SEA BOTTOM MORPHOLOGY AND SEDIMENT DISTRIBUTION OF KUALA BESAR KELANTAN RIVER DELTA AND ITS OFFSHORE AREAS

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ABSTRACT. *Kuala Besar is part of the modern Kelantan River Delta complex and exhibits continuous changes in morphology because of the erosion, wave and sediment distribution. The precision of echo sounding data and 65 grab samples are integrated to reveal the bathymetry and sediment distribution at the Kuala Besar, Kelantan River Delta. Different sediment distribution patterns are found from the nearshore towards offshore, whereas the nearshore situated the fine silt size of grain, extended to the sea are dominated with the silt to sand size with account of 86%,, meanwhile the offshore area placed the sand size of sediment ranging from the 0.11 mm to 1.31 mm account for 100% maximum value. As per difference of the sediment distribution lead to the contribution of the bathymetry pattern change from the mouth bar towards the marine shelf due to the increasing of the distance from the land. These changes are brought about by the interactions of the various factors such as river influx, wave and climate that hits the coastal of east Peninsular Malaysia, where located the study area; thus resulting in morphological changes and sediments deposits pattern. The combinations of these factors produce a newly formed of the area which showing a retreat pattern of the sediment distribution promote by a gentle slope gradient of seabed morphology. Hence, the sediments distribution at different zone indicates the evolution of destructive wave types of the study area.*

KEYWORDS. Kuala Besar, Kelantan River Delta, bathymetry, sediment distribution, destructive delta

INTRODUCTION

Kelantan River Delta is located in the northeastern corner of Peninsular Malaysia and in the southwestern border land of South China Sea; at the entrance of the Gulf of Thailand (Figure 1) and is drained by one of the largest rivers, named Kelantan River. The delta covers a large area from the Tumpat in the north, Kuala Besar, Kota Bharu, Bachok to Pantai Sabak in the south. This study focusses at the Kuala Besar, part of the complex river delta that has experienced rapid morphological changes due to continuous erosion and position of the sediment (Kamal *et al*., 1997).

Kelantan Delta is influenced by the northeast and southeast monsoons. This monsoon generally sets in from the months of November to February, and hits in full force during December to January (Koopsman, 1972) with wind velocity between 4 to 7 Beaufort scale (Dale, 1956). The monsoon season bring the heavy rains to eastern of Malaysia and leads to increasing of water volume in the Kelantan River.

During the northeast monsoon season, the surface winds blows produce a constancy of surface sea current direction from South China Sea towards Kelantan Delta area. Meanwhile, during the northwest monsoon season, usually March to August, indicates the contradictive motion of the surface sea current which from South China Sea outwards the Kelantan Delta area.

Koopsman (1972) recorded that the Kelantan River Delta had influenced a destructive wave type that caused erosion at the upper beach and deposited at the offshore bars during the northeast monsoon. This energy of waves hitting the coast and eroded the longshore and disseminated the sediments deposited by the river (Kamal *et al.*, 1997), caused the distribution pattern of the sediments retreated from delta extended toward offshore area.

Therefore, this study tries to integrate findings from the bathymetry data and 65 grab samples to reveal about the morphology and distribution pattern of sediments in the Kelantan Delta. From which, the interpretation of integrated seabed morphology and sediment distribution patterns will then provide insights into the processes that control the sediment transportation, deposition and their influence on the response of the shoreline. Accordingly, the character and future evolution of this destructive delta will be better understood and predicted.

MATERIALS AND METHODS

Bottom survey and sample collection were carried out in March and May 2014. A systematic sampling type was determined, set by interval of ~3 km from one locality to other localities. Overall 65 samples were collected covering an area about ~1386 km^2 at the interval of about 3 km (Figure 2). Fieldwork involves two parts; i.e. hydrographic survey and sea bottom surface sediment sampling.

Hydrographic Survey and Bathymetry Analysis

The hydrographic survey was investigated using a portable handheld echo sounder. This equipment has fully application of electro-magnetic sound waves for depth measurement. This portable echo sounder was placed around 1 cm below the water surface and the depth reading was displayed at the backlit screen. The echo sounder reading showed the depth of the water to the bottom of the seabed. The collected depth data were processed with Surfer version 9 software to produce bathymetric contour map of the study area.

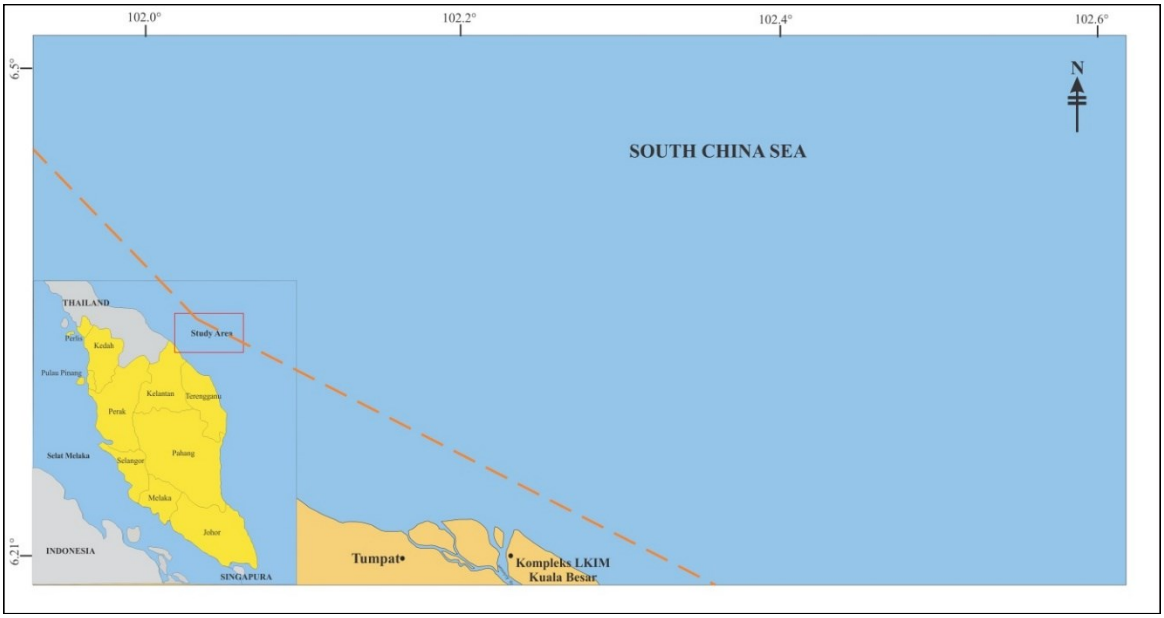

Figure 1: Location of the study area.

Sediment Sampling and Analysis

The surface sediments were collected using Petit-Ponar grab sampler. Each sample collected is retained in a plastic bag, labelled with the coordinates and placed in the storage box for laboratory analysis purpose.

The particle size analyses were carried out to find the grain size distribution by using the standard particle size analysis; wet sieve and hydrometer analysis. Before the sediments were analysed, the sediments need to dry using oven for one night to remove water content in the sediments. The sediments ranging from 4.0 mm to 0.063 mm were analysed using the sieve, however if the sediments passed through the pan sieve; and remained in the sieve opening less than 0.063 mm, the hydrometer analysis technique was used. The results obtained were presented in the Table 1.

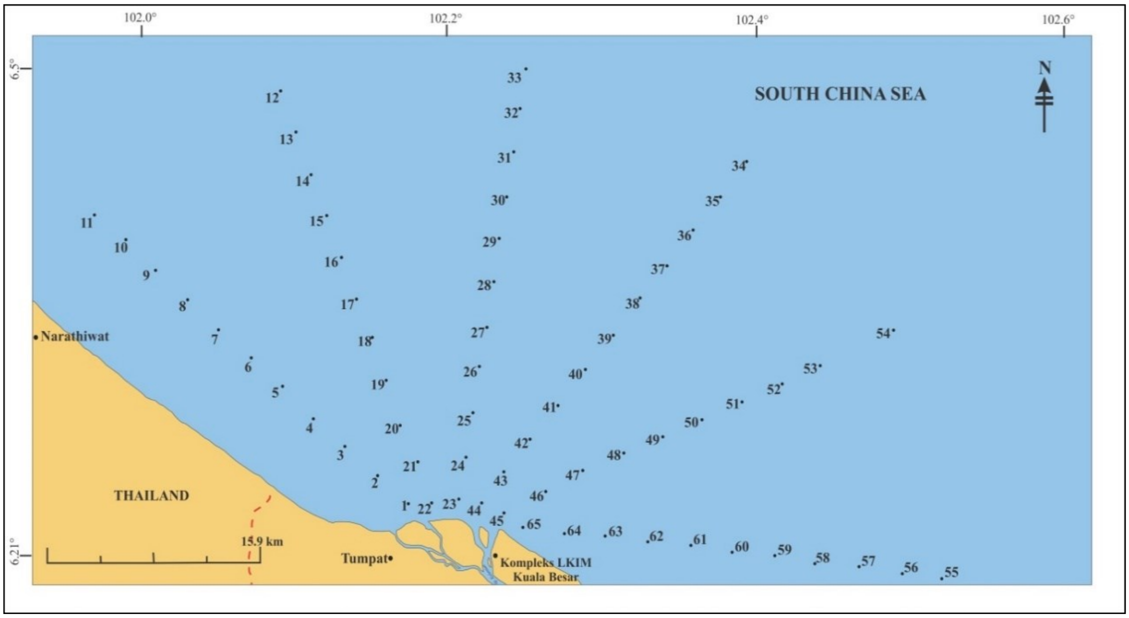

Figure 2: Sampling location in the study area.

RESULTS AND DISCUSSION

From the hydrographic survey, the contour depths of the water surface to the bottom of seabed were determined. The bathymetric map (Figure 3) showed the depth increases away from the land. Near the shore, the depth is mostly shallower than 5 m. Moving forward to the sea, the zone is characterized with the depth about 15m to 20m and at the last point of the hydrographic survey, the highest depth of the sea bottom is determined by the 38m value. The sand shoal was revealed throughout the hydrographic visualization at the depth zone of 15m to 20m. This sand shoal is generally about 8 m above the nearby topography area with an area about 9 km^2 at the marine shelf portion, showing an accumulation of sediments deposits. The sediments samples are composed of poorly sorted to very well sorted, coarse silt to medium grained sands with subordinate fine-grained sands.

The representative collection of the particle size distribution is showed in the grain size table (Table 1). The size distribution of the sediment from the nearshore of the survey area mainly dominated by the silty with small amount of clay account for the maximum percentage is 86% and minimum percentage is 64%. Mean grain size range from 0.060 mm to 0.051 mm (Ø 4.07 to Ø 4.31); being slightly finer than those well to very well sorted grained. At the distance inclined seaward, the sediment distribution pattern is dominated by sandier than the nearshore with the mean grain size range from 0.051 mm to 1.067 mm (Ø 4.30 to Ø -0.09), indicates the moderately sorted to poorly sorted which account the value of maximum is 100% and minimum value is 66%. From the graphic mean, the grain size can be classified as the coarse silt to medium sand.

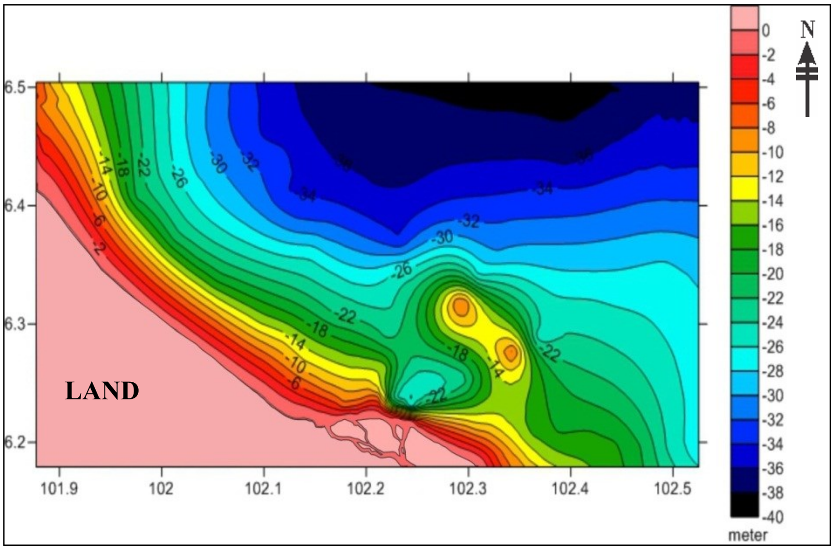

Figure 3: Bathymetry contour map of study area

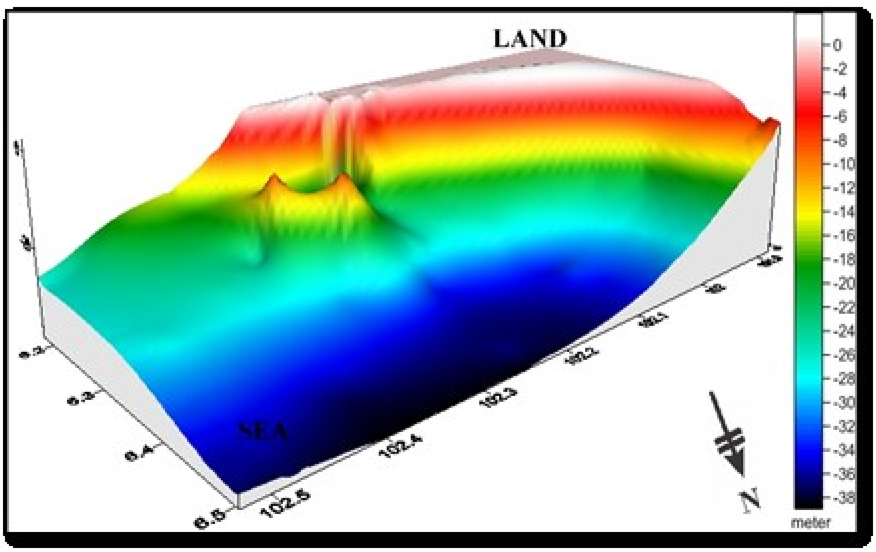

Figure 4: Model of bathymetry contour map

Table 1: Station numbers, mean, sorting, skewness and kurtosis of graphical formula from sediment analysis

St. No.	Graphical Formula			
	Mean (mm)	Sorting	Skewness	Kurtosis
1	0.051	Very well sorted	Near symmetrical	Very platykurtic
2	0.051	Very well sorted	Near symmetrical	Very platykurtic
3	0.049	Poorly sorted	Strongly negative skewed	Very platykurtic
4	1.019	Poorly sorted	Strongly negative skewed	Very leptokurtic
5	0.052	Very well sorted	Strongly negative skewed	Very platykurtic
6	0.05	Very well sorted	Near symmetrical	Very platykurtic
7	0.051	Very well sorted	Near symmetrical	Very platykurtic
8	0.051	Very well sorted	Near symmetrical	Very platykurtic
9	0.113	Poorly sorted	Strongly negative skewed	Extremely leptokurtic
10	0.417	Poorly sorted	Negative skewed	Extremely leptokurtic
11	0.256	Well sorted	Strongly positive skewed	Very leptokurtic
12	0.26	Moderately sorted	Near symmetrical	Extremely leptokurtic
13	0.219	Poorly sorted	Near symmetrical	Extremely leptokurtic
14	0.397	Poorly sorted	Near symmetrical	Extremely leptokurtic
15	0.269	Poorly sorted	Near symmetrical	Extremely leptokurtic
16	0.281	Poorly sorted	Near symmetrical	Extremely leptokurtic
17	0.203	Poorly sorted	Negative skewed	Extremely leptokurtic
18	0.274	Poorly sorted	Positive skewed	Extremely leptokurtic
19	0.126	Poorly sorted	Strongly negative skewed	Extremely leptokurtic
20	1.313	Poorly sorted	Near symmetrical	Very leptokurtic

21	0.051	Very well sorted	Near symmetrical	Very platykurtic
22	0.051	Very well sorted	Negative skewed	Very platykurtic
23	0.052	Very well sorted	Strongly negative skewed	Very platykurtic
24	0.051	Very well sorted	Near symmetrical	Very platykurtic
25	0.051	Very well sorted	Near symmetrical	Very platykurtic
26	0.352	Moderately sorted	Near symmetrical	Extremely leptokurtic
27	0.464	Poorly sorted	Positive skewed	Extremely leptokurtic
28	0.159	Poorly sorted	Strongly negative skewed	Extremely leptokurtic
30	0.213	Poorly sorted	Negative skewed	Extremely leptokurtic
31	0.128	Poorly sorted	Negative skewed	Extremely leptokurtic
32	0.285	Poorly sorted	Near symmetrical	Extremely leptokurtic
33	0.228	Poorly sorted	Near symmetrical	Extremely leptokurtic
34	0.239	Poorly sorted	Near symmetrical	Extremely leptokurtic
35	0.228	Poorly sorted	Near symmetrical	Extremely leptokurtic
36	0.137	Poorly sorted	Strongly negative skewed	Extremely leptokurtic
37	0.18	Poorly sorted	Strongly negative skewed	Extremely leptokurtic
38	0.36	Poorly sorted	Negative skewed	Extremely leptokurtic
39	0.209	Poorly sorted	Strongly negative skewed	Extremely leptokurtic
40	0.688	Poorly sorted	Positive skewed	Extremely leptokurtic
41	0.247	Moderately well sorted	Strongly positive skewed	Very leptokurtic
42	0.223	Moderately well sorted	Strongly positive skewed	Very leptokurtic

43	0.051	Very well sorted	Near symmetrical	Very platykurtic
44	0.051	Very well sorted	Near symmetrical	Very platykurtic
45	0.06	Very well sorted	Strongly negative skewed	Very leptokurtic
46	0.051	Very well sorted	Near symmetrical	Very platykurtic
47	0.051	Very well sorted	Near symmetrical	Very platykurtic
48	0.056	Very well sorted	Strongly negative skewed	Leptokurtic
49	0.734	Poorly sorted	Negative skewed	Very leptokurtic
50	0.367	Moderately sorted	Positive skewed	Extremely leptokurtic
51	0.436	Moderately well sorted	Near symmetrical	Very leptokurtic
52	0.458	Moderately sorted	Near symmetrical	Very leptokurtic
53	0.491	Moderately sorted	Strongly negative skewed	Very leptokurtic
54	0.403	Moderately well sorted	Strongly negative skewed	Very leptokurtic
55	0.564	Moderately sorted	Negative skewed	Very leptokurtic
56	0.287	Moderately well sorted	Near symmetrical	Very leptokurtic
57	0.323	Moderately well sorted	Near symmetrical	Very leptokurtic
58	0.776	Poorly sorted	Negative skewed	Very leptokurtic
59	1.067	Poorly sorted	Negative skewed	Very leptokurtic
60	0.725	Poorly sorted	Strongly negative skewed	Very leptokurtic
61	0.667	Moderately sorted	Negative skewed	Very leptokurtic
62	0.052	Very well sorted	Strongly negative skewed	Very platykurtic
63	0.051	Very well sorted	Negative skewed	Very platykurtic
64	0.052	Moderately well sorted	Strongly negative skewed	Very leptokurtic
65	0.051	Very well sorted	Negative skewed	Very platykurtic

The sediments distribution of the study area is delineated on the echo sounding data. Various sediments deposits are mainly controlled by the different types of controlling energy factors (Hong *et al.,* 2004), lead to the identification of the morphology of survey area (Figure 4). The behavior of the survey area will be discussed and interpreted according to the morphology of seabed and the sediment distribution pattern.

According to Buller & McManus (1979), skewness can be used to indicate the size of sediment fractions. The positive values usually indicate the grain size was influenced by finer particles, meanwhile the negative skewness are probably associated with the sediment affected by the hydrodynamic force.

By referring to the sediments analysis, the skewness is used to measure the degree of the sediment distribution. The values of the skewness at the study area were between -0.47 to 0.56. However, the area is dominated by near symmetrical skewed (value range from 0.10 to -0.10); indicates the moderate grain size distribution pattern from fine silt to the coarse grained. The near symmetrical skewed showed that the sediment deposited in the nearshore is influenced by the longshore current integrated with the wave energy which is play an important role to the morphology changes and the distribution pattern of the sediments in the study area.

In fact, the confluence of the winds blows from South China Sea impact the water circulation of the ocean. During the northeast monsoon, the main current flowing along South China coast and Vietnam hits the south of Kelantan Delta affect a smaller circulation current flowing at the Kelantan Delta area (Koopsman, 1972). Because of that, the pattern of sediment discharged from the river towards the sea was disturbed and made the newly formed of gentle seabed morphology and distribution pattern from nearshore extended outward into the offshore area.

Several of these dynamic interaction processes acting on the sediments lead to the formation of variety pattern of deltaic sand bodies, thus the distribution also affected by these processes (Coleman & Prior, 1982). Since the integration of these energies from the shoreline is higher and the sediment discharged from river is reworked by the wave current, the distribution pattern produced a retreat pattern of sediment distribution, called as the destructive type of wave.

CONCLUSION

The integrated echo sounding data, bathymetry and surface sediments analysis have well revealed the subsurface morphology and also the sediments distribution in the delta. The combinations of these findings provide the invaluable information and a better understanding about the process that control the sediments influx, transportation and distribution. The retreat pattern of sediment distribution showed that the area faced high integrated hydrodynamic energy of waves, monsoon season, and winds with the reworking of the sediment discharged from the river lead to the formation of new seabed morphology and grain size distribution which nearly to the destructive delta type

The result obtained from the sediment analysis shown that the sediments in the nearshore were dominated by the coarse to fine silt with clayish grain size. Meanwhile, distribution of the sediments in the extended area of the sea is varies from the silt to sand with mixture of small amount of clay. Moving towards the marine shelf, the distribution grain size patterns are dominated by the sand.

In summary, the major factors that affect the different of the grain size distribution and morphology of the Kelantan River Delta are concluded; which the hydrodynamic forces especially wave's current, wind blow and monsoon season were influenced the diverse pattern at the study area.

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