Analysis of wave measurements in November 2018, January 2019, and March 2019 in the coastal waters of Leupung and Lhoong, Aceh Besar District, Indonesia

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Abstract. The coastal waters of Leupung and Lhoong Aceh Besar District are directly adjacent to the Indian Ocean. They play a major role in fishing and tourism activities. Thus, the study of ocean waves is important to conduct. The research aims to describe the variations of waves, i.e., height and period. The research was carried out in Leupung at station 1 and Lhoong at station 2 in November 2018, January 2019, and March 2019. The height and period of the waves were collected from 2 station points located at Leupung and Lhoong beaches, using the direct measurement method, that is, a scale meter to measure the wave height and a stopwatch to measure the wave period before the breaking wave. The results show that the wave height and period in November 2018, January 2019, and March 2019 in Leupung coastal waters are 0.42 m, 12.34 s; 0.5 m, 12.43 s; 0.49 m, 13.82 s, respectively. Meanwhile, wave height and period in Lhoong coastal waters are 0.26 m, 12.31 s; 0.44 m, 13.97 s; 0.48 m, 12.22 s, respectively. It is concluded that the highest wave occurred in January and March 2019 at Leupung and Lhoong coastal waters, respectively. On average, the highest wave of the three months occurred in Leupung coastal waters.

1. Introduction
The coastal waters of Leupung and Lhoong are waters located in Aceh Besar District, which has large enough waves so that it is interesting to conduct research. This research is about ocean waves, generally, sea waves are ocean waves caused by wind, either directly or indirectly. In the wind blowing area (known as 'fetch'), an event occurs when wind energy transfers to wave energy in a wide frequency spectrum [1]. There are several studies on waves that have been carried out in Aceh, namely hydro-oceanographic factors such as waves, ocean currents, and tides that affect the condition of water [2-4]. One of these oceanographic factors is the ocean currents which are the center of attention in this study.
Sea waves are the propagation of seawater which fluctuates up and down due to being generated mainly by the wind in the deep sea generation area [5-7]. In the formation of geomorphological processes on the coast, it is influenced by ocean waves. Sea waves can occur due to wind gusts, earthquakes, and volcanic eruptions below sea level [1, 9, 10].

Until now, the description of a wave is still unclear and accurate, because sea level is a complex area with an ever-changing and unstable pattern. When the wave slope reaches the maximum limit, the waves will break and propagate towards the beach until finally, the waves move up and down on the beach surface. The beach always adjusts its profile shape so as to reduce the energy of the incoming waves. This shape adjustment is a natural dynamic response of the coast to the sea. There are two types of dynamic coastal responses to wave motion, namely responses to normal wave conditions and responses to storm wave conditions. Waves usually travel from the open sea to the coast. Waves can generate energy capable of influencing the formation of beaches, because waves can cause currents in the direction perpendicular to the coast and along the coast, causing sediment transport [11, 12].

Sea waves are one of the parameters that affect changes in coastal and marine areas apart from currents and tides. So it is necessary to study sea waves for the purposes of managing and developing the potential of coastal areas optimally. Ocean waveforms in nature are generally very complex and random and difficult to describe mathematically because of their non-linearity. However, with the wave spectrum, the characteristics of random waves can be described. The wave spectrum describes the distribution of wave energy to the frequency of the wave and the direction of wave propagation. The most common waves studied in coastal engineering are waves generated by wind and tides. The territory of Indonesia is an area that is in the tropics and is crossed by the equator. The apparent motion of the sun, which crosses the equator, causes Indonesia to experience two different seasons, namely the West Season and the East Season [11-13]. Thus, this study aims to explain the variation in height and period of ocean waves.

2. Materials and Methods
This research on ocean waves was conducted in the coastal waters of Leupung and Lhoong, Aceh Besar District, Aceh Province. The research was conducted and measured in November 2018, January, and March 2019. The determination of station points at the research location was carried out using a purposive sampling method using a GPS device. This method aims to determine the location of the research station randomly with a specific purpose at each station so that the data taken during the research process is able to represent the entire sample at each research location [7, 13-15]. The number of station points at the research location is 2 points where the locations are different, namely the station 1 in Leupung and the station 2 in Lhoong, Aceh Besar District (Figure 1).

![Figure 1. Map of research locations in the coastal waters of Leupung and Lhoong, Aceh Besar District](image)
(Red dot shows the research location area).
Wave data collection is carried out by measuring wave height at the beach using a scale meter that has been given a number. The bottom of the board is stuck into the beach sand in an upright position. When the wave comes, count the highest peak and lowest peak values to get the height of one wave. The calculation is done 1000 times of repetitions. This wave data collection was carried out at two points, namely the Leupung and Lhoong coastal waters of Aceh Besar District, and carried out 3 measurements at each location in November 2018, January, and March 2019.

First, the observer determines the position, then observes the waves at the depth (about 1-2 meters) before the waves break. Then the time is counted with a stopwatch from the first wave and the second wave arrives until the wave hits the shoreline. Wave measurement is done with the help of tools, namely scale meter, and stopwatches. The scale meter used is 2 meters, along with the height measurements.

The wave period data obtained is then calculated using the equation (1):

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

where \(t\) is the wave measurement time and \(n\) is the number of wave data. Calculation of wave height averages using equation (2):

$$Average\ value\ of\ the\ wave\ height = \frac{the\ sum\ of\ the\ wave\ height\ values}{the\ sum\ of\ wave\ height\ data}$$

3. Results and Discussion
The time series of waves at the measurement stations in the coastal waters of Leupung and Lhoong varies as shown in Figures 2, 3, 4, 5, 6, and 7. Figure 2 to 7 shows that the results of wave analysis obtained by wave measurements indicate that the wave heights of coastal waters Leupung and Lhoong in November 2018 range 10-60 centimeters (Figure 2), 10-80 centimeters (Figure 5), in January 2019 it range 0-95 centimeters (Figure 3), range 5-85 centimeters (Figure 6), and in March 2019 range 15-100 centimeters (Figure 4), range 25-90 centimeters (Figure 7). The pattern of time series results of sea waves, analogous patterns are equivalent to the results of research by researchers [3, 16, 17].
Figure 6. Time series of wave heights in Lhoong coastal waters in January 2019.

Figure 7. Time series of wave heights in Lhoong coastal waters in March 2019.

From the measurement data that has been collected in Figures 2 to 7, it is obtained the average wave height and period results in November, January, and March in Leupung coastal waters are 0.42 m, 12.34 s; 0.5m, 12.43 s; 0.49 m, 13.82 s, respectively and in Lhoong coastal waters are 0.26 m, 12.31 s; 0.44 m, 13.97 s; 0.48 m, 12.22 s, respectively. Based on these data, the highest average wave results at station 1 (Leupung coastal waters), the highest average wave results were in January with an average (0.50 m), and the lowest was in November, namely (0.42 m), while the average range of wave time with the highest distance was in March, namely (14.31 seconds), and the lowest average range in November, namely (12.34 seconds). Meanwhile, station 2 (Lhoong coastal waters) is in March with an average (0.48 m), and the lowest is in November (0.26 m). While the average range of wave time with the highest distance was in January, namely (13.97 seconds), and the lowest average range was in March, namely (12.22 seconds). The wind velocity at Leupung coastal waters in November, January, and March are 1.3 m/s, 1.8 m/s, and 1.4 m/s, respectively and in Lhoong coastal waters, 1.2 m/s, 1.3 m/s, and 1.3 m/s, respectively. Thus the results of the wave measurement analysis show that wave height in the west direction can be said that the wave strength is directly proportional to the wind.

4. Conclusion

This research is concluded that the highest wave occurred in January and March 2019 at Leupung and Lhoong coastal waters, respectively. On average, the highest waves measured for three months occurred in the coastal waters of Leupung. The highest waves on those months are driven by strong wind magnitude as the coastal area is connected to open sea of the Indian Ocean. On the contrary, wave height is less as the wind originate from land.

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