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Tidal Characteristics in the Northern Coast of Central Java (a Case Study in Semarang, Indonesia)

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ABSTRACT

Tides are a phenomenon that affects the dynamics of coastal waters. This study aims to analyze the characteristics of tides on the North Coast of Semarang, Central Java using the Least Square method. The tidal data used is in September 2020 from the Geospatial Information Agency open source data. The results showed that the tidal pattern in this area is dominated by a semi-diurnal component with a Formzahl number of 1.44, which means that the tidal type is mixed tending to be semi-diurnal. The main component identified is M2 (0.4 meters), which is the main semi-diurnal component influenced by the gravitational force of the moon. In addition, the S2 component (0.3 meters), which is a semi-diurnal component influenced by the gravitational force of the sun. In addition, the influence of extreme weather such as storms causes an increase in tide height, which triggers tidal flooding and coastal abrasion. The study concludes that an understanding of tidal characteristics is essential for sustainable coastal management. The results of this analysis can be used as a basis for mitigating environmental impacts, such as abrasion and tidal flooding, as well as for optimizing the economic activities of tide-dependent coastal communities, such as fisheries and ponds.

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INTRODUCTION

The tidal phenomenon is an integral part of the dynamics of coastal waters influenced by the gravitational forces of the moon, sun, and earth's rotation (Pasaribu et al., 2022). Tides can be divided into three main types based on the daily patterns that occur, namely semi-diurnal tides (two highs and two lows in a day), diurnal (one high and one low in a day), and mixed (a combination of diurnal and semi-diurnal) (Rompas et al., 2022). In coastal areas, tides not only affect marine activities, but also have an important influence on physical changes in coastal areas, ecosystems, and the socio-economic life of local communities (Rawena et al., 2020). Understanding tidal patterns is especially important in coastal areas with high population density and economic activity, such as the North Coast of Semarang, Central Java.

The North Coast is known as one of the areas with complex hydrodynamics (Hidayati, 2017). This region is influenced by several external factors such as the monsoon, and ocean currents originating from the Java Sea (Yarangga, 2023). Tidal phenomena in this area play an important role in regulating the distribution of water masses, sediments, and nutrients that contribute to the local ecosystem. However, the North Coast of Semarang also faces serious environmental problems, such

as abrasion, sedimentation and tidal flooding caused by a combination of climate change, sea level rise and tidal influence (Marfai, 2018).

In addition to environmental impacts, tides also affect various economic sectors. Fishermen, for example, rely heavily on tides to determine the timing of fishing (Sulaiman et al., 2023). On the other hand, the transportation of goods at ports and docks is also regulated based on the tidal cycle. Lack of in-depth understanding of tidal patterns can lead to significant economic losses, as well as potential impacts on the security of coastal infrastructure (Khojasteh et al., 2022). Therefore, research on tidal characteristics in this region is crucial to support development planning and disaster mitigation (Sutrisno et al., 2020).

The purpose of this study is to analyze the tidal characteristics of the North Coast of Semarang, Central Java. This research is expected to provide a more comprehensive understanding of tidal patterns in this area, as well as scientific information that can be used by policy makers and communities to plan coastal management more effectively. In the future, an understanding of the tidal dynamics in the North Coast of Semarang, Central Java may also help adaptation to global climate change, especially related to sea level rise which is projected to further increase the frequency and intensity of coastal flooding.

METHODS

The research site is located at the coordinates 6°55'7.81“ N and 110°23'19.38” East. Data was obtained from the Geospatial Information Agency which is available as open source. The data includes daily observations with a frequency of data collection every hour in September 2020. This research uses a quantitative approach with the Least Square method to analyze tidal data obtained from observation stations on the North Coast of Semarang, Central Java.

The Least Square method is one of the most commonly used to analyze data trends and produce complete harmonic components (Nugraha et al., 2023). This method can predict tidal elevations, which are periodic due to astronomical factors and seasonal due to meteorological factors (Febrianto, 2017). Ongkosongo (1989) explains that the equation of the Least Square method is the sum of its constituent components (sine function), which can be written as follows:

$$\eta(t) = S0 + \sum_{i=1}^{N} A_i \cos(\omega_i t - P_i) \ldots\ldots (1)$$

Description:
η(t) = Tidal elevation (function of time)
ωi = 2π/Ti, Ti is the component period
Pi = i-th phase
T = time
N = Number of Components
Ai = i-th Amplitude
S0 = Mean Sea Level

RESULT AND DISCUSSION

From the analysis of tidal data using the Least Square method, it was found that the tidal pattern in the North Coast of Semarang, Central Java is dominated by a semi-diurnal component. The main component identified is M2 (0.4 meters), which is the main semi-diurnal component influenced

by the gravitational force of the moon. In addition, the S2 (0.3 meters) component, which is a semi-diurnal component influenced by the gravitational force of the sun, also shows a considerable amplitude.

Triatmodjo (2009) explains that the Formzahl value is used to determine the type of tide as follows: (a) F ≤ 0.25 means Semidiurnal type, (b) 0.25 < F ≤ 1.5 means Mixed type which tends to be Semidiurnal, (c) 1.50 < F ≤ 3.0 means Mixed type which tends to be Diurnal, and (d) F > 3.0 means Diurnal type. The tidal data were analyzed using the harmonic method, where each tidal component is separated into amplitude and phase components. With this approach, various tidal components, such as M2 (main semi-diurnal), S2 (solar semi-diurnal), and K1 (main diurnal), can be quantitatively identified (Rahmadeni et al., 2017).

The results showed that the tidal pattern in this region is dominated by a semi-diurnal component with a Formzahl number of 1.44, which means that the tidal type is mixed tending to be semi-diurnal (Figure 1). During the September period, some tidal flooding events occurred along with high tides, along the coastline. Under these conditions, the tidal amplitude can reach more than 1 meter, which is much higher than the normal average. These effects emphasize the importance of coastal management to mitigate the impacts of climate change and extreme weather. This knowledge becomes very important in planning fishermen's activities, especially in the face of seasonal variability that occurs (Rohaini, 2021). The impact of tides is felt on coastal ecosystems, shoreline changes, and economic activities of coastal communities, such as fisheries and ponds (Maulana & Hendrawan, 2018).

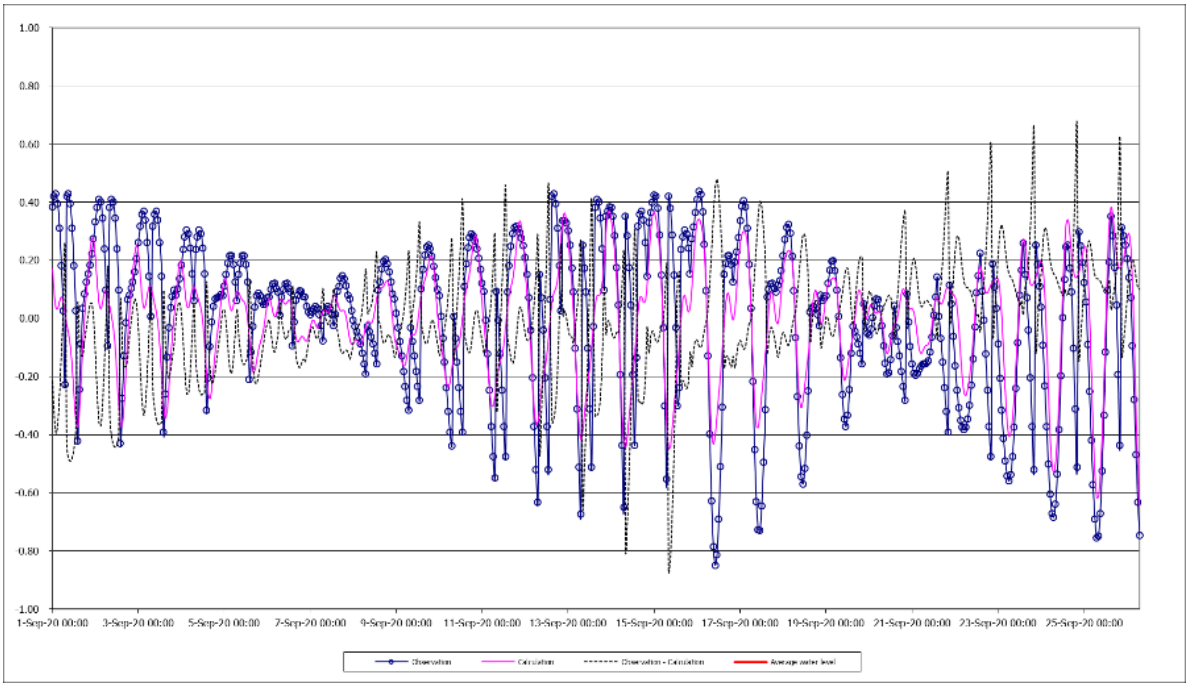

Figure 1. Tidal Fluctuations in September 2020

CONCLUSIONS

This study identifies the characteristics of tides in the North Coast of Semarang, Central Java, which is dominated by a mixed pattern tending to be semi-diurnal with two high and two low tides in a day. The main tidal components found were M2 (semi-diurnal lunar) and S2 (semi-diurnal solar), with amplitudes varying between 0.4 and 0.3 meters. The results of this study provide a comprehensive picture of the tidal dynamics in this region and can serve as a basis for more sustainable management of coastal areas. An in-depth understanding of tidal patterns is also important for mitigation efforts

against the impacts of climate change and increased disaster risk in the coastal area of Semarang North Coast, Central Java.

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