Study of Longshore Sediment Transport on Erosion and Sedimentation Beaches in South Sulawesi

H Umar1*, A Y Baeda1, F Husain1, and Taufiqurrahman1

1Department of Ocean Engineering, Engineering Faculty, Hasanuddin University, Makassar, Indonesia

*Email: hasdinar.umar@gmail.com

Abstract. Accumulation of sediment on the beaches absorbs and reflects energy which mainly comes from waves. If all wave energy is absorbed, the beaches is in a balanced condition. Conversely, if the beaches is in an unbalanced condition, erosion and sedimentation will occur which in turn will cause damage to the coastal line. To overcome the problem of erosion and sedimentation that occurs usually the first step that must be done is to look for the causes of erosion and sedimentation, so that by knowing the cause, then you can determine how to overcome them. To find out what approaches can be used to overcome erosion and sedimentation problems, a survey and study of erosion and sedimentation that occur on the beaches must first be conducted. This research was conducted by first analyzing the characteristics of coastal sediment grains then analyzing the predicted erosion and sedimentation on the beaches and calculating the magnitude of longshore sediment transport using empirical equations. Result of the research shows that Padongko Beach Mangempang Village Barru Regency has sedimentation with total longshore sediment transport was 201.71 m³/years, and Desa Aeng Batu-Batu Beach Galesong Utara Takalar Regency has sedimentation with longshore sediment transport was 169.79 m³/years

1. Introduction

The dynamic process will always adjust the shape of the profile so that it can destroy the incoming wave energy. This shape adjustment is the natural dynamic response of the beaches to the sea. Under normal wave conditions that occur for a longer time, wave energy will be easily destroyed by natural coastal defense mechanisms. However, during a storm where waves that have great energy will result in the beach's natural defenses not being able to withstand waves, so the beaches can be eroded. After the big waves subside, the beaches will return to its original shape by normal waves, but there are times when the eroded beach does not return to its original shape because the beach-forming material is carried by the current to another place and does not return to its original location. The material carried by the current will settle in quieter areas, such as in river mouths, bays, ports, etc, resulting in sedimentation in the area. In addition, the use of coastal land has also become one of the causes of several problems in coastal areas, such as: erosion, sedimentation, diverting and silting of river mouths, pollution and sea water intrusion [1]. Several studies related to coastal erosion and sedimentation have been carried out by several previous researchers. [2]. The sedimentation and erosion of the Coast of the District of Teluk Segara Bengkulu City caused by a crib building originating from the old port of Bengkulu which was not used anymore, the crib was blocking the sediment rate along the coast eastward [2]. The prediction of erosion and sedimentation of beaches in
Mattirotasi Pare-Pare Beach in South Sulawesi, show that most of the Mattirotation Beach area has sedimentation, although some areas also experience erosion [3]. Longshore sediment transport at Tanjung Bayang beach was $341.37 \times 10^3$ m$^3$/year eastward (due to wave from the west) without the installment of permeable groin, and by using 40% of permeability of groin density, the longshore sedimentation transport at Tanjung Bayang beach can be reduced up to $170.68 \times 10^3$ m$^3$/year [4]. This is caused by the presence of islands in front of the beach and beach reclamation work. South Sulawesi Province which has a capital city of Makassar with a total area of 45,574.48 km$^2$, with a coastline length of 1,973.7 km, consists of 23 regencies/cities spread over diverse topography and there are small islands with potential for natural resources both on land and in the very big sea. Some beaches in South Sulawesi experience erosion and sedimentation problems, but only 2 locations will be investigated, namely Padongko Beach Mangempang Village Barru Regency and Desa Aeng Batu-Batu Beach, Galesong Utara, Takalar Regency. These locations are representative of coastal areas that experience erosion and sedimentation problems.

2. Erosion and Sedimentation
Coastal erosion is one of the problems in the coastal area that has to get attention because coastal erosion can cause huge losses due to damage to residential areas and facilities in the area. To overcome coastal erosion the first cause must be sought first, so the solution can be found. One solution to erosion is to build a coastal protection structure, the building is used to protect the coast from waves and currents.

Sedimentation in its definition includes a variety of definitions that almost everyone has a different view in providing an understanding or definition of sedimentation, such as [1], states that Sedimentation is the entry of sediment loads into a particular aquatic environment, through water media and deposited in the media the environment, whereas sediment is the main material forming coastal morphology (topography and bathymetry). While [5] defines sedimentation as the process of forming sediments or sedimentary rocks caused by the deposition of the forming material or its origin in a place called the depositional environment in the form of a river, estuaries, lakes, deltas, estuaries, shallow seas to deep seas. As according to [6] defines marine sediments as the accumulation of minerals and rock fragments that are mixed with broken shells and bones of marine organisms and some other particles are formed through chemical processes that occur in the ocean.

3. Sediment Transport
Coastal sediment transport is the movement of sediments in coastal areas caused by waves and currents that they generate. Sediment transports studied in this case are those that occur in the area between the breaking waves and the coastal line. Coastal sediments can be classified as onshore-offshore transport and longshore transport. Transportation to and from the coast has an average direction perpendicular to the coastline, while transportation along the coast has an average direction along the coast. Coastal sediment transport is calculated using the longshore sediment transport empirical equation. The longshore sediment transport equation as a function of the velocity of the shoreline currents that will be used to calculate the amount of longshore sediment transport is derived from the CERC equation [7],

$$ Q_l = KP_l^n $$

$$ P_l = \frac{\rho \cdot g \cdot H_b \cdot C_b \cdot \sin \alpha \cos \alpha}{8} $$

$$ Q_l = 1290P_l \text{ (m}^3/\text{year)} $$

where $Q_l$ is longshore sediment transport (m$^3$/day), $K$ is the empirical coefficient, $P_l$ is longshore flux wave energy (Nm/s/m), $\rho$ is the density of water/seawater (kg/m$^3$), $\rho_s$ is the density of sedimentary
mass (kg/m³), n is the porosity of the sediment (n = 0.4), H is the height of the breaking wave (m), αb is the angle of the breaking wave (o), Cb is breaking wave velocity (m/s).

4. Prediction of Erosion and Sedimentation
Measuring height and wave period data, and particle size of sediment particles are used to predict whether the beach has erosion or sedimentation. Determination of erosion or sedimentation was done using the criteria of [8], namely:

a) Erosion if,

\[ \frac{H}{W_s T} \geq 3.2 \]  

(4)

b) Sedimentation if,

\[ \frac{H}{W_s T} < 3.2 \]  

(5)

where H is the significant wave height, Ws is the sedimentation velocity of sediment particles, T is the wave period.

5. Experimental Setup
This research was field research. Field survey measuring instruments that was sediment traps, and laboratory measuring instruments that was 1 set of sediment filters and digital scales. The field survey was conducted at Padongko Beach Mangempang Village Barru Regency and Desa Aeng Batu Batu Beach, Galesong Utara, Takalar Beach. The analysis conducted in this study was the analysis of the distribution of sediment grains in areas of erosion and sedimentation. The research data was used to determine the predicted erosion and sedimentation events and the amount of longshore sediment transport in the area.

6. Experimental Result
The occurrence of waves on the beaches was one of the factors that determine the erosion or sedimentation of the beaches. Large waves with a small period as was usually the case during storms will cause erosion on the beaches. So that the wave parameters that influence the determination of erosion and sedimentation events at the beaches were significant wave height (H) and wave period (T). In addition to the wave parameters, the characteristics of coastal sediment grains such as the diameter of the sediment grains (D50) and sediment fall velocity (W_s) are also parameters that influence in determining erosion and sedimentation at the beaches. Prediction of coastal erosion and sedimentation used in this study was a prediction using the characteristics of [8]. In the event of large waves (maximum) the beaches will tend to experience erosion and calm wave conditions (normal) beaches will tend to experience sedimentation. The results of erosion and sedimentation predictions from 2 (two) study sites were shown in the following table.

| Table 1. Erosion prediction and sedimentation of Padongko Beach Mangempang Village Barru Regency |
|-----------------------------------|-----------------|----------------|-----------------|-----------------|-----------------|-------------|
| Point                | Grain size, D50 (mm) | Fall Velocity (W_s) | Wave height significant (H_s), m | Wave period (T), second | H/W_s T | Prediction |
| PP1A               | 0.19                | 0.117             | 1.3126            | 3.48             | 3.23        | Erosion     |
| PP1B               | 0.13                | 0.097             | 1.3126            | 3.48             | 3.91        | Erosion     |
| PP1C               | 0.18                | 0.114             | 1.3126            | 3.48             | 3.32        | Erosion     |
| PP2A               | 0.17                | 0.111             | 1.3126            | 3.48             | 3.42        | Erosion     |
Table 1, shows that in the condition of normal waves \(H_s\) the coast is relatively sedimentation and longshore sediment transport of Padongko Beach Mangempang Village Barru Regency were shown in the following table.

### Table 1.\ TextAndTablesPoint  Grainsize, D50 (mm) \textAndTablesFallVelocity (W_s), \textAndTablesWaveheightsignificant (H_s), m \textAndTablesWaveperiod (T), second \textAndTablesH/W_s,T \textAndTablesPrediction

- **PP2B**: 0.18 0.114 1.3126 3.48 3.32 Erosion
- **PP2C**: 0.19 0.117 1.3126 3.48 3.23 Sedimentation
- **PP3A**: 0.20 0.120 1.3126 3.48 3.15 Sedimentation
- **PP3B**: 0.21 0.123 1.3126 3.48 3.10 Sedimentation
- **PP3C**: 0.20 0.120 1.3126 3.48 3.12 Sedimentation
- **PP4A**: 0.22 0.126 1.3126 3.48 3.00 Sedimentation
- **PP4B**: 0.18 0.114 1.3126 3.48 3.32 Erosion
- **PP4C**: 0.29 0.144 1.3126 3.48 2.61 Sedimentation
- **PP5A**: 0.19 0.117 1.3126 3.48 3.23 Erosion
- **PP5B**: 0.20 0.120 1.3126 3.48 3.15 Sedimentation
- **PP5C**: 0.50 0.189 1.3126 3.48 2.23 Sedimentation

Total longshore sediment transport to Southeast 201.71

Total longshore sediment transport at Padongko Beach Mangempang Village Barru Regency was 201.71 m³/years to the southeast. The prediction of erosion and sedimentation at Pantai Desa Aeng Batu-Batu Galesong Utara Takalar Regency were shown in Table 3 below.
Table 3. Erosion prediction and sedimentation of Desa Aeng Batu-Batu Beach, Galesong Utara Takalar Regency

| Point  | Grain size, D50 (mm) | Fall Velocity (W_s) | Wave height significant (H_s), m | Wave period (T), second | H/W_s.T | Prediction  |
|--------|----------------------|---------------------|---------------------------------|------------------------|----------|-------------|
| PP1A   | 0.19                 | 0.117               | 1.28                            | 3.43                   | 2.96     | Sedimentation |
| PP1B   | 0.13                 | 0.097               | 1.28                            | 3.43                   | 2.17     | Sedimentation |
| PP1C   | 0.18                 | 0.114               | 1.28                            | 3.43                   | 3.10     | Sedimentation |
| PP2A   | 0.17                 | 0.111               | 1.28                            | 3.43                   | 2.58     | Sedimentation |
| PP2B   | 0.18                 | 0.114               | 1.28                            | 3.43                   | 1.96     | Sedimentation |
| PP2C   | 0.19                 | 0.117               | 1.28                            | 3.43                   | 3.37     | Erosion      |
| PP3A   | 0.20                 | 0.120               | 1.28                            | 3.43                   | 2.89     | Sedimentation |
| PP3B   | 0.21                 | 0.123               | 1.28                            | 3.43                   | 2.96     | Sedimentation |
| PP3C   | 0.20                 | 0.120               | 1.28                            | 3.43                   | 2.50     | Sedimentation |
| PP4A   | 0.22                 | 0.126               | 1.28                            | 3.43                   | 2.22     | Sedimentation |
| PP4B   | 0.18                 | 0.114               | 1.28                            | 3.43                   | 2.17     | Sedimentation |
| PP4C   | 0.29                 | 0.144               | 1.28                            | 3.43                   | 3.10     | Sedimentation |
| PP5A   | 0.19                 | 0.117               | 1.28                            | 3.43                   | 3.27     | Erosion      |
| PP5B   | 0.20                 | 0.120               | 1.28                            | 3.43                   | 2.50     | Sedimentation |
| PP5C   | 0.50                 | 0.189               | 1.28                            | 3.43                   | 3.18     | Sedimentation |

Table 3, shows that in the condition of normal waves (H_s) the coast was relatively sedimentation and longshore sediment transport of Desa Aeng Batu-Batu Beach, Galesong Utara Takalar Regency were shown in the following table.

Table 4. Longshore sediment transport of Desa Aeng Batu-Batu Beach, Galesong Utara Takalar Regency

| Point  | Grain size, D50 (mm) | H_s | H_b | α_b (rad) | Q_l (m³/years) |
|--------|----------------------|-----|-----|-----------|----------------|
| PP 1A  | 0.19                 | 1.78| 0.5 | 0.322     | 12.85          |
| PP 1B  | 0.13                 | 1.78| 0.5 | 0.322     | 7.99           |
| PP 1C  | 0.18                 | 1.78| 0.5 | 0.322     | 13.51          |
| PP 2A  | 0.17                 | 1.78| 0.5 | 0.322     | 10.80          |
| PP 2B  | 0.18                 | 1.78| 0.5 | 0.322     | 6.22           |
| PP 2C  | 0.19                 | 1.78| 0.5 | 0.322     | 14.60          |
| PP 3A  | 0.20                 | 1.78| 0.5 | 0.322     | 12.533         |
| PP 3B  | 0.21                 | 1.78| 0.5 | 0.322     | 12.85          |
| PP 3C  | 0.20                 | 1.78| 0.5 | 0.322     | 10.26          |
| PP 4A  | 0.22                 | 1.78| 0.5 | 0.322     | 8.40           |
| PP 4B  | 0.18                 | 1.78| 0.5 | 0.322     | 7.99           |
| PP 4C  | 0.29                 | 1.78| 0.5 | 0.322     | 13.51          |
| PP 5A  | 0.19                 | 1.78| 0.5 | 0.322     | 14.20          |
| PP 5B  | 0.20                 | 1.78| 0.5 | 0.322     | 10.26          |
| PP 5C  | 0.50                 | 1.78| 0.5 | 0.322     | 13.85          |

Total longshore sediment transport to Southeast 169.79
Total longshore sediment transport at Desa Aeng Batu-Batu Beach, Galesong Utara Kabupaten Takalar was 169.79 m$^3$/years to the southeast.

7. Conclusion
Based on prediction results, it shows that Padongko Beach Mangempang Village Barru Regency has sedimentation with total longshore sediment transport was 201.71 m$^3$/years to the Southeast. The prediction results shows that Desa Aeng Batu Batu Beach, Galesong Utara, Takalar Regency has sedimentation too and total longshore sediment transport was 169.79 m$^3$/years to the Southeast.

Acknowledgments
The authors would like to thank to Engineering Faculty of Universitas Hasanuddin for the grant of LBE 2019 and Coastal Engineering and Environmental Laboratory, Department of Ocean Engineering, Faculty of Engineering, Universitas Hasanuddin.

References
[1] Triatmodjo B, 1999, Coastal Engineering, Beta Offset, Yogyakarta.
[2] Kesumajaya. 2005. Sedimentation and Erosion at Segara Bay District Beach, Bengkulu, Magister Thesis ITB, Bandung.
[3] Hasdinar, 2014, Identification of Coastal Problems and Erosion Predictions and Coastal Sedimentation in South Sulawesi, Final Report of the Excellence Research for Ocean Engineering Study Program, Faculty of Engineering, Universitas Hasanuddin.
[4] Hasdinar, 2018, In Use of Permeable Groin for Reducing Longshore Sediment Transport at Tanjung Bayang Beach of South Sulawesi, EPI International Journal of Engineering Volume 1, Number 2, August 2018, pp. 70-73.
[5] Pettijohn, F.J. 1975. Sedimentary Rocks Second Edition. Harper and Row Publisher.New York. pp. 626.
[6] Gross, M.G. 1990. Oceanography : A View of Earth. Prentice Hall, Inc. Englewood Cliff. New Jersey.
[7] CERC, 1984, Shore Protection Manual, US Army Coastal Engineering Research Center. Washington (SPM, 1984).
[8] Kraus, N.C., Larson, M., and Kreibel, D.L. 1991. Evaluation of beach erosion and accretion predictors. Proc. Coastal Sediments ’91, ASCE, 572-587.