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# Characteristics of Flow Hydrophysics Variables and Flood Potential Around Kuala Jengki Estuary Manado City

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## ABSTRACT

Flood disasters along the river resulted from damage to flood barrier construction along the river bank. The damage to the flood retaining wall is technically caused by the very large hydrophysical parameters of the river flow. In theory, the flow mass density parameter shows the concentration of sediment transported through one cross-section. As a result of changes in the volume of sediment transport, there will be an increase in flow energy, followed by changes in large water masses, and this is seen as a destructive force component in some equivalent places or riverbanks, which can physically be formulated in the form of a model function. It is important to do a map of the hydrophysical character variable flow and flood potential along Kuala Jengki estuary Manado City, it is important to do because the estuary is often flooded. Measurement of the hydrophysical variable mass flow density was carried out at a depth of 0.6 rivers at high and low tides. The mass density of the flow is the mass of water containing transport sediment divided by its volume. The mass of water (sample) is measured using a scale, while the volume is measured using a measuring cup or another container that has a volume measurement. For the presentation of density data profiles and other analytical purposes, the measured data were reproduced using linear interpolation techniques. The mass density data modeling was carried out using an experimental function iteration technique containing constants. The results of the research at high tide, the position which is approximately 275 meters at measurement points 10 to 13 at a distance of 675 meters to 950 meters becomes a location that is very prone to river lip damage if there is a rise in water level due to high rainfall, or a position where it becomes flood-prone when the flow density increases, along with an increase in the volume of river water, which is followed by changes in river flow velocity carrying various types of sediment. At a distance of 165 meters at low tide, the measurement position is between 10 and 13, there is an increase in large flow discharge accompanied by an increase in flow velocity that carries flow mass (mass density) with various types of sediment transport. In this condition, the location which is 165 meters away according to the model map becomes prone to river lip damage, which means that it is a location that has the potential for flooding. In contrast to measurement positions 5 and 6 at high tide, there is a significant increase in the low mass density, while at low tide this condition does not occur, this is because the flow velocity at low tide does not change significantly, causing the mass flow density to be relatively the same.

**Keywords:** *Character, Hydrophilic, Flow, Flood, Estuary*

## 1. INTRODUCTION

This study describes the condition of the flood disaster along the Kuala Jengki estuary, Manado City, which always occurs during the rainy season. The flood disaster along the Tondano River [1] resulted from damage to the flood barrier construction along the riverbank, even though the City government has made repairs, in the rainy season with the peak flow of the

river lip construction it always breaks. Damage to the flood retaining wall is technically caused by hydrophysical parameters such as very large river flow density. The variable mass flow density is one of the two parameters contributing to flooding in various estuaries such as the Kuala Jengki estuary in Manado Cyti. Theoretically, the flow velocity and mass density parameters produce a variable flow momentum. Flow momentum is seen as a component of the destructive

force along the riverbank when there is a change in flow velocity, which brings a large flow mass. Physical conditions like this can be formulated in the form of a model function.

The strategic position of the Kuala Jengki Manado estuary which defends the city of Manado and the crossing connecting the transportation of residents around the estuary makes the estuary a means of the population's economy that must be guarded and preserved. The condition of the Kuala Jengki estuary Manado City, becomes very important and strategic to maintain its function and designation, especially during the rainy season, flooding becomes a disaster that brings great damage and losses.

The occurrence of flooding in residential areas around the Kuala Jengki estuary occurred due to the breakdown of the water barrier that limited the residential areas. Damage to the hydrophysical flood barrier construction is caused by the flow of the river carrying a very large flow density. Physically, the mass flow density is the mass of water containing transport sediment divided by its volume. The mass density character of the flow will be one of the hydrophysical variables, which has destructive power for flood barrier construction and becomes a potential disaster along the estuary. Changes in flow density along the river mouth indicate an increase in flow velocity followed by an increase in water volume with various types of sediment in the area. This relationship shows that increasing the flow rate will increase the mass density of the flow. The time series analysis based on the sediment rating curve for discharge conducted by Summer et al [2] concluded that there was no time delay between the increase in discharge and the increase in sediment transport (which also means an increase in mass flow density).

The flood disaster map model based on hydrophysical variables along Kuala Jengki estuary Manado City is very urgent to be carried out as well as a research/technology breakthrough, especially disaster risk reduction mitigation, as the impact of hydrophysical flow variables and can be a decision support system for managing the utilization of the river estuary environment.

The mass density of the flow indicates the concentration of sediment transported through one cross-section. The total material carried by the flow is called the total sediment load. The total sediment load includes bed material load and wash load Ffolliott [3]. The base load itself includes suspended loads and bed loads. a) The wash load consists of fine particles and colloids resulting from the erosion of the land surface in the upstream part. This load settles very slowly even in still water. As a result of changes in the volume of sediment transport, there will be scouring in some places and deposition in other places on the riverbed,

thus generally the shape of the riverbed will always change Soewarno [4].

The relationship between floating sediment concentration and flow rate is the relationship between the density of the flow containing the rinse load and the floating load with the flow rate. This relationship shows that increasing the flow rate will increase the mass density of the flow. Time series analysis based on the rating curve of sediment to discharge conducted by Summer et al concluded that there is no time delay between the increase in discharge and the increase in sediment transport (which also means an increase in mass flow density). Changes in flow density along the river mouth indicate the deposition of sediment transport in the area. Theoretically, the rating curve of mass flow density according to the distance along the river mouth, for density data measured at a point around mid-depth, will show the sedimentation rate of drift load (mass density) in the estuary area.

The mass of the river flow at one point on the cross-section of the river is the density of water which contains three categories of transport materials; rinse load, drift load, and bed load. The base load is only found in the layer near the surface of the riverbed, while at points in the middle layer to the river surface, the transport material consists of rinse load and floating load. Because the composition of the drift load is larger, theoretically, the flow density profile in the vertical direction is in the form of a floating load Lensley [5].

As a result of changes in the volume of sediment transport, there will be scouring in some places and deposition in other places on the riverbed, thus generally the shape of the riverbed will always change. The movement speed of sediment transport is not the same as the flow velocity, but an increase in discharge (associated with an increase in flow velocity) will increase the speed of movement and the volume of mass flow that moves from the higher to the lower surface of the river bed [6], [7], [8], and [9] suggest that there is a consistent change in the particle size of sediment transport with an increase in flow rate (or velocity). This means that the increase in flow rate in addition to increasing the mass flow rate also increases the grain size carried by the flow.

Asdak [10] describes the sediment transport speed as the product of the weight of the sediment particles and the average velocity of the particles. Sediment transport velocity is a function of river flow velocity and sediment particle size. The results of field observations show that river flow always varies, during periods of large flow it is associated with increasing sediment transport rates or river aggregation rates, when the peak flow rate has been exceeded and the flow rate decreases rapidly, the sediment rate decreases which results in river degradation.

## 2. RESEARCH METHOD

The flow mass density at each measurement point is obtained by dividing the sample mass by its volume, or the mass flow density is the mass of water containing transport sediment divided by its volume. The mass of water (sample) is measured using a scale while the volume is measured using a measuring cup or another container that has a certain volume size. For each measurement point, three samples were taken, and the water mass density data at the measurement point was the average of the data obtained from the three samples. The data from the measurement of the mass and volume of the sample were carried out at the research location. The measurement data was carried out at a point of 0.6 river depth. This data is then used as the basis for interpolation of mass density variables and determination of the density vertical profile equation.

The series of measurements and analysis of research data showed that the research method developed was starting from segment determination, measurement point determination, and measurement implementation, as well as data duplication using linear interpolation. For the presentation of density profiles and other analytical purposes, the measurement data were reproduced using linear interpolation techniques. The iteration equation for data multiplication is:

$$\rho(y) = \rho_1 + ((\rho_2 - \rho_1) / (y_2 - y_1)) \cdot (y - y_1).$$

Where  $\rho(y)$  is the density at point  $y$ , while  $(y_1, \rho_1)$  and  $(y_2, \rho_2)$  are the two (known) coordinates that delimit the interpolation area (Cheney and Kincaid, 1994: p. 121).

Density data modeling was carried out using an experimental function iteration technique containing three constant quantities:  $\rho$ ,  $k_1$ , and  $k_2$ . The modeling stage begins with the identification of the function, then sets the initial value (iteration) for  $\rho_0$ ,  $k_1$ , and  $k_2$ . The suitability of the function of the modeling results is controlled by determining the bias of the iterated data against the density data of the measurement results and interpolation.

## 3. RESULTS AND DISCUSSION

Collect data, begins with determining the position of the measurement point according to distance with various considerations of uniform, steady, and non-turbulent flow under low and high tide conditions. The point that becomes the measurement position is based on the conditions and characteristics of the flow, taking into account factors such as physical boundaries that can be used as a benchmark or basis for determining

measurements. The measurement location under the flyover is up to the measurement limit and is 1300 meters away, then becomes the model limit.

The results of measurement, analysis, and presentation of density data show that the measurement data at 17-point positions along the model boundary produce a continuous function of fairly accurate modeling results. With this continuous function, data can be extrapolated freely for the range of water depths in the measurement segment, including for points closer to the river mouth, where data is difficult to obtain from direct measurements. The continuous function also facilitates and provides flexibility in the analysis and presentation of data.

Analysis of mass flow density data and the results of data modeling of flow conditions at low tide and high tide when it does not rain, both upstream and downstream of the river in six measurement segments showed different results for several measurement positions, although found in several measurement positions for points that are equidistant from the referenced show almost the same value. At the measuring position 3, 100 meters (at the time of measurement) from the reference at high tide, the mass flow density, at the same value, is 0 (zero). This means that there is no sediment transport or the flow velocity under the sediment is 0.

This condition is caused by the mass of the river flow being held back by a larger mass of flow from the sea so that the mass density of the flow becomes zero up to a distance of 100 meters from the mouth of the estuary. In conditions like this with a large increase in mass flow density, a location that is 100 meters from the reference point becomes a potential for major flooding. This is because the mass of river flow coming from upstream will be held back by a large mass of sea flow so that all water coming from upstream will be held at the mouth of the estuary up to a position of 100 meters (this location is the meeting area between the freshwater mass from upstream and the mass of fresh water from upstream). The position of the mass flow density of 0 will shift upstream, with changes in tidal conditions according to the position of the moon and the shift in the zero price will be maximum at the time of the full moon. Flood conditions will quickly decrease along with the decrease in tidal flow (Figure-1). Mulyanto [11], Tendean.M [12], when the tide rises, heavier seawater (heavier specific gravity) will infiltrate the river from upstream with lighter density so that wedges are formed, salt water under fresh water (coating).



Figure-1. Map of the mass flow density model at high tide Muara Kuala Jengki Manado

At the measuring position of 100 meters to 120 meters the relative mass flow density is almost the same as 0.23 gram/L, at 140 meters the density is increased by 0.46 gram/L, so that at the position of 210 meters the mass flow density is 0.69 gram/L. The increase in the mass flow density value up to the measurement position of 150 meters to 250 meters from the reference point is relatively small, but at a distance of 265 meters from the reference between positions 5 and 6 to a distance of 370 meters, the mass flow density value increased significantly, meaning that the sediment transport associated with the mass flow density increased quite sharply along 120 meters (1.01 gram/L at a distance of 265 meters and the highest was 1.175 grams/L at a measurement position of 315 meters) according to the model map.

The increase in mass flow density at this position identifies that at a position along the 120 meters according to the model map, it is a location that has the potential for damage to the riverbank, which means it becomes a flood location. The results of this study are closely related to the statement of Dibyosaputro [13], the amount of sediment transported so that accumulation or sedimentation occurs is very dependent on: (a) river discharge, (b) sedimentary material, (c) flow velocity. This means that the price of the mass density of the river flow is very dependent on the volume of the river flow, the type of sediment material, and the flow velocity that carries the sediment mass density. Therefore, at a position of 120 meters (at a distance of 265 meters to 370 meters from the reference point) a strong flood barrier is recommended to withstand the flow density carried by flow velocity with various types of sedimentary materials.

At measurement position 7 at a distance of 375 meters to 670 meters the increase in mass flow density is relatively small, the mass flow density price is from 0.99 grams/L to 1,128 grams/L, a decrease compared to the previous measurement position in the range of 1.175 grams/L. Up to the measurement positions 9 and 10, at a distance of 675 meters to a distance of 950 meters, the price of mass flow density increases in the range of 1.32 grams/L to 1.31 grams/L. At a distance of 800 meters, there is an increase in mass flow density of 1.5 grams/L.

This means that in a position that is approximately 275 meters away, it becomes a location that is very prone to river lip damage if there is a rise in water level due to high rainfall, or a position where it becomes prone to flooding if there is a high water level rise due to increased river water volume, along with an increase in the speed of river flow by carrying various types of sediment.

The river flow density model map (figure-1), shows the difference in the color of the legend, where the red color indicates a location that is prone and very prone to damage to the riverbank, so that there is a potential for flood-affected locations, meaning that this location is highly recommended to build stronger flood barriers, to withstand the mass density of river flows with large flow rates and large flow speeds and various types of transport materials.

The measurement and interpolation data show the difference in the value of mass flow density at low tide and at high tide, where the mass density of the flow at high tide has a smaller value but the gradient decreases greater than the mass density of the flow at low tide. This means that at each measurement position (along the model) the mass density value of the flow at low tide is always greater than the value of the mass density of the flow at high tide. Physically, it can be explained that sediment transport material (flow mass density) generally drifts to the bottom of the flow, the greater the flow velocity, the greater the concentration of sediment transport material at the bottom of the flow.

At high tide conditions, the mass of seawater will hold the river flow so that the flow speed decreases, which results in the deposition of transport material so that the mass density price of the river flow will decrease and eventually zero. Lensley, the mass density of the flow (suspended sediment) generally drift to the bottom of the flow, the greater the flow velocity, the greater the concentration, Dickinson and Bolton [14]. Tendean.M [15], the mass density of river flow in the layer near the surface for low tide conditions shows an exponential function and at high tide has a rating curve and gradient that is greater than at low tide, for distances near the coast the rating curve becomes flat, which means the flow density becomes flat.

The modeling results for low tide conditions, the mass flow density at the first measurement position has a value range of 1.25 gram/L, the same price at the measurement position 9 at high tide, physically this is caused by the flow velocity which brings the mass density much greater at low tide than at high tide. This condition is to the theory that water from upstream with the sediment material it transports will reduce the flow velocity, while Tendean.M, The density of river flow in the layer near the surface for low tide conditions shows an exponential function and at high tide, it has a rating curve and gradient that is larger than that of low tide, for

distances near the coast the rating curve becomes flat, which means the flow density becomes the same. Softer material that can still be carried by the flow at a reduced speed will be forwarded to the sea. When the tide is in the same position, the flow velocity which brings the mass density to zero due to the larger mass of seawater restrains the flow of the river from the upstream direction (Figure-2).

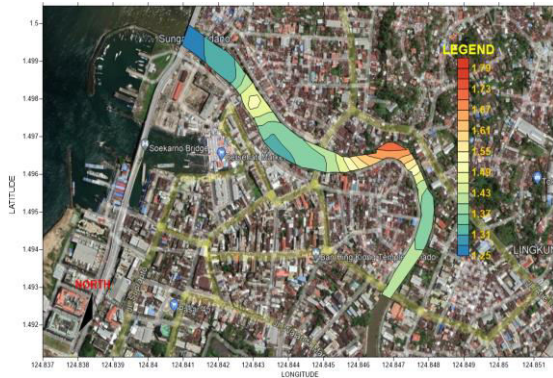


Figure-2. Map of the mass density flow model at low tide Muara Kuala Jengki Manado

From measurement position 1 to measurement position 10 at a distance of 700 meters, the mass density of the flow experienced a relatively small increase, namely in the range of 1.28 grams/L to 1.68 grams/L, physically this change is caused by an increase in flow velocity which brings a relatively small mass density. Significant changes occurred in the measuring position 10 to 13 at a distance of 695 meters to a distance of 860 meters, the mass flow density increased in the price range of 1.73 grams/L to 1.79 grams/L. This means that at a distance of 165 meters at low tide, the measurement position is between 10 and 13, there is an increase in large flow discharge accompanied by an increase in flow velocity that carries flow mass (mass density) with various types of sediment transport. In this condition, the location which is 165 meters away according to the model map becomes prone to river lip damage, which means that it is a location that has the potential for flooding.

The results are not much different from the mass flow density at high tide, which is at a position of approximately 275 meters at a measurement position of 10 to 13 at a distance of 675 meters to 950 meters, becoming a location that is very prone to damage to riverbanks, if there is an increase in water level due to high rainfall, or a position where it becomes prone to flooding if there is a high water level rise, due to the volume of river water increasing along with the increase in river flow velocity carrying various types of sediment. Being different at measurement positions 5 and 6 at high tide there was a significant increase in the flow mass density value, while at low tide this condition does not occur, this is because the flow velocity at low tide does not change significantly, causing the flow

mass density to be relatively the same for measurement positions 5 and 6 at a distance of 265 meters to 370 meters from the reference.

The results of the modeling of mass flow density data for low and high tide conditions show a change in the density function along the descending estuary, which means that the concentration of mass density flow along the estuary decreases with decreasing gradient, or the change in the mass density of flow decreases with decreasing gradient according to the distance along the estuary. Analysis of the flow density at low tide is greater than at high tide, or the mass density of flow at high tide has a lower gradient than at low tide, with the gradient becoming flattered and indicating that up to the model limits, the mass density concentrations become almost the same.

#### 4. CONCLUSION

At high tide, the position which is approximately 275 meters at measurement points 10 to 13 at a distance of 675 meters to 950 meters becomes a location that is very prone to river lip damage if there is a rise in water level due to high rainfall, or a position where it becomes flood-prone when the mass density of the flow increases along with the increase in the volume of river water and changes in the velocity of the river flow by carrying various types of sediment. At a distance of 165 meters at low tide, the measurement position is between 10 and 13, there is an increase in mass flow density followed by an increase in large flow discharge with an increase in flow velocity carrying various types of sediment transport. In this condition, the location which is 165 meters away according to the model map becomes prone to river lip damage, which means that it is a location that has the potential for flooding. At measurement positions 5 and 6 at high tide there was a significant increase in the flow mass density value (increase in flow mass density at a distance of 120 meters, according to the model map, it becomes a location that has the potential for damage to the riverbank, which means it becomes a flood location), while at low tide this condition does not occur, This is because the flow velocity at low tide does not change significantly, causing the mass density of the flow to be relatively the same.

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