CHARACTERISTICS OF BREAKING WAVES USING THE HINDCASTING METHOD ON MAMBORO BEACH, PALU CITY

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ABSTRACT

Introduction: Mamboro Beach is one of the beaches in the northern part of Palu City, Central Sulawesi Province, approximately 14 km from Palu City. Wave activity, currents, tides, and winds are some of the triggers for sedimentation. Mamboro beach is prone to sediment movement, which can result in shoreline changes such as erosion which results in the retreat of the shoreline (abrasion) or causes siltation which results in the advancement of the shoreline (accretion). As a result, changes in the shape of the coast will affect the hydrodynamic processes of the waters, such as changes in the characteristics of ocean waves. This study aims to determine the characteristics of the breaking waves and the height and depth of the breaking waves that occur on Mamboro beach, Palu City using the Hindcasting method. The input required is bathymetry data, tides for 15 days, wind data for ten years (past), and fetch data. From the results of Hindcasting calculations and analysis of wave transformation using wind data for ten years (past), it can be concluded that the characteristics of the type of Breaking Wave that occurred on the Mamboro beach, Palu City, is a surging type where the waves break right on the shore. The calculated breaking wave height is 2.0911 meters, and the breaking wave depth is 1.882 meters.

1. Introduction

Indonesia is an archipelagic country with more than 3700 islands and a coastal area of 80,000 km. This coastal area is an intensive area used for human activities, such as a central government area, settlements, industry, ports, aquaculture, agriculture/fishery, tourism, etc. [1]. The beach is the boundary between land and sea, which is found in the coastal areas of the sea and sand on the coast [2]. Coastal areas in the Central Sulawesi Region have many uses, including tourist attractions, fishing villages, pond areas, state roads, etc. Several coastal areas in Palu City have the potential for damage due to abrasion, one of which is Mamboro Beach. Wave activity, currents, tides, and winds are some of the triggers for sedimentation [3]. The beach in Mamboro is prone to sediment movement, which can result in shoreline changes such as erosion which results in the retreat of the shoreline (abrasion), or silting, which results in the advancement of the shoreline (accretion), which can then reduce the function of the beach or coastal structures [4]. As a result, the possibility of changes in the shape of the coast will later affect the hydrodynamic process of the waters, such as changes in the characteristics of ocean waves or changes in the shape of the direction of propagation of the waves themselves [5].

Based on the background described above, almost most of the community activity centers in Mamboro, Palu City, are located in coastal areas. Therefore information about the hydrodynamics of the waters in the area is needed [6-9]. There are two terms for the beach in Indonesian that are often used, namely the coast and the beach. The coast is a land area on the edge of the sea that is still affected by the sea, such as tides, sea breezes, and seawater seepage [10]. At the same time, the beach is an area on the edge of the water that is affected by the highest tide and lowest tides. Land area is an area located above and below sea level starting from the seaside at the lowest low tide line, including the sea floor and the part below it [11]. The breaking wave is a very complex system. Even in the distance before the wave breaks, the shape is no longer sinusoidal. If a wave breaks, the energy received from the wind is reduced [12]. Some of the energy is returned to the sea; the amount depends on the slope of the coast. The smaller the angle of the coast, the less energy is reversed [13]. Most of the energy is lost as heat in the small-scale mixing of water foam and sand [14].

2. Method

2.1 Primary Data

This research was conducted at Mamboro beach. In this study, the initial data needed are bathymetry and coastal tidal data. Mamboro beach is located ± 14 Km from Palu City. In this study, bathymetry data was obtained by taking directly at the research location for two days, and the tides were obtained by taken directly from the study site for 15 days for 24 hours with an interval of every 1 (one) hour.

1. Bathymetry Data

1. Bathymetry measurement process
   The bathymetry measurement process takes two days, starting from May 1, 2021, to May 2, 2021

2. Tide Data

1. Measuring tub preparation process
   The measuring instrument used in this study uses a measuring sign made of wood with a length of 4 m and is notated in the form of meters (m).
2. Measuring tool installation process
   In the process of installing the measuring instrument, first, the measuring sign is cast on a large bucket.
   Furthermore, at the time of installation of the measuring sign, the measuring sign is tied using a nylon rope to the rock. This is so that when the tide conditions, the signs do not shift or are carried away by the current.
3. Tidal measurement process
   This tidal measurement process takes place every 1 hour for 15 days of observation, starting

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from May 24, 2021, to June 7, 2021.

2.2 Secondary Data

1. Wind Data

In this study, the data collected was based on hourly wind data obtained from the NOAA Earth System Research Laboratory NCEP/NCAR. During ten years of observation, 2011–2020. The wind data collection process is as follows.

2. Thematic Maps

Thematic maps are used to calculate the area of regional wave formation, calculated using a base map using AutoCAD facilities.

2.3 Data Analysis

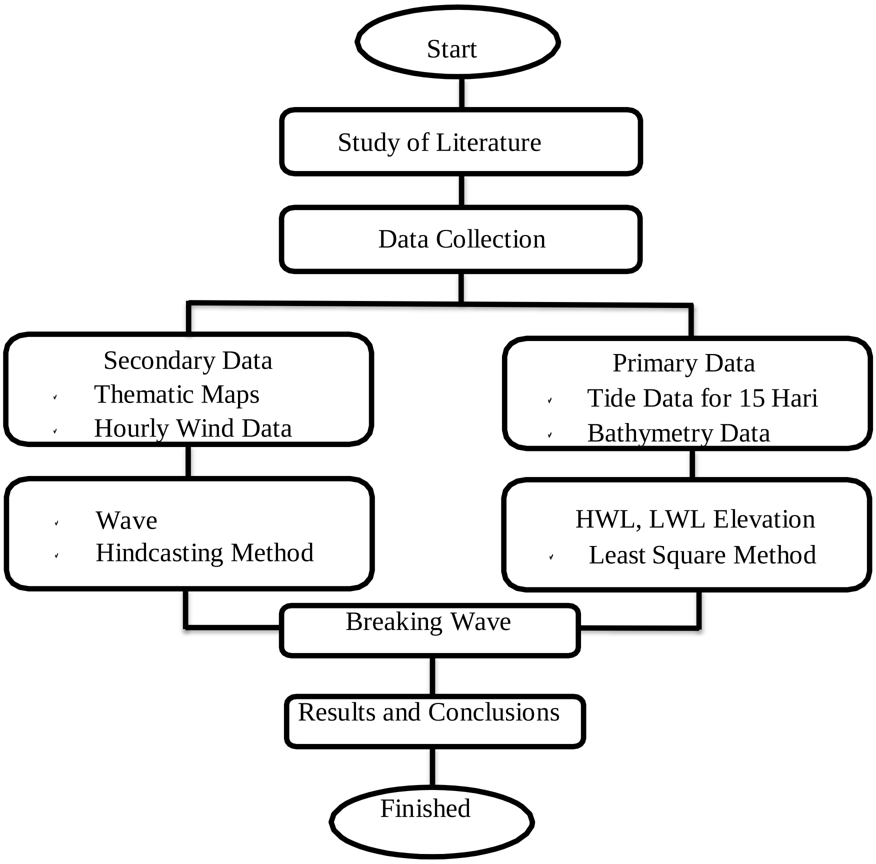

Fig 1. Research flow chart

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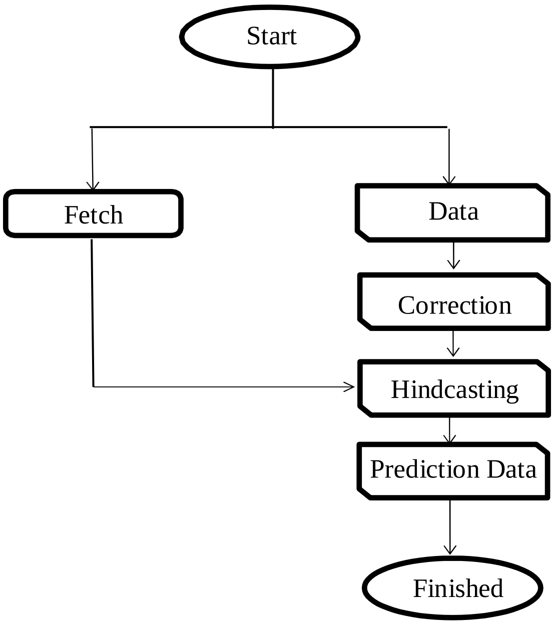

Fig 2. Data processing flow chart with Hindcasting Method

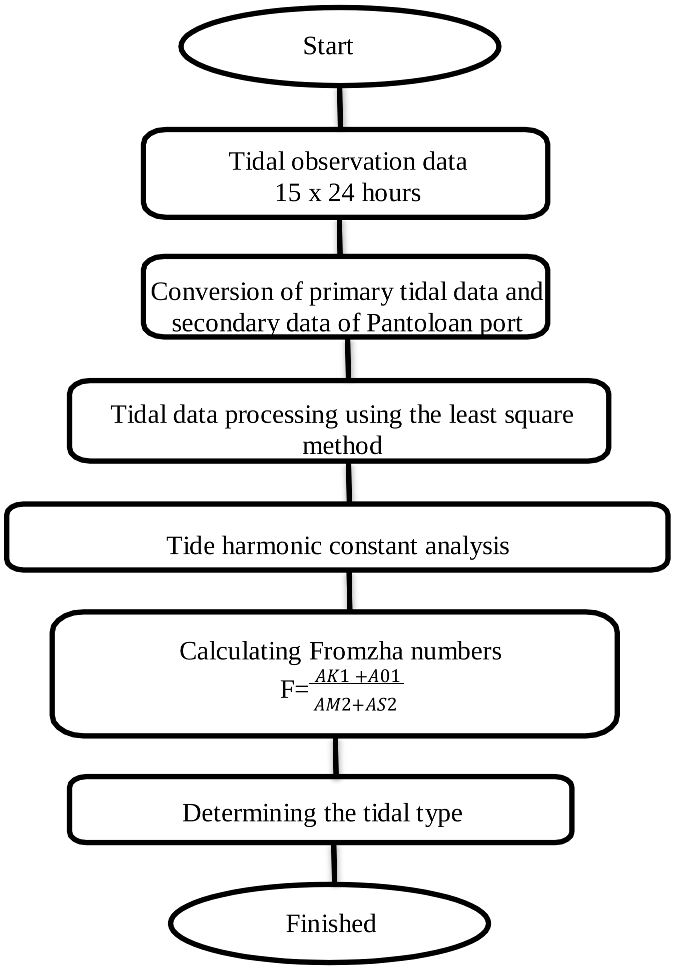

Fig 3. Data processing flow chart with Least Square Method

3. Results and Discussion

Bathymetry maps can be interpreted as a measure of the depth of the sea, both regarding the size of the seabed elevation, which is a source of information and an overview of the seabed, as well as providing many clues about the structure of the sea [15]. The following is a bathymetry map of Mamboro beach which can be seen in Figures 4 and 5.

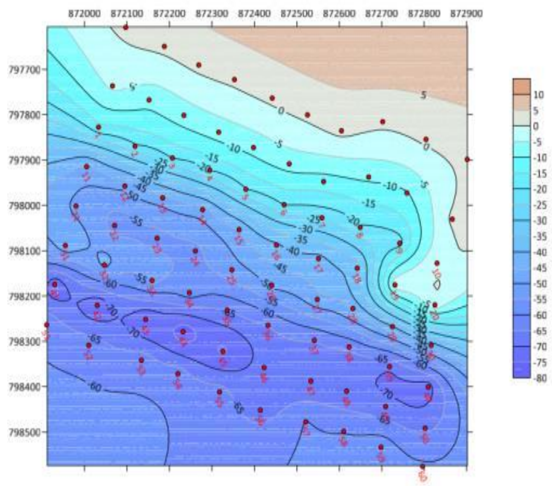

Fig 4. Bathymetry

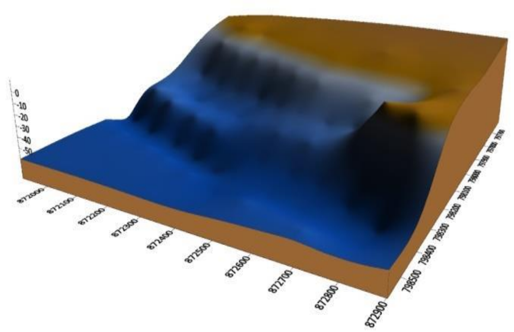

Fig 5. Mamboro beach topographic map

Tidal Data Analysis

Based on the data obtained in the field, a tidal graph can be generated. The following is a graph of the results of observations of sea tides on Mamboro beach which can be seen in Figure 6.

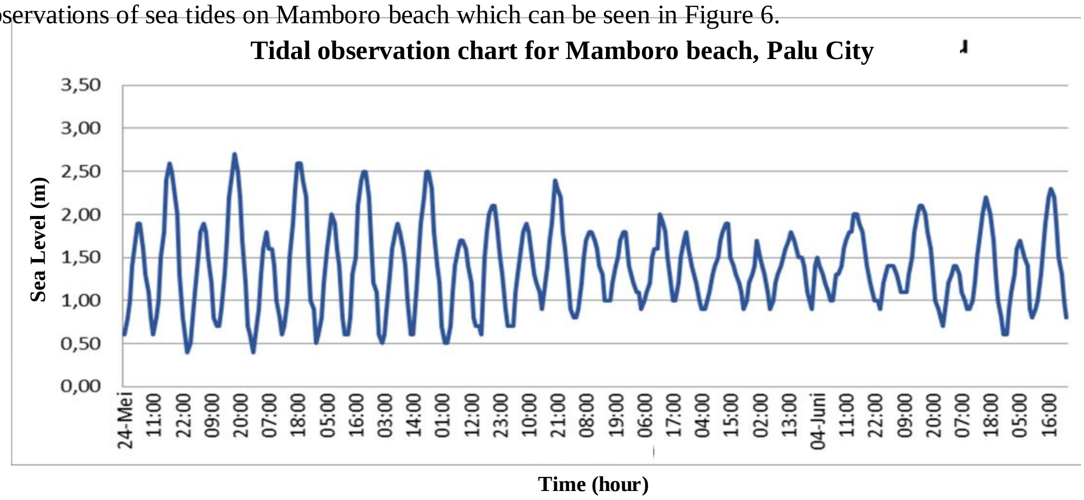

Fig 6. Graph of tidal observation results for 15 days

Least Square Method Calculation Results

Tidal data in this study was first tested using the Least Square Method, then solved using a formula in Microsoft Excel. The following is the final result of the harmonic constant between difference (g^0) Least Square Method.

Amplitude (A) and phase

Table 1 Final Result of Harmonic Constant with Least Square Method

Constant	Tidal Component (m)									
	S0	M2	S2	N2	K2	K1	O1	P1	M4	MS4
A	1,328	0,338	0,975	0,187	1,038	0,478	0,119	0,234	0,001	0,021
gr		234,030	15,649	302,642	166,121	76,814	150,011	258,925	220,554	87,691

The results of the calculation using the Least Square Method can be obtained types or types of tides based on Formzahl numbers by comparison.

Windrose Display and Histogram 2010-2019

The wind data required is wind direction and speed data. The data was obtained from NOAA, namely from
2010-2019.

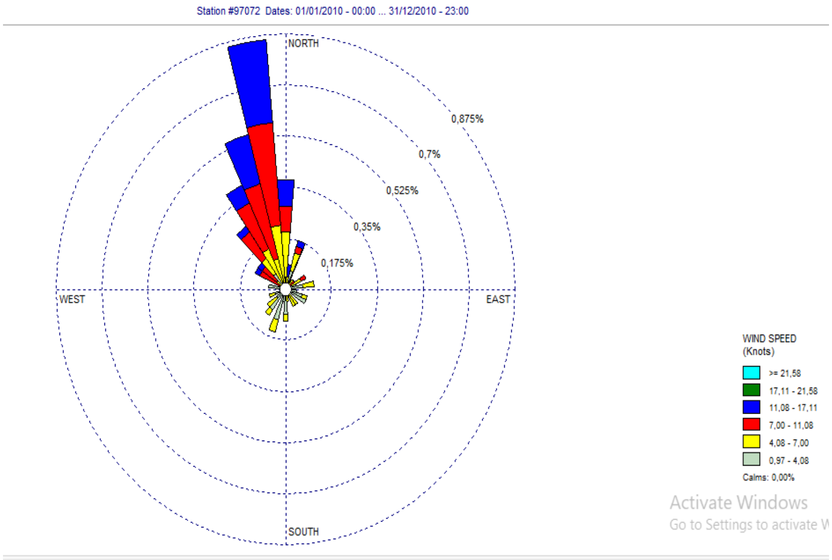

Fig 7 Windrose display in 2010

Calculating U_A Value

To calculate the U_A value of the wind stress factor, which is then used in the wave height forecasting equation. In the calculation to determine the wind stress factor, the following equation is used:
$U_A = 0{,}71\ U_{10}^{1{,}23}$

Table 2 Annual Maximum Wind Speed

No	Year	North	North east	East	South east	South	South west	West	North west
		m/det	m/det	m/det	m/det	m/det	m/det	m/det	m/det
1	2010	8,2	5,1	2,6	2,1	2,6	2,1	2,6	6,2
2	2011	9,8	4,1	1,5	2,1	2,6	3,1	5,1	6,7
3	2012	6,7	1,5	2,1	3,6	2,6	2,1	3,1	6,7
4	2013	9,9	9,9	9,9	9,9	3,6	4,6	9,9	25,7
5	2014	25,7	9,3	27,8	29,3	3,6	3,6	5,1	14,9
6	2015	9,9	7,2	8,8	4,1	9,9	3,6	12,4	17,5
7	2016	9,9	6,2	21,6	9,9	4,1	9,9	5,1	9,9
8	2017	10,3	7,2	9,9	3,1	5,7	4,6	5,1	10,3
9	2018	9,9	25,7	5,7	4,6	8,8	4,6	5,7	28,8
10	2019	9,9	18,5	5,7	4,1	3,6	5,1	5,7	9,8

Table 3 U_A Value Calculation Results

No	Year	North	North east	East	South east	South	South west	West	North west
		m/det	m/det	m/det	m/det	m/det	m/det	m/det	m/det
1	2010	9,4460	5,2671	2,2997	1,7684	2,2997	1,7684	2,29972	6,6973
2	2011	11,762	4,0270	1,1691	1,7684	2,2997	2,8552	5,26708	7,3677
3	2012	7,3677	1,1691	1,7684	3,4317	2,2997	1,7684	2,85518	7,3677
4	2013	11,909	11,909	11,909	11,909	3,4317	4,6393	11,909	38,501
5	2014	38,501	11,028	42,407	45,238	3,4317	3,4317	5,26708	19,691
6	2015	11,909	8,0497	10,303	4,0270	11,9	3,4317	15,710	23,999
7	2016	11,909	6,6973	31,091	11,909	4,0270	11,909	5,26708	11,909
8	2017	6,7590	8,0497	11,909	2,8552	6,0393	4,6393	5,26708	12,504
9	2018	11,909	38,501	6,0393	4,6393	10,303	4,6393	6,03927	44,291
10	2019	11,909	25,697	6,0393	4,0270	3,4317	5,2671	6,03927	11,762

Table 4 Effective Average Fetch

Direction	Corner	*Xi* (m)	a	cos a	*Xi* -cos a	*F* eff (m)
	335	-	-20	0,93969	-	
	330	6145,87	-15	0,96593	5936,4584	
	325	210212	-10	0,98481	210211,3402	
	320	225305	-5	0,99619	225303,9388	
Southwest	315	252462	0	1	252461,0280	84833,8
	310	15409,5	5	0,99619	15408,5178	
	305	13252,8	10	0,98481	13251,7992	
	300	11038,8	15	0,96593	11037,8811	
	295	10657,6	20	0,93969	10656,6413	
	290	8599,15	-20	0,93969	8598,2133	
	285	8223,91	-15	0,96593	8222,9401	
	280	7948,56	-10	0,98481	7947,5732	
	275	7853,39	-5	0,99619	7852,3908	
West	270	7763,06	0	1	7762,0570	7851,94
	265	7532,09	5	0,99619	7531,0928	
	260	7155,7	10	0,98481	7154,7152	
	255	6888,26	15	0,96593	6887,2931	
	250	6931,62	20	0,93969	6930,6843	
	245	7088,05	-20	0,93969	7087,1053	
	240	7412,67	-15	0,96593	7411,7021	
	235	7368,81	-10	0,98481	7367,8232	
	230	7298,07	-5	0,99619	7297,0738	
Northwest	225	7483,19	0	1	7482,1880	7997,37
	220	7792,59	5	0,99619	7791,5938	
	215	8029,86	10	0,98481	8028,8742	
	210	8327,04	15	0,96593	8326,0751	
	205	9371,37	20	0,93969	9370,4313	
	200	11290,8	-20	0,93969	11289,8553	
	195	12309,8	-15	0,96593	12308,7971	
	190	13645	-10	0,98481	13644,0592	
	185	15115	-5	0,99619	15114,0368	
South	180	15992,8	0	1	15991,8370	11484,4
	175	15635,6	5	0,99619	15634,5788	
	170	14205,8	10	0,98481	14204,7672	
	165	2568,47	15	0,96593	2567,5071	
	160	-	20	0,93969	-	

Table 5 Significant wave height and significant wave period

Significant wave height and significant wave period		
Year	**Hs**	**Ts**
2010	0,037	0,598
2011	0,029	0,522
2012	0,020	0,317
2013	0,257	1,868
2014	0,279	2,007
2015	0,287	1,978
2016	0,236	0,165
2017	0,202	1,828
2018	0,209	1,803
2019	0,162	1,654

Breaking Wave Calculation

The calculation of the breaking waves resulting from the calculation of the height and depth of the breaking waves (Hb and db) is presented in Table 6 below. Where Hb is the height of the breaking wave and db is the depth of the breaking wave.

Table 6 Calculation of the Height and Depth of the Breaking Wave

Depth (m)	Ho'	Ho'/gT^2	Hb/Ho'	Hb	Hb/gT^2	db/Hb	db
1	1,549	0,00443	1,3200	2,0447	0,00585	0,9	1,840
3	1,566	0,00448	1,3700	2,1449	0,00613	0,8950	1,920
5	1,560	0,00446	1,3500	2,1054	0,00602	0,8600	1,811
10	1,574	0,00450	1,3300	2,0940	0,00599	0,8810	1,845
15	1,585	0,00453	1,3100	2,0760	0,00594	0,9200	1,910
20	1,592	0,00455	1,2900	2,0533	0,00587	0,8910	1,829

4. Conclusion

From the results of the discussion and analysis carried out, it can be concluded that:

1. From the results of Hindcasting calculations and analysis of wave transformation using wind data for ten years (past), it can be concluded that the characteristics of the type of Breaking Wave that occurred on the coast of Mamboro, Palu City, is a surging type according to the calculation results of the value of the Irribarence number (Ni > 3,2).
2. From the results of the calculation of breaking waves using the Hindcasting method, it can be seen that the height and depth of the breaking waves at Mamboro Beach, for the height of the breaking waves, is 2.0911 m, and the depth of the breaking waves is 1.882 m.

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