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Analyzing Coastline Erosion to Save the Coastal Environment in Makassar

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Abstract. Due to the degradation of the beach, the sea level is approaching some of the buildings on Layar Putih beach. Tugu Layar Putih, which used to be accessible on foot, has been submerged. The condition of the beach looks damaged, especially at Tanjung Layar Putih, which is currently unattended and abandoned. This has a negative impact on the environment and can lead to flooding. The area from Tanjung Bunga Metro to Losari Beach is also experiencing high sedimentation. The high sedimentation is caused by the deposition of sediment carried by river currents in the area of the Jeneberang River estuary, as well as the presence of sea currents at the mouth of the river in sufficient volume. A sediment transport capacity that is not in balance with the supply is the process of beach retreat. This process is known as coastal erosion and causes changes in coastal morphology in addition to abrasion and estuarine sedimentation (accretion). While the coastal area of Makassar City is one of the beach tourist attraction areas located in Makassar City. The purpose of the study was to determine the causes of coastal erosion in order to find strategies to save the coastal environment in Makassar in order to prevent further coastal damage. The research methodology analyses beach typology, waves and sediments. The results of the study were obtained coastal sediment type clay type which has a high cohesion value, the wave direction is generally from the West and North towards the South, the most frequent wave height that can be analyzed by STWave CEDAS Genesis 4.03 Numerical Modelling for 10 years of modelling is 1.64 meters, the dynamics of shoreline change is quite balanced between erosion and accretion, the average wave period is 4.599 seconds, the sediment deposition rate is 1.66 cm/sec and sediment transport is 54,975,398.47 meter3/year. The sediment deposition rate is in a transitional (intermediate) condition so that sediment transport does not experience a significant decrease in transport. The conclusion from this study is that the beach tends to have more potential for sedimentation (accretion) than erosion (abrasion), due to the type of sediment and the construction of buildings on reclaimed land in the northern part of the study site.

Keywords: Erosion, Accretion, Waves, Sediment, Coastline

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1 Introduction

The coast is an area that has higher dynamics than other areas considering its location is a transition between land and sea [1]. As an area with high dynamics, various potentials and resources are located on the coast. As an archipelago, Indonesia has many coastal areas that have developed into coastal cities, Makassar is one of it. Makassar is an example of the largest coastal city on the island of Sulawesi as well as the largest in Eastern Indonesia. Makassar City is planned as a form of implementation of the waterfront city concept according to the agreement approved at the World Cities Summit around May-June 2011 [1]. This means that Makassar's development must lead to this concept and needs to consider current global conditions. Recently, dozens of cities along the coastline of the United States are sinking at an alarming rate, making these cities far more vulnerable to catastrophic flooding from the threat of sea level rise than previously thought. As oceans rise and coasts sink, it is estimated that up to 343,000 Ha of land there will be exposed to damaging flooding by 2050, from hazards such as hurricanes, coastal storms and shoreline erosion. In a worst-case scenario, about 1 in 50 people in the 32 cities analyzed could be exposed to the threat of flooding [2]. The threat of severe flooding in US cities that triggers sea level rise certainly has a global impact, and as part of the world's coastal cities, Makassar City cannot be ignored [3].

Makassar City is a coastal city geographically located at 119º24'17.38“ East and 5º8'6.19” LS. To the north and east it is bordered by Maros Regency, to the south by Gowa Regency and to the west by the Makassar Strait. The area of Makassar City is 175.77 km2 or 17,577.00 ha. The length of the coastline is about 32 km and there are nine small islands. The elevation from sea level ranges from 0 - 25 m. The climate is tropical wet (Am), the average monthly rainfall from 1990-2000 ranged from 13 - 677 mm with the highest rainfall in January and the lowest in July. The average number of rainy days per month is 2-22 days. The air temperature ranges from 26.5 - 30.2°C [4].

As a coastal area, the beach in Tamalate District has considerable potential to be developed as an attractive tourist attraction for both local and foreign tourists. However, the condition of this area, especially around Tanjung Layar Beach, is currently a cause for concern due to shoreline degradation. As a result of coastal degradation, the sea level is seen getting closer to several buildings there. The Tugu Layar Putih, which used to be accessible by foot, has been submerged. The condition of the beach looks damaged, especially at the point where Tanjung Layar Putih is currently unattended and abandoned. This can certainly have a negative impact on the environment and can lead to disasters, especially floods. The abrasion rate in the Tanjung Bunga and Barombong Beach areas is very high [5]. The beaches in these two areas have experienced a regression of the coastline from year to year, so that they have gone far inland. The Tanjung to Losari Beach area also experienced high sedimentation [6]. The high sedimentation is caused by the deposition of sediments carried by river currents in the Jeneberang River Estuary area and by the presence of ocean currents at the mouth of the river which can cause sediment deposition in large enough volumes. Sediment transport capacity that is not balanced with the supply is the process of retreating the beach. This event is called coastal erosion [7].

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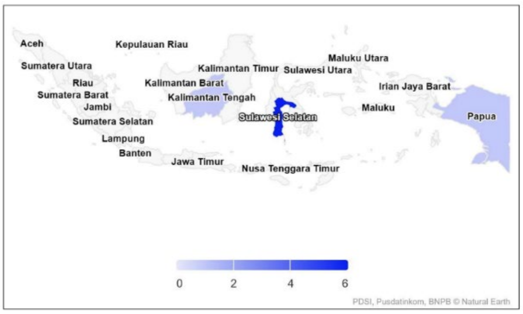

Fig. 1. Flood and Abrasion Disaster Profile in Indonesia (Source: Badan Nasional Penanggulangan Bencana, 2024)

From Figure 1, we can see that in 2024 South Sulawesi was affected by abrasion and flooding. Abrasion is erosion caused by sea waves [9]. The abrasion disaster in question is in Barru Regency which is in line with the coast of Makassar City. Based on this information, it is deemed necessary to conduct research to identify the causes of coastal erosion that result in increased severe coastal damage on the coast of Makassar City, in this case located in Tamalate District, starting from the area around the estuary of Barombong Beach to Tanjung Bunga. Along the coastline of the study area, there are several beaches that are generally utilized as tourist areas with different names, starting from the one adjacent to the Jeneberang River estuary, Tanjung Layar Putih Beach with the Tugu Layar Putih is placed there, Anging Mammiri Beach, Tanjung Bayang Beach, Akkarena Beach, and Bosowa Indah Beach. To find out the cause of coastal erosion, in this research, sediment dynamics analysis and wind-generated wave analysis were carried out and then modeled the propagation and transformation of waves coming from the sea to the coast [10].

Fig. 2. Tanjung Layar Putih Beach Condition (Source: Documentation, 2024)

From the Google Earth Pro Satellite Map, we can clearly see the changes that have occurred in the coastline, especially around the estuary of the Jeneberang River.

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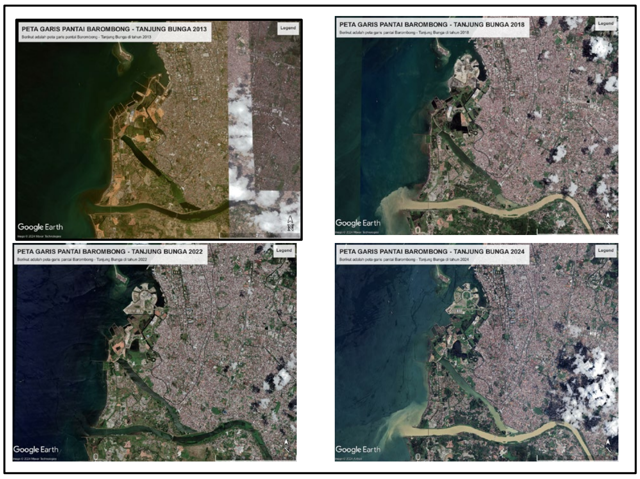

Fig. 3. Satellite Imagery of Barombong Coastline Condition at the year of tahun 2013, 2018, 2022 and 2024 (Source: Google Earth Pro)

The formulation of the problem of this research is to know how to analyze shoreline changes and sedimentation conditions on the south coast of Makassar City whether erosion or accretion to save the Makassar coastal environment, in order to solve problems related to the National Research Master Plan (RIRN) on the theme of Hydrometeorological Disaster Technology and Management with the focus area of Disaster, on the research topic of Hydrometeorological Disaster Risk Reduction Mitigation where Blue Economy is a research priority.

Beach erosion itself is the process of retreating the beach due to the absence of a balance between the supply and capacity of sediment transportation. Generally, erosion occurs on sloping beaches (sandy or muddy). While accretion is sedimentation, if estuary sedimentation occurs, it means that there is a process of closing and silting the estuary on a sandy beach [7].

2 Data and Research Methodology

2.1 Data and Research Area

In conducting research Analyzing Beach Erosion to Save the Coastal Environment in Makassar, first a literature review will collect information, then wave analysis, sediment dynamics analysis and beach typology will be conducted. Wave analysis uses the STWAVE (Steady-State Spectral Wave Model) application program which is part of the CEDAS (Coastal Engineering Design and Analysis System) software. The outputs of the STWAVE model are wave height, incident wave direction, refraction pattern and wave diffraction to and from the study site [11]. The wind data used for wave modeling is wind speed and direction data from the latest five years obtained from the Paotere Maritime Meteorological Station, Makassar City. In addition to wind data, tidal data (tidal harmonic constant), coastal bathymetry data at the research location, island

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shoreline data and effective fetch length were also inputted in the modeling, which were taken directly as primary data. Sediment dynamics analysis was conducted by taking surface sediment samples at 12 points.

In the CEDAS-NEMOS application program, the required datas are: 1-year waveform Time Series data, XYZ (ASCII) Format Bathymetry data (already combined with Topography), XY Pairs Format Shoreline data. When opening the CEDAS application, first run NEMOS first. Then we select Grid Generation. Then Build Uniform Grid. Station selection determines the depth of the station, for Genesis needs, the station is made along the offshore Genesis Boundary (parallel to the shoreline) in the zone before wave breaking. Select Define GENESIS Grid. To check the grid generator is successful, call back the saved file. If it appears, it is successful. If it does not appear, repeat the previous process. Then enter Wave Transformation (WWL DATA. For the Mean Water Depth at Datum field, the value is taken from the previous topographic and bathymetric data set that has been processed in Microsoft Excel to obtain a negative value (indicating the sea), which in this research is 11 meter. Then set the Horizontal Datum, local Vertical Datum, and MSLWorld Coordinate System, before entering WISPH3 (Wave Information Study Phase) part. Next, enter WISPH3 Configuration. Specify Water depth (Phase 3 wave Output Station). Specify the depth of the station (at the boundary of the area before the wave breaks). Input Shoreline Azimuth = 14.46. Input wave Station depth at 5.

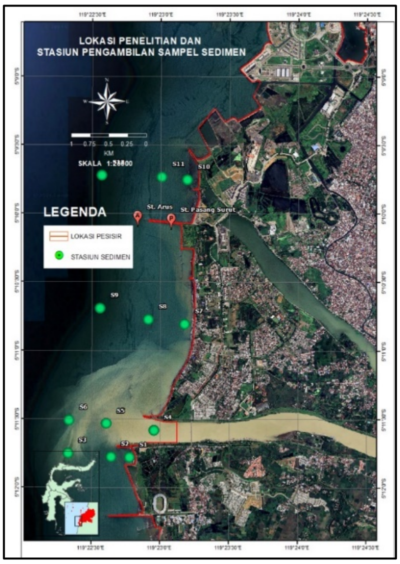

Fig. 4. Sediment Retrieval Station (Source: Documentation, 2024)

The coastline shown on the map above in this research is the Barombong coastline to Tanjung Bunga. From the tidal results for 15 days (from September 15 to October 03, 2024) the tides can be seen clearly.

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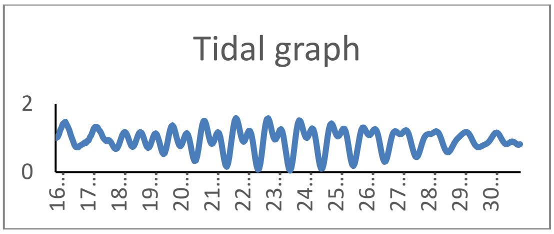

Fig. 5. The tidal waves (Source: Primary Data, 2024)

Surface sediment samples were collected using a Sediment Grab Sampler. The grabbed sediment samples were put into a sample bag and then labeled. Testing of sediment samples was carried out in the Concrete laboratory and Soil Mechanics laboratory of the Faculty of Engineering, Paulus Christian Indonesia University. The tests carried out were sieve analysis testing, and soil specific gravity. The tools needed are:

1. Oven, used to dry sediment samples
2. Sieve, used to filter the dried sediment
3. Picnometer, used to determine the specific gravity of soil
4. Thermometer, used to measure temperature
5. Cup, as a sample container

The characteristics of beach sand after testing Sieve Analysis in the laboratory will refer to the following provisions:

Kriteria untuk Menetapkan Simbol-Simbol Kelompok dan Nama-Nama Kelompok Menggunakan Pengujian-Pengujian Laboratorium[A]				Klasifikasi Tanah: Simbol Kelompok	Klasifikasi Tanah: Nama Kelompok[B]
TANAH BERBUTIR KASAR >50% tertahan ayakan No. 200	Kerikil (Lebih besar dari 50% Fraksi kasar yang tertahan ayakan No. 4)	Kerikil bersih (Butir halus[C] < 5%)	Cu ≥ 4 dan 1 ≤ Cc ≤ 3[D]	GW	Kerikil[E] bergradasi baik
			Cu < 4 dan/atau Cc < 1 atau Cc > 3[D]	GP	Kerikil[E] bergradasi jelek
		Kerikil dengan butir halus (Butir halus[C] > 12%)	Butir halus diklasifikasikan sebagai ML atau MH	GM	Kerikil[E, F, G] lanauan
			Butir halus diklasifikasikan sebagai CL atau CH	GC	Kerikil[E, F, G] lempungan
	Pasir (Lebih besar ≥ 50% Fraksi kasar yang lolos ayakan No. 4)	Pasir bersih (Butir halus[H] < 5%)	Cu ≥ 6 dan 1 ≤ Cc ≤ 3[D]	SW	Pasir[I] bergradasi baik
			Cu < 6 dan/atau Cc < 1 atau Cc > 3[D]	SP	Pasir[I] bergradasi jelek
		Pasir dengan butir halus (Butir halus[H] > 12%)	Butir halus diklasifikasikan sebagai ML atau MH	SM	Pasir[F,G,I] lanauan
			Butir halus diklasifikasikan sebagai CL atau CH	SC	Pasir[F,G,I] lempungan
TANAH BERBUTIR HALUS ≥ 50% lolos Ayakan No. 200	Lanau dan lempung Batas cair < 50	Non Organik	PI > 7 dan terletak pada atau di atas garis "A"	CL	Lempung[K,L,M] rendah
			PI < 4 atau terletak di bawah garis "A"	ML	Lanau[K,L,M]
		Organik	(Batas cair - kering oven) / (Batas cair – tidak kering) < 0,75	OL	Lempung[K,L,M,N] organik / Lanau[K,L,M,O] organik
	Lanau dan lempung Batas cair ≥ 50	Non Organik	PI terletak pada atau di atas garis "A"	CH	Lempung[K,L,M] tinggi
			PI terletak di bawah garis "A"	MH	Lanau[K,L,M] elastis
		Organik	(Batas cair - kering oven) / (Batas cair – tidak kering) < 0,75	OH	Lempung[K,L,M,P] organik / Lempung[K,L,M,O] organik
TANAH BERORGANIK	Secara primer terdiri atas zat-zat organik, berwarna gelap dan berbau organik			PT	Gambut

[A] Berdasarkan material lolos ayakan 3 inci (75 mm)
[B] Apabila contoh lapangan mengandung bongkahan atau kerakal, atau keduanya tambahkan "dengan bongkahan atau kerakal atau keduanya" pada nama kelompok
[C] Kerikil-kerikil dengan butiran halus 5% sampai dengan 12% diperlukan simbol ganda:
GW–GM Kerikil bergradasi baik dengan lanau
GW–GC Kerikil bergradasi baik dengan lempung
GP–GM Kerikil bergradasi jelek dengan lanau
GP–GC Kerikil bergradasi jelek dengan lempung
[D] $Cu = D_{60}/D_{10}$ $Cc = (D_{30})^2/D_{10} \times D_{60}$
[E] Apabila tanah mengandung ≥ 15% pasir, tambahkan "dengan pasir" pada nama kelompok
[F] Apabila butiran halus diklasifikasikan sebagai CL–ML gunakan simbol ganda GC–GM atau SC–SM.
[G] Apabila butiran halus adalah organik, tambahkan "dengan butiran halus organik" pada nama kelompok

[H] Pasir-pasir dengan butiran halus 5% sampai dengan 12% diperlukan simbol ganda:
SW–SM Pasir bergradasi baik dengan lanau
SW–SC Pasir bergradasi baik dengan lempung
SP–SM Pasir bergradasi jelek dengan lanau
SP–SC Pasir bergradasi jelek dengan lempung
[I] Apabila tanah mengandung ≥ 15% kerikil, tambahkan "dengan kerikil" pada nama kelompok
[J] Apabila batas-batas Atterberg berada di dalam daerah yang diarsir, tanah adalah lempung lanauan CL–ML
[K] Apabila tanah mengandung 15% sampai 29% tertahan ayakan No. 200, tambahkan "dengan pasir" atau "dengan kerikil" mana yang paling dominan
[L] Apabila tanah mengandung ≥ 30% tertahan ayakan No. 200 dan dominan pasir, tambahkan "pasiran" pada nama kelompok
[M] Apabila tanah mengandung ≥ 30% tertahan ayakan No. 200 dan dominan kerikil, tambahkan "kerikilan" pada nama kelompok
[N] PI ≥ 4% dan berada pada atau di atas garis "A"
[O] PI < 4% atau berada di bawah garis "A"
[P] PI berada di atas garis "A"
[Q] PI berada di bawah garis "A"

Fig. 6. Soil Classification Chart (Source: Badan Standardisasi Nasional, 2017))

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Milimeter (mm)		Mikrometer (μm)	Phi (ϕ)	Kelas ukuran Wentworth	
	4096		-12.0	Boulder	Gravel
	256		-8.0	Cobble	
	64		-6.0	Pebble	
	4		-2.0	Granule	
	2.00		-1.0	Very coarse sand	Sand
	1.00		0.0	Coarse sand	
1/2	0.50	500	1.0	Medium sand	
1/4	0.25	250	2.0	Fine sand	
1/8	0.125	125	3.0	Very fine sand	
1/16	0.0625	63	4.0	Coarse silt	Silt
1/32	0.031	31	5.0	Medium silt	
1/64	0.0156	15.6	6.0	Fine silt	
1/128	0.0078	7.8	7.0	Very fine silt	
1/256	0.0039	3.9	8.0	Clay	Mud
	0.00006	0.06	14.0		

Fig. 7. Sediment Particle Size Classification (Source: Wentworth in Romdani (2022))

For data analysis purposes, wave height and period data, as well as sediment particle grain size will be used to predict whether the beach is eroding/abrading or accretion/sedimentation. In addition to wave parameters, sediment particle size and sediment particle settling velocity (Vs) also determine whether the beach is eroding or accreting. The settling velocity is related to the size of the bottom sediment particles where the larger the particle, the greater the settling velocity. Sediment particle settling velocity Vs is determined through the relationship between sediment particle size and settling velocity [10]. Calculation of sediment transport charge parallel to the shoreline using the Coastal Engineering Research Center (CERC) formula [14];

$$Q_s = \mathrm{K}.A_1 \frac{\rho_{l}\, g^2}{64\pi} T H_b^2 sin2\alpha_b$$

With:
Qs= longshore directional sediment transport load (m3/year)
K = non-dimensional constant of correlation between sand transport and longshore energy flux (taken as 0.39)
A_l = parameter dependent on sediment characteristics where:

$$A_l = \frac{1}{[(\rho_{s(l_c)} - \rho_l)(1-p)]}$$

$\rho_{s(lc)}$ = sediment density for longshore current transport (2650 kg/m^3)
ρ_l = seawater density = 1025 kg/m^3
g = acceleration of gravity = 9.81 m/s^2
p = sediment porosity = 0.4
T = wave period (seconds)
H_b = breaking wave height (m)
α_b = angle formed between breaking wave and shoreline

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For the calculation of sediment deposition rate (settling velocity, Vs) using the Stokes-Newton Law formula [14]:

$$V_s = \frac{gD_s^2(\rho_s - \rho)}{18\mu}$$

With:
Vs = settling velocity (m/s)
Ds = particle diameter (mm)
μ = liquid viscosity

Even though in the numerical analysis process using CEDAS the studied coastline is considered without any coastal structures, but in the existing condition there are already some coastal structures (breakwater) built. Therefore, in the calculation of sediment load used is Longshore Sediment Transport (LST). LST or longshore drift is the movement of sediment along the coastline carried by the longshore current and determines the morpho dynamics of the beach [13]. The structural approach to coastal buildings affects the loading of LST which causes erosion and accretion processes. Wind-generated waves form an angle to the shoreline. Longshore Current that travels along the coast carries LST loads that are retained by structures perpendicular to the coast which results in sediment deposition occurring on the updrift side (upstream of the current flow) and erosion occurring on the downdrift side (downstream of the current flow).

The classification of sediment settling velocity can be seen in the following graphic image. Laminar flow is regular turbulent flow, while turbulence flow is the opposite, which is irregular. In the transition area is a transitional area. Generally, ocean currents are turbulent, but flows in the transition area show moderate velocities as they approach the shoreline.

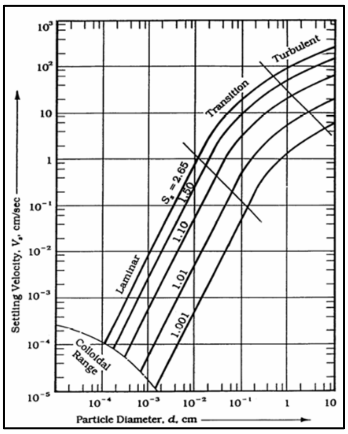

Fig. 8. Particle deposition in water (Source: Reynolds (1982) in Pitt & Shirley Clark (2014))

The output of the Beach Typology Analysis will show the beach type, beach sand condition and vegetation around the beach. Makassar City beaches are generally

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sloping and sandy with a slope of 3%. The beach type of the Tallo River estuary at this location is a muddy beach with minimal mangrove vegetation and is a sloping beach. In the western part of the beach, there have been beach reclamation activities around 200 m as land for wood processing industry activities. The area at the mouth of the canal has generally been hardened with seawalls, because most of the beaches in this area are fish landing bases (PPI Rajawali) and coastal settlements [4].

The results of wave modeling using the STWAVE model from the CEDAS program illustrate the distribution of the maximum possible wave height and wave transformation towards the study site. Wave conditions in a body of water determine the occurrence of erosion or accretion on the beach. Wave modeling in CEDAS will also produce a Windrose diagram, which is a diagram that presents the value of wind speed in each cardinal direction with the aim of knowing the dominant direction of the wind that occurs in the place under study [16]. From the results of the wave data filter above, a classification of significant wave height for each wave direction is made in the form of a table showing the number and percentage of daily (hourly) wave events and then a wave rose is made [11]. From the results of the wave data filter, a statistical analysis of the waves is carried out with the WSAV module by determining the first band limits of wave height and period in accordance with or representing the filtered wave data. Where the wave height band limits are 0.50 m intervals and the wave period band limits are 2 second intervals while the band limits of the wave incidence angle are not changed (the WSAV module automatically adjusts the band limits according to the wave input angle). From the determination of the band limits, the mean is then calculated.

In addition to wave parameters, sediment particle size and settling velocity (Ws) also determine whether the beach is eroding or accreting. The settling velocity is related to the size of the bottom sediment particles where the larger the particle, the greater the settling velocity. This research is expected to produce information that can be continued by future research related to coastal degradation.

3 Results and Discussion

3.1 Coastline typology

From 12 sediment collection points along the coast of Barombong - Tanjung Bunga Beach, the results of grain gradation, specific gravity (SSD) and hydrometry were obtained. The effective grain entered into the CEDAS Genesis application is 0.15 mm. The average specific gravity of the fine aggregate was 2.137 gr/cm3. The laboratory measurements revealed that the sediment type was predominantly clay (96.9%) and if referring to Figures 2.3 and 2.4, it can be classified as clay-fine silt. This type of sediment has a high cohesiveness and is therefore more resistant to erosive forces caused by water or wind. This type of clay-fine silt can form a fairly dense layer on the shoreline that can serve as a protective barrier against erosion if the seawater current is large enough. Conversely, this type of sediment has the potential to cause accretion or sedimentation because its cohesion is able to trap fine particles carried by water, settle and eventually accumulate and bring the shoreline forward into the sea area.

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The type of beach in this research location is sloping. The slope of the beach tends to radiate wave energy slowly as it approaches the shore. Waves will break further from the shoreline and lose some of their energy before reaching land. This can reduce the level of erosion on the shoreline, but conversely sloping beaches tend to favor the process of sedimentation (accretion). Seasonal wave energy on sloping beaches can cause beach abrasion. Waves with greater energy during certain seasons (e.g. during the monsoon season). Sloping beaches favor the presence of coastal vegetation. But while sloping beaches can reduce wave energy, under extreme conditions such as large storms or high tides, they can be eroded because seawater can reach further inland and carry sediment back to the sea, accelerating erosion.

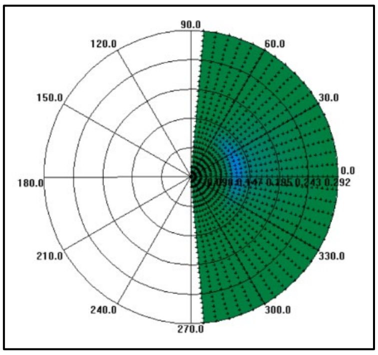

Fig. 9. Wave Energy Polar Diagram (Source: Analysis Results, 2024)

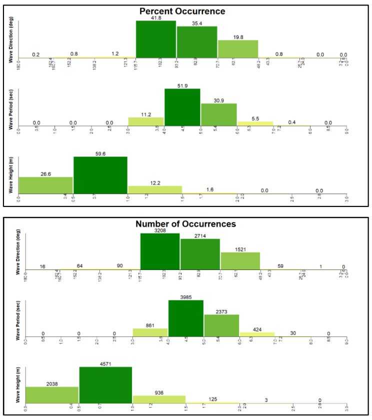

Fig. 10. Histogram of Percentage and Number of Wave Events (Source: Analysis Results, 2024)

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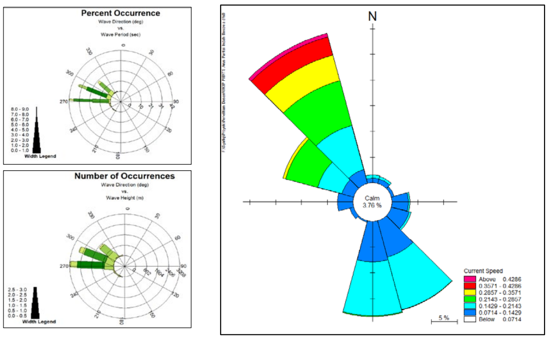

Fig. 11. Windrose Percentage and Number of Wave and Current Windrose Events from manual data processing (Source: Analysis Results, 2024)

Table 1. Export results from the wave modeling application

	Period(sec)										
Height(m)	0-1	>1-2	>2-3	>3-4	>4-5	>5-6	>6-7	>7-8	>8-9	>9	Total
0 - 0.5	0	0	0	624	1069	334	9	2	0	0	2038
>0.5 - 1.0	0	0	0	237	2857	1358	117	2	0	0	4571
>1.0 - 1.5	0	0	0	0	59	673	199	5	0	0	936
>1.5 - 2.0	0	0	0	0	0	8	99	18	0	0	125
>2.0 - 2.5	0	0	0	0	0	0	0	3	0	0	3
>2.5 - 3.0	0	0	0	0	0	0	0	0	0	0	0
>3.0	0	0	0	0	0	0	0	0	0	0	0
Jumlah Kejadian											7673

(Source: Analysis result, 2024)

As seen in Figure 3.3, the results of deep sea wave forecasting show that the highest waves (>2.0 - 2.5 meters) are waves from East North East (ENE) or East North East, namely with the number of occurrences 3 times so that it is not significantly shown in the Windrose Diagram percentage. While the most frequent waves are waves with a height of 0.5 - 1.0 meters, coming from the West North West (WNW) and North West (NW) directions. For the next wave distribution modeling in the wave event that can be analyzed by the CEDAS application is about 61 because only significant changes are calculated by the application.

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The modeling results illustrate the distribution of maximum wave height and wave transformation from the deep sea to the study site. The direction of the wind carrying the waves can be seen in the black arrow, the brown color represents the contours of both topography and bathymetry, the light blue color is the sea and the green color is the land.

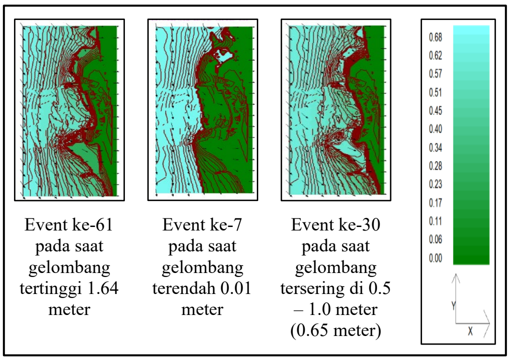

Fig. 12. Wave transformation model from North to South Southeast (Southward inclined) towards the shoreline (61st event highest wave 1.64 meters (Source: Analysis Results, 2024)

Wave transformation from the deep sea to the shoreline as shown in Figure 3.4. The dominant deep-sea waves came from the South-Southeast direction and underwent wave transformation after reaching the shoreline. The highest wave reached 1.64 meters. Based on the analysis of the percentage of wave occurrence with the eight cardinal directions and the results of the wave modeling model, it can be assumed that the waves coming from the West to the shoreline and the South from the North are the cause of beach erosion on the side near the mouth of the Jeneberang River (Tanjung Layar Putih Beach) but also at the same time cause accretion in the area around the existing embankment that divides Bosowa Beach and Akkarena Beach. For more details, please see the results of running the Genesis application in NEMOS CEDAS which due to device limitations, was only taken for 5 (five) years, namely from January 01, 2018 to December 31, 2022.

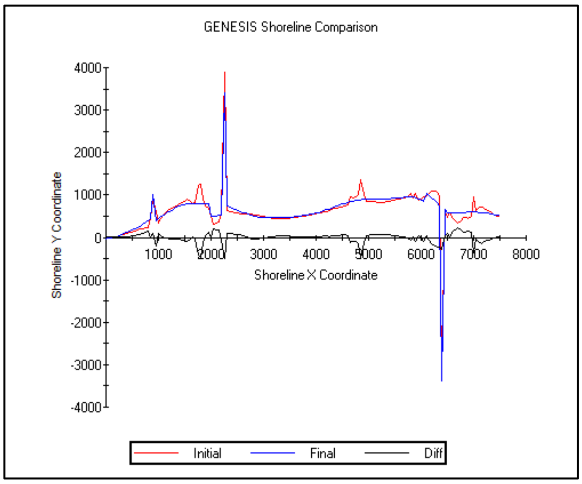

Fig. 13. Comparison of Changes in the Barombong Coastline - Tanjung Bunga (Source: Numerical Modeling Results)

The red line (initial) is the initial shoreline model (01012018) while the blue line (final) is the final shoreline model (31122022). Diff or Difference is an indication of the distance or change between the shorelines at the time or condition being compared. If the Diff value is positive, it indicates that there is an increase in area due to sedimentation, which is caused by the accumulation of sand or the expansion of the coastline towards the sea. Otherwise, it means erosion, or the shoreline moving inland. The dynamics of shoreline change along the research site can be clearly seen on the Diff line. The results of the wave statistical analysis show that the representative waves to be used in the simulation consist of 61 wave events with varying wave height, period and angle. Finally, in the Genesis Spectrum section, there is a comparison animation of the dynamics of shoreline change that has been represented in Figure 3.5.

3.2 Sediment Transport

From the calculation of sediment transport where the average wave period is 4.599 seconds, the breaking wave height is taken at 1 meter, the angle formed between the breaking wave and the shoreline is 14.46°, the grain diameter is 0.00015 meters and the dynamic viscosity is taken 0.0012, the sediment transport discharge is 0.219494595 meter^3/second or brings about 47,790,119.15 meters^3/year. While the sediment transport rate is 1.660546875 cm/second. From Figure 2.5 we can see that the sediment deposition rate is included in the transition area (intermediate). Meanwhile, if the sediment transport rate is high, it has the potential to reduce sediment transport and cause erosion of the coastline. From Figure 3.5 we can see that in coastal areas there is a dynamic balance between erosion and accretion. Erosion in one part will produce sediment that will be transported and deposited to another part, maintaining the balance of the landform. When erosion occurs, the sediment carried by the flow often contains

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mineral loads, nutrients but also pollutants. Sediment transport can affect water quality downstream or in coastal waters and can also cause siltation of estuaries.

4 Conclusion

From the coastal typology analysis, wave analysis and sediment transport, it can be seen that the dynamics of the Barombong - Tanjung Bunga coastline are more likely to experience accretion than erosion. But it can be seen that there is a dynamic balance in the morphodynamics of the coastline. On the one hand erosion occurs and on the other hand accretion occurs. It can be said that the dynamics of shoreline change occur but the coastal ecosystem still maintains its own balance. This is not only caused by wind and waves, but can also be caused by the reclamation development to the north of the research site where many buildings have been built on reclaimed land that can inhibit the sediment deposition rate due to waves. Erosion in the Tanjung Layar Putih area has the potential to be reduced in number, provided that the embankment structure at the mouth of the estuary is in adequate condition. Some coastal barriers and breakwaters have also been constructed, while the sediment type in coastal waters tends to be cohesive and favor sedimentation. To prevent the expansion of sedimentation on the coast or to control it, structural engineering and natural solutions can be used. Erosion and sedimentation need to be controlled so as not to damage the coastal environment in this case the coastal ecosystem because it carries a load of pollutants that can pollute the area. Structural engineering that may be able to proceed is to add coastal barrier structures, shorebreaks, and natural solutions.

References

[1] Muh. A. Marfai, *Banjir Pesisir (Kajian Dinamika Pesisir Semarang)*. Yogyakarta: Gadjah Mada University, 2014.

[2] Ramirez. Rachel, “Where sinking cities are pushing sea level rise into overdrive,” CNN. Accessed: Mar. 07, 2024. [Online]. Available: https://www.cnn.com/2024/03/06/climate/sinking-cities-us-sea-level-rise-climate

[3] H. Singgih, “The Integration of Retention Pond And Composite Sluice in Flood Prevention in Makassar City,” *IOP Conf Ser Mater Sci Eng*, vol. 846, no. 1, p. 012074, May 2020, doi: 10.1088/1757-899X/846/1/012074.

[4] M. F. Samawi, “Desain Sistem Pengendalian Pencemaran Perairan Pantai Kota (Studi Kasus Perairan Pantai Kota Makassar),” Institut Pertanian Bogor, Bogor, 2007.

[5] Y. Suleman, “Tinjauan Degradasi Lingkungan Pesisir Dan Laut Kota Makassar Terhadap Kebijakan Pengelolaan Kawasan Pesisir,” *Seminar Sains dan Teknologi Kelautan , Gedung CSA Kampus Fakultas Teknik UNHAS Gowa 28-29 September 2018*, Sep. 2018.

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Vol 5, Issue 1, September 2024, Pages 329-343
ISSN: 2745-5351 (Media Online)
DOI: https://doi.org/10.58905/jse.v5i1.438

[6] B. Koddeng, “Zonasi Kawasan Pesisir Pantai Makassar Berbasis Mitigasi Bencana (Studi Kasus Pantai Barombong-Celebes Convention Centre),” vol. 5, no. ISBN : 978-979-127255-0-6, Dec. 2011.

[7] H. Suprijanto and Serbian Mirdeklis Beselly Putra, *Buku Ajar Teknik Pantai*. UB Press, 2017.

[8] Badan Nasional Penanggulangan Bencana, “Profil Bencana Indonesia,” digital library BNPB. Accessed: Mar. 23, 2024. [Online]. Available: https://dibi.bnpb.go.id/home/index2

[9] Winarni, *Buku Pintar Penanggulangan Abrasi*, 1st ed. DIVA Press, 2021.

[10] M. Lanuru, “Analisa Erosi Pantai Pulau Barrang Caddi Kota Makassar,” *Prosiding Simposium Nasional Kelautan dan Perikanan II Universitas Hasanuddin, Makassar 2015*, no. ISBN: 978-602-71759-1-4, Oct. 2015.

[11] M. La Mury, “Step By Step CEDAS NEMOS Versi 4.03,” 2017, *Scribd*. Accessed: Nov. 01, 2024. [Online]. Available: https://www.scribd.com/document/355724072/Step-by-Step-CEDAS-NEMOS-Versi-4-03-by-Muriadin

[12] Badan Standardisasi Nasional, “Standar Nasional Indonesia Persyaratan Perancangan Geoteknik (SNI 8460:2017),” 2017. [Online]. Available: www.bsn.go.id

[13] A. Romdani, *Transport Sedimen (Proses, Efek dan Morfodinamika Pantai)*. Sumedang: Mega Press, 2022.

[14] Setiyadi, Suratno Lourentius, Ezra Ariella W, and Gede Prema MS, “Menentukan Persamaan Kecepatan Pengendapan pada Sedimentasi,” *Jurnal Ilmiah Widya Teknik*.

[15] R. Pitt and Shirley Clark, “Module 4b: Characteristics and Monitoring of Stormwater Particulates ,” 2014, *Alabama*. Accessed: Nov. 03, 2024. [Online]. Available: https://www.researchgate.net/figure/Type-1-discrete-settling-of-spheres-in-water-at-10-C-Reynolds-1982_fig9_268041312

[16] A. Ardiansyah, “Perhitungan Diagram Windrose dan Fetch Efektif Untuk Mencari Tinggi dan Periode Gelombang,” Surabaya, 2016. Accessed: Nov. 01, 2024. [Online]. Available: https://www.academia.edu/29603213/PERHITUNGAN_DIAGRAM_WINDROSE_DAN_FETCH_EFEKTIF_UNTUK_MENCARI_TINGGI_DAN_PERIODE_GELOMBANG

