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Analysis of Physical Hydro-Oceanographic Factors for Abrasion at Pasir Jambak Beach, Padang City, West Sumatra Province

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ABSTRACT

Abrasion is a common problem in coastal areas. This is due to natural factors that influence the phenomenon of abrasion in a coastal area, including the hydro-oceanographic processes that take place in the sea. Pasir Jambak Beach is one of the beaches in Padang City that is experiencing worrying abrasion. Therefore, it is necessary to research the analysis of physical hydro-oceanographic factors for beach abrasion. This survey was conducted in February - April 2023 at Pasir Jambak Beach. This study aimed to determine the degree of abrasion and its relationship to the hydro-oceanographic physics of the beach. The method used is survey and purposive sampling. The data obtained were tabulated and descriptively quantitatively analyzed by multiple linear regression. The results showed that the beach experienced a dominant abrasion process in the period 1995-2023 compared to accretion with an abrasion rate of 77.94%. The highest average wear rate occurred in 2019-2023 of 3.86 m/year and the lowest in 2003-2007 of 1.9 m/year. Physical hydro-oceanographic factors at Pasir Jambak Beach have a significant influence on the abrasion phenomenon that occurs.

Keywords: Abrasion, Physical Hydro-Oceanographic, Pasir Jambak Beach

1. INTRODUCTION

The coastal area is a transition area between land and sea that is formed by the ongoing geomorphological processes. This area is known to be sensitive to natural phenomena such as tides, waves, wind, and currents. Abrasion is a common problem in coastal areas. This is because coastal zones are areas that are highly sensitive to natural phenomena, in particular to environmental factors such as climate variability, climate change, and rising sea levels (Hamuna et al., 2018).

Abrasion is defined as land erosion events that occur in coastal areas. Abrasion is also defined as the continuous release of beach material (sand or clay) due to the impact of sea waves or a change in the balance that occurs in sediment transport on a beach (Munandar & Kusumawati, 2017).

The phenomenon of abrasion in a coastal area is caused by two factors, namely natural and anthropogenic factors. Anthropogenic factors such as the development of coastal areas can cause land subsidence and tidal flooding that can change the coastline (Mahendra et al., 2017). In addition, one of the natural factors is the existence of hydro-oceanographic processes occurring in the sea. The hydro-oceanographic process referred to includes wave breaking, changes in current patterns, winds, and tides that take place (Munandar & Kusumawati, 2017). Of the two factors that cause the phenomenon of abrasion on the beach, the hydro-oceanographic factor is the dominant factor that makes the phenomenon of abrasion difficult to overcome. This is why hydro-oceanographic factors are referred to as natural factors causing coastal damage (Fadilah, 2021).

Pasir Jambak Padang Beach is located in Pasir Nan Tigo, Koto Tangah, Padang City, West Sumatra (Yusri et al., 2019). Based on the news from the Antara Sumbar newspaper, there are again problems with Pasir Jambak beach on Monday, August 1, 2022. It should be noted that the results of the beach abrasion process usually transport sediment to other areas. Sediment transport is also largely influenced by waves, tides, ocean currents, and coastal currents.

In the case of abrasion at Pasir Jambak Beach, sediment transport, which is closely related to hydro-oceanographic factors, has a negative impact in the form of transporting sediment from the beach, resulting in shoreline damage and the fall of coastal protection trees. If this continues, there is a good chance that this abrasion phenomenon can reach the living environment in the coastal area (Triyatno, 2014). Therefore, based on the presentation of the existing problems, it is necessary to research the analysis of physical hydro-oceanographic factors for abrasion at Pasir Jambak Beach, Padang, West Sumatra.

2. RESEARCH METHODS

Time and Place of Research

This survey was conducted in February - April 2023 at Pasir Jambak Beach, Padang City, West Sumatra Province. Data analysis was performed in the Laboratory of Oceanographic Physics, Department of Marine Sciences, Faculty of Fisheries and Marine, Universitas Riau.

Method

The method used in this study is survey and purposive sampling. The data obtained were tabulated and quantitatively descriptively analyzed by multiple linear regression. The data obtained includes data on waves, currents, wind, tides, abrasion rate, and coastal slope.

Procedure

Determination of Research Locations

The survey site was conducted along the coast of Pasir Jambak Beach, Jalan Teratai, Pasie Nan Tigo, Koto Tangah District, Padang City, West Sumatra, Indonesia. In this study, the data collection is divided over two stations, namely Station 1 (far from the breakwater) and Station 2 (close to the breakwater).

Physical Hydro-Oceanographic Parameters

Wind data is needed to determine the size and height of the waves; and wind direction and speed. Data was obtained from the website *https://marine.copernicus.eu*.

Wave data will be obtained from measurements using scaled piles and from the related website, namely https://marine.copernicus.eu. Then the data is entered into the equation:

Wave Height

$$H = H_{max} - H_{min}$$

Information:

H = Average wave height (m)
H_{max} = Highest wave height (m)
H_{min} = Lowest wave height (m)

Wave Period

$$T = \frac{t}{N}$$

Information:

T = Wave period (seconds)
t = Duration of wave observation (s)
N = Number of wave observations

Wavelength

$$L = 1{,}56 \text{ x } T^2$$

Information:

L = Wavelength (m)
T = Wave period (seconds)

Total Energy

$$E = \frac{\rho g h^2}{8}$$

Information:

E = Total energy (Nm/m^2)
ρ = Seawater density (1024 kg/m^2)
g = Gravitational (9,8 m/s^2)
h = Wave height (m)
1/8 = Wave blow constant value

Current data is obtained by measuring the current at each station using a current drogue. The obtained figure is entered into the equation (Manik et al., 2017):

$$V = \frac{s}{t}$$

Keterangan:

V = Current speed (m/s)
s = Mileage
t = Time (s)

Furthermore, data has also been obtained from the related website, namely *https://marine.copernicus.eu.*

Tide observations were made using a tide bar. The sea level will be observed every other day for 15 study days. Observational data is processed using the admiralty method and is entered into the formzahl number equation as follows (Nugraha et al., 2013).

$$F = \frac{AO_1 + AK_1}{AM_2 + AS_2}$$

Note:

AM_2 = The amplitude of the main double tidal component caused by the pull force of the moon

AS_2 = The amplitude of the main double tidal component caused by the attraction of the sun
AK_1 = The amplitude of the main single tidal component caused by the attraction forces of the moon and sun
AO_1 = The amplitude of the main single tidal component caused by the pull force of the moon

Furthermore, the formzahl numbers that have been obtained will be classified based on the following classification (Korto et al., 2015).

1. Double daily ups and downs if F ≤ 0,25
2. Mixed tides (double dominant) if 0,25 < F ≤ 1,5
3. Mixed tides (single dominant) if 1,5 < F ≤ 3
4. Single daily ups and downs if F > 3

Tidal observation data is also obtained from related websites, namely *https://marine.copernicus.eu*

Beach Slope

Measurement of the slope of the beach is carried out using piles. The procedure for measuring the slope of the beach will be guided by Mardianto (2004) using the equation, namely:

$$K = \frac{C}{L} x100\%$$

Information:
K = Beach slope (%)
C = Depth (m)
L = Distance from the coast towards the sea from the highest ide (m)

Furthermore, K values will be classified according to the following Table 1.

Table 1. K value classification

K Value Interval	Information
0 – 2 %	Flat
> 2 – 8 %	Ramps
> 8 – 30 %	Crooked
> 30 – 50 %	Rugged
> 50 %	Very steep

Abrasion Speed

Abrasion measurements are carried out by meter and stopwatch. This measurement was carried out based on Junaidi who used the equation among others (Suwarsono et al., 2011):

Abrasion Speed

$$V = \frac{m}{\frac{A\rho}{t}}$$

Information:
V = Abrasion Speed (m/year)
m = Abrasion mass of substrate
A = Abrasion surface area
ρ = The density of abrasion substrate ($1{,}6\ x\ 10^3$ kg/m^3)
t = time (year)

Abrasion Mass of Substrate

$$m = (p \times l \times t) \times \rho$$

Information:
p = The length of the beach is abrasive
l = Abrasive beach width
t = Cliff height due to abrasion
ρ = The density of abrasion substrate ($1{,}6\ x\ 10^3$ kg/m^3)

Abrasion Surface Area

$$A = p \times l$$

Information:
p = The length of the beach is abrasive
l = Abrasive beach width

Image Data Processing

Image Data Download

Download image data on the website https://earthexplorer.usgs.gov/ according to the desired location. The image data downloaded is Landsat 5 TM Level 2 image data and Landsat 8 image data OLI/TIRS Level 2 Pasir Jambak Beach in 1995, 1999, 2003, 2007, 2011, 2015, 2019, and 2023.

Radiometric Correction

Radiometric correction is done by calculating the following equation in the raster calculator menu in the Arcgis 10.4 software.

$$\text{Radiometric Correction} = \frac{Band\ n}{Sin\ \theta}$$

Information:
Band n = Nth band (1, 2, *dst*...)
Sin θ = The sin value of the sun elevation of the corrected image data.

Band Composite

Bands from image data will be merged. The band combinations used are bands 6, 5, and 4 on Landsat 8 and band combinations 5, 4, and

3 on Landsat 5.

Image Data Cropping

Image cutting is done to be able to cut the desired area on the satellite image so that researchers can do data processing that only focuses on the area to be studied.

Image digitization

The image data to be digitized are the image data from 1995, 1999, 2003, 2007, 2011, 2015, 2019 and 2023.

Overlay

The overlay is the process of combining two shapefile data (shp) into one shapefile data (shp). The overlay data is analyzed and calculated using the EPR (End Point Rate) method. The obtained shoreline change values are classified based on Table 2 (Abuodha & Woodroffe, 2010).

Table 2. Classification of coastline change scales

Criterion	Area of coastline changes
Accretion	≥ +2,1 m/ year
Stable	1.0 – 2,0 m/ year
Low Abrasion	-1 – +1 m/ year
Moderate abrasion	-1,0 – -2,0 m/ year
High Abrasion	≤ -2,0 m/ year

Map Layout

The final stage of this process is the map layout. The map formatting process is performed to make the analysis area look neat and orderly or to map it.

Correlation of Hydro-Oceanographic Factor Correlation to Abrasion

To determine the correlation between hydro-oceanographic factors and abrasion, it can be determined using multiple linear regression analysis. The data to be used is Hydro-oceanographic and abrasion rate data from Pasir Jambak Beach every four years for 28 years, from 1995 to 2023. The following equation is used in the correlation analysis.

$$y = f(x)$$

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4$$

Note:

y = Dependent variable (Abrasion Rate)
a = P constant
b_{1-4} = Regression coefficient
x_{1-4} = Independent variables
x_1 = Wind Speed
x_2 = Wave Energy
x_3 = Current Speed
x_4 = Sea Level (Tidal)

The level of correlation according to Sarwono & Budiono (2012) can be seen in Table 3.

Table 3. Correlation level

Correlation percentage	Correlation Type
0	None
0 – 0,25	Very weak
0,25 – 0,50	Enough
0,50 – 0,75	Strong
0,75 – 1	Very Powerful
1	Perfect

Data Analysis

Primary and secondary data will be analyzed quantitatively using Microsoft Excel, ArcGIS, and SPSS software. Secondary data (abrasion rate and hydro-oceanography data from Pasir Jambak Beach in 1995-2023) will be analyzed using multiple linear regression analysis techniques.

3. RESULT AND DISCUSSION

Description of Research Location

Pasir Jambak Beach is one of the tourist beaches in Padang City. This beach is located in Pasir Nan Tigo, Koto Tangah, Padang City, West Sumatra, 17 km from the center of Padang City (Yusri et al., 2019). This beach has a fairly long coastline of about 3 km and is therefore considered vulnerable to natural phenomena such as abrasion and tsunamis. The condition of several parts of Pasir Jambak Beach is characterized by severe land erosion. Land erosion occurring on this beach has reached residential areas and has even uprooted some coastal vegetation on the beach, such as pine trees.

Based on the research activities carried out, the wave data was obtained per station (Table 4). The data presented in Table 4, show that the observed wave component values are influenced by tidal phenomena. This is evident from the difference in the value of the wave component at ebb and flow on the beach. The calculated data is usually of greater value when the beach is at low tide. This is presumably due to factors other than tides affecting wave formation. For example, weather and climate factors can cause an imbalance in hydro-oceanographic processes on a coast. This condition can accelerate the attrition process in a coastal area (Octavian et al., 2022).

Table 4. Pasir Jambak Beach wave data

Station	Wave Height (m)			Wave Period (s)			Wavelength (m)			Wave Energy (Nm/m^2)		
	High Tide	Low tide	Average	High Tide	Low tide	Average	High Tide	Low tide	Average	High Tide	Low tide	Average
1	0,25	0,24	0,24	6,48	7,65	7,06	69,29	97,68	83,49	79,90	74,45	77,02
2	0,25	0,27	0,26	7,25	7,28	7,27	82,74	83,14	82,94	81,70	94,00	87,85

All in all, the height, period, length, and energy of the waves have a greater value at station 2 than at station 1. This is probably due to the influence of wave-generating factors. The fact that there is a breakwater at station 2 is not enough to have a major impact on the amount of wave energy generated on the beach. However, this condition can also be caused by differences in factors that influence and generate waves, such as speed, wind, duration, wind direction, and wave action (Adriat et al., 2021).

Based on the research activities conducted at Pasir Jambak Beach, Padang City, current data are obtained at each research station (Table 5).

Table 5. Pasir Jambak Beach flow data

Station	Current Speed (m/s)		
	High Tide	Low tide	Average
1	0,30	0,27	0,29
2	0,35	0,24	0,30

Based on (Table 5), it appears that the average flow velocity at station 2 is greater than the average flow velocity at station 1, which is 0.30 m/s. This is due to the presence of a breakwater as a beach protector at station 2. In addition, there is a difference in value between when the beach is ebb and flow. This is because the current is influenced by tidal forces.

The flow rate caused by maximum and minimum tides is influenced by the difference in sea level, both during high tide and low tide. The magnitude of the current velocity value at high tide is because the current velocity value tends to reach its maximum when the water level is towards the highest tide (Indrayanti et al., 2021).

Based on research activities conducted at Pasir Jambak Beach, Padang City, tidal harmonic component data is obtained from the results of tidal data processing for 15 days (Table 6).

Table 6. Tidal harmonic component data of Pasir Jambak Beach

Component	A0	M2	S2	N2	K1	O1	M4	MS4
H (feet)	189.9382	14,72981	17,63711	13,97637	10,07589	4,743317	0,906846	0,195562
g°	-	218,1113	282,2003	192,6213	311,3418	246,2691	16,64444	284,6853

Based on the calculations and data analysis performed, the value of the formzahl number is 0,458. Based on the classification according to Korto et al. (2015), it was found that the characteristics of the tides in Pasir Jambak Beach are mixed, predominantly semidiurnal tides. This means that the beach experiences two highs and two lows per day.

Table 7. Pasir Jambak Beach slope data

Station	Beach Slope (%)	Information
1	4,89	Ramps
2	4,70	Ramps
Average	4,80	Ramps

The average beach slope at Pasir Jambak Beach is 4,80% with a slope at station 1 of 4,89% and at station 2 of 4,70% (Table 7). Based on the classification, Pasir Jambak Beach is known to be classified as a sloping beach. This is in line with what was stated in previous studies that this beach has a long, wide, and sloping beach (Rahmadianti & Sepdanius, 2021).

Changes in the Pasir Jambak Coastline of Padang City

Based on the calculations performed, the abrasion rate data obtained at Pasir Jambak

Beach was observed in the field (Table 8).

Table 8. **Pasir Jambak Beach abrasion speed field data 2023**

Station	Abrasion Speed (m/year)
1	0,68
2	0,15
Average	0,42

Based on the Table 8, it is obtained that the average wear rate of Pasir Jambak Beach when measured is 0,42 m/year, with the abrasion rate at station 1 being greater than the abrasion rate at station 2, namely 0,68 m/year. The size of the sanding rate at station 1 compared to station 2 is due to the presence of breakwater in the form of groins on the beach (Setiawan et al., 2020).

Based on the results of data processing performed using landsat image data, the data on the change of the coastline over 28 years is obtained at the study site. The following is data on changes in the coastline of Pasir Jambak Beach every four years from 1995 to 2023 at each station (Table 9).

Table 9. **Four years of coastline change data at each research station 1995-2023 using Landsat imagery data**

Year	EPR Value (m/year)		Category	
	Station		Station	
	1	2	1	2
1995-1999	-6,18	2,81	High Abrasion	Accretion
1999-2003	12,05	-2,12	Accretion	High Abrasion
2003-2007	9,47	6,19	Accretion	Accretion
2007-2011	-0,34	0,90	Low Abrasion	Low Abrasion
2011-2015	-3,91	-0,43	High Abrasion	Low Abrasion
2015-2019	5,80	-0,02	Accretion	Low Abrasion
2019-2023	-2,96	-1,36	High Abrasion	Moderate abrasion

Pasir Jambak Beach at each station experiences quite different conditions of shoreline changes. It can be seen that Pasir Jambak Beach has undergone 4 categories of shoreline changes over the last 28 years, namely high abrasion, moderate abrasion, low abrasion, and accretion.

Pasir Jambak Beach experienced high abrasion with the largest value in 1995-1999 of -6,18 m/year at station 1. In the same year station 2 on this beach experienced accretion with an EPR value of 2,81 m/year.

Moderate wear only occurs in 2019-2023 at station 2 of -1,36 m/year. In contrast to the beach conditions at station 1, which experienced a high abrasion of -2,96 m/year. The smaller abrasion value that occurs at station 2 compared to station 1 is caused by the presence of a breakwater at that station that can minimize the influence of waves, currents, and tides. Apart from that, this condition is also caused by a lack of sediment supply obtained by the area due to the groins or coastal protection that received the sediment supply first on the left (Setiawan et al., 2020).

Pasir Jambak Beach experiences little wear with the largest value in 2011-2015 at station 2 of -0,43 m/year. However, there is a difference at station 1, namely that it experiences a high wear rate of -3,91 m/year. This is due to the presence of a breakwater that can only be found in station area 2.

The highest accretion took place in 1999-2003 with a value of 12,05 m/year at station 1. In contrast to station 2, where a high wear rate of -2,12 m/year occurred. Fouling that occurs at station 1 is caused by the sedimentation process that takes place there. In this sense, it is suspected that sedimentary material carried by seawater has been deposited at this location as a result of currents leading to that location (Setiawan et al., 2020). The existence of sediment transport from the river body to the ocean is the strongest factor for accretion at station 1. This is due to the location of station 1, which is close to the Muara Batang Anai site.

Furthermore, to be able to find out the overall condition of the changes in the coastline Thar took place in the period 1995-2023 at Pasir Jambak Beach (Table 10).

Shoreline changes occurring over a 28-year time frame at both research stations were stable for station 1 and low abrasion for station 2. At station 1, the EPR value showed a value of 1,60 m/year. While at station 2 the EPR value shows a value of 0,36 m/year. The EPR value at station 1 is greater than the EPR value at station 2.

Table 10. Shoreline Change Data at each research station 1995-2023 using Landsat Imagery Data

Station	EPR Value (m/year)	Category
1	1,60	Stable
2	0,36	Low Abrasion

The presence of strong natural factors is believed to be the cause of this condition. The natural factors in question are hydro-oceanographic processes leading to breaking waves, changes in current patterns, tidal variations, and climate change (Fadilah, 2021). In addition, it is also caused by the uneven distribution of coastal protection in the form of groins along the coast, which means that the conditions at the two stations are different. Coupled with the fact that the first new Coast Guard was built at the end of 2012, this is also one of the causes of variations in shoreline changes at Pasir Jambak Beach over 28 years (Setiawan et al., 2020).

The following is the shoreline change data obtained from 1995-1999 from the processing of Landsat image data which can be seen in Figure 1.

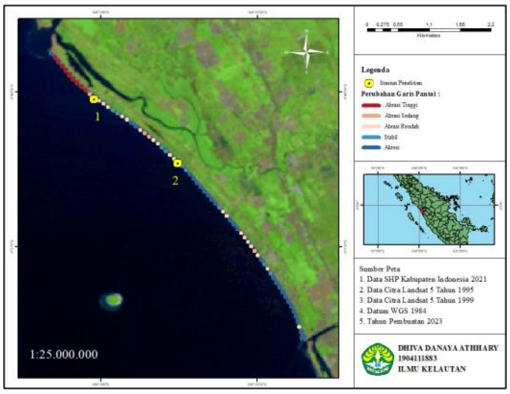

Figure 1. Changes in the coastline at Pasir Jambak Beach in 1995-1999

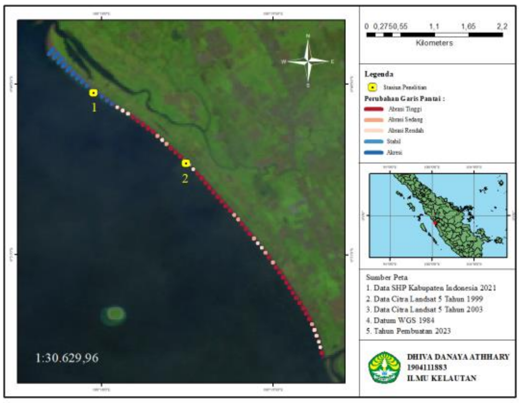

Figure 2. Changes in the coastline at Pasir Jambak Beach in 1999-2003

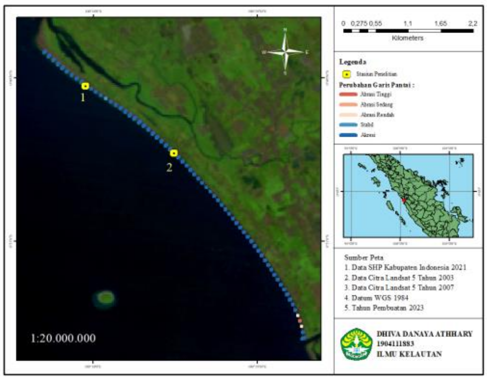

Figure 3. Changes in the coastline at Pasir Jambak Beach in 2003-2007

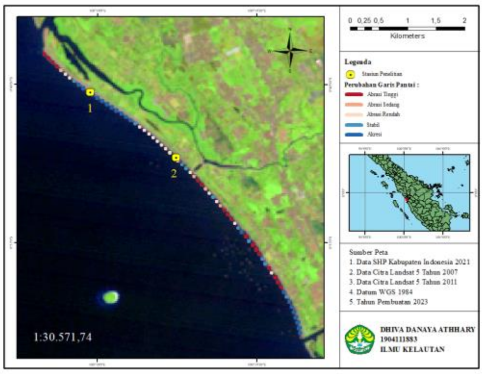

Figure 4. Changes in the coastline at Pasir Jambak Beach in 2007-2011

Pasir Jambak Beach experienced shoreline changes in 1995-1999 with high abrasion, medium abrasion, low abrasion, stable, and accretion categories, which as a whole is dominated by shoreline changes of 48,57% on 34 transect lines.

Pasir Jambak Beach experienced shoreline changes in 1995-1999 with categories of high abrasion, medium abrasion, low abrasion, and accretion dominated as a whole by changes in shoreline abrasion of 79,41% on 54 transect lines (Figure 2).

Pasir Jambak Beach experienced shoreline changes in 2003-2007 with high abrasion, low abrasion, stable, and accretion categories, which as a whole is dominated by shoreline changes of 94,12% on 64 transect lines (Figure 3). Pasir Jambak Beach experienced shoreline changes in 2007-2011 with high abrasion, moderate abrasion, low abrasion, stable, and accretion categories, which as a whole is dominated by shoreline abrasion changes at 55,07% on 38 transect lines (Figure 4).

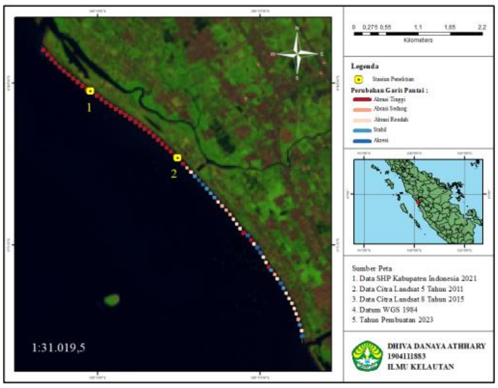

Figure 5. Changes in the coastline at Pasir Jambak Beach in 2011-2015

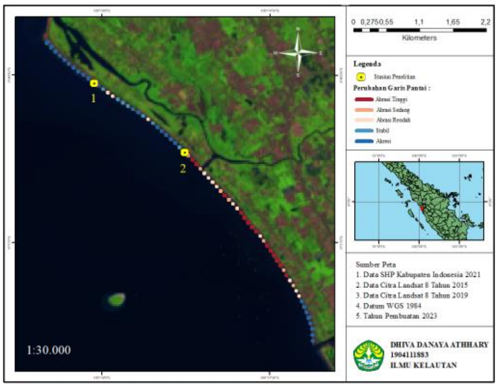

Figure 6. Changes in the coastline at Pasir Jambak Beach in 2015-2019

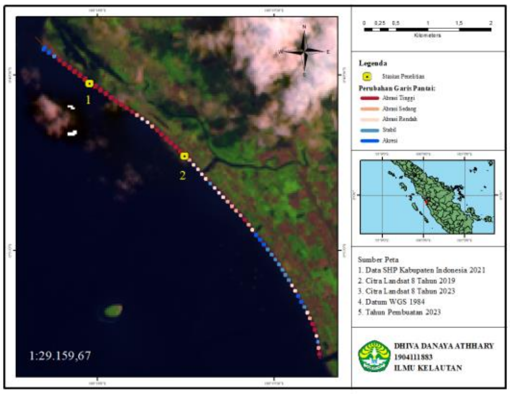

Figure 7. Changes in the coastline at Pasir Jambak Beach in 2019-2023

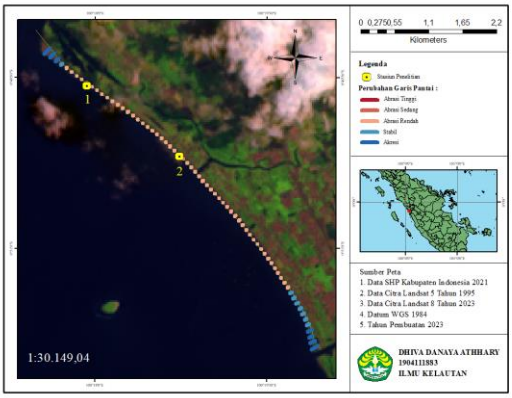

Figure 8. Changes in the coastline at Pasir Jambak Beach in 1995-2023

Pasir Jambak Beach experienced shoreline changes in 2011-2015 with high abrasion, moderate abrasion, low abrasion, stable, and accretion categories, which as a whole are dominated by changes in shoreline abrasion with 80% on 56 transect lines (Figure 5). Pasir Jambak Beach experienced shoreline changes in 2015-2019 with high abrasion, medium abrasion, low abrasion, stable and accretion categories dominated as a whole by shoreline abrasion changes of 50,72% on 35 transect lines (Figure 6).

Pasir Jambak Beach has experienced shoreline changes in 2019-2023 with high abrasion, medium abrasion, low abrasion, stable, and accretion categories dominated as a whole by shoreline abrasion changes of 73,53% on 50 transect lines (Figure 7). Pasir Jambak Beach experienced shoreline changes in 1995-2023 with low abrasion, stability, and accretion categories dominated as a whole by shoreline changes of 77,94% on 53 transect lines (Figure 8).

Based on the shoreline change data processed with image data, the categories of shoreline change that occur along the shoreline are known to vary quite a bit. This is evidenced by the differences in the phenomenon of shoreline change over a 4-year time frame over a 28-year time frame. This proves that Pasir Jambak Beach is very dynamic. The dynamism of a beach is caused by the beach's ability to adapt its profile shape to the movement of seawater. What influences the dynamic process of this beach is coastal transport, defined as the movement of sediments in the area near the coast (Suhendry, 2014). Still, it can be said that Pasir Jambak Beach has undergone mostly abrasion over the last 28 years (1995-2023).

The Relationship between Physical Hydro-Oceanographic Factors and Abrasion at Pasir Jambak Padang Beach

The following are Pasir Jambak Beach wear rate and hydro-oceanographic data for 1995-2023, which can be seen in Table 11.

The data shows that the highest abrasion occurred in 2019-2023 at 3,86 m/year and the lowest in 2003-2007 at 1,90 m/year. In general, the data shows that the values of the four parameters being processed do not follow the size of the abrasion value. To learn more about this, below are the results of data analysis with multiple linear regression.

Table 11. **Abrasion rate and hydro-oceanography data of Pasir Jambak Beach 1995-2023**

No.	Year	Wind Speed (X1) (m/s)	Wave Energy (X2) (N/m^2)	Current Speed (X3) (m/s)	Sea Level (X4) (m)	Abrasion Rate (Y) (m/year)
1	1995-1999	2,620	285,410	0,175	0,485	3,750
2	1999-2003	2,384	290,469	0,124	0,494	2,660
3	2003-2007	2,392	139,330	0,118	0,481	1,900
4	2007-2011	1,904	287,812	0,133	0,521	2,850
5	2011-2015	1,666	297,865	0,161	0,536	3,460
6	2015-2019	1,767	154,880	0,122	0,535	2,630
7	2019-2023	1,746	285,889	0,180	0,549	3,860

The results of the regression analysis show that the hydro-oceanographic factor simultaneously has a significant influence on the abrasion disaster that occurred at Pasir Jambak Beach. The percentage of influence given was 99.3%, which is proof that this natural factor made a very large contribution to the abrasion catastrophe that occurred. This follows the correlation coefficient, which is classified as very strong at 0.996. This is in agreement with what has been described in previous studies, which stated that the coastline is constantly changing due to the continuous influence of hydro-oceanographic factors to shape coastal hydro-oceanographic processes (Figure 9).

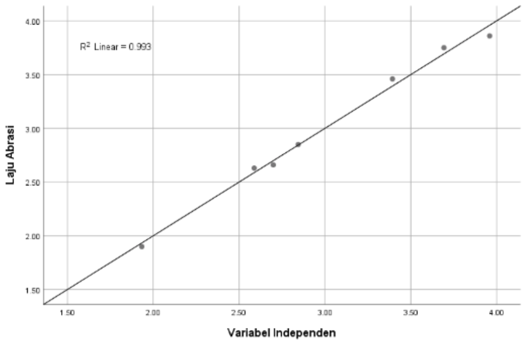

Figure 9. Multiple linear regression equation

Nevertheless, several studies state that there is a partial influence of physical hydro-oceanographic factors on abrasion. The difference in results is believed to be due to a source of uncertainty related to the hydro-oceanographic value data and the rate of abrasion used. For example, instrumental parameter measurement errors, model estimates of secondary data used, and spatial variability of sediment properties and vegetation cover may lead to hydro-oceanographic factors being partially unrelated (Yuliani & Rejeki 2020).

4. CONCLUSIONS

Pasir Jambak Beach has already experienced abrasion for 28 years, namely from 1995-2023 of 77,94%. Based on the average abrasion rate over 28 years, it is known that the highest abrasion occurred in 2019-2023 at 3,86 m/year and the lowest abrasion in 2003-2007 at 1,9 m/year. The results of the analysis show that the hydro-oceanographic factors at Pasir Jambak Beach have a significant influence on the abrasion phenomenon that occurs. This is evidenced by the percentage of influence given, which is 99.3%, and a very strong correlation level of 0,996.

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