ABRASION WAVE OBSTRUCTS TOURISM DEVELOPMENT IN COASTAL REGIONS OF BINUANGEUN, LEBAK - BANTEN

By :

Delyuzar Ilahude [1 2], Udaya Kamiludin[1] and Abdul Wahib [1]

(Manuscript received 7 February 2011)

ABSTRACTS

Geographically, the study area is located in the southern coast of Java and also exposed to the influence of wave energy from the southeast, south and southwest. The energy flux of waves generated by surface wind components that affect the coastline and the surrounding waters of Binuangeun. The impact of the wave coming from southeast direction caused a continuous abrasion process in Binuangeun coast and its adjacent areas, included the tourism area in the eastern part of Binuangeun coast towards the center of the study area. The current movement along the coast was accompanied by sediments deposition which tends to westward. The value of sediments supply (Vq) in sample area point number 9 was bigger than the sample area number 4 about 33.703 m3/year within the same direction tendency of sediments deposition.

Western part of Binuangeun coastal area would presumably become the sediment accumulation point throughout the year, while the erosion process in the central part of the study area were expanding and occured seasonally.

Keywords : abrasion, Binuangeun, flux energy

SARI

Secara geografis daerah penelitian terletak di pesisir selatan Pulau Jawa dan termasuk pantai terbuka terhadap pengaruh energi gelombang dari arah tenggara, selatan dan barat daya.

Energi fluks gelombang yang dibangkitkan oleh komponen angin permukaan berpengaruh terhadap garis pantai perairan Binuangen dan sekitarnya. Efek gelombang dari arah tenggara mengakibatkan proses abrasi di pantai Binuangen dan sekitarnya, terutama kawasan wisata bagian timur pantai Binuangen hingga ke bagian tengah. Pergerakan arus sepanjang pantainya disertai oleh pengendapan sedimen yang cenderung mengarah ke barat. Nilai pasokan sedimen (Vq) pada titik tinjau 9 lebih besar dari pada di titik 4 yaitu sebesar 33.703 m3/tahun dengan pasokan sedimen cenderung bergerak ke arah barat.

Daerah pesisir kawasan bagian barat Binuangen diperkirakan akan menjadi zona akumulasi sedimen sepanjang tahun, sementara proses erosi di bagian tengah daerah penelitian tetap berkembang dan berlangsung secara musiman.

Kata kunci : abrasi, Binuangen, energi fluks

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1. Marine Geological Institute of Indonesia, Jl. Dr. Junjunan No. 236, Bandung-40174
2. ilahude_mgi@yahoo.com

INTRODUCTION

Geographically, the study area is located in the southern coast of Java between 105o48'00"-106o06'00 "E and 06o46'00" - 06o50'00 "S. It was situated in Lebak, Banten district (Figure 1). Apart from its potential in fisheries and seaweeds, this area was also highly potential in marine tourism. Developments of marine potential were hypothetically suppressed by persisted periodic coastal abrasions. In the other part of this abrasion of coastal area, the occurrence of sedimentations had the tendency to cover up the estuaries in the entire study area.

The process of abrasions and sedimentations along the southern coast of Binuangeun was caused by the east monsoon currents and waves, which then caused some coastal areas to both abrasion and sedimentation. The intensive sediment movement along the coastline is an indication of coastal abrasion in the western part of Binuangeun. It is characterized by the shape of beach along that area. A significant coastal abrasion was involved in the shaping of the shoreline and the loss of sand-sized materials in the particular area. These landscape changes showed negative effects of increasing land area in the coastal zone. The occurred coastal abrasion was relatively strong, as it was characterized with loss of trees in some areas. Other the abrasion of coastal area is located in the eastern region of Tanjung Binuangeun, which has undermined some part of the land and tourist sites. The occured abrasion in eastern Binuangeun became a dilemma to develop the tourist sites nearby. Moreover, abrasion in western Binuangeun caused the estuaries in particular area to be covered up by sediment deposition.

Therefore, a research on hydro-oceanographic and geological aspects to determine the cause of coastline changes due to abrasion and sedimentation in those areas was required.

To examine the abrasion that occurred in both eastern and western Binuangeun, the 5-years (2000 to 2004) oceanographic parameter and wind data were collected from National Institute of Aeronautics and Space (Lembaga Penerbangan dan Antariksa Nasional – LAPAN) Aerospace Observer Station in Pameungpeuk, Garut, as climatologic data from the station were representative to characterize the entire study area. These data were further analyzed using deep-water-wave forecasting.

Lithology

Based on geological data of Binuangeun and its adjacent areas, lithology of the study area is composed of Bojongmanik Formation, Cipacar Formation, alluvium. Bojongmanik Formation consist of sandstone, claystone, marl, conglomerate, limestone, tuff and lignite. Cipacar Formatian is characterized by tuff, pumice, sandstone, and marl. While alluvium composed of mud, pebble, gravel, pumice; (Sudana and Santosa, 1992). These terrace sediments are classified as not compacted material and easily eroded. Moreover, the edge of Binuangeun beach had been developed into tourism areas and settlements. Due to the fact, the Binuangeun Beach and nearby areas are facing directly to the Indian Ocean, hence the year-round monsoon have adequate influence the condition of coastline. The instability of coastline is strongly influenced by West and East Monsoon climate. It is characterized by wave abrasion and sedimentation processes that occur in several locations.

The process of coastal erosion is caused by two wave seasons, East and West Monsoon, which is characterized by beach erosion in the eastern region of Binuangeun. This erosion process is an indication of wave activity that triggered the parallel current and sediment movements to several locations. It causes the incision in the coastal slopes in several locations along Binuangeun. Therefore, to

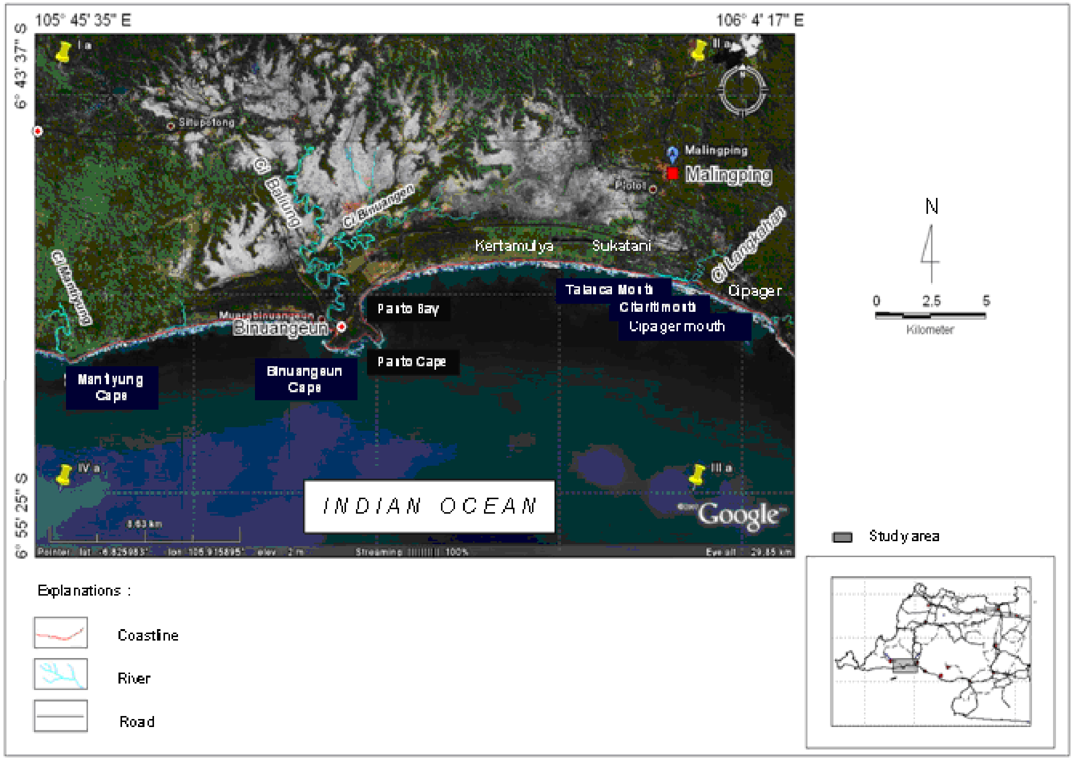

Figure 1. Location of study area (Earthgoogle, 2010)

know the process of abrasion, dominant oceanographic parameter that influence Binuangeun coastline and nearby areas will be examined.

METHODS

To examine the factual wind influence on the coastline, some measurements were taken on 13 locations along the coast of Binuangeun. Perpendicular wind direction to the coastline obtained will be used to determine the prediction of sediment movements.

To analyze the wave height and period in the study area, deep-water-wave forecasting curve is utilized according to Bretschneider (1970). As to calculate the amount of energy flux of wave along the shore, wave height prediction that refers to the wind data for 5 years from National Institute of Aeronautics and Space (Lembaga Penerbangan dan Antariksa Nasional – LAPAN). These data will be analyzed qualitatively to obtain the value of wind direction frequency (n) on each wind direction component.

The wind direction frequency data was used to analyze oceanographic parameters and sediment movements along the coastline. By substituting the water density (ρ) equal to 1025 kg/m3, wave angle (Ø), as well as wave period (T), and wave height (H) into an empirical linear equation formulated by Ijima and Tang (1967) below, the value of energy flux (Fo) in units (Newton-meter/sec) can be obtained from the following formulation:

$$Fo = 0.09952\ n\ \rho\ H^2\ T\ \sin Ø \qquad (1)$$

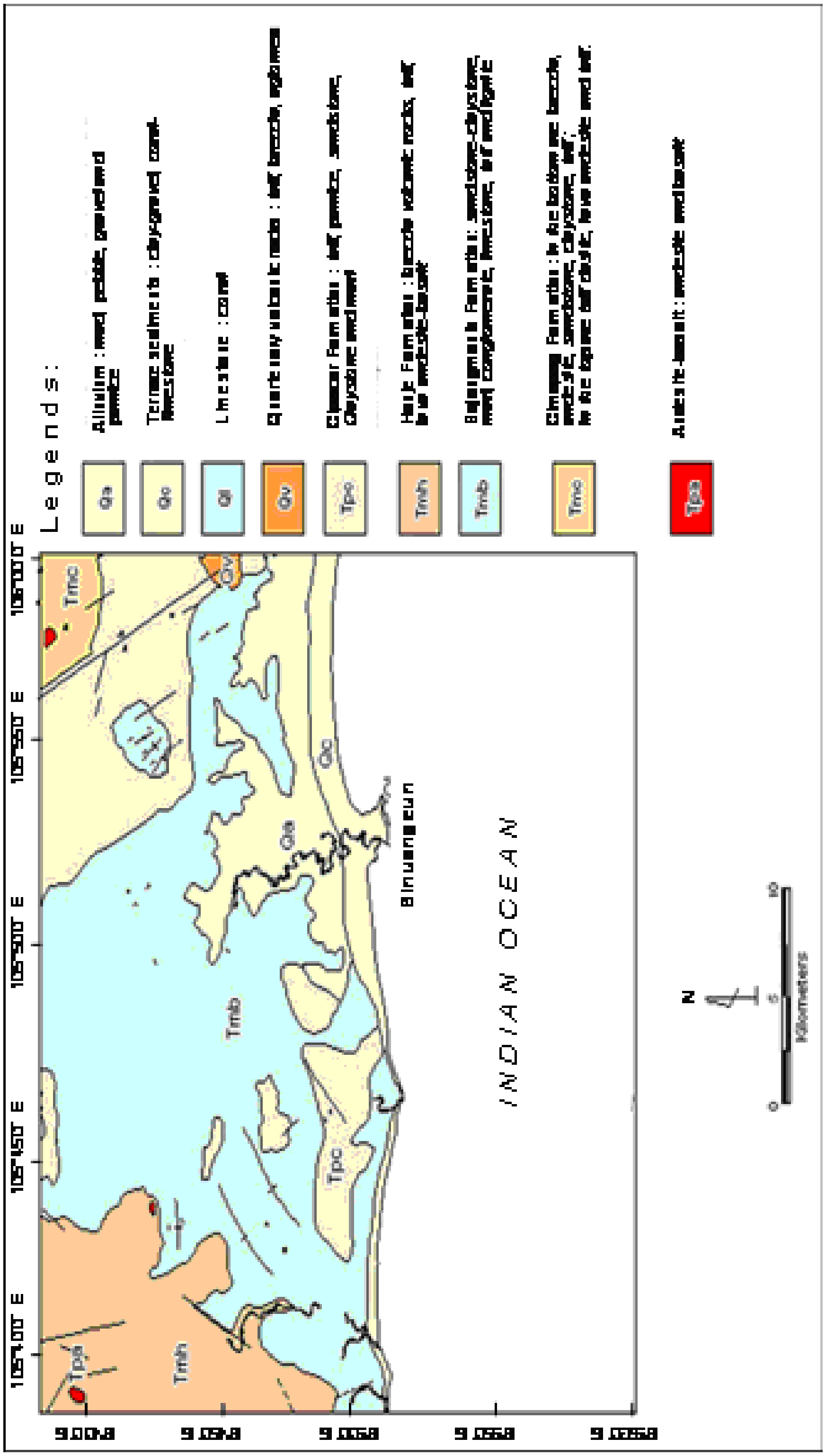

Figure 2. Geological map of study area, Cikarang Sheet (Sudana and Santosa, 1992)

This (Fo) value is presented in the sediment movement map along the coast. Furthermore, to know the volume rate of eroded sediment supply per time unit (Vq), an approachment is made by using empirical linear equation formulation (Komar and Inman, 1974 in Bijker, 1988) by substituting the results of average wave data analysis which will be further presented in the map of Binuangeun.

The Vq value obtained from the formerly explained empirical approach is the average rate of transported-longshore sediment supply due to wave abrasion in cubic meter per year units. Assuming gravity acceleration (g) is 9.81 m/s^2, sediment porosity (p) is 0.4, constant (C) is 1288, and sediment density (ρs) is 2650 kg/m^3, then empirical approach to the amount of sediment supply can be calculated using Komar and Inman's formulation (Bijker, 1988), as follows :

$$Vq = K\ Fl / (\rho s - \rho)\ g\ (1 - p) \quad (2)$$

By substituting the value of wave angle to the coastline (Ø), and the flux of wave energy (Fo) to longshore energy flux (F_1) formulation below:

$$Fl = Fo\ 0.5\ \sin 2\ Ø \quad (3)$$

Thus the volume rate of eroded sediment supply per time unit can be obtained.

RESULTS

Characteristic of Shore Lithology and Climatology Data

Characteristics of Binuangeun coastal area can be described as sandy beach, with coral limestone outcrop, lumped sand (in pocket beach) and "sea wall". Sand-coral beach was consisted of Quaternary limestones (Pleistocene to Recent) with moderate resistance **(Figure 3).** This is a particular type of a cape beach, such as Binuangeun and Mantiyung beaches (Kamiludin, 2009)

The sediments in the coastal area consist of fine-grained deposits which composed of widely distributed sand, whereas silt sand was spread out along the coast and generally occupying the estuaries. The sediments were supplied by currents and waves toward both offshore and longshore directions.

Lithological resistance of the coast to the wave energy was relatively weak to moderate, mainly in the eastern part of Tanjung Binuangeun. This is caused by the coastal lithology that composed of river sediments consists of clay, sand, gravel, and unconsolidated to medium dense sediments, that easily eroded (Figure 2). Moreover, although the wave energy is quite strong, but it is less influence to coastal lithology. This condition indicates that in the particular zone, wave refractions that produce shore-paralleled current did not occur, hence the coastal condition in that zone was relatively stable.

Indication of these currents and waves activities can be seen in Kertamulia (sampling spot 8) and Sukatani (sampling spot 10), eastern part of Binuangeun, with sandy lithological arrangements. Abrasion in this area is marked by declining shoreline with scattered coarse-grained deposits due to low tide, while deposit accumulation occured in its western part. While in the eastern part of the coast (between sampling spot 11 and 12) was relatively stable although its coastal rock constituent was sand.

Dominant wind directions such as southeast, southwest, and west has significantly influence shores of south Java (Table 1).

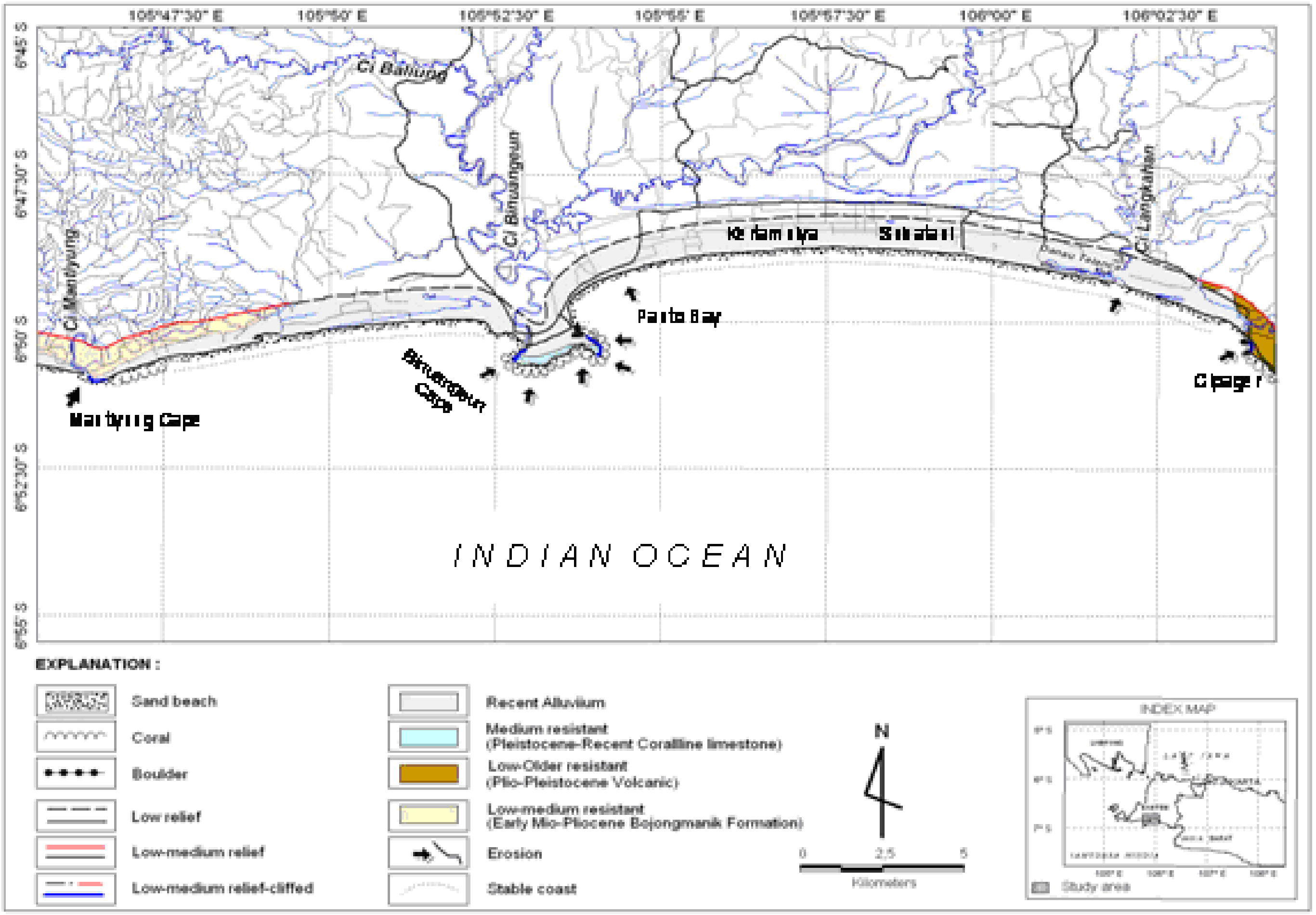

Figure 3. Coastal characteristic map of Binuangeun and adjacent area

Table 1. Average frequency percentage of surface wind directions (n) in 2000 – 2004 of Binuangeun and adjacent area.

Components of Wind Direction	Average Wind Velocity > 10 Knots
E	17.95%
SE	34.45%
S	2,66%
SW	3.38%
W	21.84%
NW	0
N	0
NE	0

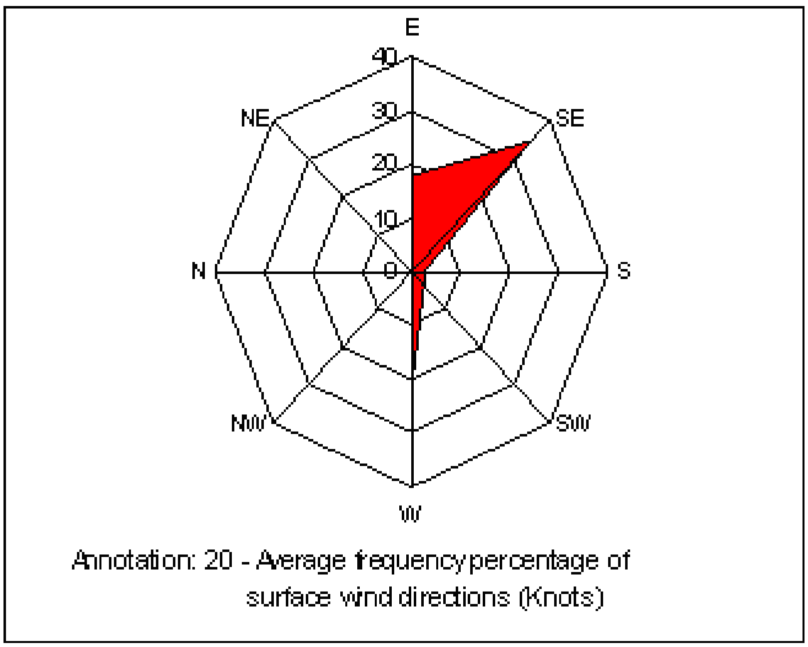

Figure 4. Windrose diagram of dominant wind directions taken from Aerospace Observer Station in Pameungpeuk, Garut in 2000 to 2004.

Wave Energy.

Analysis of 5-years' wind data for wind velocity above 10 knots in 13 sampling spots showed that the study area were periodically influenced by monsoon wind coming from southwest, south, and southeast, depicted in the windrose diagram (Figure 4).

Whereas for western coast of Binuangeun, the coastal dynamics dominantly influenced by wave energy than wind stress from southeast and south directions, while for eastern Tanjung Binuangeun, the wave energy is less affected by wind stress from west, southwest, and south directions.

The difference of predicted wave parameters resulted in each sampling spots had caused the difference in the flow of energy wave at every spot. Interpretation of calculated wave energy flux plotted to the sampling spots in the shoreline would give some indications of longshore current direction and coastal process that occurred.

Analysis of wave prediction from deep-water-wave forecasting were conducted to represent the extended time scale, while the direct observation were representing particular seasons only, hence wave prediction analysis from the 5 years length surface wind data is required.

Due to the wind and deep-water curve data, the range of wave height (H) in Binuangeun and surrounding waters are between 1.5 and 3.5 meters, with time period (T) between 2 and 5 seconds (Figure 5). The wave angle (Ø) in each sampling spot along the coastline varied between 0o and 90o. The value of wave angle was used as a correction factor to obtain the value of energy flux (Fo), hence the direction of wave propagation in western coast of Tanjung Binuangeun was derived from southeast, while in the eastern part is originated from west and southwest.

The frequency of wind data (n) has widely varied values and are calculated based on wind data frequency statistics on each component of wind direction. By substituting the waters density (ρ) and height and wave period to the formulation of empirical linear equation (Ijima and Tang, 1967), and the value of wave energy flux (Fo) can be defined. Using those data, the prediction value of wave energy in Binuangeun waters can be obtained (Table 2).

Visually, the wave height along the coast of Binuangeun was increasing toward the shore due to the changes in depth and refraction after passing through the breaker zone. Generally, the maximum energy wave occurs when the oceans tide reach maximum height, due to the superposition of waves from the shore.

Table 2. Value of wave energy in Binuangeun waters

Wave observation point	Fo (Newton-meter/second)
1	-3.56
2	-12.83
3	-16.84
4	-19.57
5	-9.02
6	-6.48
7	-6.21
8	-12.01
9	23.51
10	-11.47
11	-3.6
12	-4.34
13	-2.57

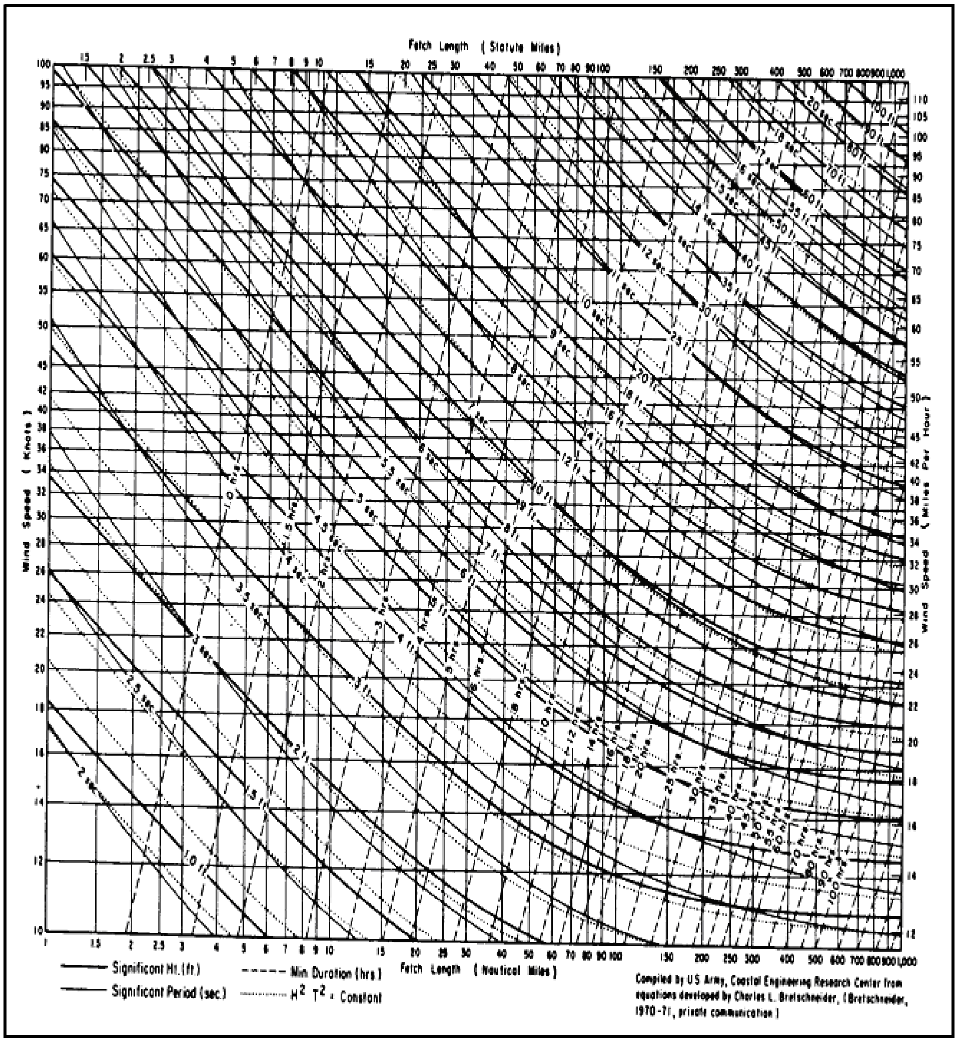

Figure 5. Deep water wave forecasting curves (Bretsneider, 1970)

The approach formulation in equation (1), the value of energy flux was shown in the graph of wave energy flux chart, which shows sedimentation and abrasion curve (Figure 6). Significant increase was occurred in the location of number 8 to 9, indicating the abrasion process had been occurred in particular part of coast, while drop sharply was occurred in the location of number 9 to 10, indicating the occurrence of significant sedimentation in the coast.

The direction of material movement was shown in positive and negative values of energy flux at each location of sampling spot. As the negative energy flux values run counter-clockwise (left) and positive values run clockwise direction (right), hence the dominant directions of material movements tend to go to the west direction, which depicted in the zone of abrasion and sedimentation analysis.

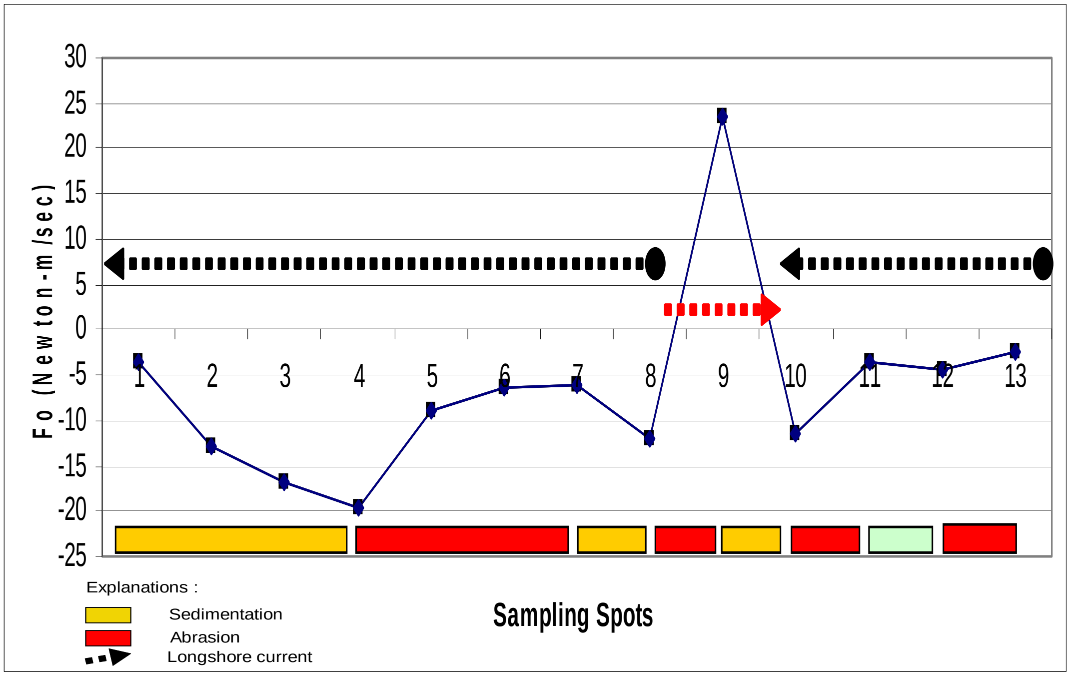

Figure 6. Flux energy curve in Binuangeun waters

Analysis of Wave Energy and Sediment Supply

Analysis of sediment supply from the abrasive coastal zone on Binuangeun coast can be calculated from two sampling spots which considered representative to characterize their surrounding coastal zone. Longshore currents generated by wave energy plays an important role in supplying sediment around the coast. This current generally contains sediments and partially accumulates in the estuaries. The movement of sediment-contained currents is likely going towards the coast to the west and also a natural process that occurs throughout the season.

Indication on the occurrence of sediment supply was marked by abrasion in the coast of Binuangeun and its eastern part. Visually, the longshore currents would occur after the refraction of wave energy due to the change of depth off the coast of Binuangeun. Generally, the wave energy and sediment movement occurs when the oceans tide reach maximum height after passing through the wave breaking zone.

The analysis of sediment movement shows that abrasion areas were consist of eastern and western region of Binuangeun cape, with longshore current movement accompanied by sediment deposition dominantly go towards west direction. This analysis was supported by visual observation that marked with the occurrence of eroded coastline in the eastern and western part of Binuangeun cape, hence made its coast profile tend to be cliff form that has greater than 45o (Figure 7).

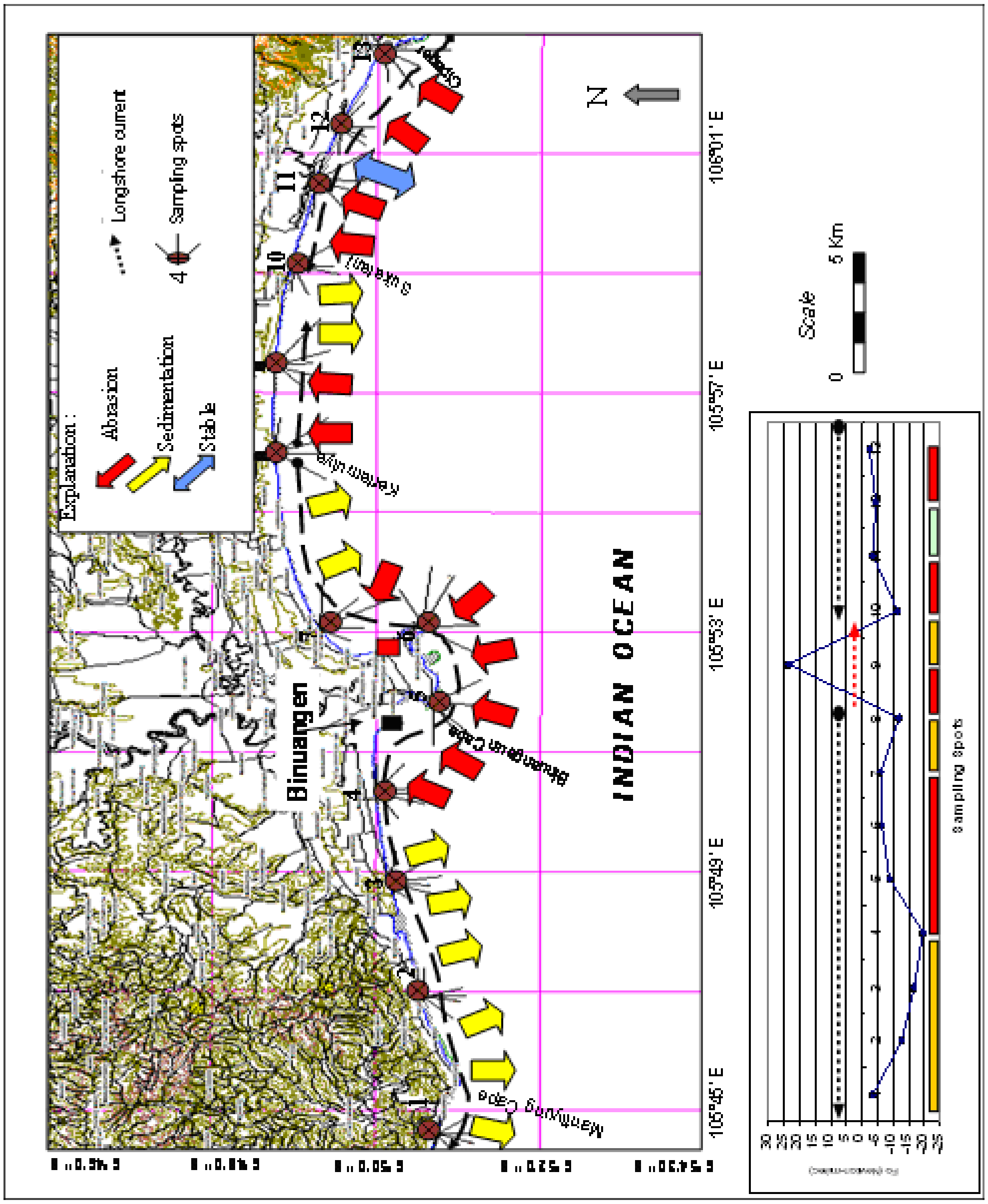

Figure 7. Projections of energy wave to the sampling spots in the map of Binuangeun.

Considering the coastal condition in the study area, the calculation approach were conducted in two locations (point 4 and 9) which located in the western and eastern region of Binuangeun, as it was required to define the amount of sediment supply from the abrasion zone in both locations.

Assuming gravity acceleration (g) is 9.81 m/s2, sediment porosity (p) is 0.4, constant for sediment supply (K) is 1288, and sediment density (ρs) is 2650 kg/m3, thus empirical approach to the amount of sediment supply can be calculated using formulation (2) that applied by Komar and Inman in Bijker, 1988.

By substituting the value of wave angle to the coastline (Ø), and the flux of wave energy (Fo) to the longshore energy flux formulation (F1), the volume rate of average sediment supply along the coast (Vq) is obtained below. Using this method, mathematical relationship showed that the cumulative value of KF_1 was a linear function from Vq. Thus, energy flux value obtained in Binuangeun and its surrounding waters, was used as a reference to define the value of average sediment supply (Vq) per unit time. In the east and west Monsoon, this Vq value will increase if its longshore-energy flux factor (F1) increase to western region of Binuangeun.

Map of the sediment-contained flow movement and prediction of average sediment supply along the coast, shows the value of average sediment supply per year (Vq) from east to west in point 4 are 28.054 and point 9 are 33.703 m3/year.

The lowest wave energy flux is in the western region of Tanjung Binuangeun, whereas the highest occurred in eastern region. Nonetheless, due to the occurrence of Tanjung Binuangeun, wave refraction from southeast direction caused the current to flow towards east direction. The sediment-contained current was partially supplied to eastern and western part of the coast.

The value of sediment supply (Vq) was fluctuating, but the trend or pattern of decreasing or increasing sediment supply value (Vq) on each of these locations were relatively similar. Correspondingly, the changes of F1 value on both east and west monsoon would change the value of average sediment supply.

Because the values of oceanographic parameters (wave and longshore current) were dynamic, thus empirical approach (Vq) could at least describe that the amount of sediment supply significantly move westward per year. The amount of sediment supply (Vq), largely was determined by velocity of longshore current that trigger the erosion in eastern and western region of Binuangeun.

Based on wave height prediction result, and average sediment supply the coast of Binuangeun and its adjacent waters was possible significant coastline change, due to the abrasion activity in the eastern region, from sampling spot 6 to 7 and sampling spot 10 to 13. Meanwhile, the sedimentation process tend to occur in the western region, from sampling spot 1 to 4.

If compare with the map of coast characteristics, the high-resistance lithological condition would be located in the central part of the research area, at sampling spot 5 and 6 (Binuangeun Cape). Coastal lithology of this particular area consists of corals, that forms a cliff, while the stable beach is located on Mantiyung Cape (sampling spot 1 to 2), and Cipager Mouth (sampling spot 13), arround the western and eastern part of the study area. Coastal lithology in both of these places were coral reefs that forms rugged beaches, while other types of beach were sandy with low resistant. Based on the results of wave energy flux and coastal characteristics analysis, the areas that is will be suspected significant erosion process are the rural areas of Kertamulya and Sukatani. Thus, if a coastal disturbance occurs by coastal protection system or seaport constructions, it cautiously will trigger a greater erosion in the vicinity.

CONCLUSIONS

The significant wave abrasion process, which was indicated by eroded coast in some areas, occurs in the eastern part of Binuangeun while it slightly happens in the western part.

The erosion process in the east occurs naturally and seasonally, but if any disturbance in the coast happens, such as coast protector construction by local people, hence wave refraction that accelerate the coastline change would possibly occur. The abrasion process would restrain the tourism development of Binuangeun and nearby areas. However, the occurrence of sediment flow from east to west would expand the sedimentation area in the western region of Tanjung Binuangeun, which would bring positive impacts for its coastal environment.

ACKNOWLEDGMENTS

The authors would like to thank Mr. Subaktian Lubis the Head of MGI for his great support and deeds in finishing this report. Thanks are due to Hananto Kurnio and Ediar Usman for the critical comments and english text correction.

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