Sediment Profiles and Distribution of Losari beach
Ujungpandang District Makassar City

H Sirajuddin1, Kaharuddin1, and Sultan1

1Geology Engineering Department, Engineering Faculty, Hasanuddin University, Makassar, Indonesia

*Email: haerany_sirajuddin@yahoo.com

Abstract. Research on Losari beach sediment profiles and distribution aims to analyze subsurface conditions and composition of coastal sediment materials based on hydrodynamic processes consisting of currents, waves and tides, analysis of sediment textures and subsurface profiles. The research method used in the form of primary data collection consisting of hydrodynamic and coastal characteristics data, and sediment data collection using SES 2000 and grab sampler. Bathymetry measurements show depths ranging from 0.5 to 13 m. Current direction from west to east and southwest to north at speeds of 0.05 - 0.25 m / sec, wave direction from west to east with speeds between 1.50 - 6.50 m / sec and height of 0.30 - 1.00 m. The distribution of the type of sedimentary material consists of sand, silty sand, silty clay and clay. This research is expected to be useful in adding evidence and information regarding the profile and distribution of coastal sediments, both to the local government and the surrounding community, so that it can become a reference for local government and as a material for consideration in efforts to deal with coastal damage and serve as a basis for decision making and policies to preserve nature and develop tourism.

1. Introduction
As a maritime country supported by data from the Ministry of Maritime Affairs and Fisheries (2011), that Indonesia has around 17,504 islands and about 70% of its territory is a sea with a shoreline of 104,000 km or is fourth in the world after the United States, Canada and Russia. Objective conditions with large coastal areas and have considerable potential such as aquaculture, industry, beach tourism and others. Changing coastal environment, working processes and shoreline change history are very important variables to be used in explaining the level of coastal vulnerability [1]. Although the index obtained cannot be compared with specific physical changes, the action to determine it is the first step to examine the factors that contribute to changes in the coast. Several factors that influence the development of the coast, especially the West coast of South Sulawesi, can be reviewed based on marine disasters combined with approaches to landforms that contain information in the form of coastal morphology, coastal material, geomorphic processes, geological and chronological structures.

The marine disaster is based on the factors that cause it, namely morphodynamics, hydrodynamics, ecodynamics and geodynamics [2]. Research on the profile and distribution of the coast is the first step in management and utilization efforts in developing the coastal environment, then the data and information obtained can be used to make a map of the coastal environment zone that is useful in composing steps to manage the coastal area [3]. Losari Beach has a coastline of ± 1 km that stretches from south to north in an area that has been widely used as a tourist site, and at several locations
reclamation has been carried out for the utilization of infrastructure and several other coastal structures so that it has an impact on the coastal environment both in profile and distribution of sediment. The condition and physiography of the island as such occur by the hydrodynamic activity of coastal waters towards the island, especially the west and east seasons. This tends to occur on all islands in the area of Sangkarang, Makassar Strait [4].

Seeing this phenomenon, it is necessary to make a study to explain and analyze the profile and distribution of coastal sediments as one of the first steps towards coastal protection efforts so that this area is protected from damage, considering that this area has a very strategic value both in economic and social terms. Considering the potential hazards and damage that can be caused by the presence of coastal processes in the study area, especially if there are neighboring buildings or coastal protection structures, this research is expected to be useful in adding evidence and information regarding the profile and distribution of coastal sediments and their relation to the environment beach, both to the local government and the surrounding community.

Through the information obtained is expected to be a reference for local government and as a material consideration in efforts to deal with coastal damage and serve as a basis for decision making and policies to preserve nature and tourism development [5]. Through the results of this study, it is hoped that the handling steps can be carried out early based on an analysis of the coastal environment. The more important thing is to be able to increase knowledge about the profile and distribution of coastal sediments along with their causal factors.

2. Overview of Losari Beach

Losari Beach according to [6], composed of volcanic rocks. Generally composed of alluvial coastal deposits that are prone to abrasion, so that beach and building damage and roads occur quickly. The beach topography is relatively gentle with a slope of ± 25o, but at the sea level about 0.5-1 km the coastline is relatively steep.

Losari Beach is one of the tourist sites and centers of community activities in the city of Makassar, which is visited daily by the surrounding community and from outside the city (Figure 1). Besides that, as one of the objects of research by lecturers and students of the Department of Geology, Faculty of Engineering, Hasanuddin University. It is clear that changes in the coast and its buildings due to reclamation that has been going on for decades, so that the impact on the coastal environment, including the underwater profile and distribution of sediment. It can be estimated, how much is the cost spent by the government in the reclamation effort. The understanding of beaches is essential to coastal management [7].

![Figure 1. Location map of Losari Beach](image-url)
Reclamation can have both positive and negative impacts on people and coastal and marine ecosystems. These impacts can be short-term and long-term depending on the type of impact and condition of the ecosystem and the community in the reclamation site and its surroundings. The positive impacts of reclamation activities include an increase in the quality and economic value of the coastal area, reducing land that is considered less productive, additional areas, protection from erosion, improving the condition of aquatic habitats, improving the hydraulic regime of the coastal area, employment and others. While the negative impacts of reclamation activities on the environment include physical impacts such as hydro-oceanographic changes, coastal erosion, sedimentation, increased turbidity, sea pollution, changes in groundwater regimes, increased flooding potential and inundation in coastal areas; biological impacts such as disruption of ecosystems (mangrove ecosystems, coral reefs, seagrass beds, estuaries and others) and degradation of biodiversity.

Losari Beach is located west of Makassar on Jalan Penghibur. The coastal area or coastal plain of Makassar City was formed by sediment transport of the Tallo river 6.5 km from the northern city center and the Jeneberang River with a situation of 4.5 km south of the city. The sediment is dominated by clay and silt, a small fraction of fine sand. The discharge flow of the Jeneberang River in the rainy season can reach 2,800 m³/s, far greater than the Tallo River discharge.

In identifying coastal problems and predicting erosion of coastal sedimentation in South Sulawesi [8], the Kraus equation is used with parameters consisting of significant wave heights (H) and wave periods (T), in addition to diameter parameters grain (D50) and sediment fall velocity (Ws). Predict shoreline changes using Google Earth.

The shape of the beach profile is strongly influenced by wave attack, sedimentary properties such as mass density and resistance to erosion, particle size and shape, wave and current conditions and bathymetry. The processes of coastal dynamics of the result of interaction between different hydrodynamic process in the spring and summer east west along the year, will have an impact on the vulnerability of abrasion [9]. In general, in the west season (October to April), the energy of waves and currents much stronger than east monsoon (June to August).

3. Results and Discussion

3.1. Oceanography and Sedimentation

Based on the current conditions, Losari beach is no longer original because it has been reclaimed by the city government and several other civilian buildings. However, it still can be explained the appearance or general form which is part of the coast of Makassar, Maros, Gowa and Takalar. Losari Beach is formed by the composition of river sediment and a small amount of marine material from coral sand in a Jeneberang delta system which is classified as a primary beach [10], a beach whose constituent material is sourced from inland activities. The field observation and laboratory analysis has been done to complete this study. The purpose field observation is to see the beach appearance both the composition and topography [11]. Laboratory analysis is done by texture observation. All of sand samples were collected at 20 sandy beaches.

3.1.1. Oceanography. Before being reclaimed, the Losari beach still revealed a form of sediment in the form of spit, lagonal and several sand piles (bars) and the Laelae Island (Figures 2a and 2b). The basic morphology of the Losari coast is relatively gentle, about ± 2 km west to the Laelae island, and outward with a greater depth of 5 m, it is relatively steep.

Between Laelae Island and Losari beach there is a small basin with a depth of 3 - 3.5 m, the bottom of the beach is covered by loose sediment in the form of sand, silt sand and silt clay in the form of mud bonds. Losari Beach receives sediments throughout the year from the Jeneberang and Tallo rivers which form the physiography of bird foot deltas.

Human activities and coastal reclamation (Figure 3), including the presence of the Bili-bili dam, cause the balance of the beach environment to be disturbed and totally changed from its original form, so that no body forms of sand deposits have even been lost.
Figure 2. The appearance of Losari Beach satellite imagery before (a. 2008)) and after (b. 2019) reclamation

Figure 3. Appearance of several buildings on the reclaimed land to the west of Losari beach

Measurement of the physical properties of seawater is one of the methods in this study, besides taking sediment material samples using grab sampler [12]. The physical condition of the measured Losari beach consists of temperatures ranging from 22 - 31°C during the day, salinity around 20 - 29 ‰ (dry season), pH 7.5 - 8.0. Sea currents in the morning from north to south, southwest to north (N45 - 60°E) with varying speeds of 0.05 - 0.25 m/s. Wave direction from west to east with speeds between 1.50-6.50 m/sec and height of 0.30-1.00 m (Table 1, 2 and Figure 4, 5).

3.1.2. Sedimentation. The main source of sediment in the Losari coastal area comes from the Jeneberang river sediment material spill following the Tallo river. These sedimentary waters arrive in coastal waters and are then spread by currents and waves around the coast, both on the mainland and on the Laelae island. This sediment is slightly mixed with coral sand, especially on the Laelae island and outward in the west. The sediment distribution map shows that there are 4 (four) types of sediment that cover this area, consisting of:

- Sand, covering the shallow terrain and edge of the Laelae island and spread out relatively long along the shoreline
- Silty sand, spread in the middle of shoreline
- Silty clay, covering the middle and the edge of the beach which is closed lagonal area
- Clayey silt, occupying the outer and southern parts of the coastal area that extends westward to the depth region
## Table 1. Measurement results of Losari beach sediment type and current

| St. | Depth (m) | Current | Sediment (types) |
|-----|-----------|---------|------------------|
| 1   | 0.8       | 45      | Sand             |
| 2   | 1.25      | 60      | silty sand       |
| 3   | 0.6       | 90      | Sand             |
| 4   | 0.7       | 65      | Sand             |
| 5   | 2.5       | 65      | silty sand       |
| 6   | 3.5       | 60      | silty clay       |
| 7   | 2.5       | -       | clayey silt      |
| 8   | 3         | 120     | silty sand       |
| 9   | 5         | 115     | clayey silt      |
| 10  | 11        | 110     | silty clay       |
| 11  | 13        | 155     | silty clay       |
| 12  | 5.1       | 160     | silty clay       |
| 13  | 2.2       | 135     | clayey silt      |
| 14  | 0.5       | 137     | silty sand       |
| 15  | 0.7       | 95      | sand             |
| 16  | 0.6       | -       | clayey silt      |
| 17  | 0.6       | -       | clayey silt      |
| 18  | 0.8       | 145     | sand             |
| 19  | 2         | 125     | silty clay       |
| 20  | 8.5       | 125     | silty clay       |

## Table 2. The results of the calculation of texture analysis on sand sediments

| Stasion | Sands (%) | Silt (%) | Clay (%) | Aperture (µm) | Total (gr) |
|---------|-----------|----------|----------|---------------|------------|
| ST-01   | 47.59     | 31.05    | 20.63    | 1.19 3.87 14.18 18.75 9.60 31.05 20.63 | 99.27     |

![Figure 4. Sand frequency curve](image)
Losari Beach is the western part of Makassar city that is in contact with sea water, including Laelae Island, Kayangan Island and Samalona Island as part of the Sangkarang island group or also called the Spermonde Archipelago [13], but what is discussed in this study only reaches Laelae Island because it is representative for the observation location. The development of the coast is influenced by the factor of the amount of sediment supply from the Tallo river in the north and Jeneberang river in the south, as well as the influence of coastal hydrodynamics, namely wave activity, currents and tides. Jeneberang and Tallo rivers spill sediment material every year on the coast, especially during the western monsoon, when it is a rainy and flood season.

The sediment will be redistributed by hydrodynamic agents along the coast in the form of spits, bars and tidal flats. The activity of westerly winds tends to be trending from the southwest to the northeast during the rainy season, giving rise to the direction of the waves in the direction of the wind, causing the growth of sedimentary bodies to the north formed by longshore current, which moves from north to south at a speed 1 m/s in the morning (5am - 10am), and from south to north at a speed of 0.5 m/sec in the afternoon (12:30 - 15:00).

3.2. Conditions of the Beach Profile
In the Losari beach, Laelae Island is located about 1 km away, formed by coral reefs covered by a mixture of river sand and coral sand (Figure 6). The bottom of the seabed coastline based on the profile on the sediment distribution map and data collection underwater profiles using SES 2000 (Figure 7a and b), shows the relative morphology of the sloping especially near the shoreline, being outward with a depth of about 5 m indicates a relatively steep relief changes. This relatively steep topography is a trace or former erosion of currents and waves on the base sediment deposits, which during the flood season is covered by sediment. Interpreted that in the west or the rainy season there is an expansion of sediment exposure which is gently sloping by sediment piles from the mainland, then spread by currents and waves along the coast.
Figure 6. The appearance of the Laelae island (△) on the west of Losari beach

Figure 7. Sea bottom profile near the Losari shoreline (a) and at a depth of about 5 m (b)

While in the east monsoon (dry season), the supply of river sediments decreases, so that in coastal areas subsurface erosion occurs causing steep terrain to advance near the coastline. On the other words, in the shoreline zone, sedimentation occurs which forms a spit, bar and beach. The bottom surface of the beach is covered by sand sediment, silt sand, silt silt and silt clay in the form of active sediment which is still loose so that at any time it can be moved (retransportation) by currents and waves.

3.3. Sediment Distribution

Sediment material shed by the Tallo and Jeneberang rivers in their estuaries will be retransported and spread by currents and waves. The shape and extent of its distribution depends on the amount of energy between the river and the sea that works and interacts with each other, and the amount of sediment supply carried by the two rivers.

Based on the results of oceanographic measurements (Figure 8) show river energy is greater than sea energy at the time of flooding. River current velocity is 1.28 m/sec while sea currents are around 0.05-0.25 m/sec and wave velocity is 0.50-6.50 m/sec. Marine energy is significant enough to offset the influence of river energy, but due to the large supply of sediment during the flood season, sedimentary deposits develop into the sea forming a bird foot delta. Current and wave conditions in the Losari beach at the time of measurement on August 17, 2019 at 11:00 to 13.30, indicate in the northern part of the current direction from west to northeast with a speed of about 0.35-0.4 m/sec. While in the middle and south direction of the current from west to east and turning southeast with a speed of about 0.05-0.25 m/sec.

The difference in direction and velocity of the current is caused by the influence of the island of Laelae, where refraction of currents and waves occurs which causes the diverting of the direction of the current and increasing its speed in the north under narrow waters.

This large hydrodynamic energy in the north causes intensive washing/sorting of sediments and causes sand material to be left dominant in the north, while silt and clay materials are transported and deposited in the central, western and southern of coastal. Based on the analysis of sediment grain size
as outlined in the sediment distribution map, there are 4 (four) types of sediment that cover the bottom of Losari beach, namely:

- Sand, covering Laelae island and Losari beach with relatively large current and wave energy and good sorting
- Silty sand, occupying the northern and middle part with medium sorting
- Clayey silt, spread in the west, east and center in the condition of energy-weak with moderate sorting
- Silty clay, covering the west and south with moderate relative energy and medium sorting

The appearance of bottom sediment distribution in the coastal waters on the incision/profile of the sediment distribution, generally shows in areas that are relatively >5m deep and the energy is weak-moderate, covered by fine sediments namely clay and silt. While in the shallow area, where relatively large energy is deposited, coarse sediments are being sand, silty sand and silty clay (Figure 9).

The presence of the island of Laelae as part of the Losari coast causes disrupted water conditions and distribution of coastal bottom sediments, deviating from the distribution of coastal system sediments and river mouths based on the shape of the beach bottom profile. Ideally, from river mouths to sea with increasing depth will show coarse to fine sediments, which is different from the distribution of sediments in the waters of the Losari beach due to its beach profile due to the Laelae island.

3.4. Coastal Environmental Conditions
The natural condition of Losari Beach has now been disrupted even some have been damaged due to beach reclamation and other physical development. Before the reclamation, around the 1990s, the natural shape of the Losari beach was still visible with the growth of spit, barbed sand, tidal flat exposure and visible coastal terrace clear along the coast and at the mouth of the river.

![Figure 8. Measuring station map](image-url)
After reclamation and other physical development, the physiographic forms of the beach have been damaged or even gone, leaving only the exposure covered by material deposits from the mainland [14]. This can increase the turbidity of coastal waters and threaten the disruption of the coastal ecosystem. The accumulation of coastal from soil material, is easily eroded and transported by currents and waves (Figure 10 and 11), especially during the western season where the wave current will work proximaously. Heap material which is overturned and transported by currents and waves to the north will influence or accelerate the silting and turbidity of the Soekarno Hatta harbor.
4. Conclusion

1) The physical condition of the measured Losari beach consists of temperatures ranging from 22 - 31°C during the day, salinity around 20 - 29 ‰ (dry season), pH 7.5 - 8.0. Sea currents in the morning from north to south and southwest to north (N45° - 60°E) with varying speeds of 0.05 - 0.25 m/s. Wave direction from west to east with speeds between 1.50-6.50 m/sec and height of 0.30-1.00 m.

2) The appearance of bottom sediment distribution generally shows in areas that are relatively >5m deep and the energy is weak - moderate, covered by fine sediments namely clay and silt. The presence of the island of Laelae as part of the Losari coast causes disrupted water conditions and distribution of coastal bottom sediments.

3) The natural condition of Losari Beach has now been disrupted even some have been damaged due to beach reclamation and other physical development. The natural shape of the Losari beach was not as the growth of spit, barbed sand, tidal flat exposure and visible coastal terrace clear along the coast and at the mouth of the river.

Acknowledgments

The author are grateful to my institutes through LBE grants which has provided motivation and support in the preparation of this journal. We would also like to thank Kaharuddin, Anggit Kurnia, Muhammad Kinandjar, Adhayani Hajarinanda, Sumiati, Fadel Muhammad, Dian Pratiwi and others student also assistance at Department of Geology for help in the field and data processing. This study is contributed to the research in Geology Engineering Hasanuddin University especially for Marine Geology and for scientific progress.

References

[1] Pendleton, E.A., Thieler, E.R., Williams, S.J., 2010, Importance of Coastal Changes Variables in Determining Vulnerability to Sea and Lake Level Change, Journal of Coastal Research, Vol 26 No 1, p. 176 – 183.
[2] Wahyudi, Haryanto, T., Suntoyo., 2009, Coastal Vulnerability Analysis in the Coastal Areas of the North Coast of East Java, SENTA Journal 2009, FTK-ITS Surabaya.
[3] Koddeng, B, 2011, Zonation of the Makassar Coastal Area Based on Disaster Mitigation (Case Study of the Barombong Beach-Celebes Convention Center), Prosiding Hasil Penelitian Fakultas Teknik, Vol. 5, Grup Teknik Arsitektur.
[4] Kaharuddin, Husain, R., Busthan, 2018, The Mitigation of Coastal Abrasion On Islands, Special Reference to The Kodingareng Keke Island Makassar City, Indonesia, International Journal of Engineering & Technology IJET-IJENS Vol:18 No:01.
[5] Kaharuddin, Mawaleda, M., Husain, R., Busthan, 2016, The Vulnerability of Coastal Abrasion in the Islands Area Case Studies in Kodingareng Keke Island Makassar City, International OPEN ACCESS Journal of Modern Engineering Research (IJMER), Vol. 6 Iss. 12 Dec. 2016 (1).

[6] Sukamto. R., 1982, The Geology of Ujungpandang, Benteng and Sinjai Quadrangle, Research Centre and Development of Geology, Bandung.

[7] Abanades,J., Greaves, D., Iglesias, G., 2015, Wave Farm Impact, on Beach Modal State, Marine Geology 361 (2015) 126-135.

[8] Umar, H., Rahmana, S., Baeda, A.Y., Klara, S., 2015, Identification of Coastal Problem and Prediction of Coastal Erosion Sedimentation in South Sulawesi, Procedia Engineering 8th International Conference on Asian and Pacific Coasts (APAC 2015) 116, 125 – 133, 1877-7058 Published by Elsevier Ltd. www.sciencedirect.com.

[9] Kaharuddin, Imran, A.M., Abdullah, C.I., Jaya, A., 2019, Olistostrome and its Implication to Geological disaster on Coastal Area with Special Reference to the Bantimala Tectonic Complex, Pangkep Regency South Sulawesi Province, OP Conf. Series: Earth and Environmental Science 235 (2019) 012043 IOP Publishing.

[10] Shepard, 1973, F.P., Submarine Geology, Harper and Row Publisher, New York, Everston, San Fransisco, London.

[11] Sirajuddin, H., Suriamihardja, D.A., Imran, A.M., Thaha, A., 2015, Influence of Sediment Texture on Beach Morphodynamic State, International Journal of Development Research Vol. 05, Issue 08, pp. 5249 – 5254.

[12] Sirajuddin, H., Suriamihardja, D.A., Imran, A.M., Thaha, A., 2015, Coastal Vulnerability Zonation of Pinrang District and Parepare City Based on Morphodynamic Review, International Journal of Inventive Engineering and Sciences Volume-3 Issue-12, pp. 23-26, December 2015.

[13] Imran, A.M., Kaharuddin, M.S., Suriamihardja, D.A., Sirajuddin, H., 2013, Geology of Spermonde Platform, Proceedings of the 7th International Conference on Asian and Pacific Coasts (APAC 2013), Bali, Indonesia, September 24 – 26, 2013.

[14] Saengsupavanich, C., 2012, Assessing and Mitigating Impacts of Shore Revetment on Neighboring Coastline, International Conference on Environment Science and Engineering IPCBEE vol.3 (2), Singapoore.