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Identification of Coastal Problem and Prediction of Coastal Erosion Sedimentation in South Sulawesi

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Abstract

Dynamic processes that occur on the coast and the development of coastal areas can cause problems in coastal areas such as erosion and sedimentation. To solve these issues, some types of coastal protection can be applied. On the other hand, to determine the right choice of protection, it must be known in advance whether the erosion or sedimentation would be issued. Incidence of erosion or sedimentation on the coast can be predicted by using the wave parameters for instance wave height and wave period. For the case of grain sediment, the parameters are performed such as diameter and settlement velocity of sediment grain. To predict the erosion and sedimentation, the Kraus's equation is used. It is predicted that erosion and coastal sedimentation in South Sulawesi shows the sedimentation occurs on the Pare-Pare Mattirotasi Beach with the small wave conditions (normal), while the big wave conditions at several points along the eroding shoreline. For the case of Tanjung Bayang, te erosion takes place either in small wave or big wave. On the other hand, the wave height in Tanjung Bira obtained from the wave forecasting results based on the wind data BMKG Selayar waters relatively large yield is 0.89~1.64 m. So that the sediment grain size is relatively large will experience sedimentation and the smaller grains will easily carried away by the waves and currents that occur so easily eroded.

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Keywords: erosion; sediment; coastal

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1. Introduction

Indonesia is a maritime country has the fourth longest coastline in the world after the United States, Canada and Russia. The length of coastline in Indonesia is 95181 square kilometers (http://id.wikipedia.org/wiki/Pantai). As the country with the longest coastline Indonesia experienced various problems beach. The issue of beach erosion and sedimentation Indonesia is recently received special attention from the government and society because of the effect has direct impact on community life, among others, destruction of infrastructure, settlements, transportation, tourist attractions, and other coastal property loss. One example of coastal erosion and sedimentation problems can be seen in Pinrang Beach, South Sulawesi Figure 1.

Figure 1. The erosion and sedimentation in Pinrang Beach, South Sulawesi (2009)

The Coastal erosion also happen in Pasauran Serang Regency, Banten (Junarsa, 2006). It is observed that erosion, abrasion and damage to coastal structures such as sea walls. Common facilities, particularly the highway connecting Anyer-Labuan threatened damaged by erosion and abrasion. The coastline has connectivity with the road and if it is not handled immediately, the erosion and abrasion will continue and may cause damage to the road.

Figure2. The damageson the seawall south Pasauran beach (Junarsa, 2006)

To overcome the problems of erosion and sedimentation is usually applied as follow; looking for causes of erosion and sedimentation, so that by knowing the cause, it can be determined how to handle it.
In coastal engineering, there are two approaches that can be used to overcome the problems of the beach. The first approach is the soft approach, i.e. non-structural approaches such as artificial sand beach (beach nourishment), vegetation, sand by passing, and the coastal border policy. The second approach is a hard approach or structural approach, for example, build breakwaters, jetties, groins, sea walls and etc. Both of these approaches each have advantages and disadvantages and their application depends on the characteristics of the beach.
To find out what approaches can be used to overcome the problems of erosion and sedimentation, it must be the first conducted surveys and studies on the prediction of erosion and sedimentation events that happened on the beach.

2. Coastal Sediment

Coastal sediments derived from the erosion can occur on the shoreline, from the land that was brought by the river and from the sea in the drift to the beach area. To study the processes of erosion and sedimentation on the beach, one of the important parameters must be known are the properties of coastal sediments. The properties of the beach sediment are the particle size and distribution of sediment grain, density, shape, sedimentation rate, resistance to erosion and etc. The most important properties of the sediment are sediment grain size distribution.

2.1. Sediment Particle Size Distribution

Sediment grain size distribution can be analyzed with a sieve and presented in the form of cumulative weight percentage curve. Generally, the size distribution of grains of sand's approaches is a logarithm normal distribution. The median grain size D50 is the most widely used for the size of a grain of sand. Based on the logarithm normal distribution, the mean grain size D_m and standard deviation σ_D can be calculated as follows:

$$D_m = \sqrt{D_{16} D_{84}} \tag{1}$$

$$\sigma_D = \sqrt{\frac{D_{84}}{D_{16}}} \tag{2}$$

With the notation Dp is the size and p% of the weight of the sample is more subtle than the grain diameter. To measure the degree of grain size distribution of the mean value is often used coefficient so which is written as follows:

$$S_o = \sqrt{\frac{D_{75}}{D_{25}}} \tag{3}$$

If $1 \leq S_o \leq 1{,}5$ uniform sand grain size, for $1{,}5 \leq S_o \leq 2$ medium sand grain size distribution, and if $2 \leq S_o$ gradation of sand grain size varies greatly.

Classified by the coastal sediment grain size becomes sediment clay, silt, sand, gravel, coral, and cobble stones. Table 1, shows the classification according to Wenthworth that widely used in the field of coastal engineering (CERC, 1984).

Table. 1. Classification Wenthworth sediment grain size (CERC, 1984).

Classification		**Grain diameter**	
		mm	phi
Stone		256	-8
Cobble		128	-7
Coral	Great	64	-6
(*Pebble*)	Moderate	32	-5
	Small	16	-4
	Very Small	8	-3
Gravel		4	-2
Sand	Very rough	2	-1
		1	
	Rough	1	0
		0,5	
	Moderate	0,5	1
		0,25	
	Smooth	0,25	2
		0,125	
	Very Smooth	0,0125	3
		0,063	4
Mud	Rough	0,031	5
	Moderate	0,015	6

	Smooth	0,0075	7
	Very Smooth	0,0037	8
Clay	Rough	0,0018	9
	Moderate	0,0009	10
	Smooth	0,0005	11
	Very Smooth	0,0003	12

2.2. Settlement Velocity of Sediment

In addition, the sediment properties are also important in the study of sediment transport mechanism is the settling velocity. For non-cohesive sediments, such as sand, settling velocity can be calculated by Stokes formula, depending on the sediment and water density, viscosity of water, dimensions and shape of sediment particles. Most of the sand that exists in nature is not spherical, then the necessary calculations granular form factor expressed by the following:

$$SF = \frac{D_1}{(D_2 D_2)^{\frac{1}{2}}} \tag{4}$$

where D1, D2 and D3 are the long axes of the shortest, medium and longest, respectively. Figure 3 shows the influence of the shape of the settling velocity (Sleath, 1982).

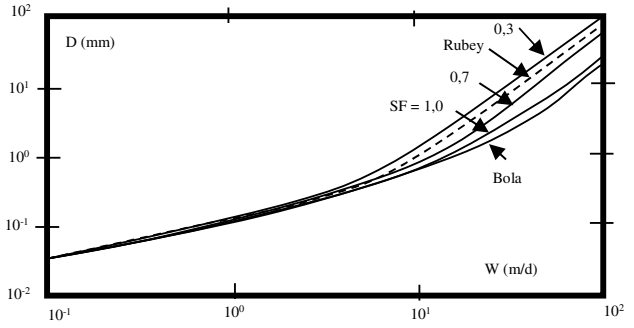

Figure 3.The influence of the form factor of the settling velocity (Sleath, 1982)

2.3. Prediction of Erosion and Sedimentation

Wave Incidence of on the beach is one of the factors that determine the occurrence of coastal erosion or sedimentation. Incidence of a great wave with a small period as commonly occurs during the storm will result in coastal erosion. Therefore the wave parameters that influence in determining the incidence of erosion and sedimentation on the beach is the significant wave height (H) and wave period (T). Fopr the wave parameters, the characteristics such as the beach sediment grain diameter (D50) and settling velocity of sediment (Ws) are alsosignificant parameter in determining the occurrence of erosion and sedimentation on the beach. Prediction of coastal erosion and sediment used in this study is the prediction using Kraus.et.al characteristics (1991) in Lanuru (2011),

a. Beach categorized eroded if

$$\frac{H}{W_s\, T} \geq 3.2 \tag{5}$$

b. Sedimentation if,

$$\frac{H}{W_s\, T} < 3.2 \tag{6}$$

where H is the significant wave height, Ws is the settling velocity, T is the wave period. The result of erosion and sedimentation prediction of three (3) research sites on small and large wave events are shown in the following table.

Table 2.Prediction of Erosion and Sedimentation Mattirotasi Beach, City of Pare-Pare, Higher Wave Conditions.

Point	Grain size (mm)	Settling velocity (W_s)	Wave height (H),m	Wave period (T), second	$H/W_s.T$	Prediction
1	0.37	0.075	3.66	8.69	5.62	Erosion
2	0.44	0.08	3.66	8.69	5.27	Erosion
3	0.75	0.15	3.66	8.69	2.83	Sedimentation
4	0.49	0.1	3.66	8.69	4.21	Erosion
5	0.45	0.08	3.66	8.69	5.27	Erosion
6	0.78	0.15	3.66	8.69	2.80	Sedimentation
7	0.95	0.17	3.66	8.69	2.45	Sedimentation
8	0.65	0.13	3.66	8.69	3.24	Erosion
9	0.50	0.10	3.66	8.69	4.21	Erosion
10	0.80	0.15	3.66	8.69	2.80	Sedimentation

Table 2, shows that the relative condition of large waves eroding beaches, but there are some locations experienced sedimentation measurements. It is caused by the island in front of the beach and the reclamation work that makes some parts of the coastline experienced sedimentation. At small wave conditions (normal), the prediction results are shown in Table 3 below.

Table 3. Prediction of Erosion and Sedimentation Mattirotasi Beach, City of Pare-Pare, Small Wave Conditions

Point	Grain size (mm)	Settling velocity (W_s)	Wave height (H),m	Wave period (T), second	$H/W_s.T$	Prediction
1	0.37	0.075	0.56	2.49	2.99	Sedimentation
2	0.44	0.08	0.56	2.49	2.81	Sedimentation
3	0.75	0.15	0.56	2.49	1.51	Sedimentation
4	0.49	0.1	0.56	2.49	2.25	Sedimentation
5	0.45	0.08	0.56	2.49	2.81	Sedimentation
6	0.78	0.15	0.56	2.49	1.50	Sedimentation
7	0.95	0.17	0.56	2.49	1.31	Sedimentation
8	0.65	0.13	0.56	2.49	1.73	Sedimentation
9	0.50	0.10	0.56	2.49	2.25	Sedimentation
10	0.80	0.15	0.56	2.49	1.5	Sedimentation

Table 3 shows that the condition of the small wave / quiet (normal), coastal sedimentation Mattirotasi experience. The shoreline changes of Mattirotasi beach since 2006 until 2013 shows that shoreline changes indicate that erosion occurs along the shoreline. It showed the difference between prediction results with an overview of shoreline changes. For more detailed results it is necessary further research to Mattirotasi Beach.

Figure 4.The shoreline changes of Mattirotasi beach (Google Earth 2006, 2009, 2013)

The whole point of measurement along the coastline experience sedimentation. Location The second study was TanjungBayang Beach, Makassar. The location of measurement points starting from the mouth of the River Jeneberang towards TanjungBunga. The distance between the measurement point approximately 200 m. The prediction results of erosion and sedimentation in a large and small wave conditions are shown in Tables 4 and 5.

Table 4. Prediction of erosion and sedimentation Tanjung Bayang beach, Makassar, large wave conditions.

Point	Grain size (mm)	Settling velocity (W_s)	Wave height (H),m	Wave period (T), second	$H/W_s.T$	Prediction
1	0.38	0.07	6.56	12.80	7.30	Erosion
2	0.60	0.12	6.56	12.80	4.26	Erosion
3	0.65	0.13	6.56	12.80	4.10	Erosion
4	0.25	0.03	6.56	12.80	18.94	Erosion
5	0.35	0.05	6.56	12.80	9.83	Erosion

Tabel5. Prediction of erosion and sedimentation TanjungBayangbeach, Makassar, small wave conditions

Point	Grain size (mm)	Settling velocity (W_s)	Wave height (H),m	Wave period (T), second	$H/W_s.T$	Prediction
1	0.38	0.07	3.60	8.60	5.98	Erosion
2	0.60	0.12	3.60	8.60	3.48	Erosion
3	0.65	0.13	3.60	8.60	3.35	Erosion
4	0.25	0.03	3.60	8.60	15.50	Erosion
5	0.35	0.05	3.60	8.60	8.05	Erosion

Wave height of the wave forecasting results is relatively higher in Makassar, both large and small wave conditions ranged between 3.6~6.56 meters. Hence, the prediction results on the location of Tanjung Bayang beach indicates that the coast is eroding both the large and small wave conditions. To validate the prediction results can be seen in Figure 4, which shows the changes of Tanjung Bayang shoreline since 2000 until 2013 (Google Earth). The figure shows that erosion occurs in the north of the estuary of the Jeneberang river (research location). It is in accordance with the prediction result of erosion and sedimentation of Tanjung Bayang beach.

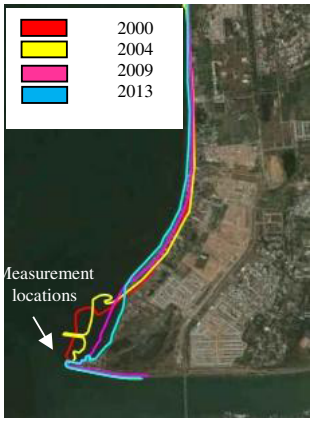

Figure 5.The shoreline changes of Tanjung Bayang beach (Google Earth 2000, 2004, 2009, 2013)

The third research location is Tanjung Bira beach, Bulukumba. Wave height forecasting results based on wind data BMKG Makassar is approximately 0.89~1.64 meters. The prediction results of erosion and sedimentation in a large and small wave conditions are shown in Tables 6 and 7 below.

Table 6. Prediction of erosion and sedimentation Tanjung Bira, Bulukumba, large wave conditions

Point	Grain size (mm)	Settling velocity (W_s)	Wave height (H),m	Wave period (T), second	$H/W_s.T$	Prediction
1	0.65	0.13	1.64	5.77	2.27	Sedimentation
2	0.60	0.12	1.64	5.77	2.40	Sedimentation
3	0.20	0.03	1.64	5.77	11.40	Erosion
4	0.30	0.05	1.64	5.77	5.70	Erosion
5	0.20	0.03	1.64	5.77	11.40	Erosion

Tabel7. Predictionof erosion and sedimentation TanjungBira, Bulukumba, large wave conditions

Point	Grain size (mm)	Settling velocity (W_s)	Wave height (H),m	Wave period (T), second	$H/W_s.T$	Prediction
1	0.65	0.13	0.89	3.85	1.85	Sedimentation
2	0.60	0.12	0.89	3.85	1.93	Sedimentation
3	0.20	0.03	0.89	3.85	9.25	Erosion
4	0.30	0.05	0.89	3.85	4.62	Erosion
5	0.20	0.03	0.89	3.85	9.25	Erosion

Tables 6 and 7 shows that the wave and sediment grain size parameters are significant influenced to erosion and sedimentation. According to those tables, with the same wave conditions for grains larger sediment will occur sedimentation and sediment smaller grains will be more easily transported due to erosion.

In Lanuru research (2011), who also perform predictive analysis of erosion and sedimentation in TanjungBira show that the condition of a large wave erosion and the small wave conditions (normal) occurred sedimentation. So researchers are trying to use the data of wave height and wave period based on the Lanuru research (2011), the wave height at the time of the small wave is 0.29 meters and the period is 4.9 seconds. The predicted results of the erosion and sedimentation in Tanjung Bira, Bulukumba for small wave conditions are summerized in table 8 as follow.

Table 8.Predicted Erosion and Sedimentation TanjungBira, Bulukumba, Small wave conditions (wave data Lanuru, 2011).

Point	Grain size (mm)	Settling velocity (W_s)	Wave height (H),m	Wave period (T), second	$H/W_s.T$	Prediction
1	0.65	0.13	0.29	4.9	0.47	Sedimentation
2	0.60	0.12	0.29	4.9	0.493	Sedimentation
3	0.20	0.03	0.29	4.9	2.37	Sedimentation
4	0.30	0.05	0.29	4.9	1.18	Sedimentation
5	0.20	0.03	0.29	4.9	2.37	Sedimentation

Table 8 shows that when using a small wave height data, the measurement results Lanuru (2011), the predicted results show that the Tanjung Bira beach sedimentation along the coast. For a validation of the results of prediction performed a simple analysis of the picture of Tanjung Bira shoreline changes from 2006 to 2014. Figure 6 shows that there is a significant change from 2006 to 2014, shoreline in 2006 is more forward than in the year 2012 to 2014. It shows that erosion occurs along the shoreline of Tanjung Bira. Based on the comparison between the results of prediction by the picture of shoreline changes indicate that the prediction results close to the results analysis of shoreline changes.

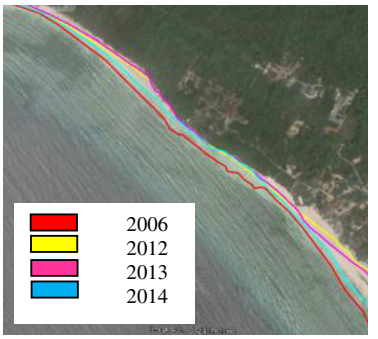

Figure 5.The shoreline changes of Tanjung Bira beach (Google Earth 2006, 2012, 2013, 2014)

3. Conclusions

Based on the results of field surveys and data analysis, the following conclusion can be drawn:

1. Sediment grain size Mattirotasi Beach Pare-Pare ranges 0.37~0.95 mm. Wave forecasting using wind data BMKG generate maximum wave height of 3.66 meters with the period of 8.69 seconds gives a prediction of erosion and sedimentation that varies in each measurement point. At the measurement point in the southern part of the coastline is eroding (points 1 and 2), then the 3 point sedimentation, erosion points 4 and 5, 6 and 7 sedimentation point, point 8 and 9 erosion and sedimentation last 10 points. At small wave conditions are based on the results of forecasting waves of 0.56 m and a period of 2.49 seconds may predict that along the coastline to experience sedimentation.
2. The sediment grain size of Cape Coast shadow of Makassar ranged 0.25 - 0.65 mm. Wave height and wave period of maximum wave forecasting results of using wind data BMKG is equal to 6.56 m and the period of 12.80 seconds. Wave forecasting results are very high so that the prediction of erosion and sedimentation in the shadow of Cape Coast shows erosion along the coast. Likewise, the small wave conditions in the amount of 3.60 m and a period of 8.60 seconds is still quite large relative to predicted results also showed erosion along the shoreline.
3. Sediment grain size Tanjung Bira beach, Bulukumba ranged between 0.20~0.65 mm. Wave height obtained from the wave forecasting based on wind data BMKG Selayar waters yield relatively large, namely 0.89 - 1.64 meters. So that the grain size is relatively large sediment will undergo sedimentation and the smaller grains will be easily carried away by waves and currents that occur so easily eroded.

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