SEDIMENTATION RATE BASED ON OCEANOGAPHIC PARAMETERS REVIEWS IN THE ESTUARY OF KAPUAS, CENTRAL KALIMANTAN

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SARI

Secara geografis daerah penelitian terletak di muara Sungai Kapuas Kalimantan Tengah. Kawasan pantai ini sangat terbuka dipengaruhi oleh aksi gelombang dari arah tenggara, selatan, baratdaya dan barat. Di pesisir pantai muara Sungai Kapuas terdapat arus sejajar pantai yang bergerak masuk ke arah muara. Pergerakan arus sejajar pantai tersebut memasok sedimen dari arah tenggara dan barat ke muara. Sedimen tersebut cenderung diendapkan di sisi barat dari muara Kapuas. Hal ini menjadi kendala alur pelayaran di muara Sungai Kapuas.

Kata kunci : arus sejajar pantai, muara, Kapuas

ABSTRACTS

Geographically, the study area is located on the coast of Kapuas River mouth, Central Kalimantan. This open beach area is affected by wave action from southeast, south, southwest and west direction. The longshore current drifts to the estuary on the coastal zone of the Kapuas River. It gives potential sediment supply from the southeast to the north. The sediment tends to be deposited in the western part estuary of Kapuas.This particular thing evokes the ship navigation in Kapuas estuary.

Keywords : longshore current, estuary, Kapuas

INTRODUCTION

The study area was geographically located on 3º20'00" - 3º30'00" S and 114º 07'00"- 114º20'00" E, approximately 150 km southeast of Palangkaraya (Figure 1). Secondary data showed that the depth of estuarine waters in Kapuas was ranged from 0.5 to 8 meters (Hydro-Oceanography Service of Indonesian Navy). Located in the southern part of Kalimantan, Kapuas estuary became one of many accessed to enter Central Kalimantan by sea, and thus making this area important for coal transportation as well as national-scaled shipping.

The estuary and coastal region of the particular study area was a unique, dynamic, and vulnerable to any environmental alterations. Factors that may influence the

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Figure 1. Study area (Earthgoogle, 2010)

estuarine environment of Kapuas are as follow : deforestation, activities on the mainland mining activities in the upstream areas, population growth, climate change and the dynamics of coastal environments. Deforestation is considered to be the most influential factor to accelerate sedimentation in downstream areas, which impacts on shoaling in the estuary. Moreover, Kapuas waters was influenced by dynamic interaction between oceanic sea-water input and freshwater.

Freshwater flow into the sea is a function of watershed, surface runoff, and groundwater flow characteristics. The balance of freshwater and seawater at the estuarine is influenced by the precipitation rate and evapotranspiration. Various human activities on land of Central Kalimantan, push the coastal environment alteration. Natural external influences to the coastal dynamics are ocean energy, in the form of oceanographic parameters, wave, tide and current while material input in the form of sediments, particles and pollutant are generally fluxed through the river flow.

However, those material inputs would not always causing negative impacts to the development of coastal environments.

Alteration of coastal environments was likely due to the natural processes that periodically affect the coastal areas, such as fluctuations in oceanographic parameters and dynamics of local climate.

The material of sediment flowing toward the sea is strongly influenced by currents and waves dynamics in the coastal area, either from eastern or from western parts of Kapuas estuary. Hence, the interaction of oceanographic parameters dynamics with sedimentation that yield in silting in the estuary, was examined. This research was conducted at the initiative of Agency for Mining and Energy of Central Kalimantan Province, in collaboration with Marine Geology Institute (P3GL) in 2004.

PHYSIOGRAPHY AND LITHOLOGY

Physiographically, the study area it an open water area influenced by wave activities of East and West Monsoon; while local dominant influencing natural factors of this coastal estuary are waves, currents, sea level fluctuations, sedimentary material supply, and local climate dynamics.

The lithology is comf…. alluvial, deposits sand and gravel. Beach slope is 5 to 20 degrees. to the south. Major river that drain into this area, is Kapuas River.

METHODS

Methods utilized were oceanographic parameters observation, climatologic data collection, and mapping of sea depth (sounding). The Mapping was performed simultaneously with tidal observations to obtain average elevation of water surface (Mean Sea Level/MSL). Climatologic data utilized was 5 years surface wind data from Palangkaraya Airport Meteorological Station (1998-2002).

The five year wind direction frequency data were utilized to analyze sediment movement along the shore (longshore drift); while the values of oceanographic parameters, such as wave height (H) and period (T) were also used to analyze the alongshore current using deep water wave forecasting curve (Bretschneider, 1954).

Furthermore, to determine the amount of sediment supply (Q), the approach was using empirical linear equation formulated by Komar and Iman in Bijker (1988). The amount of sediment rate supply can be approached using following formulation :

$$Q=C * P_l / (\rho_s - \rho)g (1 - p) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Assuming value of gravity acceleration (g) 9.81 m/s^2, sediment porosity (p) 0.4, constant (C) 1288, water density (ρ) equal to 1025 kg/m^3 and sediment density (ρ_s) 2650 kg/m^3 were used. P1 is energy flux.

Q values obtained from this empirical approach were the average supply of transported sediments along the shore (longshore-transport rate) in units of cubic meters per year (m^3/year), while the alongshore current value was obtained from sediment movement curve formulated by Ijima and Tang (1967). P1 was obtained substituting the value of wave angle to the coastline (Ø), and the flux of wave energy (Po) to the formulation below:

$$P_l=Po(0.5)Sin2Ø \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Alongshore flow visualization was presented in the alongshore sediment movement map.

A twenty six hours static observation was done in the estuary of Kapuas to determine the speed and direction of tidal currents.

Sediment sampling was conducted at several locations to examine the seabed sediment deposits. The result yielded were then processed and classified according to the

Folk grain size classification (1980) (grain size analysis).

RESULTS

The climatological data had been processed to estimate the percentage frequency of wind direction such as shown below (Figure 2).

sea depth is decreasing and offshore sandbar was found as well. The sandbar was allegedly originated from Kapuas estuary indicated by the alongshore currents movement on the southwest side of the estuary.

The result of grain size analysis using Folk's clasification (1980) showed that sediment in Kapuas estuary consisted of four types of sediment spread from north to south : silt (Z), sandy silt (sZ), silty sand (zS), and sand (S) (Figure 4). The silt was scattered in the southeast, of Kapuas estuary, while the sandy silt was generally occupying the middle estuary towards offshore direction. Moreover, the sand and the silty sand occupied the southwest Kapuas and formed delta sediments (sandbar). Movement direction of these sediments was influenced by tidal and long shore current dynamics, which can be acknowledge from the 26-hours static stream measurement results (Figure 5), and also alongshore current movement analysis results (Figure 6).

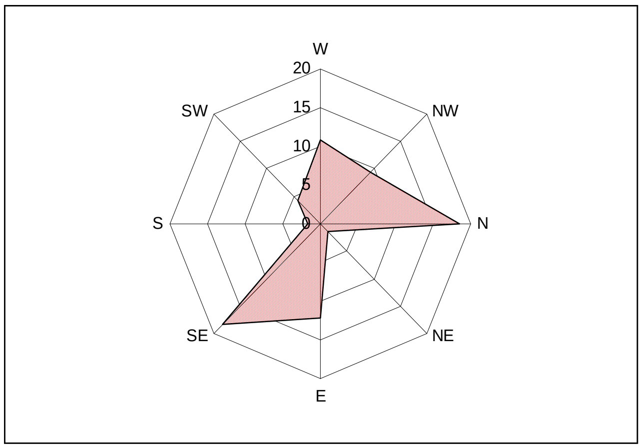

Figure 2. Windrose diagram of surface wind percentage frequency in the study area year 1998-2002

Depth Contour and Sea Floor Sediment

The sounding results showed that the depth of the study area ranges from 1 to 5 meter (Figure 3). Sea depth increases towards southeast and south, and it decreases towards the southwest directions. The pattern of sea depth contour tends to shallowing towards southeast-southwest directions, with relatively flat seabed morphology.

In the southwestern part of Kapuas estuary, a sand bar extending parallel to the coast was found during low tide. Silting in the estuary was likely moving from the western to the southwestern side of Kapuas. Likewise, in the southeastern part of Kapuas estuary, the

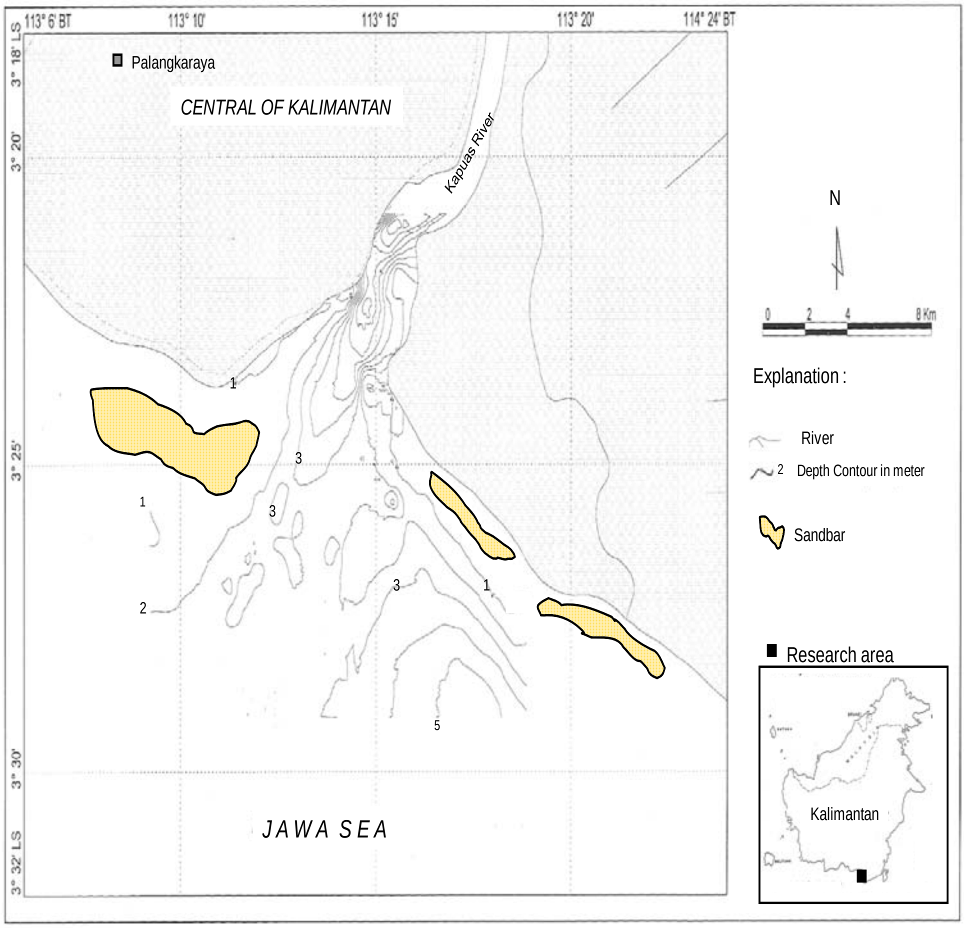

Figure 3. Sea depth map of Kapuas estuary

Tidal Current and Longshore Current Analysis

Tidal currents in Kapuas estuary were measurement for 26 hours with 15-minutes intervals. The flow velocity to the tide was 77 cm/s towards the upstream of the river, while maximum flow velocity to ebb was 131.14 cm/s towards the downstream (Java Sea) with 211 degrees direction. This condition indicates that the flow velocity to ebb is greater than one to the tide. Visualization analysis of flow and velocity of component directions is depicted in stationary flow diagram, below (Figure 5).

Components with blue notation indicates the flow direction, as the red line notation shows the velocity of tidal currents. This diagram inferred that the sediment forces from the upstream was more dominant than forces from the offshore.

In estuary area, the tidal and the long shore currents collide in opposite directions, hence there was an interaction between them which triggered deposition of sediments in the

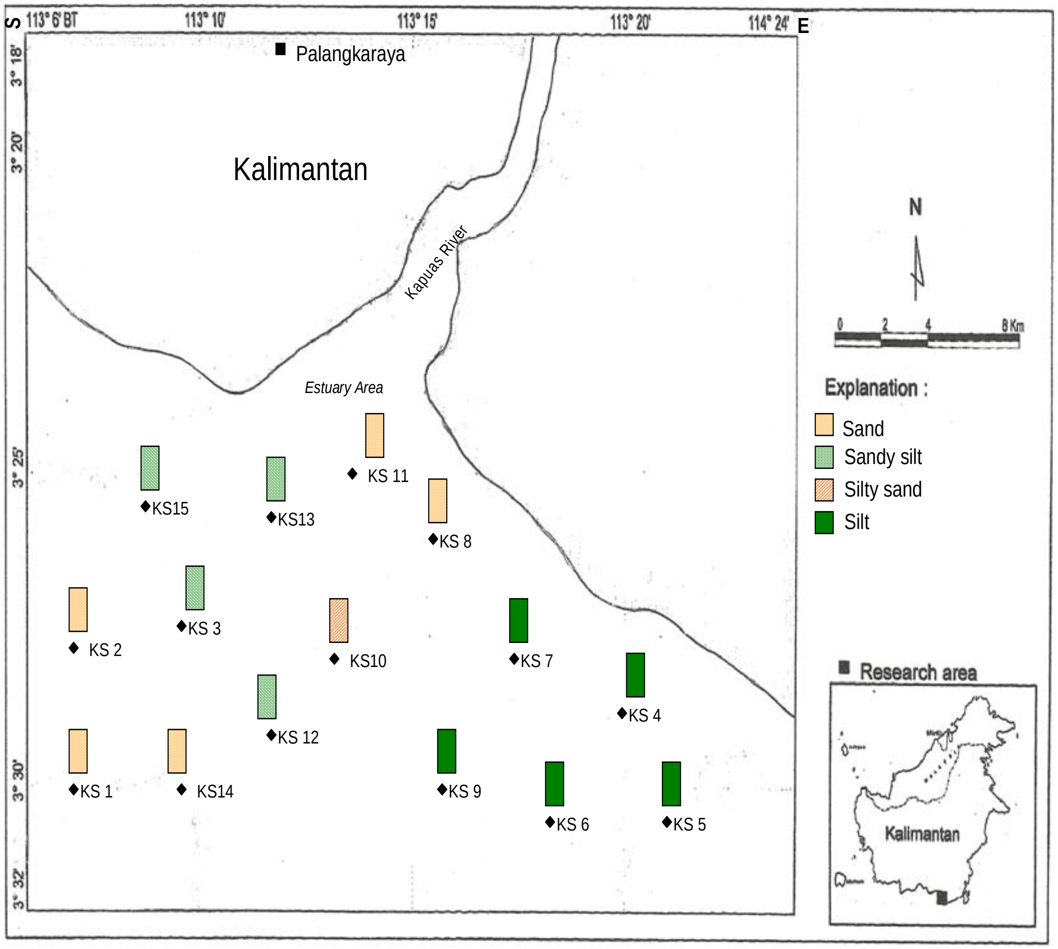

Figure 4. Sampling locations and grain size analysis result of sediment in Kapuas estuary, Central Kalimantan

southwestern and southeastern part of Kapuas River estuary (Figure 6).

This sediment movement triggered by alongshore currents in southeastern and southwestern part of Kapuas estuary, was a dominant natural process that occurs throughout the season. Thus, if sediment supply frequency from the estuary increased in the whole year, then the silting process in southwestern part of it continuous to grow.

Both Ijima and Tang (1967) approach method and deep water wave forecasting curve (Bretschneider, 1954) shows that the long-shore current direction in southwestern part of the estuary moved from point 1 to point 3, and then it went the opposite direction of longshore current from the Kapuas estuary itself. Correspondingly, the longshore current in the southeastern part of the estuary moved towards it and some part of it moved to the southeast. Long-shore current movement in

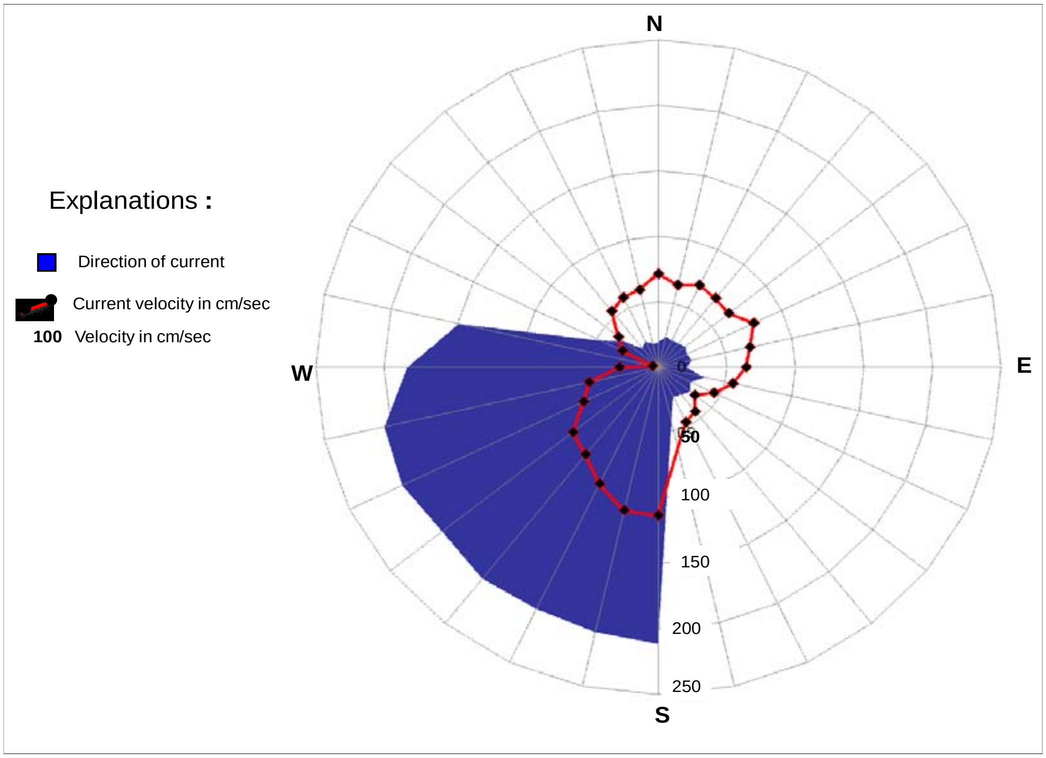

Figure 5. Analysis of flow direction and velocity components diagram in Kapuas estuary, Central Kalimantan

the southeastern part would accelerate the sedimentation in the estuary.

Conversely, the speed of tidal currents documented in the study area was rather explicitly high, hence it significantly affects the sediment movement. This was indicated by the sand-sized sediment deposited off the coast of Kapuas.

Assuming the gravity acceleration (g) 9.81 m/s^2, sediment porosity (p) 0.4, constant of sediment supply (C) 1288, and sediment density (ρs) 2650 kg/m^3, thus empirical approach to the sediment supply can be done applying to formulation of the equation 1.

Using above formulation, the mathematical relation shows that cumulative value of ($C\ P_1$) is a linear function from Q value. Therefore, the flux energy curve obtained from Kapuas estuary and its water surroundings, was a scalar quantity to determine the average material supply (Q) per time unit.

From the map of longshore currents movement, at sampling point 3 and 4 (Figure 6), Q value on the southwest side of estuary was 53.758 and -86.013 m^3/year, while on the southeast side at sampling point 9, the particular Q value was -43.006 m^3/year. The negative value means that sedimentation occurred in sampling points 3, 4, and 9 are marked by sandbars that developed in those regions.

Since the oceanographic parameter values were dynamic, thus the empirical approach of

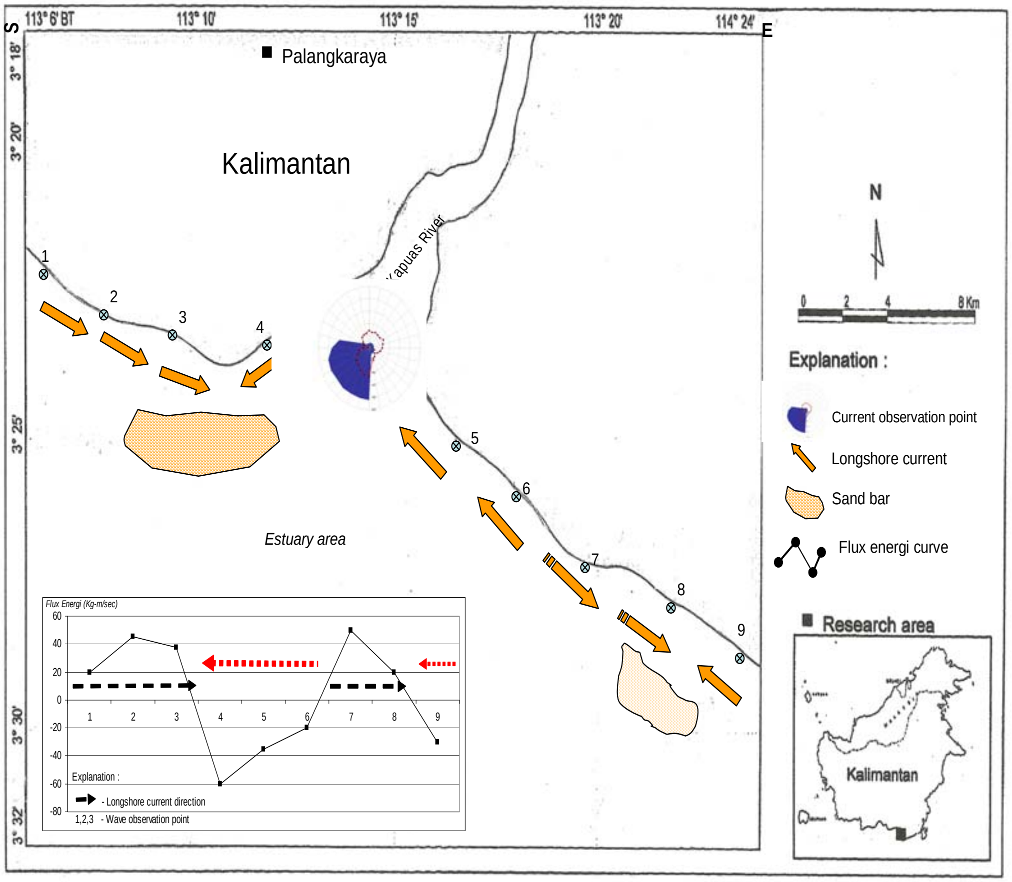

Figure 6. Map of longshore current movement analysis using Ijima and Tang method (1967)

Q value per time unit can highlight the sediment supply that moves towards southwest, southeast, and vice versa as significant. With sediment supplied from the estuary and vice versa, it can be estimated that sediment deposition in the estuary has been developed and narrowed navigation channel in Kapuas estuary, as shown in satellite images taken from Google Map (Figure 7). This particular thing evokes the shipping flow in Kapuas estuary.

CONCLUSIONS

Long-shore currents yielded from wave energy from the southeast had developed sufficient cause of significant sedimentation in the southwest of estuary, while it was relatively slighter in the southeast. This sedimentation process occurs seasonally.

The presence of sediment movements towards the Kapuas River estuary would suppose a sediment accumulation zone in the estuary and its surrounding area throughout the year. Therefore, it is necessary to make sediment trap systems (pier) at sampling points 5 and 6 in the southeast part of Kapuas

Figure 7. Current images of Kapuas River estuary, taken from satellite(Earth Google, 2010)

estuary, facing 180-degrees towards the offshore. It is required to restrain the rate of sedimentation and reduce coastal erosion in the region.

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