Analysis of tidal currents modeling at Baubau City fuel oil terminal with adcirc model - SMS software

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Abstract. Tidal Currents are one of the important hydro oceanography components for studying coastal characteristics. The purpose of this study is to find out the types of tides and tidal current patterns at the fuel oil terminal in Baubau City (Buton). The method used to determine the speed of tidal currents and tidal type models using SMS (Surface Water Modelling System) applications with ADCIRC models taking into account the data of bathymetry and some components of the tidal currents in Baubau city Fuel oil Terminal area. The results obtained in the study showed that the type of ups and downs that occur in the Baubau fuel oil terminal is Mixed Tidal Leaning to Double Daily. The Highest Sea Level Elevation of the least-squares method is 1.07 m and Lowest at -1.07 m, on SMS modeling ADCIRC Highest Sea Level Elevation ranges from 0.78 m and the lowest at -1.02 m. The result of current speed using SMS ADCIRC modelling obtained the highest tidal current speed value in Baubau Fuel oil Terminal which is 0.63 m/s and the lowest current speed of 0.01 - 0.06 m/s. The direction of the current at low tide towards the dominant tide to the Southwest while at high tide towards the tide dominant current to the South.

1. Introduction
The coastal area is an area that is very intensively used for human activities, such as the central government area, settlements, industry, ports, aquaculture, agriculture/fishery, tourism, and so on. These various activities can lead to an increase in the need for land, infrastructure, and so on, which in turn will lead to new problems such as erosion, soil arising from sedimentation, and others [1].

The waters of the Baubau Fuel Oil Terminal are waters located in the Sulaa sub-district, Betoambari sub-district, Baubau City, Southeast Sulawesi Province. Currently being planned a jetty Terminal fuel III owned by PT. Pertamina for the appointment of special goods in this case in the form of fuel oil which is located around the waters of the Fuel Oil Terminal [2].

Hydro-oceanographic factors such as waves, ocean currents, and tides greatly affect the conditions in waters. Current is a mass transfer of water caused by several factors, including differences in the density of water, pressure differences, other generating forces such as long waves and wind. Current patterns and characteristics which include the dominant current type, speed, and direction as well as the movement pattern of ocean currents cause the condition of water to become dynamic. The movement of currents carries the materials and properties contained in a body of water. This causes the current to have an important role in determining the condition of the waters [3]. This study was conducted to determine the type of tide and the direction and speed of tidal currents at Baubau City Fuel Oil Terminal which can later be used as reference material in the development of the jetty.

2. Literature Review
2.1 Beach
The definition of a beach in Indonesian there are two terms about the beach that are often used confusedly, namely the coast (coast) and the beach (shore). An explanation of several definitions of this
beach can be seen in the picture. Coastal is a land area by the sea that is still affected by the sea such as tides, sea breezes, and seawater seepage. While the beach is the area of the water's edge that is influenced by the highest tide and lowest tide.

Land area is an area located above and below the land surface starting from the highest tide limit. Ocean area is an area located above and below sea level starting from the seaside at the lowest low tide line, including the seafloor and the earth below. The coastline is the boundary line between land and seawater, where the position is not fixed and can move according to the tides and coastal erosion that occurs. Coastal borders are certain areas along the coast that have important benefits for maintaining the sustainability of coastal functions. The criteria for the coastal border island along the edge whose width is following the shape and physical condition of the beach, at least 10 m from the highest tide point towards the mainland [4]. The definition of the beach is illustrated in the Figure 1.

Figure 1 Definition of the beach

2.2 Bathymetry
Depth sounding is a process and activity aimed at obtaining an image (model) for the Seabed Surface. The process of describing the bottom of the waters (from measurement, processing to visualization) is referred to as a bathymetric survey [5].

2.3 Sea wave
Ocean currents are the movement of water masses from one place (position) to another. Ocean currents occur anywhere in the ocean. In essence, the energy that drives the mass of seawater comes from the sun. The difference in solar heating to the earth's surface also causes differences in the energy received by the earth's surface [6].

2.4 Tidal Currents
Tidal Currents are fluctuations (rising and falling) of sea level due to the attraction of objects in the sky, especially the moon and sun, to the mass of seawater on earth. The attractive force between the moon and the earth affects the tides more than the attraction between the sun and the earth because the moon's attraction to the earth is 2.2 times greater than the sun's attraction to the earth. This happens because the mass of the moon is smaller than the mass of the sun, but the distance of the moon to the earth is much closer than the distance of the earth to the sun [7].

2.5 Surface Water Modeling System (SMS)
Surface Modeling System (SMS) is software for environmental modeling with one, two, or three-dimensional models. Numerical modeling will be calculated with various information that can be applied to the Surface Modeling System. In principle, this application will model hydrodynamics in water areas including tidal and flow velocity calculations for shallow water problems. The modeling is equipped with two models, namely the steady model and the dynamic model [8], [9].
ADCIRC is one of the models contained in the SMS program. ADCIRC is an advanced circulation model where the programming system is based on time, free surface circulation, and transportation problems in two and three dimensions. The program makes use of the finite element method in space allowing for very flexible use of unstructured grids. The applications of the ADCIRC model are tidal and wind circulation modeling, storm surge, and flood analysis, sediment transport including dredging and material disposal, as well as larval transport studies [10].

3. Methods
The modeling location is located in the waters of the Baubau city fuel oil Terminal, Sulaa Village, Betombari District, where this location is in geographical coordinates 5°30'58.84" LS and 122°33'19.07" BT, as is shown in Figure 2.

This study uses tidal data for 15 days starting from July 31 - August 14. Tidal data is used to determine the type of tide. For Flow Modeling using data in the form of bathymetry data which is then carried out by digitizing the data in SMS 12.1 software. Then proceed with making a boundary that is useful as the boundary of the research area or the area being observed. The mesh fabrication is carried out on the coastline which uses segments within the scope of its boundary.

Then the module selection is ADCIRC wherein the ADCIRC model control several changes and inputs are made including Bottom stress is used constant a quadratic, and the time step is entered 4.0 sec and the run step is inputted 3 days. Then fill in the ramp value of 1 day. The output files used are fort 63 and 64 which include: elevation time series (global) and velocity-time series (global). Next, enter the tidal/harmonic, but before that on the mesh, changes are made to the conversion coordinates.
At tidal/harmonic, tidal components are entered, namely K1, K2, L2, M2, N2, O1, S2 from the Leprovost file on ADCIRC SMS. The flow chart of this study is shown in Figure 3.

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4. Results and Discussion

4.1. Least Square Tidal Analysis

Generally, tidal data is analyzed using the harmonic analysis method. The harmonic analysis aims to obtain the values of the amplitude and phase of the tidal components, the method used for tidal analysis is the Least Square method using tidal data which is calculated every hour for 24 hours for 15 days, namely July 31 - August 14 at Jetty 1 Terminal Baubau fuel which is attached in the attachment.
4. Fill in the Tidal Observation Data

The first step is compiling tidal observation every hour for 15 days of observation where the data used is observation data from July 31, 2018, to August 14, 2018. The height value is input in meters.

4.3 Tidal Harmonics

Harmonic analysis is carried out to obtain the harmonic components that appear in the water level signal. The number of harmonic components analyzed is highly dependent on environmental conditions and can be set by the analyst as needed. The tidal harmonics constants obtained from the tidal harmonic analysis of the Baubau Fuel Oil Terminal for 15 days using the Least Square method are as depicted in Table 1. The tidal chart using the Least Square Method is shown in Figure 4.

| No | Symbol | Z0    | A       | B       | phase | phase |
|----|--------|-------|---------|---------|-------|-------|
| 0  | Z0     | 14.181| 14.181  |         |       |       |
| 1  | M2     | -0.2046| -0.4878| 1.943056| 2.472416| 43.152|
| 2  | S2     | -0.2483| -0.1931| 2.184028| 2.178717| 38.026|
| 3  | N2     | 0.368056| 0.977083| 1.04375| 693.567| 12.105|
| 4  | K2     | 1.429861| 0.0036| 1.429861| 6.909028| 0.120833|
| 5  | K1     | -0.0034| -0.2628| 1.825| 2.692.617| 46.995|
| 6  | O1     | -0.1833| 0.727083| 1.465972| 1.502.568| 26.225|
| 7  | P1     | -0.1574| -0.0605| 1.170833| 2.010.134| 35.083|
| 8  | M4     | -0.0021| -0.0013| 0.0025| 2.106.237| 36.761|
| 9  | MS4    | 0.0034| 0.0031| 0.0046| 426.743| 5.172222|

Formzhal Value = \( \frac{AK_1+A01}{AM_2+AS_2} \)

= \( \frac{0.2628+0.2111}{0.2798+0.3145} \) = 0.8

Based on the Formzhal value, the tidal criterion is the mixed type of mixed tides (Mixed Tide Semidiurnal)

![Figure 4 Tidal Chart using the Least Square Method](image-url)
4.4 The Tides
For Mixed Tide Semidiurnal then the elevation is obtained as is depicted in Figure 5.

![Figure 5 Tidal Least square method](image)

4.5 Determination of the Type of Tidal Least square method
The results of tidal data processing using the least-square method on July 31, 2018 – August 14, 2018 show that the final results are obtained in the form of amplitude and phase angle values for S0, and the values of the 9 main components of tidal generators, namely M2, S2, N2, K2, K1, O1, P1, M4, and MS4. The most dominant tidal component in S2 is because it has the highest wave amplitude. S2 has an A value of 0.3145 m. Based on Formzahl's calculations, it is known that the type of tide is mixed tide, double daily tilt with Formzahl value of 0.8. Mixed tides are mixed with double daily slopes, where there are two high tides and two low tides that differ in height and time each day.

4.6 Currents Modeling at Baubau Fuel Terminal
The ADCIRC Running Process is carried out for 3 days, namely 9-12 August 2018. However, what will be used as a comparison is 11 August 2018. The results obtained on 11 August are shown in Figures 6-11. The largest velocity (velocity) occurred at 00.00 with a speed of 0.63 m/s while the smallest velocity occurred at 07.00 with a speed of 0.00 – 0.06 m/s. The largest Surface Elevation occurred at 04.00 – 05.00 AM with a speed of 0.78 m while the smallest Surface Elevation occurred at 11.00 – 12.00 AM with a speed of 1.02 m. Based on the simulation of SMS 12.1, there are 2 high tides and 2 low tides with different elevations. The first tide starts at 01.00 – 06.00 and the second tide occurs at 3.00 – 8.00 PM. Meanwhile, the first low tide occurred at 07.00 – 2.00 PM and the second ebb occurred at 9.00 – 11.00 PM.

![Figure 6 The Biggest Flow at Baubau Fuel Terminal](image)
Figure 7 Smallest Current at Baubau Fuel Terminal

Figure 8 The Biggest Elevation At Baubau Fuel Terminal

Figure 9 Smallest Elevation at Baubau Fuel Terminal
5. Conclusions

From the Tidal data processing of the Baubau fuel oil Terminal, the tidal components are obtained as follows. For the Least Square method, the Tidal component is obtained, whereby using the Formzahl number the Tidal type that occurs is the Mixed Tidal Tide Leaning to the Daily Double with a Formzahl value of 0.8. The lowest sea-level elevation is -1.07 m and the highest sea level elevation is 1.07 m. Based on the results of the ADCIRC SMS Running, the current pattern that occurs follows the tidal movement pattern with Mixed Tidal Type Leaning to Double Daily with the lowest sea-level elevation -1.02 m and the highest sea level elevation 0.78 m. The current pattern that occurs when conditions recede, the current moves from the land to the sea in a dominant southwest direction. Meanwhile, during high tide conditions, the ocean currents move towards the land in a dominant direction of the South. The current velocity that occurs at Baubau BBM Terminal is the largest current with a speed of 0.63 m/s while the smallest is 0.00 – 0.06 m/s. A more in-depth study is needed so that the results of the analysis with this software can resemble the form of Flow Forecasting according to Field Results.
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