Preliminary sediment modeling at the confluence of the Mahakam and Karang Mumus River

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Abstract. The sedimentation process can move slowly and continuously during sediment transportation is still ongoing from the mainland. The sediment evidence has been done by pairing the current bathymetric measurement of the previous data from the bathymetric map of the DISHIDROS of the Indonesian Navy 2011 in the confluence of the Mahakam and Karang Mumus River. Initially, the tidal measurements were carried out on 15-29 January 2019 while the bathymetry measurements were measured on 21-22 January 2019 during spring tide was over 800 m from upstream to downstream river confluences. Contour modeling measured using Software Surfer while the tidal is using the Admiralty method., to get discharge sediment performed contour coupling from both using AutoCAD software. The results of tidal analysis at the confluence of this river type Mixed Tide, Prevailing Semi Diurnal with MSL119 cm, HHWL 275 cm and LLWL-29 cm. Besides, the results of the sedimentation calculation showed an increase of 251,621.52 m³ in the tempo of 8 years from different Years of measurement. Most of the deposits occur on the opposite side of the Karang Mumus River, and this may be due to the small current velocity of the inner side of the Mahakam River that is curved towards the Karang Mumus River. Further research should also be modeled on current patterns and numerical modeling to ensure the morphological changes of the confluence of the present river.

1. Introduction
The confluence of the Mahakam River and Karang Mumus River influencing by the tides and fluvial discharge, which can result in water mass movements [1]. Most of the area of Samarinda is estimated at 365.27 Km² (50.09% of total area) included in DAS Karang Mumus with a total length of about ± 40 Km stretching from north to south of Samarinda [2]. The confluence of the Mahakam River and Karang Mumus River is important in playing the role of water output and sediment from the Karang Mumus River.

Due to the influence of tides at the confluence where, according to [3], tidal movements affect the current pattern. Then the tidal behavior is like a wave that drove upstream at the time the tide entered the river, and the distortion was then lost due to the friction under the flow of the river. The stage between the difference in velocity and elevation of water on the direct flow drives changes in relationships, with low and flood tide occurring in their respective lower and high tide. Besides, the amplitude of tidal velocity will increase with increased discharge [4]. Hadi et al. [4] also explained that the discharge of the river significantly affects circulation.

Other consequences of tides and fluvial discharge are one of them, resulting in the occurrence of sedimentation transport. This will be a big problem in the future when the confluence of this river that...
also becomes the estuary of the Karang Mumus River does not see an increase in its dimensions. Based on the results of the Bathymetric map data that has been done in DISHIDROS of the Indonesian Navy 2011, the sedimentation development can be seen by coupling the current measurements with the results of map data bathymetric that has been carried out in the DISHIDROS of Indonesian Navy 2011. So the purpose of this research focuses on the water level, and prediction of the level based on the Admiralty method as well as increased sedimentation occurred after the bathymetric measurements returned at the confluence of the Mahakam River and the Karang Mumus River.

2. Material and method
The data used in this research in the form of primary data are tidal and bathymetry measurements. Besides, it also uses secondary data on the map of the bathymetry of the Kutai River and the estuary of East Kalimantan with a scale of 1:75,000 obtained from the Naval Office of Hydro-Oceanography in 2011.

![Figure 1. Location the confluence of the Mahakam River and the Karang Mumus River](image)
2.1. Tidal
Tidal measurements have been made on 15-29 January 2019 at the confluence of the Mahakam River and Karang Mumus River. This measurement is done by manually recording using the Levelling Staff for 15 days. The harmonic analysis uses the Admiralty method, which has three stages namely the first stage, the second stage, and the third stage compiled from schemes 1 to scheme 8. The first stage is to separate the main components of the tidal by their daily processes. The second stage is by separating the main components of the tidal based on the monthly process. The third stage is the last stage, where the mean sea level \( S_0 \) is achieved as well as the constant value of the main components of the tidal such as \( M_2, S_2, N_2, K_1, O_1, M_4, MS_4, K_2, \) and \( P_1 \). The value of this constant is the value of the amplitude (\( A \), in centimeters) and the phase value (\( g \), in degrees)[9].

\[
MSL = S_0
\]

\[
HHWL = S_0 + Z_0
\]

\[
MHWL = Z_0 + (M_2 + S_2)
\]

\[
LLWL = S_0 - (M_2 + S_2 + N_2 + K_1 + O_1 + P_1 + M_4 + MS_4)
\]

\[
MLWL = Z_0 - (M_2 + S_2)
\]

\[
Z_0 = M_2 + S_2 + N_2 + K_2 + K_1 + O_1 + P_1 + M_4 + MS_4
\]

The tidal in Indonesia is divided into four types of tidal based on the value of Formzahl number where \( 0.25 \leq F \leq 1.5 \): Semi Diurnal Tide is one day occurring twice high and low water with almost the same height, tidal occur sequentially. Average tidal period of 12 hours 24 minutes, \( 0.25 < F \leq 1.5 \): Mixed tide, Prevailing Semi diurnal is in one day occurs twice high and low water, but the height and the periods different, \( 1.5 < F \leq 3 \): Mixed Tide, Prevailing diurnal is in a day happened One time high and low water, but the height and the periods are different, and \( F > 3 \): Diurnal Tide is one day going on a one-time high and low water. Average tidal period 24 hours 50 minutes, with the formula [9]:

\[
F = \frac{AK_1 + AO_1}{AM_2 + AS_2}
\]

Where \( F \) is the number of Formzahl, \( AK_1 = K_1 \) amplitude, \( AO_1 = O_1 \) amplitude, \( AM_2 = M_2 \) amplitude and \( AS_2 = S_2 \) amplitude

2.2. Bathymetry
Bathymetry measurements were conducted on 21-22 January 2019 at the confluence of the Mahakam River and Karang Mumus River. Bathymetry surveys are related to the collection of depth data from the underwater section of the study area [5]. The type of bathymetry method used in this research is the contour method. It is a type of bathymetry survey in which the survey results are used to produce contour maps at different altitude intervals that can be used to calculate the volume [5].

According to [6], the data of the bathymetry measurements must be corrected against the surface of the sea level \( MSL, Z_0 \) and \( TWL \) at the time of measurement and correction of the distance sinking transducer (transducer correction) to be obtained depth. Reduction (correction) to the tidal of seawater is formulated as follows:

\[
r_t = TWL_t - (MSL + Z_0)
\]

\[
D = dT - rt
\]
Where $r_t$: Reduction magnitude (correction given to the result of depth measurement at $t$), $TWL_t$: True water level at the time $t$, $MSL$: Mean Sea Level, $Z_0$: The depth of the face of the below $MSL$. Equation of formula 8 generates the magnitude of correction against the tidal of the seawater and then calculates the actual depth, as in formula 9, where $D$: Actual depth $dT$: correction depth of transducer and $rt$: Low tide (correction) Sea.

Bathymetry data is displayed in the form of depth contours and 3-dimensional contours to view basic topographical forms. Contour Mapping and spatial modeling 3 dimensional this is based on Surfer software. Surfer is one of the software used for the creation of contour maps and three-dimensional modeling by basing on the grid [1]. The Data was processed using Surfer 11 with Kriging method of geostatistic interpolation or as a smoother, which can connect extreme points without isolating them [2].

Figure 2. Bathymetry data

3. Results and discussion
After the tidal measurements have been carried out in the field, data is processed using the Admiralty method to generate the value of major tidal constants (table 1). The guidelines of the major tidal constants value allow us to calculate the number of Formzahl where the type of Tidal is obtained. Besides, there is water level such as Mean Sea levels ($MSL$), Highest High Water Level ($HHWL$), Lowest Lower Water Level ($LLWL$), Mean High Water Level ($MHWL$), Mean Low Water Level ($MLWL$). The depth of the face of the below $MSL$ ($Z_0$).
Table 1. Major tidal constants of admiralty method

| $A$ (Cm) | $M_2$ | $S_2$ | $N_2$ | $K_1$ | $O_1$ | $M_4$ | $M_{S4}$ | $K_2$ | $P_1$ |
|----------|-------|-------|-------|-------|-------|-------|---------|-------|-------|
| 118.92   | 67.82 | 24.42 | 1.68  | 19.73 | 17.89 | 1.83  | 8.22    | 7.00  | 7.00  |
| 158      | 261   | 237   | 320   | 197   | 284   | 327   | 261     | 320   |       |

The major tidal constants indicate the Formzahl number of 0.408 which is categorized as Mixed Tide, Prevailing Semi Diurnal Type, with $MSL = 119$ cm, $HHWL = 275$ cm, $MHWL = 248$ cm, $LLWL = -29$ cm, $MLWL = 63$ cm, and $Z_0 = 156$ cm. Figure 2 gives a water level chart for 15 days, the Highest High Water Level, and Lowest Lower Water Level Predictions.

Figure 3. Tidal observation used admiralty method

Figure 3 explains the measurement of tidal for 15 days and the results of an analysis of Admiralty methods for water level. This data is then used for bathymetry measurements at the time of measurement and the correction of the sinking distance of the transducer (correction of the transducer) to obtain actual depth. Contour result of further bathymetry measurement in the modeled using Surfer software.

The results of the bathymetry at the base of the water show the confluence of the Mahakam River, and Karang Mumus River is shallow water with a depth of 0-20 meters. The region has a basic morphological condition that ramps and increasingly towards the center of the meeting are getting deeper. The Karang Mumus River ranges from 1 to 5 meters, after entering the meeting, which takes place in the middle of the Mahakam River with a depth of 20 meters (figure 4 and figure 5).

In this research, they have only performed Groundchek water depths (figure 5). Also, the recording results are paired with the digitization of the bathymetry from the map of Dishidros. The results obtained from both of these data are distinct in-depth. The recording of bathymetry data with the data of Dishidros is depicted along the Karang Mumus river to the cross of the Mahakam River, where in the early research seems to occur basic sedimentary deposition and the middle of the river Mahakam occurs which may be learned more about whether bedload or suspended a load.
Figure 6. Cross-section of the couple between average bathymetry data measured and average bathymetry data from Disidros

Figure 6 represents the depth of the average cross-section of the measured data and the data digitized bathymetry from the map of Disidros at the confluence of the Mahakam River and the Karang Mumus River. It was also seen an increase in sedimentation for 8 years from 2011 to 2019. With the help of AutoCAD 2018 software made cross-section each interval of 25 meters from the measurement length of Long section 800 m that has been measured from upstream to downstream from the confluence of Mahakam River and Karang Mumus River. The image of AutoCAD provides information in the form of a high difference and the area of both of which can be calculated discharge sediment. The result of the calculation of discharge obtained 251,621.52 m³.
Sediment is located on the opposite side of the Karang Mumus River discharge output. This is possible because the Mahakam river shape is curved when entering the meeting where the place lacks the rush from the current when the ebb-tide or the water towards the downstream (see figure 1), this corresponds to the research [8] on modeling hydraulics and sediment transport at River Confluences.

4. Conclusion
The tidal that have been taken over the past 15 days are analyzed by the Admiralty method providing an overview of the amplitude \( A \) and the phase value \( \varphi \) for the major tidal constants and also providing results in the form of tidal type and the prediction of water level, Where the result shows the value of Formzahl number \( F \) of 0.408 which is included in the type Mixed Tide, Prevailing Semi Diurnal and the result of the elevation of water of \( MSL =119 \) cm, \( HHWL =275 \) cm, \( MHWL =248 \) cm, \( LLWL =-29 \) cm, \( MLWL =63 \) cm, and \( Z_0 =156 \) cm. Subsequent results are used in correcting the depth in the measured bathymetry measurements.

Then a couple between the results of the measured bathymetry measurement with data digitized bathymetry from the map of Dishidros at the confluence of the Mahakam River and the Karang Mumus River, clearly seen an increase in the amount of sedimentary discharge of 251,621.52 m\(^3\) in 8 years from 2011 to 2019. The Software used here is successful in helping to facilitate both calculations and model the development of sediment that occurs at the confluence of the Mahakam River and the Karang Mumus River.

Acknowledgments
The author thanked Dr. Eng Idris Mandang, Msi, for his input in a preliminary survey conducted, and Kuswantoro, ST. MT and his colleagues who have given the spirit and opportunity to participate in conducting Research of Mahakam River-Karang Mumus River, as well as university students of 17 August 1945 and Universitas Hasanuddin University students headed by Arif and the navigation district of Class 1 Samarinda.

References
[1] Nur A, Hatta M P, Thaha M A, and Surimihardja D A 2019 Preliminary Modeling of Characteristics of Current and Batimetry in The Confluence of Mahakam River and Karang Mumus River IJEScA, 6(1) 55-164.
[2] J I Pariwono 1985 Tides and tidal phenomena in the ASEAN region 392 Flinders University of S.Aust.
[3] E Budiyanto 2005 Contour Mapping & Spatial modeling of 3 dimensions using surfers. Yogyakarta: Andi Publisher
[4] S Hadi, Ningsih N S, and Tarya A 2006 Study on Seasonal Variation of Cohesive Suspended Sediment Transport in Estuary of Mahakam Delta by using A Numerical Model J Civil Engineering, 13(12)
[5] Biron P M, and Lane S N 2008 Modeling hydraulics and sediment transport at the river confluences. In: River confluences, Tributaries and the Fluvial Network (S. rice, B. Rhoads, & A. Roy, Eds.) Chichester, West Sussex, England: John Wiley & Sons Ltd.
[6] Ferrari R and Collins K 2006 Reservoir survey and data analysis. In: Erosion and Sedimentation Manual Bureau of Reclamation, Sedimentation, and River Hydraulics Group, U.S. Department of the Interior, Denver, Colorado.
[7] Hatta M P, Thaha M A, and Lakatua M P 2018 Simulation Model Pattern Distribution Sediment at Ambon Bay, Indonesia. MATEC Web of Conferences 203, EDP Sciences
[8] Keckler D 1994 Surfer for Windows, Contouring and 3D Surface Mapping: User's Guide. Golden Software. Pensylvania: McGriwth.
[9] Leonardi N, Kolker A S, and Fagherazzi S 2015 The interplay between river discharge and tides in a delta distributary. *J. Int. Science* **80**(2) 69-78.

[10] Sukmara R B, Wu R S, and Ariyaningsih 2017 *Analysis of Flood Discharge Reduction in Karang Mumus River, Samarinda City, Indonesia* Environmental Resources Sustainable Development Seminar, At Taiwan

[11] Soeprapto 2001 *Survey Hidrografi* Gadjah Mada University, Yogyakarta