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Sedimentation Rate Analysis Waters in Tegalsari Beach Fishery Port, Tegal

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Abstract

Tegalsari Coastal Fishing Port (PPP) is a fishing area located in Tegal City and is a port with fairly dense ship activity. With the conditions owned by the Tegalsari PPP, the coastal fishing port has high economic potential. Conditions that affect activities at Tegalsari PPP include the silting of shipping lanes, which causes sedimentation in the port pond or in the shipping channel. Therefore, information about bathymetry and sedimentation rates is needed to facilitate shipping flows at PPP Tegalsari. The purpose of this study is to identify hydrooceanographic conditions in Tegalsari PPP, analyze sedimentation rates in Tegalsari PPP, and provide recommendations for the results of sedimentation rate analysis. The data used in this study contained three types of data: bathymetric data, tidal data, and sedimentation rate data. For data processing using Mike 21 software. The results that have been carried out in this study have varied results on bathymetric conditions and sedimentation rates in Tegalsari PPP. The results of bathymetric modeling In existing conditions, PPP Tegalsari has an average depth of 1.2–3.6 m; in alternative 1, it has a depth of 3.0–7.2 m; and in alternative 2, it has a depth of 2.5–7.0 m. The sedimentation rate in PPP Tegalsari within the research period of 15 days, namely in existing conditions ranging from 0.01095 mm/year, in alternative 1 ranging from 0.00438 mm/year and in alternative 2 ranging from 0.00486667 mm/year, The results of the research conducted show that the level of sedimentation conditions in Tegalsari PPP is low. Thus, sedimentation does not affect the shipping channel at PPP Tegalsari.

Keywords: Tegalsari Coastal Fishing Port, hydrooceanographic, bathymetric, sedimentation, shipping channel

1. Introduction

Tegal City is located on the north coast of Java Island and has a lot of fishing potential. The sustainable capacity of Tegal Sea waters is 35,838 tons per year. Fishing in the sea is carried out by fishermen for short-term fishing (one-day fishing), and the area is still around the coast (inshore fishing) north of Tegal City, which not only fulfills local fresh fish needs but also sends them to the surrounding environment in the form of fish. fresh. Pindang or gurami. Tegal City is located on the west coast of Central Java province (Hastari *et al.,* 2016).

As a maritime city, Tegal City operates in the marine fisheries sector and has two fish landing sites (PPI), namely PPI Harbor and PPI Murareja. Apart from that, there is also a fishing port called PPP Tegalsari (Febrianto *et al.,* 2015). Fishing ports or fish landing bases can provide a multiplier effect for the growth of other economic sectors, which can ultimately improve community welfare. Construction and development of fishing ports and fishing landing bases can contribute to regional economic development while increasing government and regional income (Usman, 2022).

Not only that, dredging is also needed to reduce the silting that occurs in the harbor pool. This is because, during certain periods, such as Eid al-Fitr, the anchorage pool cannot be passed by ships due to the large number of ships going in and out. The development of the onshore area at the fishing port, however, can also be aimed at being used as development land and is intended to provide fish landing facilities that are safe from waves and sedimentation and capable of accommodating fishing vessels weighing up to 200 GT, whose activities have so far been hampered by base due to sediment transport parallel to the coast (Post, 2021).

One of the challenges at the Tegalsari Coastal Fishing Port (PPP) is related to shipping lanes due to the shallowing of sedimentation in ponds and harbor channels. This situation is made worse by the presence of shipwrecks, which often prevent vessels from entering the Tegalsari Coastal Fishing Port (PPP). The harbor has been filled with mud for years, and it is unclear what the water depth in the harbor is due to sedimentation. High sedimentation in shipping channels will reduce the depth of shipping channels (Kementerian Kelautan dan Perikanan, 2021).

Sedimentation is the process of deposition of sediment grains from water pools to the bottom of the waters. Coastal areas are characterized by fine sand sediments, and oceanographic activities in the form of currents, waves, and tides greatly influence the sedimentation process. The movement of coastal sediments can be caused by currents, waves, tidal currents, and winds around the coast. Sediment from rivers, coastal cliffs, and seabed erosion is often carried by currents into the open sea. On the other hand, sediment from offshore to the coastline will be transported via wave currents (mass transport) and longshore currents (Harwis, 2021).

The sedimentation problem that occurs at PPP Tegalsari requires research into the sedimentation rate in the harbor pond. The sedimentation rate analysis process requires continuous support from hydroocenography data or parameters, including bathymetry, tides, wind, and waves. Waves or currents from ships contain sediment particles that are layered near the bottom, causing suspended material to rise to the surface of the water (resuspension). This high speed will carry suspended particles away from that location. This will result in lower sedimentation levels in these waters compared to other locations (Kementerian Kelautan dan Perikanan, 2021).

2. Research Methods

The location of this research study is Tegalsari Beach Fishing Harbor, Tegal City. Map of the research location for the Tegalsari Coastal Fishing Port, located in the north of Central Java This port is located in Tegalsari Village, West Tegal District, Tegal City, Central Java. The operational area is at 109° 7' 33.13''–109° 7' 50.48'' East Longitude and 06° 51' 2.29''–06° 5 50' 36.56'' South Latitude (Dwijayanti Hastari *et al.,* 2016). The Tegalsari Beach Fishing Harbor is an artificial harbor in which the water is protected by a coastal structure called a breakwater (Novia, 2020). Figure 1 shows the research location.

Figure 1. Map of the Tegalsari Beach Fishing Harbor Research Location, with the Yellow Points being Mike 21 Analysis Test Points (Source: Google Earth Pro, 2023)

This research process was carried out by collecting relevant data for hydrodynamic modeling. Secondary data was obtained from websites and journals to obtain complete data in order to complete this research (Table 1).

Table 1. Equipment used

No	Equipment	Information
1	*Echosounder*	A navigation tool for measuring sea depth by sending acoustic waves or vibrations from the surface to the seabed, which will be received again by a transducer installed on the bottom of the ship. This data can be used to determine the classification of seabed sediments and identify seabed objects.
2	*Tide Gauge*	The simplest tide gauge, this tool is a tool that can detect tsunamis and is installed in waters to quickly detect tsunamis. The data generated through these sensors will be automatically stored in the data recording machine, which is also in a panel box that also contains the three sensors.
3	*Mike 21*	This is software used for the process of modeling current patterns and sediment changes.

Source: Research Results (2023)

Research variable

This research is a quantitative descriptive study with independent (not influenced) and dependent (influenced) variables, namely as follows:

a. Independent Variable:
   1. Bathymetry
   2. Ups and downs

b. Dependent variable:
   1. Sedimentation

Hydrodynamic Model Analysis

A. Bathymetric Data Analysis

This research has been carried out in the form of making plans for main lanes and cross lanes. This research area includes routes frequently used by ships entering and exiting the port. Then the first step is to carry out sounding in the field by preparing the facilities and equipment installations that will be used in the sounding. The echo sounder,in the form of a bar check,must be calibrated. After the echosounder is calibrated, it then takes depth or sounding measurements. After the sounding is done, the data is checked. The CHC D580 Single-Beam Dual-Frequency An echosounder is a tool used to carry out depth measurements using acoustic waves emitted by a transducer to the bottom of the sea surface, then reflected by the bottom of the surface and captured again by the transducer. The data recorded by the transducer is the travel time of acoustic waves from the transducer to the bottom of the sea surface and back to the transducer. The depth of the sea can then be calculated using the formula:

$$D = v \times {}^{1}/_{2}\, t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where :
D: Ocean depth
v : Speed of acoustic waves in water
½ t : ½ the travel time of the acoustic wave

B. Tidal Data Analysis

Tides are measured using a tide gauge for 15 days, namely April 1–April 15, 2023, with an observation time interval of 30 (thirty) minutes. Next, the data obtained will be processed using the admiralty method in order to determine a tidal graph at the time during which the measurement is conducted.

Tides have two main components, namely M_2, S_2, K_1, and O_1. There are four components that can determine the type of tide. A classification of tidal types can be based on a comparison of the total amplitude of the diurnal constants (K_1 and O_1) with the total amplitude of the semidiurnal constants (M_2 and S_2). According to Pond and Pickard (1981 in Siagan (2010), to get the type of tide, you can use the formula (Supriyadi *et al.,* 2019).

$$F = \frac{AK_1 + AO_1}{AM_2 + AS_2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Information:
F: Formzahl number.
AK1: Amplitude of the main single tidal component caused by the gravitational pull of the moon and sun.
AO1: Amplitude of a single major tidal component caused by the gravitational force of the moon.
AM2: Amplitude of the main double tidal component caused by the gravitational force of the moon.
AS2: Amplitude of the main double tidal components caused by the gravitational force of the sun.

So the F value to determine the type of tide according to (Triatmodjo, 1999), namely:

Table 2. Tidal Types Based on Formzahl Numbers

Formzahl Value	Type of Tides	Information
0,00 < F ≤ 0,25	Half Daily (Semidiurnal/Double)	✓ There are two high tides and two low tides a day. ✓ Symmetrical waveform
0,25 < F ≤ 1,50	Mixtures with a double type are more prominent (Double Leaning)	✓ There are two high tides and two low tides a day. ✓ The shape of the first tidal wave is not the same as the second tidal wave (asymmetrical) with a semi-diurnal skew shape.
1,50 < F ≤ 3,00	Mixtures with a single type are more prominent (Single Leaning)	✓ There are two high tides and two low tides a day. ✓ The shape of the first tidal wave is not the same as the second tidal wave (asymmetrical) with a diurnal skew shape.
F > 3,00	Daily (Single)	✓ In a day there is one high tide and one low tide.

Source : (Supriyadi *et al.,* 2019)

To determine sea level as a high reference, observations are made of the position of sea level at certain time intervals, for example daily, monthly or annually. The results for determining the high and low tides are determined using the following formulas:

MSL = Z0 (2.34)

HHWL = Z0+(M2+S2) + (O1+K1) (2.35)

MHWL = Z0 + (M2+S2) (2.36)

MLWL = Z0 – (M2+S2) (2.37)

LLWL = Z0 – (M2+S2) – (O1+K1) (2.38)

Where:

MSL = Mean sea level (Mean Sea Level) is the average water level between the average high water level and the average low water level. This elevation is used as a reference for elevation on land (Supriyadi *et al.,* 2019).

C. Wind Data Analysis

Wind data plays a role in inputting windrose data into the hydrodynamics module. Wind direction and speed are important weather conditions for flight operations. Weather information, including wind direction and speed information, is required for takeoff and landing. Wind direction and speed data collected by aviation weather stations for long-term monitoring can be used as a basis for evaluating the feasibility of airport weather analysis (Fadholi, 2013).

D. Flow Data Analysis

The measurement of current speed data is done by immersing the current meter into the water surface until the water surface is parallel to the boundary line on the current meter, then waiting a few minutes until the numbers stabilize, and then the tool can automatically work (Fauzi Respati et al., 2020). This research was carried out at low tide. The formula obtained from the current speed is:

$$v = \frac{s}{t} \quad (3)$$

Where:

v : Current speed (m/s)
t : Required time (dt)
s: Distance traveled

Based on the compass used, the direction of the current will determine the path in the direction shown on the current meter.

E. Sedimentation Rate Analysis

The simulation of hydrodynamic modeling (sedimentation rate) is not presented in its entirety but is only presented in existing conditions, and the visualization is in the form of a display for 15 days. The assumption used is that the specific gravity of the sediment material is 1900 kg/m3 because the clay and clay fractions are dominant (results of sediment analysis). The source of the material comes from the river, with the assumption that the river emits TSS of 250 mg/l for 9 hours a day because human activity is high at 08.00–17.00. The river discharge around PP Tegalsari is ±2,000 liters/second; in the modeling, it is assumed that the river discharge in the worst condition is 4,000 liters/second.

The sedimentation study carried out in Muarareja Tegalsari has the aim of being able to find out the answer to the problem formulation that has been determined previously to obtain the results of the given hypothesis. This activity is a grouping of data based on variables. Through analysis with the Mike 21 application, this research was carried out to measure several observed parameters.

Sedimentation rate data is processed using calculations using the formula (Hastari *et al.,* 2016), namely: Sedimentation Rate = A – B / area / week (g/area of pralon / week)

$$= \left(\frac{10}{\pi r2}\right)(A-B)\left(\frac{\frac{kg}{m^2}}{days}\right) \quad (4)$$

Sedimentation rate

$$= \left(\frac{10000}{\pi r2}\right)(A-B)\left(g/m^2/days\right) \quad (5)$$

Information:

A : Weight of aluminum foil + sediment after heating 105 ˚C in grams.
B : Initial weight of aluminum foil after heating 105 ˚C in grams.

After getting the results from sieving and pipetting, it can then be used to find the type of sediment by calculating the percentage of sediment constituents such as gravel, sand, silt and clay.

3. Results and Discussion

The potential for a Tsunami disaster is moving Megathrust. The Sunda subduction in the south of the island of Java is a potential disaster issue; the potential for the subduction zone to move between the Eurasian plate and the Indo-Australian plate, extending from the west of Sumatra to the south of Java, Bali and Nusa Tenggara, this subduction zone is called the Sunda subduction arc, has several segments, the Java segment has a lower magnitude and frequency of earthquakes, as shown in Figure 1 below:

A. Bathymetric Analysis Modeling and Sedimentation Rates

The bathymetric analysis carried out at the Tegalsari PPP Port is the result of calculations carried out by Mike 21 software. The bathymetric map processed includes maps of sounding results for two weeks carried out in 2023 starting from 1 April - 15 April 2023. It can be seen in the picture Below are the bathymetry results before interpolation and after interpolation (Figure 2). The results that can be presented in this research in Figure 2 are the results of the bathymetry at the Tegalsari Beach Fishing Harbor in existing conditions before the interpolation was carried out.

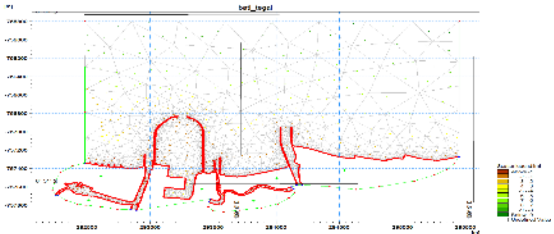

Figure 2. Existing Bathymetry of PPP Tegalsari Before Interpolate

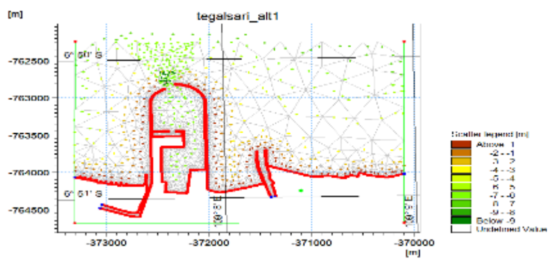

Figure 3. Tegalsari PPP Existing Bathymetry After Interpolate

Figure 3 is the result of bathymetric modeling at the Tegalsari Beach Fishing Harbor in existing conditions after interpolating. It can be seen that the anchor pool in the existing bathymetry in Figure 4 is very low with an average depth of 1.2 – 3.6 m.

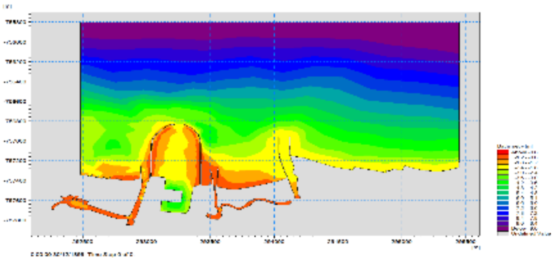

Figure 4. Alternative Bathymetry 1 PPP Tegalsari Before Interpolate

The sedimentation rate for 15 days taken from the middle of the anchor pool at coordinates long 293249.9568966 and lat -757002.8912716 has a value of 0.045 millimeters. Then the annual sedimentation rate is 1.095 mm/year. The sedimentation that occurs is not very worrying for the surrounding area (Figure 4).

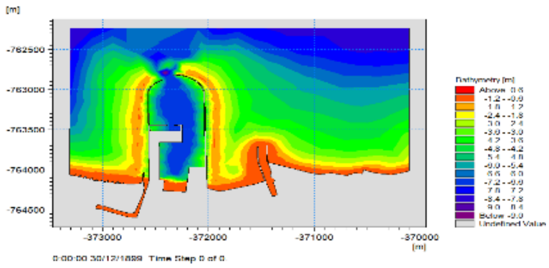

Figure 5. Alternative Bathymetry 1 PPP Tegalsari After Interpolate

The results that can be presented in this research in Figure 5 are the results of the bathymetry at the Tegalsari Beach Fishing Harbor in alternative 1 before interpolating. Figure 6 shows the results of bathymetric modeling at the Tegalsari Beach Fishing Harbor in alternative 1 after interpolating. The interpolate results of alternative 1 show that the anchorage pool has deepened to an average depth of 3.0–7.2 m. It can be seen that there has been quite significant deepening compared to the bathymetry in the very shallow existing conditions.

The sedimentation rate for 15 days taken from the middle of the anchor pool at coordinates long -372285.5915104 and lat -763098.2784896 days has a value of 0.018 mm/day. Then the annual sedimentation rate is 0.438 mm/year. The sedimentation that occurs is not very worrying for the surrounding area.

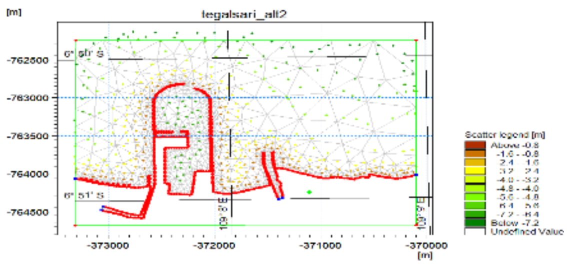

Figure 6. Alternative Bathymetry 2 PPP Tegalsari Before Interpolate

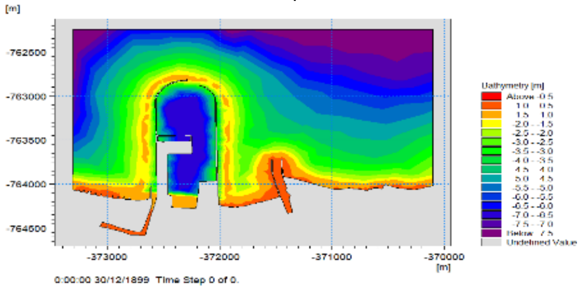

Figure 7. Alternative Bathymetry 2 PPP Tegalsari After Interpolate

The results that can be presented in this research in Figure 6 are the results of the bathymetry at the Tegalsari Beach Fishing Harbor in alternative 2 before interpolating. In Figure 7, it can be seen that the bathymetric modeling results at Tegalsari Beach Fishing Harbor are in Alternative 2 after interpolating. The results obtained in alternative 2 are not much different from the results of alternative 1, where the average depth in alternative 2 is 2.5–7.0 m.

This modeling was carried out to determine the depth of the anchor pool at the Tegalsari Beach Fishing Harbor. It can be seen from the three bathymetric designs in existing conditions, alternative 1 and alternative 2, where alternative 1 design has a depth of 3.0–7.2 m compared to the existing design and alternative 2 design.

The sedimentation rate for 15 days taken from the middle of the anchor pool at coordinates long -372295.8996254 and lat -763108.4384073 has a value of 0.020 mm/day. Then the annual sedimentation rate is 0.486667 mm/year. The sedimentation that occurs is not very worrying for the surrounding area.

B. Turbidity Modeling Results at PPP Tegalsari

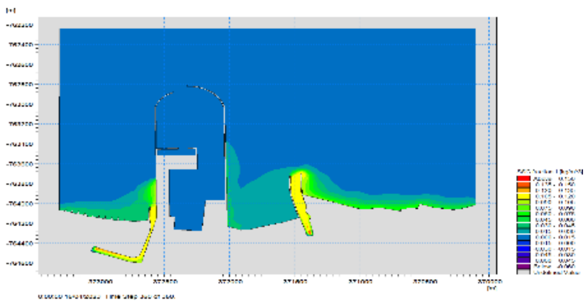

Figure 8. Turbidity Distribution Alternative Design 1

The results of the turbidity distribution for alternative 1 waters in the east season can be seen in Figure 8, showing the highest turbidity level at 120 mg/l. During modeling within 15 days, turbidity did not enter the anchored pool area.

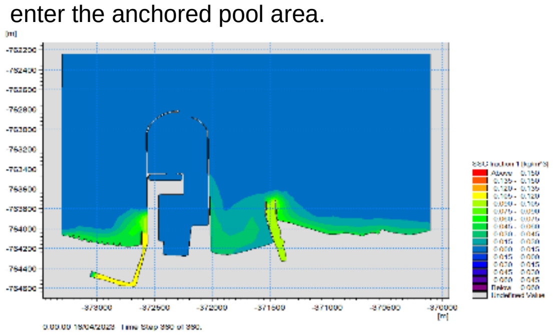

Figure 9. Turbidity Distribution Alternative Design 2

Then the results of the turbidity distribution for alternative 2 waters in the east season can be seen in Figure 9, showing the highest level of turbidity at 105 mg/l. During modeling within 15 days, turbidity did not enter the anchored pool area.

4. Conclusions

The hydrodynamic model, namely the bathymetry results obtained, shows that the average sea level (MSL) in PPP Tegalsari waters is 0.34023 in 2 weeks. The Formzahl value on April 1–15 in the research area was 1.391460383. Therefore, a mixed type of tidal pattern with a double type (semi-diurnal tide) occurs twice a day, with two high tides and two low tides. In dominant wind conditions, from the north towards the harbor, then to the west side of the harbor, which causes sea currents.

From the results of sedimentation rate modeling at PPP Tegalsari in existing conditions, alternative 1 and alternative 2, it can be concluded that the existing condition has the highest sedimentation rate value with a figure of 1.095 mm/year, compared to the alternative 1 design with the pool mouth facing west and having The sedimentation rate with a height of 0.438 mm/year is lower than the existing design. Alternative Design 2 with the pool mouth facing east has the highest sedimentation rate value, namely 0.486667 mm/year. Therefore, it can be concluded that alternative design 1 has the lowest sediment rate, which can be used for development at the Tegalsari PPP.

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