

Spatial and temporal bottom sediment characteristics of Pahang River-Estuary, Pahang, Malaysia

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ABSTRACT

Bottom sediment samples from Pahang river- estuary were analyzed for the sediment characteristics in order to understand better sedimentation processes in the estuary. The mean, sorting, skewness and kurtosis values of each sample were determined by the Moment's method. This study showed that the sediment characteristics were not significantly differ ($p > 0.05$) with the seasonal changes, except for sorting ($p < 0.05$). The sediment mean size becomes finer towards the estuarine area with the range of very coarse sand to fine silt. This indicates that the characteristics of deposited sediments at each station are much dependant upon the combination of physical forces such as freshwater run-off, tidal currents and waves.

Key words: Pahang river-estuary, sediment characteristics, mean size, sorting, skewness, kurtosis, pre-monsoon, post-monsoon.

INTRODUCTION

Estuaries and rivers are often regions of high sedimentation, serving as traps for minerals from inland sources transported seaward by rivers, and materials from the coastal ocean transported landward. Determinations of the relative contributions of inland and marine sources of sediments in estuaries are necessary for predicting and controlling sedimentation in harbours, and becoming the sites of major discharges of urban and industrial pollutants. Grain size analysis is a classical sedimentological method which has been widely used in the studies of sedimentary environment and sedimentary process. In the recent 20 years, many geologists tried to recover transport directions and paths of sediments

according to the spatial distributions of sediment grain size parameters (Shi Xuefa *et al.*, 2002). McLaren (1981), McLaren and Bowles (1985) demonstrated that there is a relationship between net transport direction of sediments and certain spatial variation of grain size parameter, and four grain size parameters; average grain size (X_p), sorting coefficient (σ_p), skewness (Sk_p), and kurtosis (K_p) were commonly used to recover the transport direction of sediments. Gradually, the method of grain size trend analysis has been set up (Gao and Collins, 1992; 1994). At present, this method has been widely used in the study of coarse-grained sedimentary environments such as estuary, coastal zone and tidal channel, but it is relatively seldom applied to continental shelf (Gao and Collins, 1998; Cheng Peng and Gao, 2000).

In Malaysia, there is little research done regarding spatial and temporal variation of bottom sedimentation along the river. The information about sedimentation rate or erosion aspects is very limited. Nevertheless, detailed investigation concerning both spatial and temporal variability are required in order to better understand the sedimentation processes in the estuaries and along the Kuala Pahang river. In view of the importance of the bottom sedimentation data to various aspects of the environment, this study was carried out. The aim of this research is to determine the sediment characteristics such as mean size, sorting, skewness and kurtosis as well as their distribution patterns.

MATERIAL AND METHODS

Sampling sites

The study was carried out at Pahang river- estuary (Fig. 1). Pahang river- estuary located at Pekan, which is situated about 50km south of Kuantan. This area has a humid tropical climate with two monsoon periods, characterized by bimodal patterns: southwest and northeast monsoons. Pahang river- estuary is mostly influenced by the semidiurnal tides with two high tides and two low tides within a lunar day. A total of 62 bottom sediments which lies between longitude 103°25'56.48" E to 103°29'10.55" E and latitude 03°33'01.78" N to 03°30'50.38" N, were collected during pre-monsoon (August) and post-monsoon (April) seasons using Ponar grab.

Analytical Methods

Grain sizes of the sediments were determined using the standard dry and wet sieving techniques (Folk, 1974). Samples which consists of more than 90% sand were analysed using the dry sieving method, while samples having more than 90% fine sediments were analysed using the laser diffraction method. The median grain size of the sediment was estimated by linear interpolation of the distribution curve. Both median and mean grain size were used in the preliminary data analysis, although only the mean is presented in this study because both parameters show equivalent results. Sedimentological characteristics are reported in phi (ϕ) units using the conversion factor of Folk (1974) as below. By using the negative value, coarse grain size will have a lower phi (ϕ) value which tend to increase when the particles size become finer.

$$\phi = -\log_2 D$$

where D is diameter of particle in mm.

The mean, standard deviation and skewness of each sample were calculated by the moments method using equations defined by McBride (1971). The method of moments uses data from every grain plot data to obtain statistical information concerning the sedimentary population. The formula proposed by McBride (1971) used to calculate the sedimentological characteristics of mean, skewness and sorting are as follows:

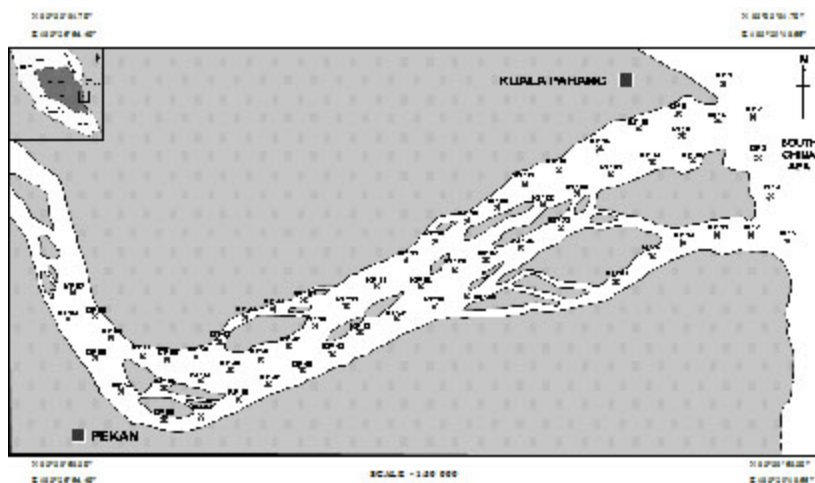


Fig. 1: Location of the study area along Pahang River- Estuary, Pahang

$$X_{\phi} = \frac{\sum fm}{n} \quad \dots(1)$$

$$\sigma_{\phi} = \sqrt{\frac{\sum f(m-X_{\phi})^2}{100}} \quad \dots(2)$$

$$Sk_{\phi} = \frac{\sum f(m-X_{\phi})^3}{100\sigma_{\phi}^3} \quad \dots(3)$$

where

X_{ϕ} = mean size

σ_{ϕ} = sorting

Sk_{ϕ} = skewness

ϕ = weight % or volume % (frequency) of each size class

n = number of sample

m = mid-point of each size class

Silt and clay content of the bottom sediment were analyzed using the laser diffraction method. The laser diffraction technique is based on the principle of laser ensemble light scattering. Briefly, samples were prepared by first dissolving all carbonates using 4M hydrochloric acid (HCl) solution. Then the organic components were removed by adding 20% hydrogen peroxide (H₂O₂) solution, and finally with calgon (dispersing agents) solution to break up the flocs that may have formed with clays. The solution was stirred, and measured using the subjected ultrasonic bursts of 10 to 15 seconds duration, before being poured into the Particle Size Analyzer (PSA) system.

RESULTS AND DISCUSSION

Figs. 2, 3, 4 and 5 showed the distribution patterns of sediment mean size, sorting, skewness and kurtosis for both pre- monsoon and post-monsoon seasons, respectively. Mean size usually serves a simple indication of the force applied to the sediment to move the grains, or a very rough indicator of energy state. In this study, stations at the upstream area were much coarser compared to the downstream area for both seasons. This phenomenon was also proved by the spatial statistical analysis ($p < 0.05$); where the sediment was dominantly coarsely type (Figure 2). The mean size indicate that the fine sand were deposited at a moderately low energy conditions and the coarse

sand were deposited at a high energy conditions. The variation in phi mean size, therefore, reveals the differential energy conditions leads to the deposition of these kinds of sediments in different locations.

In general, sorting identifies sediment in terms of the variability in the size of its particles. Sorting commonly occurs throughout the process of weathering, erosion and deposition (Briggs, 1977; Dyer, 1985). This study shows that most of the stations were occupied by the poorly sorted sediment, with the ranges of 0.74 to 2.37 ϕ and 0.74 to 1.70 ϕ for both pre- monsoon and post-monsoon seasons (Fig. 3). This indicates a wide range of particle size had been occurred. These ranges of grain size typically result from fluctuations in the velocity of the transporting agents, such as water or wind. The greater the speed and energy involved, the larger or heavier are the particles that can be transported. These conditions also explained the reasons of the significant differences observed among the stations and seasons ($p < 0.05$) for the sorting distribution.

Skewness is the measure of the degree of symmetry to provide a measure of the tendency of the data to spread preferentially to one side of the average value. The average of skewness values for pre- monsoon and post- monsoon seasons are $0.10 \pm 0.45\phi$ and $0.13 \pm 0.32\phi$, respectively (Fig. 4). The symmetry of the samples varies from strongly fine skewed to strongly coarse skewed nature for both seasons. The strongly fine skewed and fine skewed sediments (which are dominant in this study) generally imply the introduction of fine material or removal of coarser fraction (Friedman, 1961) or winnowing of sediments (Duane, 1964). The predominant fine skewed nature of sediments indicates excessive riverine input. The positive skewness of sediments also indicates the unidirectional transport or the deposition of sediments in sheltered low energy environment (Brambati, 1969).

Kurtosis is a statistical value measuring the degree of peakedness of a normal distribution curve for mean size distribution and is associated with standard deviation (sorting) value. According to this study, majority of the samples falls under

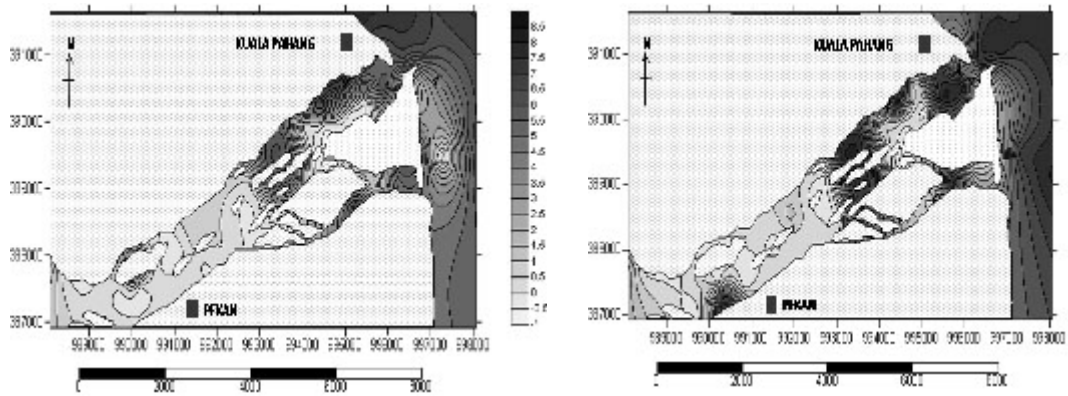


Fig. 2: Mean size distribution pattern during pre-monsoon and post-monsoon seasons

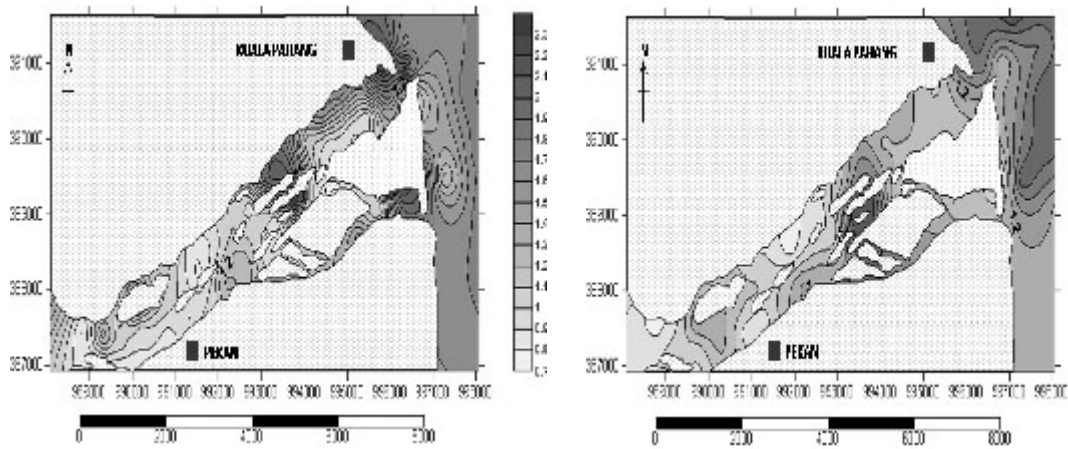


Fig. 3: Sorting distribution pattern during pre-monsoon and post-monsoon seasons

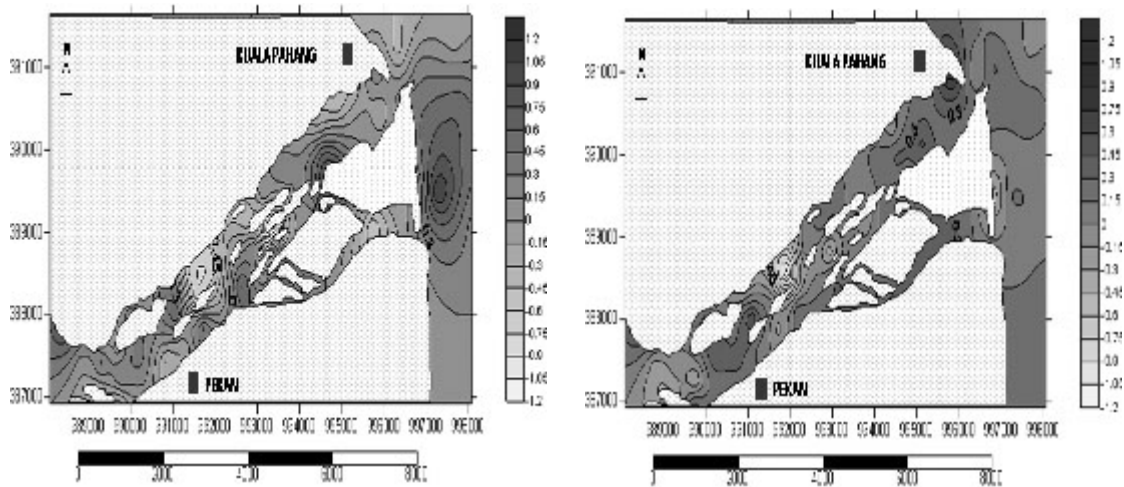


Fig. 4: Skewness distribution pattern during pre-monsoon and post-monsoon seasons

leptokurtic to very leptokurtic nature of distributions, which varied from 1.83 to 5.77 ϕ and 1.75 to 5.32 ϕ for both pre- monsoon and post- monsoon seasons (Fig. 5). Friedman (1962) suggested that extreme high or low values of kurtosis imply that part of the sediment achieved its sorting elsewhere in a high energy environment. The variation in the kurtosis values is a reflection of the flow characteristics of the depositing medium (Seralthan and Padmalal, 1994; Baruah *et al.*, 1997). Finer in size and dominant leptokurtic nature of sediments typically reflect maturity of the sand and variation in the sorting values are likely due to continuous addition of finer or coarser materials in varying proportions (Prabhakara Rao *et al.*, 2001).

Fig. 6 shows the correlations between mean size and sorting, skewness, and also kurtosis for both seasons. Most researchers proposed that the employment of mean size & sorting value as a tool of an indicator to the sediment distribution pattern. Therefore, this study indicates that the transformation of sediment transport was most probably happen with the proportion of coarse sand & poorly sorted sediment. The correlation between mean size & skewness indicated that the symmetry of skewness tended to be positively skewed with the increasing of mean size. Besides, the correlation among mean size and kurtosis showed that the leptokurtic of sediment decreasing as the mean size in phi increasing.

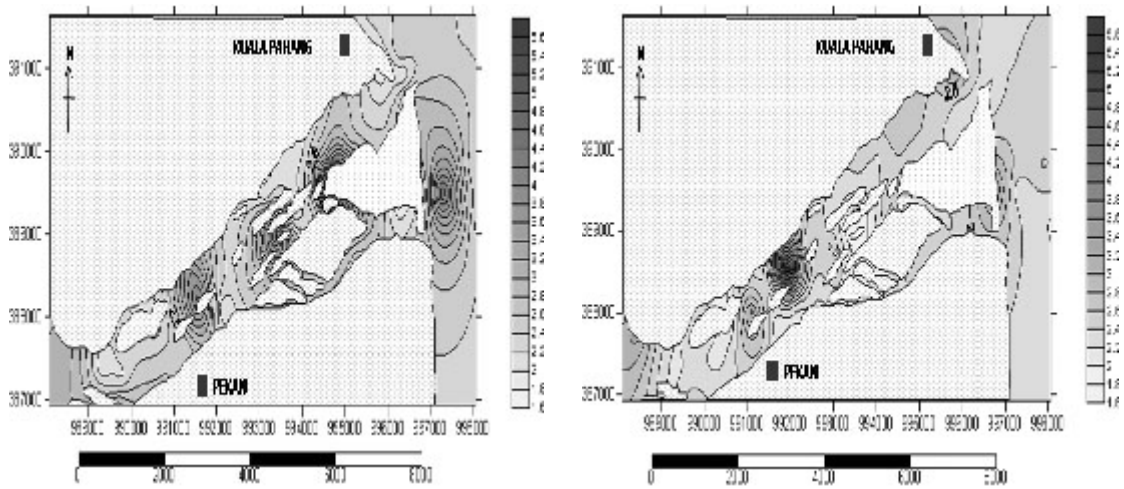


Fig. 5: Kurtosis distribution pattern during pre-monsoon and post-monsoon seasons

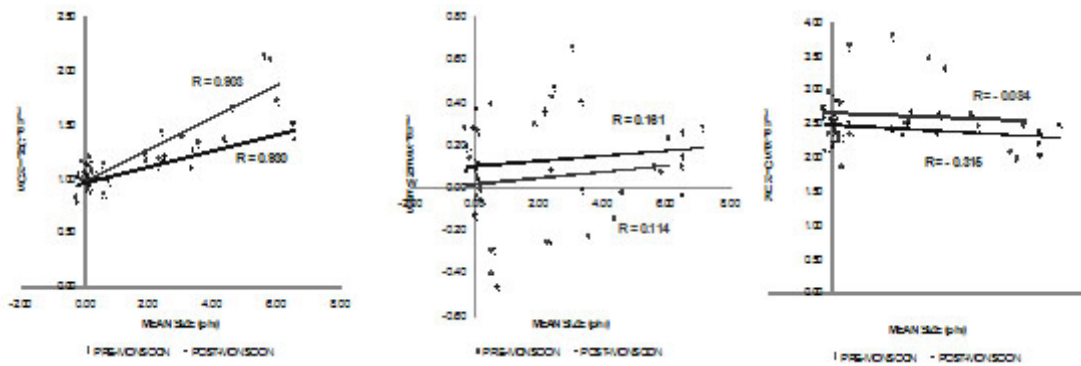


Fig. 6: Correlations between sediment characteristics during pre-monsoon and post-monsoon seasons

CONCLUSION

The statistical analyses for all four sediment parameters implied that there were no significant differences observed with the changes of seasons, except sorting. However, spatially there were significant differences obtained for the all four parameters; mean size, sorting, skewness and

kurtosis. Thus, it can be concluded that sediment characteristics in the study area are not much influenced by the monsoon seasons. The characteristics of deposited sediments at each station are possibly dependant upon the combination of physical forces such as freshwater run-off, tidal currents and waves, even though those combinations were not discussed in this study.

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