233,3

After obtaining the results of the calculation of the mean total value of suspended solids in high and low tide conditions and the total value of suspended solids in the river mouth, then interpolation is done to gain a distribution map of suspended sediments on

Perancak and Pengambengan Beaches. The following Figure 4 and 5 presents map of suspended sediment interpolation during high and low tide.

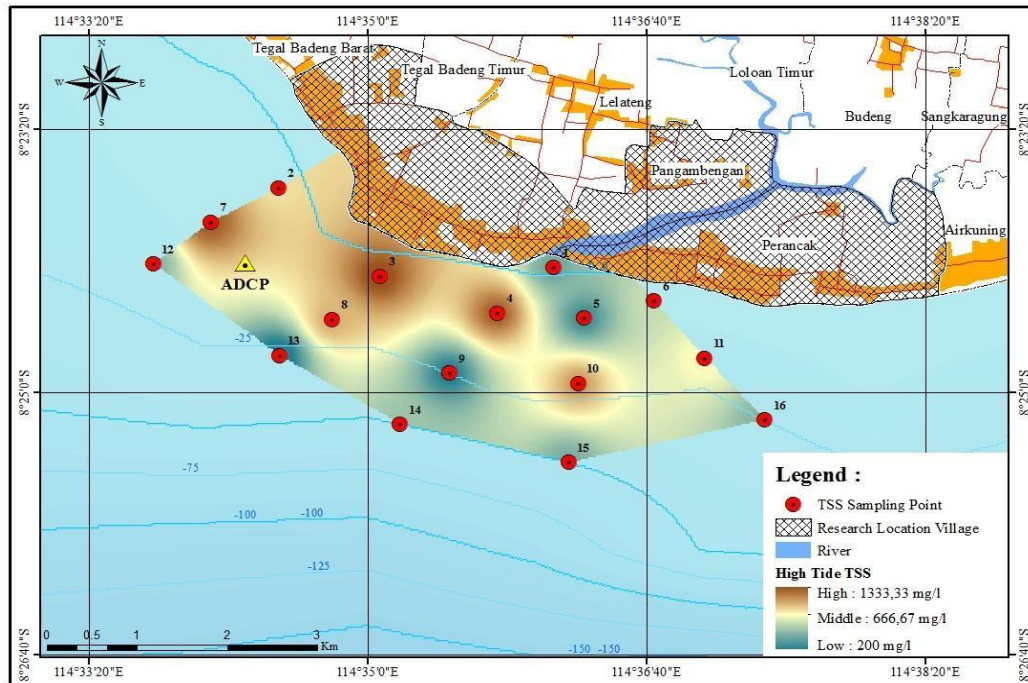


Figure 4. TSS Distribution Map at High Tide

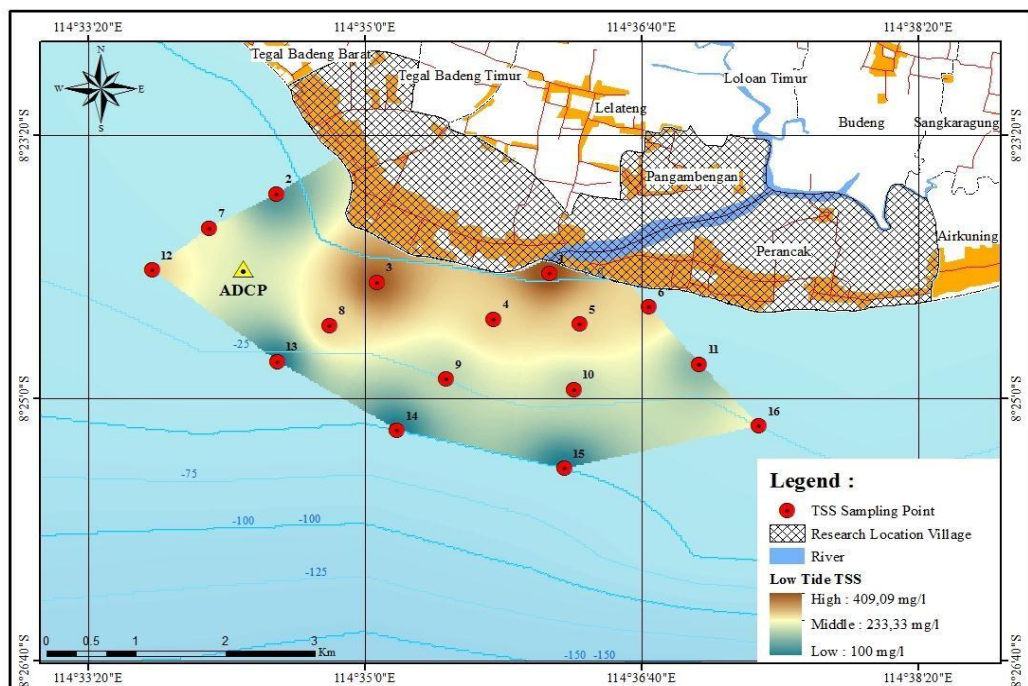


Figure 5. TSS Distribution Map at Low Tide

Based on the interpolation results, it is found that the map distribution of suspended sediment at high tide in the waters with highest concentration is by 1333,33 mg/l in station 3. Then, the suspended solids with medium concentration is by 666,67 mg/l in station 6, and the lowest one is by 200 mg/l in station 13. Meanwhile, the map distribution of suspended sediment at low tide with highest concentration is by 409,09 mg/l in station 1. Then the suspended solids with medium concentration is by 2333.33 mg/l in station 7 and 16, and the lowest one is by 100 mg/l in station 13, 14, and 15.

The concentration tends to elevate if there is a high tide and the highest TSS concentration is at station 3, as it is exactly situated at the front of river mouth. High tide conditions are generally accompanied by large currents and waves, so that it will stir the sedimentary material at the bottom to be mixed with water and the water becomes turbid, resulting in an increase in the TSS value. The level of turbidity has a positive correlation with suspended solids, where the higher the turbidity value, the higher the suspended solids value. This is caused by various factors, namely, tides, run-offs, human and fishery activities around these waters. This condition is in line with Wisha et al.'s study (2017), when there is a tide, the current moves towards the land and transports a large amount of suspended sediment from the sea to the land, thus the value of the suspension concentration is large.

During low tide, the highest concentration is found in station 1, where it is situated at the river mouth. This is due to the large water volume at low tide having gotten into the river flows out, hence the sediment source is only originated from the remnants of river flow. In addition, waters condition during low tide tend to stay still hence the sedimentary materials sediment and the water becomes clearer. This condition generally has relatively small current and wave velocity, thus the sediment material in the column and at the bottom of the water does not undergo stirring and mixing with water but instead settles at the bottom. This condition is in line with Solihuddin's claim (2009) that the ocean currents which occur both due to tides and waves are one of the parameters in controlling the dynamics of TSS distribution in waters because of the presence of TSS in floating waters, so that its movement depends on the current.

Sediment Transport

The modelling of sediment transport is simulated by using supporting parameter, namely tides, bathymetry, wind and currents which are formed into two-dimensioned hydrodynamics model. The results of it consider the transport condition on the parameter of tides. The following Figure 6 and 7 provide the map of sediment transport during high tide and low tide.

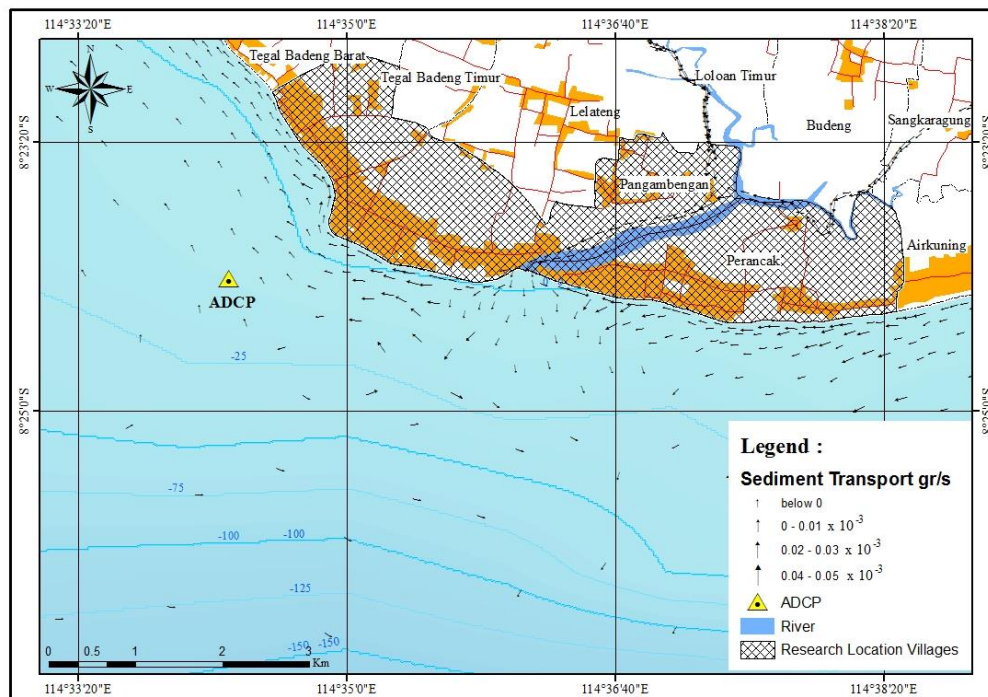


Figure 6. The Map of Sediment Transport at High Tide

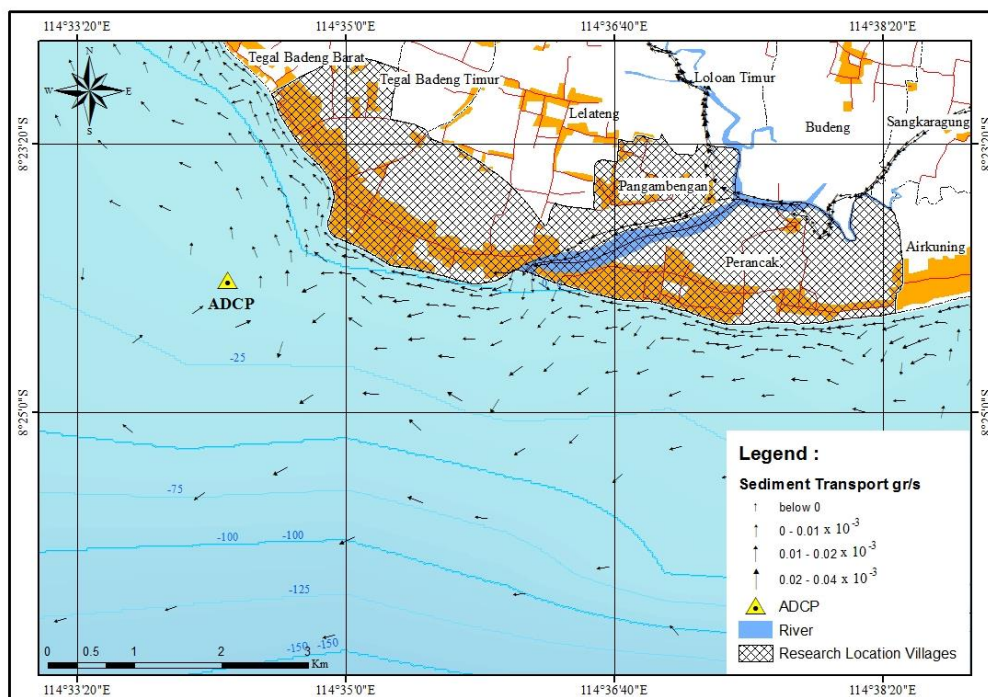


Figure 7. The Map of Sediment Transport at Low Tide

The highest amount of sediment transport occurring in the estuary at high tide reaches $4,65 \times 10^{-3} \text{ gr/s}$ and moves towards 310° , where the movement of sediment during the dominant high tide is towards the northwest. Sediment movement is affected by tidal currents, where at high tide the movement of currents leads from the southwest to the northeast. Therefore, the sediment carried by the current when the dominant high tide settles to the east of the river mouth. This condition is in line with Sugianto's remark (2009), where the direction and current velocity tend to fluctuate in line with the tidal pattern, as in another word that tidal currents are the dominant currents in these waters. Tidal current has a pivotal role in the process of estuary and coastal dynamics (Arifin, 20212). In addition, the coastline is a very dynamic area with sediment transport which occurs continuously and forms a new morphology of the characteristics of the sediment grain size (Jayakumar and Malarvannan, 2016; Muskananfola et al., 2020).

Then the highest amount of sediment transport occurring in the river mouth at low tide reaches $3,96 \times 10^{-3} \text{ gr/s}$ and moves towards 353° , where the movement of sediment during dominant low tide is towards the northwest. This condition can happen as the relatively small current velocity, around $0,03 \text{ m/s}$ on average, is unable to move the sediment with an average size of $0,5 \text{ mm}$, resulting in sediment deposition events. The current originating from the river mouth carries sedimentary material towards the sea, but when the current velocity is low it makes sediment deposition higher. High sediment deposition is due to small ocean currents (Dwinanto et al, 2017). This is also relevant with the statement of Siregar et al (2014), that the formation of the incidence angle of waves will affect the value of the longshore current, which can allow the bottom sediment to move along the coast and be deposited in areas where the current velocity is no longer able to move sediment.

CONCLUSION

The sediment distribution is composed of medium sand. The percentage of medium sand deposits at high or low tide reaches 100%. The other results obtained, which are sediment granulometric calculations at high tide, sequentially are sorting, skewness and kurtosis, namely, $-0,83$ categorised as very well sorted, $0,06$ as nearly symmetrical, and $0,78$ as platykurtic (flat). Then at low tide, the results obtained respectively are sorting, skewness and kurtosis, namely, $-0,78$ categorised as very well sorted, $0,88$ as very positively skewed (very inclined towards coarse sand), and $0,78$ mesokurtic (normal). The TSS concentration was also obtained, which at low tide tends to be smaller than at high tide. The TSS value at high tide is $1333,33 \text{ mg/l}$ and at low tide is $409,09 \text{ mg/l}$. Likewise in the estuary area, TSS concentrations increase at high tide compared to low tide with an average of $442,86 \text{ mg/l}$. Furthermore, the highest amount of sediment transport at high tide is $4,65 \times 10^{-3} \text{ gr/s}$ with 310° moving dominantly towards the northwest and at low tide it is $3,96 \times 10^{-3} \text{ gr/s}$ with 353° moving dominantly towards the northwest. Areas with high current velocity of the transport mechanism are also high so they tend to be eroded, while areas with weak current velocity, stirred sediment will easily settle.

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