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Flow Rate Profile as Determining Parameter of the Geomorphology of Lake and Beach Estuaries

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Abstract: The influence of the tide causes different coastal estuary to the mouth of the lake. Changes and differences in river flow profile at the mouth of the lake and the beach will be closely linked to the potential for erosion and sedimentation, in the estuary of the lake on the season as well as differences in coastal estuaries on the difference in the seasons and tides. Area analysis flow velocity profile being the location changes geomorphoologi rivers, lakes and estuaries estuary beach is on the lip position lakes and beaches up to 700 meters upstream of the river. Delimitation of the measurement position is consistent research purposes to measure the physical parameters of flow and changes over the estuary, then analyze and evaluate the basic morphology of the mouth of the lake and the beach under the control of two main factors namely the seasons and the tides. Changes in the morphology of the riverbed because the process can only be analyzed and evaluated based on the physical parameters of the flow velocity.

Theoretically, the flow rate of the river with sediment material that is brought is not the same, but the data is read and analyzed into a single unit with mass flow. In each segment of flow velocity measurements made on the two points on the layer near the surface of the river (bed stream flow) and at a depth of 0.6 positions are calculated on the riverbed on the segment. The flow velocity in the layer near the surface of the riverbed was measured pace using a current meter, at position 4 cm to 6 cm above the bottom of the river. This position is the closest measurement points riverbed possible, without interfering with the movement of materials in the riverbed.

Rating curve profile coastal estuary flow velocity in v0 and, v0,6 depth almost flat during low tide shows that only a small portion of material deposited sediment transport in the estuary at the site boundary studied, when the tide showed a pronounced decrease of sediment material prices the rating is characterized with steep curves in a position slightly upstream, and in a position more toward the shoreline gradient of the curve is almost constant. Physically this condition is caused by the intermingling between the mass of river water carries sediment transport cause the rating curve v0 and, v0,6 become more curved and in this position the mouth of the geomorphology process occurs as a result of slowing the speed of the river flow by seawater.

Rating curve gradient v0 and v0,6 in the dry season in the top position when entering the rainy season, and vice versa rating curve gradient v0 and v0,6 is at its lowest point when puncat rainy season, when the dry season of the rainy season and the rating curve v0 v0,6 will be turned up simultaneously decreasing the volume of the lake water and lake water level. Conversely when the rainy season than the dry season and v0,6 rating curve v0 will turn down along with the growing volume of river flow. Physically this condition is characterized by sedimentary material transport movement is during the dry season the rainy season is currently on top of the amount of the reverse process geomophologi estuary will be turned up along with the increasing flow rate followed the increase in volume of the mass flow of the river. Thus entering the dry season of the rainy season rating curve profile v0,6 flow velocity v0 and will be turned up along with the movement of sediment material were followed by a decline in volume and height of the water muaka lake, in these conditions increased process geomorphology at the mouth of the lake to the outlet.

Keywords: Profile speed, parameter, geomorphologi, the mouth of the lake, the beach.

1. INTRODUCTION

Sediment transport phenomenon in alluvial river really depends of change of sediment transport mechanism, sediment transport classification and change of flow transporting sediment concentration. Sediment transport material and its changes depends on sediment composition, slope and riverbed morphology, as well as weight of transported sediment. Several studies provided parameter of flow rate and its change can determine various other physical variables such as flow mass, flow momentum and drag force of river flow, as well as controller of geomorphological process of estuary with various types of sedimented transport material (B.Chen and K.Wang, 2008, G. Mouri, M. Shiiba,T. Hori, and T.Oki, 2011, Kumajas M.2005, Tendean, 2012). There are various impacts of river flow rate, such as change of sediment transport volume, erosion in several locations and sedimentation in other locations cause riverbed to keep changing. Therefore, geomorphological process is substantially tightly related with river flow activity, sediment transport material transportation process and its sedimentation.

Morphological process of riverbeds in lake and beach estuaries can be controlled physically by two main power, i.e. seasonal condition in lake estuary and tidal and seasonal condition of beach estuary. Seawater tidal effect makes beach estuary different from downstream lake estuary. Generally, riverbed slow in lake estuary is smaller than downstream beach estuary, so the flow rate in lake estuary is lower than downstream beach estuary. The physical parameters cause difference of river flow patterns in lake estuary and beach estuary. Flow pattern will impact the characters of transport materials in lake estuary and beach estuary. Change and difference of river flows in lake estuary and beach estuary are tightly related with erosion and sedimentation potentials (geomorphological processes) in lake estuary area in seasonal condition and beach estuary in seasonal and tidal conditions. In reality, river flow condition and high tide in beach estuary can produce alluvial formations (agradation) such as delta, sandbar, while low tide can cause riverbed erosion, causing degradation along the estuary. The potential of formation of morphological formations in the bottoms of lake and beach estuaries can be studied physically from sediment transport material mechanism by observing any change of flow rate parameter profile from time to time.

Actually, river flow parameters are very complex as a reuslt of various characters of fluid flow, such as steady-unsteady, uniform–non uniform, and rotational – irrotational. Physical assumptions of flow can be used as basis of measurement and calculation with basic physical equations for every review point where flow rate parameter can have fixed price for measurement interval. In this condition, the review would focus on analysis of profile of river flow rate as a determining of the geomorphology of lake and beach estuaries. Specifically, the analysis aimed to evaluate the flow rate profile of rivers which end in lake and rivers which end in beach as the determining parameter of change of sediment transport material (geomorphology) along lake and beach estuaries.

2. THEORETICAL REVIEW

The position of river flow of lake and beach estuaries is unsteady where the speed of fluid particles passing every point is a time function, meaning the speed of fluid particles passing a section is time and space functions. In another point, fluid particles may have different speed from the speed of fluid particles passing the first point. This condition can be achieved at low flow rate or when water flows calmly. Properties of fluid similar with the property of the flow above are described by Ven Te Chow (1984), Asdak C. (2002) as steady–unsteady, uniform–

non uniform, and rotational – irrotational, becoming physical assumptions which can be used as basis for measurement and calculation. If the assumptions that the flow is steady, doesn't whirl, isn't compressed, uniform and isn't dense are met, basic physical equation can be used in every area or review point where physical variables such as flow rate, current density can have certain and fixed price for measurement interval. If the assumptions aren't met, physical equations can only be applied on microscopic area and in very narrow interval. So, the procedure and calculation to describe a macroscopic phenomenon become very complex. For field study on fluid movement, it's usually assumed that it's steady, doesn't whirl, isn't compressed, uniform (Ven Te Chow, 1984, R.J. Uncles and J. A. Stephens. 2010, M. Singh, I. B. Singh and G. Muller. 2007). Actually, river flow parameters are very complex because of the characteristics of fluid flow. For example, to meet the steady requirement, we don't have perfect solution, but only approaches (Huang H, 1992). The approaches include step analysis by limiting interval where change of speed is assumed to be very small and then analysis for steady condition can be applied (Ven Te Chow, 1984). It can be assumed that flow rate is a controller of sediment transport, transport material sedimentation and riverbed erosion. Generally, transport material deposition on the base and along river bend happens at low speed or flow discharge, or when water surface is low (Arsyad, 2006). Sediment remobilization happens during high discharge period or increasing in high water surface condition, De Boer (1992).

Jansson (1992), who measures and studies relation between duration of rain, flow discharge and sediment transport concentration, finds significant log-linear regression relation between duration and flow discharge and between duration and concentration, log-log regression between flow discharge and suspended sediment concentration. Soewarno (1991), describes that in river flow, the amount of caught sediment depends on hydraulic condition (flow rate, turbulence, riverbed slope), and caught sediment can be separated into bed load and suspended load.

The relation between suspended load concentration and flow discharge is the relation between current density which contains wash load and suspended load, and flow discharge. The relation shows that increased flow discharge will increase current mass density. Time series analysis based on sediment rating curve on flow discharge, which is performed by Summer et al (1992), concludes that there is no time delay between increased flow discharge and increased sediment transport (which also means increased current mass density). Change of current mass density along river estuary shows geomorphological process in the area. Theoretically, the rating curve of flow mass density by distance along river estuary for density data measured around medium depth will show that suspended load sedimentation level in estuary is associated with increased morphological change of the bottom of estuary by suspended load sediment.

Bed load is sediment transport component moving in the layer near riverbed (bed stream). Movement of bed load may be rolling or leaping due to collision (momentum) between particles (Garg, 1979, Ven Te Chow, 1984). The speed of bed load isn't the same as flow rate, but increase of flow discharge (with increased flow rate) will increase the speed of the movement and bed load volume moving from higher riverbed to lower riverbed (Zhian X., and Gangyan Z., 1992, Garg, 1979). Ongley (1992), Walling (1977). Foster et al. (1992) state that there is consistent change of sediment transport particle size compared with increased flow discharge (or speed). It means increased flow discharge increases bed load flow discharge and particle size carried by current, which is associated with increased morphological change of the bottom of river estuary due to bed load sediment.

Yuqian (1992), states that sediment transport phenomenon in alluvial river really depends of change of flow and capacity of sediment transport with adjustment of bed composition change, slope and morphology of riverbed. Research results show that flow rate and its change strongly determine the flow discharge and transported or sedimented material composition. Flow rate of the layer near riverbed also determines erosion of riverbed. Bartnick et al. (1992) state that if parameters hydrology and particle size distribution are known, the critical value of can be determined as long as riverbed particle size distribution has been measured before and after flood. As a result of the change of sediment transport volume, erosion happens in several places and sedimentation happens in other places in riverbed. Therefore, generally the shape of riverbed (morphology) will keep changing (Soewarno, 1991). Widiyanto, (1986), M.Singh, I.B. Singh, and G.Muller, (2007), the geomorphological processes at work include transporting sediment from upstream. Some is immediately sedimented (in estuary), some enters sea or lake. Substantially, geomorphological process is tightly related with hydrology. River flow activity which causes surface erosion (change of land shape), or sediment transport and sedimentation is the main exogenous force of geomorphology. Component of geomorphological process (defined as morphological process) is especially related with water flow activity, which is a hydrology study.

Formation and morphological process of riverbed in estuary area is controlled by two main parameters, i.e. river water flow and seawater tide, where tide causes the estuary to be quite different from the upstream (J.Z.Shi, 2010). Generally, riverbed slope in estuary is smaller than upstream, so flow rate in estuary is lower than upstream. Another factor related with flow rate is erosion potential in estuary is lower than upstream. In most rivers, estuary is material sedimentation or sediment transport carried from upstream (Widiyanto 1986, Dibyosaputro, 1979, S.M.Yadav and B.K.Samtani 2008). River flow condition and seasonal activity, tide in estuary creates alluvial formations (morphological process) such as: alluvial plain, delta, sandbar, laguna etc. Potential for the formations above can be studied physically through sediment material transport mechanism, and conversely geomorphological process as a result of physical parameter pattern profile of flow in estuary can be studied from observation of change of formation from time to time. Dibyosaputro (1979), state that the amount of transported transport material which causes sedimentation depends on: (a) river flow discharge, (b) sediment material, (c) flow rate.

3. MATERIAL AND METHODS

The area of flow rate profile analysis which was the location pf geomorphological change is Panasen river estuary, Tondano Lake from the edge of the lake to ± 700 meters to downstream and Ranoyapo Amurang river estuary, which was between the upper limit of the highest tide to around ± 700 meter s downstream of the edge of the beach. The measurement position limit was established consistent with the purpose of the study, which was measuring physical parameters of river flow and its change along estuary and analyzing, evaluating morphological process of river estuary under the control of two main factors, i.e. season and tide. Change of riverbed due to morphological process can only be analyzed and evaluated by physical parameters of flow rate.

Generally, this research would study the morphological process of lake and beach estuaries by studying flow rate parameter profile, which was operationally stated as rate of movement of water mass which contains sediment past a section of a river. River flow rate was measured current meter. The reading of data of flow rate was speed of water with transport material when passing a section of current meter. Although theoretical, water speed with materials or sediment it carries differs, but the data reading was analyzed as a flow mass unity. In every segment, flow rate measurement was performed in two points, i.e. the layer near riverbed (bed stream flow) and 0,6 depth calculated from the riverbed in the segment. The flow rate in the layer near riverbed was the speed measured by current meter, four to six cm above riverbed. This measurement position was the closest possible position to riverbed without disturbing the movement of riverbed materials. Measurement right on riverbed is difficult, especially because of disturbance of riverbed surface materials (Yugian L, 1992). The unit of the speed measured by current meter was feet per second, which was then transferred into centimeter per second ($cm.sec^{-1}$). The analysis and evaluation of morphological process of riverbed was determined by analysis of physical parameters of critical threshold velocity for riverbed erosion and critical speed of sedimentation. Critical threshold velocity of erosion is determined by physical scales such as particle speed, particle diameter and specific gravity (Schwab et.al., 1981). Erosion potential of the bottom of the estuary was determined by critical speed range value suitable with the ranges of particle size and specific gravity. If the flow rate exceeds critical threshold velocity (for particle diameter and specific gravity) consistent with riverbed materials, the particles in the riverbed will be transported downstream. Conversely, if the flow rate is lower than critical threshold velocity, riverbed won't be eroded and riverbed materials won't be transported.

Critical velocity of sedimentation is the maximum speed limit for sedimentation in a point in a river segment. The speed depends of variables depth and cvr (critical velocity ratio) value, which depends on sediment type. cvr value can be determined from "recommended values of cvr" table after identifying sediment type. The potential of bed load sedimentation and geomorphological potential are determined by physical scales, such as critical velocity, critical value ratio, which depends on sediment material type and water depth. According to Zhian and Gangyan (1992), C.Yang, C.Jiang, and Q.Kong, 2010), although there are many calculation methods developed to determine bed load, no calculation can be used universally for all sediment size, riverbed configuration and flow regimes. The main difficulty is the calculation method of determining the size distribution of particle moving in riverbed. Bartnik et al. (1992) state that bed load transport happens if flow discharge exceeds critical value. It's not easy to determine flow discharge where bad load will start moving.

4. RESULT AND DISCUSSION

The method and analysis aimed to measure the physical parameters of flow rate and its change along river estuary and evaluate the morphological process of river estuary under two main factors, i.e season and tide. Change of riverbed due to morphological process only can be analyzed and evaluated by physical parameter flow rate. It's because riverbed sediment material transport is physically controlled by critical velocity of river flow rate. The physical assumptions used as basis of measurement and calculation, such as steady, not whirling, not compressed, uniform and not dense, must be met, so basic physical assumptions were used. In this condition, physical parameter flow rate had certain and fixed value for measurement interval, such as flow rate in seasonal condition (rain and dry) measured in lake estuary and measurement condition (tide) of beach estuary in the rainy season. Profile and function and flow rate and its change along lake estuary during dry and dry seasons and beach estuary during low tide and high tide are shown in the Figure below.

Profile of flow rate of beach estuary shows that the rating curve (v_0) during low tide is higher than Graph (v_0) during high tide as shown by Figure-1. This shows that river flow rate during low tide is bigger than during high tide. The rating curve (v_0) during low tide has lower gradient than during high tide. It's because sea water resists river flow rate, so that ± 600 meters toward shoreline the value of (v_0) during high tide becomes zero. Bogen. J. (1992) finds that flow rate profile in estuary has declining gradient by distance. Analysis of beach estuary flow rate shows that rating curve (v_0) during high tide shows that increased height of high tide increases

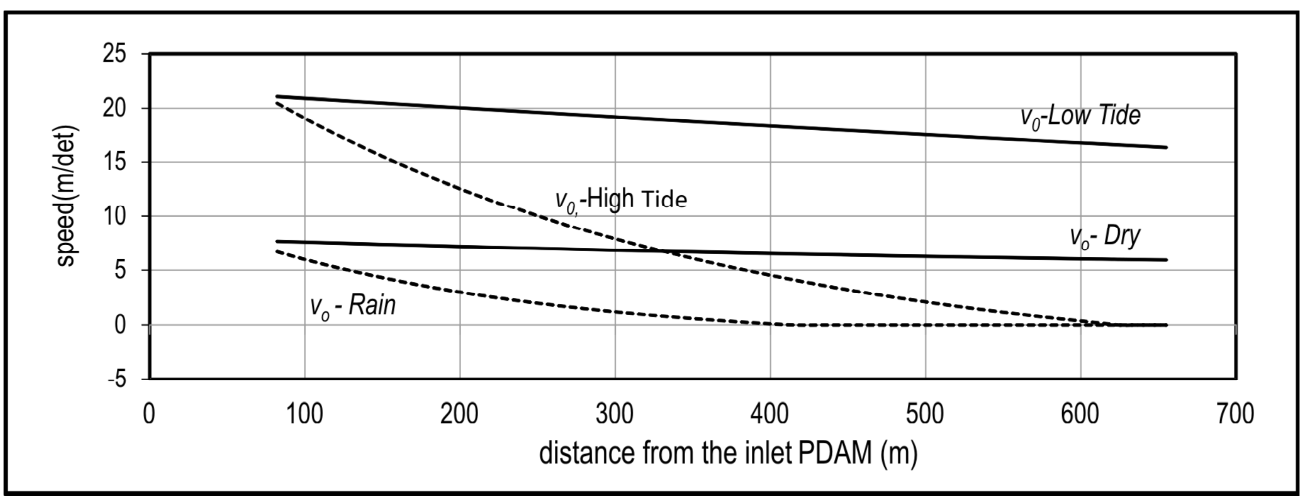

Figure 1: Profile of flow rate in the bottom (v_0) of lake estuary and beach estuary

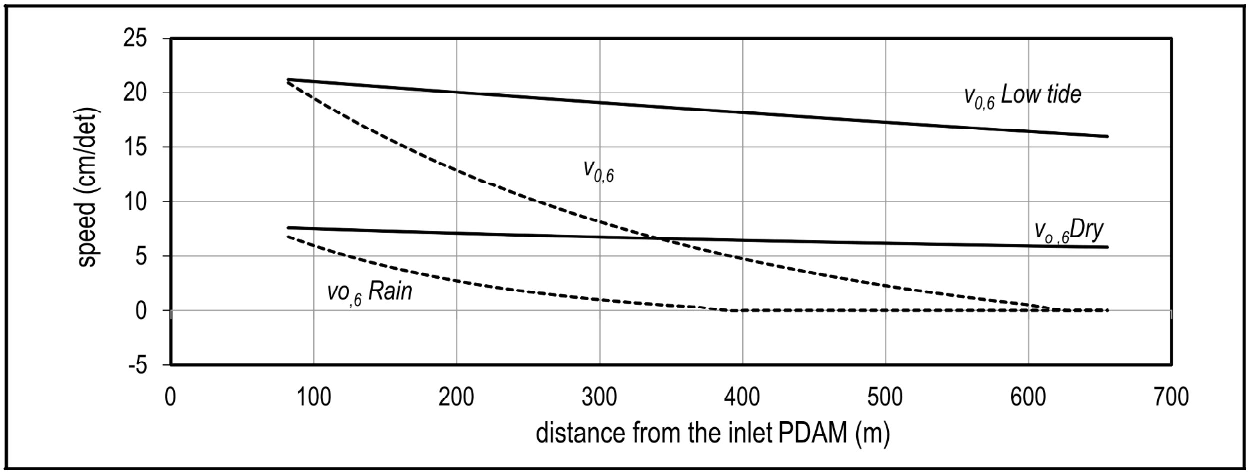

Figure 2: Flow rate profile 0,6 ($v_{0,6}$) from the bottom of lake and beach Estuaries

the gradient of the rating curve, and the point with zero velocity moves downstream. Physically, increased high tide accompanies the mixing of water mass carried by river flor with seawater mass, followed by sediment material sedimentation process (morphological process of the bottom of estuary) in area closer to downstream.

Analysis and modeling of $v_{0,6h}$ during high tide shows that velocity change function declines polynomially, so the rating curve of $v_{0,6h}$ during low tide is above the graph of $v_{0,6h}$ during high tide. It means flow rate during low tide 0,6 from the bottom of the river is bigger than the flow rate during high tide. The rating curve of $v_{0,6h}$ during low tide has lower gradient than high tide. It's because seawater resists river flow rate so that ± 700 meters to the shoreline $v_{0,6h}$ during high tide becomes zero. The river flow rate profile shows that the rating curve of $v_{0,6h}$ during high tide is zero starting from 600 meters toward the shoreline. At > 600 meters, the flow rate at 0,6 depth is zero. Increased height of high tide increases rating curve gradient and the point which has zero speed will move upstream. Similar thing happens because there is thicker bed load concentration in the riverbed, so that there is riverbed friction, which reduces the flow rate.

Comparative analysis of graphs v_0 and $v_{0,6h}$ during high tide shows that the flow rate in the bottom layer becomes zero closer downstream that then speed at 0,6 depth. Physically, it's because the density of seawater is higher than the density of river water, so the profile of the boundary of the meeting of both densities will have reduced gradient closer downstream. In this condition, lower water mass layer will slow down closer downstream (Schwab et al.1981, Kiyoto Mori et al, 2003) and (Tendean, 2006). Mulyanto (2010), Tendean (2012), during high tide, heavier sea water (higher specific density) will slip under river water flow from downstream with lighter specific density to form wedge, salt under freshwater (layering). Theoretically, flow rate in the middle (vertical direction) is bigger than the riverbed.

The measured rating curves of beach estuary flow rate (v_0,$v_{0,6}$) during low tide and during high tide were parameter too evaluate geomorphological process (bed load, suspended load and wash load transports and sedimentations) of the bottom of the estuary. The nearly flat rating curves of v_0 and $v_{0,6h}$ during low tide shows that only a small part of sediment transport material is sedimented in the estuary, in the boundary of the research location. The rating curve of $v_{0,6}$ during high tide shows drastic reduction of sediment transport material value closer downstream and toward the shoreline the curve gradient is almost constant. Drastic reduction of sediment transport material value is characterized by steep curve (Figure-1, Figure-2), showing that flow the position closer downstream to the position where curve (v_0,$v_{0,6}$) slopes (almost flat) there is geomorphological process. The process happens because river flow rate is slowed by seawater. Nearly flat graph (v_0,$v_{0,6}$) closer to the shoreline shows that sediment transport material is almost homogenous. In this condition, geomorphological process in beach estuary reaches the highest point.

Similar to bed load, the positions of suspended load and wash load sedimentations depend on the height of sea level. When the height of sea level increases, sedimentation position with morphological change of riverbed will move downstream. Conversely, when sea level lowers, the morphological position of the bottom of the estuary will move to the shoreline. Because the materials are lighter, it's estimated that the morphology of the bottom of the estuary which has been formed during high tide will be partially carried back during low tide due to increased river flow rate in the riverbed surface layer.

The difference of erosion critical velocity and flow rate in the layer near riverbed during measurement was relatively small, showing that if flood rises, the riverbed morphology which has been formed in the estuary can be eroded. So in normal condition to medium flood, the morphological process taking place in the estuary is sedimentation. The rate of morphological change of the bottom of the estuary will rise during high tide because river water flow slows because of the resistance of seawater. The result is consistent with theory of (Bird, 1964, P. Gao, 2011, M.Singh, I.B. Singh, and G.Muller,2007), that geomorphologies of estuary and beach depend on seawater tide. The same theory is stated by short and wright in widiyanto (1986), that the morphology at a time is the function of the characters of sediment and seawater tide. The same study is performed by Bogen J. (1992), Tendean (2006), who find that flow rate profile in estuary has lowering gradient by distance.

The flow rate profile of lake estuary show that rating curve (v_0) during dry season is higher than Graph (v_0) during rainy season, as shown in Figure-1 and Figure-2. The condition shows that river flow rate during dry season is higher than during rainy season. The rating curve of (v_0) during dry season has lower gradient than during rainy season. The rating curves of v_0 and $v_{0,6}$ in lake estuary during rainy season shows that functions v_0 and $v_{0,6}$ declines polynomially, meaning flow rate along the estuary declines with lowering gradient the further it is from the estuary, forming a lowering curve, or declining flow rate change profile by forming lowering curve by distance along the estuary. This happens because the water mass of the lake resists river flow rate, so that ± 400 meter toward the edge of the lake, (v_0) of rainy season is zero. It means there is more still lake water mass layer than the water mass carried by river slow and the restrained flow rate to an amount immeasurable by current meter. When density is the same and temperature difference of the water carried by sea water and lake water causes water mass mix which resists river flow to the edge of the lake declines sharply (Mulyanto, 2010, Tendean 2015). Analysis of flow rate function of Panasen estuary of Tondano Lake shows that the Rating curves of (v_0) and ($v_{0,6h}$) during rainy season shows increased height of lake water, increasing the gradients of the rating curves, and the point which has zero speed will move downstream.

The comparative analysis of the rating curves of v_0 and $v_{0,6}$ in rainy and dry seasons shows that the flow rate during rainy season has smaller value but the gradient declines more than in dry season. It means that in every measurement position, the values of v_0 and $v_{0,6}$ during dry season are always higher than the values of v_0 and $v_{0,6}$ during rainy season. In this condition, sediment transport material will be carried by the current. The bigger the flow rate, the bigger the concentration of sediment transport material carried by the current. During rainy season the measurement of the rating curves v_0 and $v_{0,6}$ is flatter at 400 meters. It shows that from the position to the boundary of the measurement location, the concentration of sediment transport material is nearly the same. It happens because the mass of river water carrying sediment transport mixes up, making the curve more curved and in this position there is morphology process in the bottom of the lake estuary. The result is consistent with the theory of (Lensley 1972), that suspended load is generally carried by current. The higher the speed, the bigger the concentration. The same opinion is stated by Dickinson and Bolton (1992) .

The gradients of the rating curves of v_0 and $v_{0,6}$ during dry season are at the highest position when entering rainy season. However, the gradient of the rating curve of v_0 and $v_{0,6}$ are at the lowest point at the peak of rainy season. When entering dry season, the rating curves of v_0 and $v_{0,6}$ increase along with declining lake water volume and the height of lake water. Conversely, when entering rainy season, the rating curves of v_0 and $v_{0,6}$ decline along with increasing volume of river flow. Physically, this condition is characterized by the highest amount of movement of sediment transport material when entering rainy season. Conversely, the geomorphological process of the bottom of the estuary will increase along with increased flow rate, followed by increase volume of river flow mass. The peak of the morphological process of the bottom of the estuary is when entering rainy season, characterized by declining gradient profiles of the rating curves of v_0 and $v_{0,6}$ to the smallest during the peak of rainy season. So entering dry season, the profile of the rating curves of v_0 and $v_{0,6}$ of flow rate will increase along with the movement of sediment material, followed by declining volume and height of lake water estuary. In this condition, there is increased geomorphological process in the mouth of the lake toward outlet. The peak of the increase of the gradients of the rating curves of v_0 and $v_{0,6}$ of flow rate is at the peak of dry season, characterized by the smallest morphological process of the bottom of the estuary.

5. CONCLUSION

The morphological process of the bottom of beach estuary depends on sea tide, which is associated with sea level. When sea level increases, sedimentation with morphological change of the bottom of the estuary will move downstream. Conversely, when sea level declines, the morphological position of bottom of the estuary will move to the shoreline. Due to lighter materials, it's estimated that the morphology of the bottom of the estuary which has been formed in high tide will be partially carried back during low tide due to increased river flow rate in riverbed layer.

The peak of the morphological process of the bottom of the lake estuary happens when entering rainy season, characterized by declining gradient profile of the rating curve to the smallest number at the peak of the rainy season. So, when entering the dry season, the profile of the rating curve of slow rate will increase along with movement of sediment materials, followed by declining volume and height of lake water surface. In this condition, there is increased geomorphological process in the mouth of the lake toward outlet.

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