TIDAL ANALYSIS AT KUALA LANGSA AND PUSONG ISLAND USING ADMIRALTY METHOD

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A research about tidal analysis at Kuala Langsa and Pusong Island with different physical condition had been done, where Kuala Langsa is an estuary and Pusong Island is a coastal area in Kota Langsa District, Aceh Province. The purpose of this research is to determine tidal type on both locations. This research used secondary data which is obtained from Kuala Langsa – Pusong Island Hydro – Oceanographic Survey and primary data which is taken about 29 hours at both locations. Admiralty method had been using to analyze the tides and from this method can be obtain amplitude and phase lag based on Formhazl number. The result of this research according to Formhazl number for Kuala Langsa and Pusong Island are 0.12 and 0.23 respectively. Both values of Formhazl number of the locations are smaller than 0.25, it concluded that both locations had showed same tidal type, i.e. semidiurnal. The phase lag for tidal types in Kuala Langsa for M_2 is 359^0while for Pusong Island is 330^0. While for the amplitude of both locations for M_2 is 56 cm for Kuala Langsa and 48 cm for Pusong Island. It is shown that the amplitudes at Kuala Langsa are a little bit higher than that of Pusong Island. The difference is suspect due to the different physical condition of the observation areas.

Keywords: *tidal, Admiralty method, Formhazl number, semidiurnal*

Introduction

The body of sea water at the shoreline, the place at which land and sea water meet, are never still at one elevation only, but always fluctuate up and down due to the tidal cycle. Sea water surface is rising gradually until reach the maximum which so called high water level and then lowering down gradually to the minimum at lower water level. Most of the earth surfaces are covered by water or about 361.3 million sqkm (Mays,2001:4), that sea water always moves every time. This movement is generated by wind, sea waves, tides and currents.

Indonesia is one of archipelago country that relatively wide which consists of 13,466 islands and has 99,093 km shoreline length. Because of its very wide sea water surface in Indonesia, the tidal phenomena are very well known to the people. The knowledge of sea water tide is used in sea-transportation, port activities, and the coastal area development. So, the knowledge of tidal is very importance to be studied by whom that prefer to work in river and coastal problems.

The sea water tidal is the results of gravityattractive forces and centrifugal effects. The centrifugal effect is the forces outer direction from the rotation centre, so that the gravity forces vary proportionally to the earth mass but inverse proportion to the distance (Triatmodjo,2012:85).For the sea water tides, the peak of its wave is called high tide and the valley of the waves is called low tide. The difference of vertical range of the high and lowtide is called the tidal range.

There are several types of tides, i.e., diurnal tide, semi diurnal tide, and some other more. The type of tide at one area, can be known by measuring the elevation of sea water surface fluctuation at the observe area every day. Whenever the measuring place has one high tide and one neap tide every day in about 24 hours, the area has diurnal tide type. On the other hands, whenever the object area has its high tide and neap tide twice in a day, the area has a semi diurnal type of tide. Another type of tide is the mixed tides which is the transition between diurnal and semi diurnal tides (Wyrtki, 1961:155).So, the research was conducted to see the comparison

between the tides at Kuala Langsa which area is the river estuary and Pusong Island which is the coastal area using one method of tidal prediction which is called *admiralty* method.

Methods of Analysis

Tidal analysis which occurs at Kuala Langsa and Pusong Island was conducted using secondary tidal data available from Hydro - Oceanographic Survey recorded for 15 days and a primary tidal data was collected for 29hours by recording directly at the sites using staff gauges. The distance between the two locations is about 5.6 km which Kuala Langsa is located at 4.52^0N 98.17^0E and Pusong Island at 4.53^0 N 98.06^0 E at Kota Langsa District, Aceh Province(PLN-FT Unsyiah, 2013). The tidal data was analyzed using admiralty methods which flowchart diagram is shown in Fig.1.

The method is a method of tidal calculation which conducted to get the mean sea level obtained from tidal constant calculations (Ongkosongo and Suyarso, 1989:40). From harmonic analysis, two harmonic constants, i.e., amplitude and phase difference are calculated using admiralty method at each corrected tidal constants and corrected mean sea level. The results will be diurnal tide constants, i.e., K_1, O_1, P_1, semi diurnal tide constants M_2, S_2, N_2, K_2, and shallow water tidal constantsM_4, MS_4. Whenever the tidal constants were obtained, the type of tide is defined using Formhazl number as (Wyrtki, 1961:159):

(1)

where: F = Formhazl number; O_1= harmonic constant of moon declination; K_1 = harmonic constant of moon and sun declination; M_2 = harmonic constant of moon; and
S_2 = harmonic constant of sun.

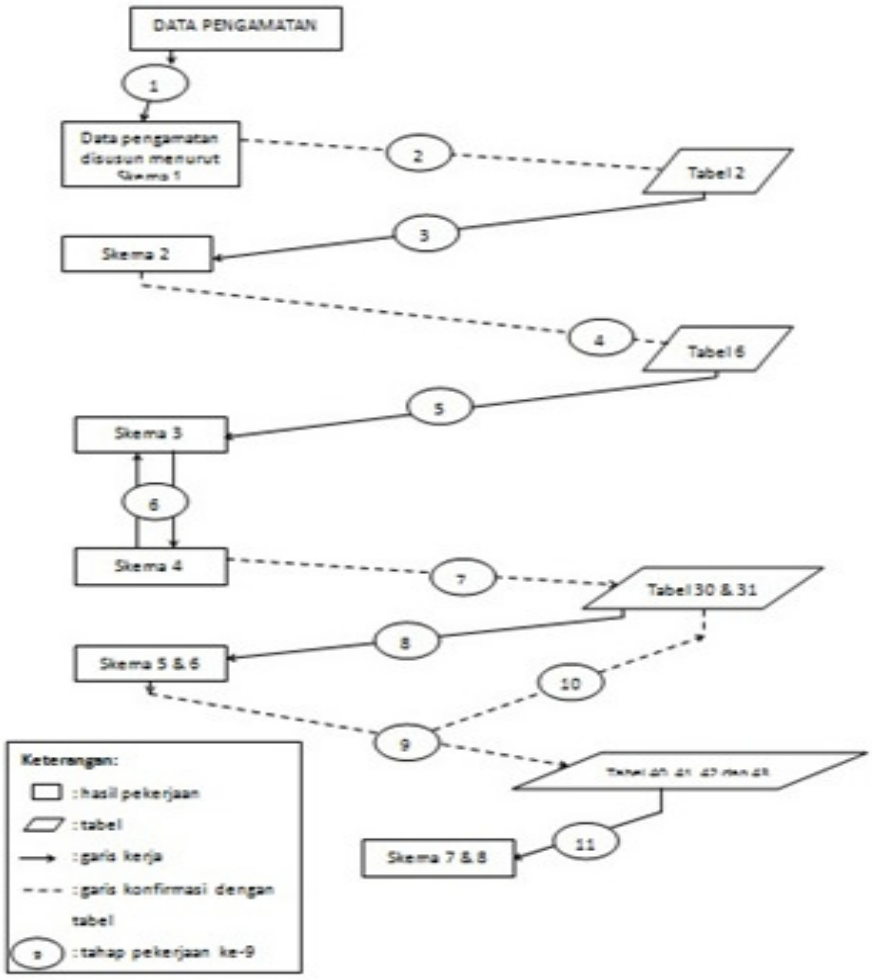

Figure 1. Flowchart of Admiralty Method

The result obtained based on Formhazl number calculations is used to classify the type of tide at the observed locations, with the conditions as the following:

$F \leq 0.25$: semidiurnal type of tide

$0.25 < F \leq 1.5$: mixed tide prevailing semidiurnal

$1.5 < F \geq 3.0$: mixed tide prevailing diurnal

$F \geq 3.0$: diurnal type of tide

Analysis Results

Tidal Constants at Kuala Langsa and Pusong Island

The results of tidal constants, amplitude and phase lag, based on admiralty methods for Kuala Langsa and Pusong island are shown in Table 1 and Table 2.

Table 1.Tidal constants at Kuala Langsa

	S_0	M_2	S_2	N_2	K_2	K_1	O_1	P_1	M_4
A (cm)	291	56	43	45	1	5	7	11	20
g (°)	0	359	28	181	200	200	143	28	45

Table 2. Tidal constants at Pusong Island

	S_0	M_2	S_2	N_2	K_2	K_1	O_1	P_1	M_4
A (cm)	147	48	40	14	11	8	13	21	2
g (°)	0	330	27	21	175	81	175	57	27

From Table 1, it is obtained that the M_2 constant at Kuala Langsa is dominating compare to other constants which the M_2 amplitude value is 56 cm and its phase lag is 359^0. While Table 2 shown the dominating tidal constants also for the M_2 amplitude and phase lag which values are 48 cm and 330^0 respectively. This happened due to at the two locations are very influence by the moon's attractive force rather than that of the sun.

Tidal Type

The Formhazl numbers which calculated using Eq. (1) have the F values of 0.12 for Kuala Langsa and 0.23 for Pusong Island. So, the tide classification based on the value of F for the two locations has a semi diurnal tidal type which the F value obtained is less than 0.25.

Tidal Graph

Beside the tidal constants calculations for the two observed locations, the comparison of tidal graphs between secondary data collected and the measured primary data also had been conducted. Fig. 2 shown the tidal graph at Pusong Island with the primary data assimilation, while Fig. 3 shown the tidal graph at Kuala Langsa.

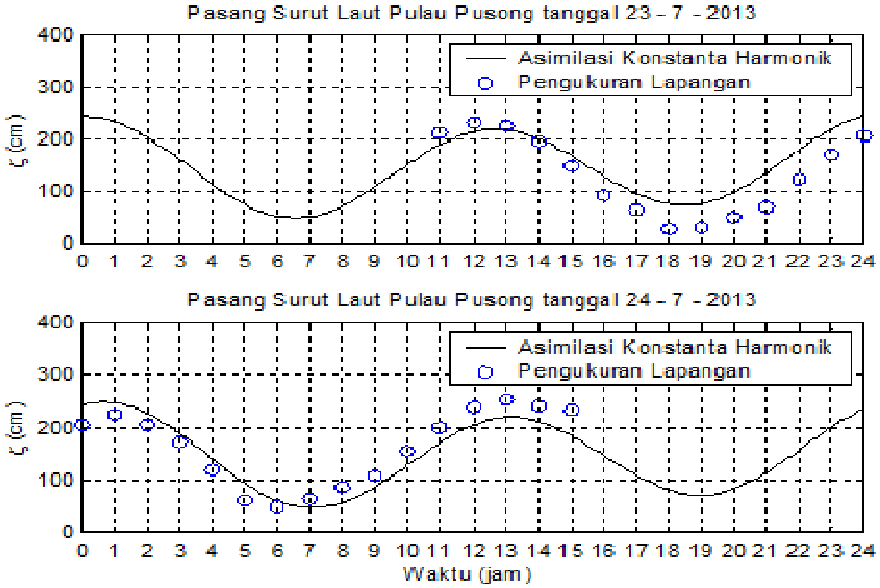

Figure 2. Tidal graph at Pusong Island with the primary data assimilation

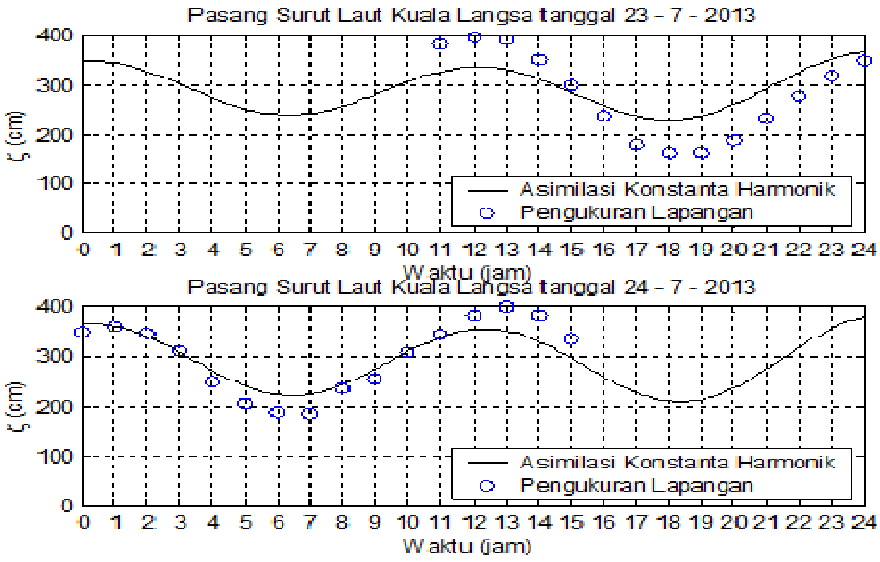

Figure 3. Tidal graph at Kuala Langsa with the primary data assimilation

Fig. 2 and Fig. 3 shown the comparison between the tidal graphs obtained from the secondary data and the primary data. The two set of graphs have the similar pattern of the tidal graph which in one day there are two high tides and two low tides. So, either at Kuala Langsa or at Pusong Island, both of them has semi diurnal tide characteristics.

Discussion

Tidal harmonic constants which are the amplitude and phase lag are obtained based on Admiralty method. The dominating tidal harmonic constant at the two observed locations at Kuala Langsa and Pusong Island is M_2 or principal lunar, i.e. a tidal harmonic constant which has period of 12.42 hour or 12 hour and 25 minutes.

While the tidal type is defined by using the Formhazl number. The number using diurnal tide and semi diurnal tide constants. The values of Formhazl number at the two observed locations are 0.12 at Kuala Langsa and 0.23 at Pusong Island which are less than 0.25 which is semi diurnal tide.

So, either using tidal harmonic constants or using tidal types with Formhazl number, the type of tide is semi diurnal at Kuala Langsa as river estuary and also at Pusong Island which is a coastal area. A bit differences in amplitude and phase lag values of the two locations for M_2, i.e., 56 cm and 359^0 at Kuala Langsa, and 48 cm and 330^0 at Pusong Island is shown in Table 1 and Table 2. The other phase lags for tidal types in Kuala Langsa for S_2, O_1 and K_1 are 28, 143 and 200 respectively while for Pusong Island are 27, 81, 175. While for the amplitudes of both locations for S_2, O_1 and K_1 are 43 cm, 7 cm and 5 cm for Kuala Langsa and 40cm, 13cm and 8cm for Pusong Island which are also shown in Table 1 and Table 2. Generally it is also shown that the amplitudes at Kuala Langsa are a little bit higher than that of Pusong Island. The difference is suspect due to the different physical condition of the observation areas.

Conclusion Remark

Water domain at Kuala Langsa is as an estuary and its surrounding of wetlands, mangrove forests, and river water flow downstream. The situation tend to make a little bit longer time for tide at Kuala Langsa to reach its peak compare to the tidal fluctuation at Pusong Island. The approximation results between assimilation harmonic constant data that obtained from admiralty method calculations, shows nearer values of the constants at the two locations.

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References

1. PLN-FT Unsyiah, Final Report in *Kuala Langsa-Pusong Island Hydro-Oceanographic Survey* (Engineering Faculty of Syiah Kuala University, 2013)
2. Mays, L.W., *Water Resources Engineering*, (John Wiley & Sons Inc, New York, 2001)
3. Ongkosongo, O.S.R. and Suyarso, Tides in *Asean- Australia Cooperative Programs on Marine Science Project 1: Tide and Tidal Phenomena* (LIPI, Jakarta ,1989, in Indonesian)
4. Triatmodjo, B., *Coastal Structure Design*(Beta Offset, Yogyakarta, 2012, in Indonesian)
5. Wyrtki, K., Naga Report, Volume 2 in *Physical Oceanography of the Southeast Asian Waters*(The University of California, La Jolla, California, 1961)