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AGGREGATE SIZE DISTRIBUTION OF SELECTED TERENGGANU BEACH AREA

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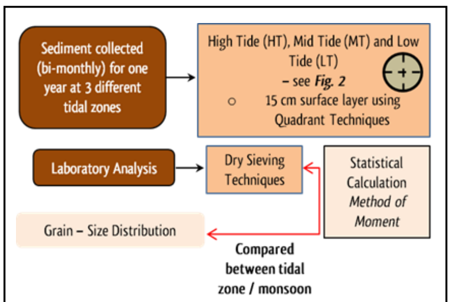
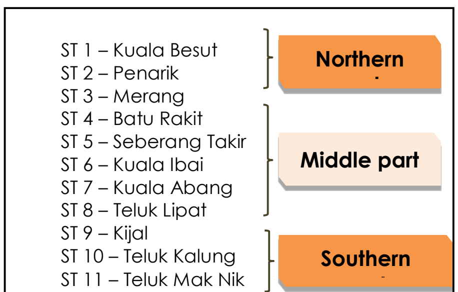
Graphical abstract



Methodology Outline



Geographical province

Abstract

In general, the Terengganu beaches consist mainly of medium- to coarse-grained sand. Grain sizes were determined by dry sieving sediments; samples represent the upper 15 cm of surficial sediment, collected from the three main geomorphological tidal units during one year observation periods, covering the southwest and northeast monsoon seasons. The result demonstrates a good relationship between the monsoonal processes and the corresponding geomorphological elements. There are some differences between the various geomorphological tidal units, with a subtle trend from the low tide to high tide zone. Grain size decreases slightly from the low tide to the high tide. The sediment size fraction averaging from -0.48phi to 1.87phi. The most fine material was found at Kuala Besut (northernmost Terengganu) while the coarsest particle was found at Seberang Takir. However, the grain size parameters at different beach locations do not suggest a general trend of long-shore variations, except on the beach close to the river mouth. The differences between the seasons were larger than those between the geomorphological tidal units. During the northeast monsoon the mean size was coarser, sorting was worse and the distribution was more positively skewed.

Keywords: Grain size, sediment, beach and monsoon

Abstrak

Secara amnya, pantai di Terengganu terdiri daripada butiran pasir sederhana hingga kasar. Saiz butiran dikenalpasti menggunakan kaedah ayak kering. Sampel diambil pada 15 cm dari permukaan pantai dari tiga aras pasang surut berbeza sepanjang tempoh satu tahun kajian yang meliputi musim monsun timur laut dan barat daya. Keputusan menunjukkan perkaitan yang kuat di antara faktor monsun dan elemen geomorfologi. Terdapat perbezaan di antara unit pasang surut dengan tren dari aras pasang surut rendah hingga tinggi yang menunjukkan saiz butiran semakin mengecil dalam julat -0.48phi hingga 1.87phi. Butiran paling halus diperolehi di Kuala Besut manakala paling kasar didapati dari Seberang Takir. Walaubagaimanapun, parameter saiz butiran dari pantai berbeza tidak menunjukkan kepelbagaian dari sudut bujuran pantai kecuali di kawasan yang terletak dekat dengan muara sungai. Semasa monsun timur laut, saiz min butiran lebih kasar, penyisihan tidak sempurna dan kepencongan taburan adalah positif.

Kata kunci: Saiz butiran, sedimen, pantai, monsun

1.0 INTRODUCTION

Historically, coastal areas always been primarily chosen for residential and settlement purposes. As the consequences of social importance and high economic demand in the littoral surrounding, urban areas developed in the vicinity and, as a result, generated more researchers to dedicate their focus towards the coastal dynamic and environment studies.

In Peninsular Malaysia, the erosion problems in the majority of the coastline due to high energy wave climate, especially in Terengganu led to an increasing amount of development studies. The purpose of these studies was to have better insights of the coastal related processes subjected to beach dynamics and behavior for instance beach erosion, sediment transport and shoreline changes; which are directly or indirectly reliant on the sediment grain size and characteristics [1] [2] [3].

The analysis of grain size distribution has been widely used by sedimentologists to classify sedimentary environments and elucidate transport dynamics. It is a powerful tool for describing the geomorphic setting and sedimentological trends a particular site. Grain size distribution is affected by other factors such as distance from the shoreline, distance from the source (river), source material, and topography and transport mechanisms. The grain size analysis provides clues to the future landform development and of pass processes [4]. This variation in particle size is a fundamental property of sediment, which is the result of sediment transport and deposition.

To facilitate cross comparison of samples, four statistical measures (known as moment) have been developed and are commonly used; mean sizes, sorting coefficient (analogous to standard deviation), skewness and kurtosis. This aspect of sediment characteristics in this study arose out to adequately describe the sediments of the different coastal environments within the study area.

Within this context, this research was conducted in order to determine particle size distribution in term of grain size characteristics from various geomorphological settings with respect to tidal aggregations and seasonal variability. This elucidates that the study was designed with consideration of the spatio-temporal aspects that always become an attention for geomorphologists. Comparison of beach sediment between tidal aggregations can explain the different energy forces that transport the sediment to the shore. Seasonal variation, however, modifies the beach morphology and associate sediment size with respect to regional climatic changes that relates to physical parameters such as wind, wave and precipitation distribution.

2.0 MATERIALS AND METHOD

2.1 Geological Setting of Terengganu

The geological history of the eastern coast of Terengganu begins with the deposition of sedimentary rocks since Late Palaeozoic, followed by granitic intrusion on the Early Triassic. Weathering processes took place after rock exposure and followed by erosion and beaches formation during the Post - Pleistocene. These processes were possibly responsible for the exposure of the morphology or beach ridges along the East coast of Peninsular Malaysia during this time [5]. The geological setting of a location controls the shoreline response to energy inputs, sediment availability, and the nature and extent of energy input modification [6]. Besides, geology and topography can impact on wave transformation, nearshore currents, sediment transport, and beach platform and beach morphodynamic [7] [8] [9] [10].

Terengganu is dominated by deposits, including meta-sediment, carboniferous quaternary (most abundant), perm and granite [11]. A major part of the coast between Kuala Besut and Chukai is occupied by the sandy beaches of Quaternary deposits. These deposits comprise both marine and continental sediment. These marine deposits are mostly of white quartz sand with some amount of shell fragments. However, the coastline in the vicinity of Bukit Chendering, Bukit Bubus and Bukit Keluang is occupied by Triassic to Permian deposits. These deposits mainly comprise of quartzite, with subordinate interbedded grit, conglomerate and shale.

The southeastern part of Terengganu consisted of Carboniferous or older meta-sedimentary rocks [12], especially schist, phyllite and slate, surrounded by Early Triassic granite and Quaternary sediments [13]. Granite exposure along the beach in Bukit Dal, Dungun was characterized with dense jointing caused by previous deformation. The soil pH in the area ranges from neutral to very acidic. Acid sulphate soil was found in Batu Rakit, Terengganu [15]. As such, construction in these soils may pose problems of corrosivity due to their acidic and saline character [16].

2.2 Study Site Description

This study was conducted along the Terengganu coast stretching from Besut (northern region) down to Kemaman (southern region). Terengganu can be described as a coastal state due to its long stretches of coastline in Peninsular Malaysia. The coastline is devoid of cliffs and its long stretch of sandy beaches whose continuity is interrupted by river mouth.

Study area comprises of eleven stations, which randomly selected based on its importance, such as economy, transportation, residential and recreational functions towards the people. The areas were also chosen based on their unique features such as variable morphology and setting. Distances between the stations are uneven, with each other as this study examines the changes of the beach according to the lateral arrangement (Figure 1).

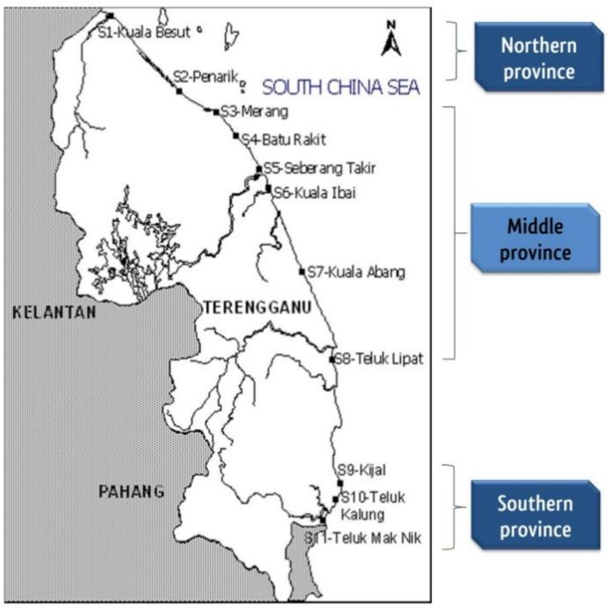


Figure 1 Map of the study area showing the sampling points

2.3 Climate

Climatic conditions of Terengganu are strongly influenced by the monsoonal factor with various weather elements that closely tied-up with the monsoons. The climate is characterized by the fluctuations of the seasonal rainfall distribution, high humidity and temperatures with large diurnal variation as well as cloudy skies, incessant rains and strong winds during the northeast monsoon.

2.3.1 Rainfall

Northeast monsoon brings heavy rainfall, particularly in the east coast states of Peninsular Malaysia, whereas the southwest monsoon normally signifies relatively drier weather. Therefore, the high rainfall during the monsoon seasons increase the sediment transport from the land and alongshore. The mean monthly rainfall data which were accumulated over 10 years showed drier weather conditions which were obtained from April to September and rainy weather conditions from November to January. The highest reading was recorded as 670 mm in November during Northeast Monsoon period whilst February showed the minimal rate rainfall with 98 mm (Figure 2). The climatic data indicate the dry season occurred from May to September with temperature averaging between 30°C to 32°C and rainy season occurred in October to December. It is noticeable that the lowest temperature was recorded during the monsoon with temperature of 26°C.

The periods of monsoon season begin and end, however, varies from year to year. Normally, they were determined by the beginning of rain spells and the predominant wind direction. The rainfall distribution data shown was obtained from the Malaysian Meteorological Department, Malaysia where the meteorological data at Kuala Terengganu Airport were used as representative of all along the study area to illustrate the trend of the rainfall.

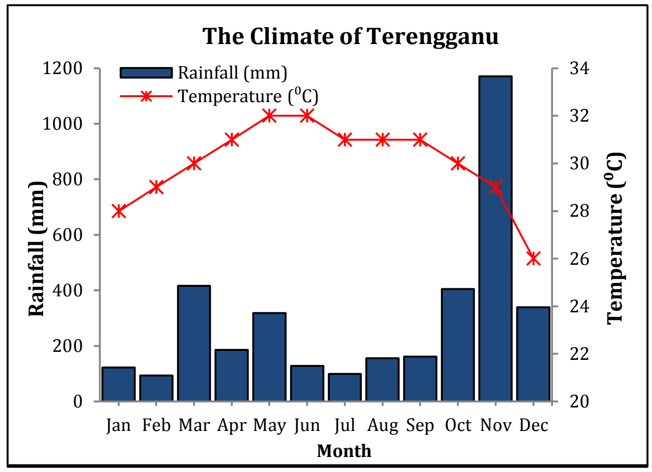


Figure 2 Relationship of rainfall over temperature at Terengganu

2.3.2 Currents

Numerous investigators have studied the surface currents in the South China Sea region. As reflected to the east coast of Peninsular Malaysia province, the coastal current usually flow parallel to the coastline. The flow is towards a southerly direction during the northeast monsoon, but is reversed for the rest of the year [17]. They found that the pile up of water during the northeast monsoon along the east coast of Peninsular Malaysia is greater than during the southwest monsoon [18] [19] [20]. However, the pattern of the current is different depending on the monsoon period because of the strong influence of the monsoon winds [21].

2.3.3 Wind and Waves

Wind conditions in the study area are controlled to some extent by the monsoons. Off the East Coast of Peninsular Malaysia, the northeast monsoon wind established during November and blows until January. During this time, wind directions over the open sea are predominantly north easterly; the winds tend to blow in successive pulsations.

Waves in Kuala Terengganu approached from the northeast direction at an angle of 40° to 45° [22]. Somehow, the amount of energy reflected depends on both the size of the wave and the steepness of the beach. The high wave energy was present during the northeast monsoon season and in general the main directions are from the north (N) and northeast (NE) [23]. Thus, the seasonality factor plays an important role in the fluctuation of the wave energy and henceforth drawn to the changes of the beach morphology and sedimentary types.

2.3.4 Tides

In the east coast of Peninsular Malaysia, the tides are characterized by two types; diurnal and semidiurnal [24]. The rise and fall of the tides may result in small scale and short term topographical changes on the beach. Small-scale beach erosion occurs when the tide rises while accretion occurs when it falls [25]. The coast of Terengganu has a mean spring tide range of 1.8m [26]. Meanwhile, the tidal range at Kuala Terengganu could exceed 2m and the area was classified as low mesotidal, according to the classification of coastal types based on tidal range [27]. This is parallel with the annual tide data of Royal Malaysian Navy in 1992 and 1993 which denoted that the highest astronomical tide in Kuala Terengganu is 2.7m [28].

Tidal range has same correlations with the geomorphology characteristics of the beach [29]. A tidal range of more than 4m reflects that beaches were dominated by land tide while the tidal range less than 2m showed that wave is the most dominant processes. The tidal range is relevant when calculating maximum storm run-up and assessing beach rollover processes and inundation risks [30].

2.4 Sampling Protocol

The beach sediment collection was conducted periodically in two-month intervals. Beach sediment samples were collected from the surface layer using a small shovel at three different tidal levels, namely high tide (HT), mid tide area (MT) and low tide (LT). Samples were placed in plastic bags, and the related detail information was tagged to the samples (Figure 3).

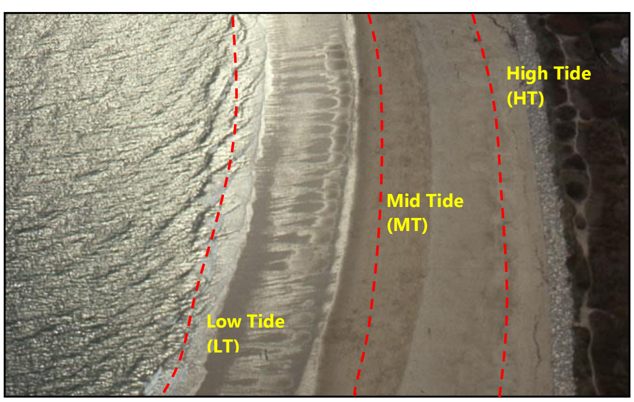


Figure 3 Zonation of sediment collection of three different tidal levels

2.5 Laboratory Analysis

All sediment samples collected were first washed carefully at the laboratory to remove the salt content and then air-dried before being quartered by the hand [31] [32]. All exotic materials such as woods, leaves, seashells and other carbonate fragments were also being removed.

Sieving is the most widely used method for determining grain size for analysis and results are highly reproducible [33] as data from this study are easily comparable to similar studies elsewhere. Besides, this method is the simplest and most widely used for grain size analysis [34]. Samples with below 10% of < 63µm in size were generally measured using the dry sieving method. Thirteen sieves with mesh sizes were arranged consecutively finer downward.

Approximately, 100g of sediment samples were put to the sieves set and shaken for about 10 - 15 minutes using the mechanical shakers. The weight of the sample retained in each mesh was accurately weighted on an electronic balance. The sedimentological characteristics of mean, sorting, skewness and kurtosis were calculated using moment method.

2.6 Statistical Analysis

The data obtained from both methodologies were calculated for their sedimentological characteristics using the proposed moment [35] [36]. In sedimentological calculation, phi (φ) unit is commonly used as a metric unit, used to several geological terms i.e. mean sizes, skewness, standard deviation (sorting) and kurtosis.

The phi units were calculated by the following formula:

$$\varphi = -\log_2 D$$

Where, **D** = diameter of the grain size in millimeter units.

Mean is a general indicator of sediment size measurement due to its weight. The decreasing of a mean size value indicates an increase in sediment grain size and vice versa. The value of mean is obtained either from the calculation of the gravity center under the grain size curve or the gravity center of the cumulative distribution curve. Mean value can be calculated by the following formula:

$$\textbf{Mean } (X_\varphi) = \frac{\sum fm}{n}$$

Where, ***f*** = weight of each grade particle size (100g)
m = median of each particle size
n = total number of the samples

The standard deviation (σ) of a grain distribution indicates how well-sorted the grain distribution is, and this can provide clues as to the transport mechanisms that have operated on the sediment. The calculation of standard deviation is given by:

$$\textbf{Standard Deviation } (\sigma\varphi) = \sqrt{\frac{\sum f(m-x)^2}{100}}$$

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. The skewness of a sediment distribution is a particularly useful indicator of the history of the sample symmetrical distribution indicates the different sizes of sediments are similarly distributed. The calculation of skewness is calculated with the following formula:

$$\textbf{Skewness (Sk)} = \frac{\sum f(m-x)^3}{100\phi\sigma^3}$$

3.0 RESULTS AND DISCUSSION

3.1 Temporal Variability of Beach Sedimentary Grain-Size Distribution

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 [7]. It is the most important part in grain-size analysis. In this study, there are strong trends of mean size found elongated the beaches based on their geographical positions except for station 11 as clearly illustrated in Figure 4. Stations located at the middle-part (stations 4, 5, 6, 7 and 8) were sequentially much coarser compared to the northern and southern parts. Station 11 was rather out of the trend as it has the coarsest sediment found even though, the station located at south-end of the study area. This situation was due to higher compaction of energy hit towards this station since station 11 located very close to the headland and identified as down-drift side based on its longshore drift direction. The occurrence of headland intercepted the longshore drift direction and thus, the beach will accreted on the up-drift side and erode on the down-drift side [37] [38]. Coarse grain material can also be found in most pocket beaches, especially those located in the vicinity of rocky headland [39].

The highest average mean value was found at Station 6 (June 2008) whilst the lowest value was determined at Station 5 (February 2008) with value ranged from -0.12φ to 1.81φ, respectively. On average, the majority of the beach sediment samples falls in coarse sand and medium sand category throughout the study period. The variation in phi mean size, therefore, reveals a different energy condition that leads to the deposition of these kinds of sediment in different locations. The mean size generally indicates that the fine sand was deposited at a moderately low energy condition and the coarse sand were deposited at rather higher energy conditions [37]. It is suspected that the coarser sediments (less than 1 phi) transport mechanism were by means of bedload, while the remaining fraction (in the size ranged from 1 to 2 phi) were by saltation and, fraction of sizes beyond 2 phi was by means of suspension [40].

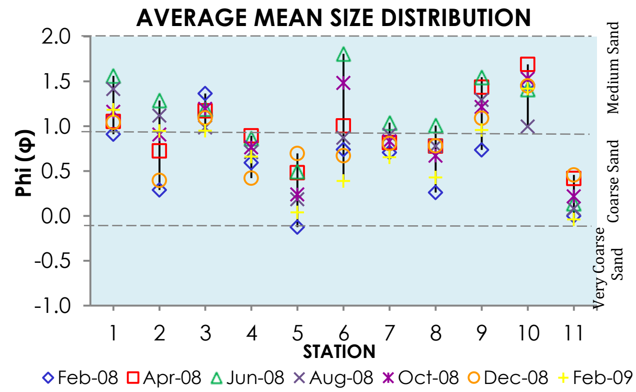


Figure 4 Average mean size distribution over stations of study area

The sorting of sediments along a beach profile produces cross-shore variations in sediment grain sizes. It indicates the range of forces, which determine the sediment size distribution [41] [42]. The variability of sorting is somewhat dependent upon the distance of transport, but it is primarily affected by the medium of transport [43]. Sorting tends to become better in the direction of regional transport due to the selective transport of sediment by waves [44]. In this study, the average sorting coefficient data set generally shows a comparable pattern. Sediment in the middle region of Terengganu was poorer in sorting value compared to the northern and southern region (Figure 5). This specifies that tidal level and other physical forces in the middle region, especially stations 4, 5 and 6 were given much impacts to the beach as water is known as an excellent medium for sorting mechanisms of all, but only for the finer grain size [39].

This variation of the average values, therefore, reveals the sediment sorting ranged from 0.38 φ (station 7) to 1.06φ (station 6) which both were occurring in August 2008. This situation typically resulted from fluctuations in the velocity of the transporting agents, such as water and wind. A large value of sorting (poor sorting) indicates that little selection of grain had taken place during transportation deposition [45]. Well sorted, indicated by a low sorting value, on the other hand, it's produced by the selective action of energy, which transport and deposits limited range of size. Station 7 was confined with well sorted sediment throughout the study period. The plausible reason of this situation is might due to the geological control (rocky beach) that influenced the beach platform.

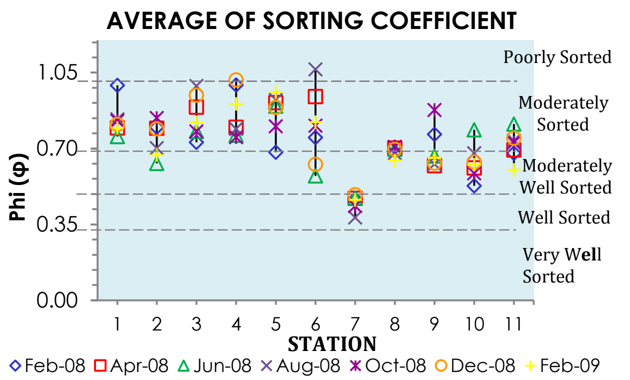


Figure 5 Average sorting distribution over stations of study area

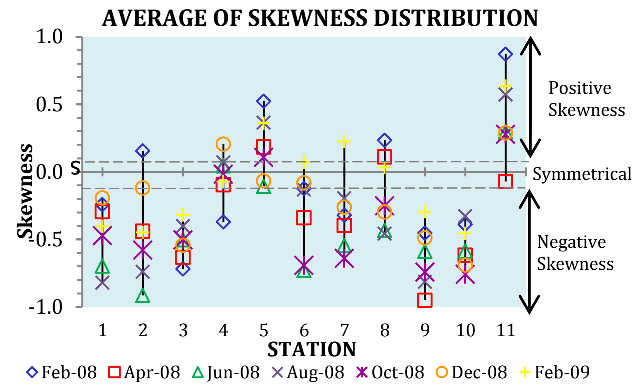


Figure 6 Average skewness distribution over stations of study area

Skewness indicates whether sediments contain an excess of fine or coarse grained particles. It provides a measure of the tendency of data to spread preferentially to one side of the average value in which the range limited between -1.0 to +1.0. The average values of skewness distribution of all stations were demonstrated in Figure 6. It is considerable that most of the samples were negatively skewed for most of the time (except for stations 4, 5 and 11) with the average value ranged from -0.81 to 0.87. Negative values of skewness indicate that the normal distribution is influenced by coarser sizes or due to mixing in unequal proportions of the sediments and subjected to variations of wave energy. Furthermore, the negatively skewed areas could probably be associated with sediments deposited in an environment dominated by strong currents and might be due to the accumulation of coarse grains in these areas [10].

On the contrary, sediments at station 4 showed the symmetrical type distribution or possessed a distinct fine tail of skewness quite often during sampling period. This elucidate that there were equal composition of coarse and fine fraction found at this station as an effect of selective transport by waves and wind induce. On the other hand, stations 5 and 11 noted to be the stations with more frequent positive skewed which exhibited with finer particles. The positive skewness of sediment indicates the unidirectional transport or the deposition of sediment in a sheltered low energy environment [46]. In general, the size and frequency distributions of beach sediments tend to be symmetrical, negatively or slightly positively skewed due to the back and forth motion of waves [47] [48].

Kurtosis values signify to be excessively peaked distribution throughout the sampling periods. The value measured shows that the plunge point samples are very leptokurtic to extremely leptokurtic nature of distributions, with values clustered from 2.14 φ to 5.73 φ. The highest and lowest values were obtained from station 1 in February and station 6 in June, respectively (Figure 7). Extremely high or low values of kurtosis imply that part of the sediment achieved its sorting elsewhere in a high energy environment [4] [47]. However, the peakiest distributions of kurtosis were revealed at stations 6, 7 and 10 predominantly exhibit with extremely leptokurtic in all periods of study. Finer in size and dominance leptokurtic nature of sediments typically reflects the maturity of the sand and variation in the sorting values is likely due to continuous addition of finer or coarser materials in varying proportions [49].

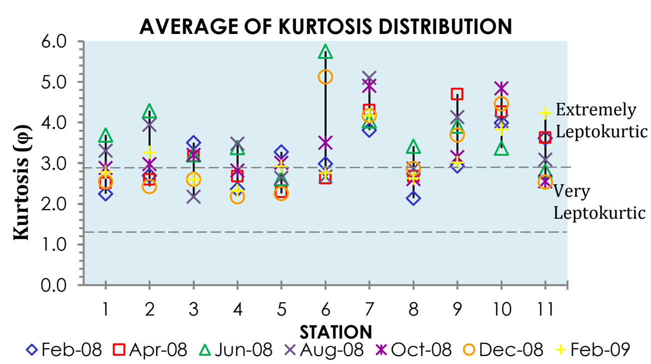


Figure 7 Average kurtosis distribution over stations of study area

3.2 Sediment Composition Based On Tidal Aggregation

The collection of beach sediment data according to distinct tidal level attributes at the approximate high, mid and low-tide levels of the beach allows observation of the variation in grain sizes in the shore normal direction. The shore normal plain is subject to variation due to the distribution of processes acting on the portions of the beach [4]. The mid-tide area is likely to be subject to action of breaking waves for the maximum time. Low-tidal areas are covered by water for the maximum time, while the high-tide areas are left high and dry for the maximum time. Mid-tidal areas undergo two cycles of breaking wave action, during both the rising and falling tide. Given this assumption, samples from these areas can be thought of as the best examples of material most heavily influenced by breaking wave action. The same train of thought then assumes that the low-tide samples are most likely to be influenced by nearshore and tidal currents, while the high-tide samples are likely to be composed of swash deposited material, storm deposits (usually coarse sand and gravel) and wind deflated material.

3.2.1 Shore Normal Mean Sizes

On average, mid-tide samples appear to be finer than both the high and low-tide samples, although the pattern is certainly not conclusive. Samples of high-tide show strong trend and its comparable across stations, but however the trend became loose when cross to the much lower down of tidal level. This signifies the differential energy forces that act on the respective sections. Most active sediment changes were occurring between low-tide and mid-tide level. Based on the overall trend, station 5 and 11 shows the coarsest particles at all the three tidal levels. However, the sizes become coarser at mid-tide and finer at low-tide level compare to the high-tide samples of this particular station. This may be because the backwash energy was the only strength enough to bring back the finer particles at low-tide and leave the coarser particles at mid-tide level. The other stations that contain with finer particles at low-tide rather than mid-tide are Station 3, 4, 7 and 8. These alternate changes somehow rather vary from time to time.

The concept of variation in grain size down the beach has been explored extensively by many authors, and has been related to beach steepness, angle of wave approach and on/offshore winds. The most important factor in determining the relative percentage of grain size in shore-normal direction is flow asymmetry. In general on low gradient beaches, swash is of sufficient strength to move both coarse and fine particles up the beach face; however, the backwash may have sufficient strength to move only the finest material back down the face. A consequence of this is the redistribution of coarse material to the upper portion of the beach and finer material to the lower portion. The degree of asymmetry in swash and backwash might also depend on the sorting of the beach material. Well-sorted sediments will have more pore space than those composed of many different sizes, i.e. poorly sorted. Pore space allows rapid percolation of backwash, diminishing its power and velocity. A consequence of this theory, therefore would be that as sorting increases in a longshore direction, the material on the upper portion of the beach will become coarser relative to the sediments lower down the beach [4].

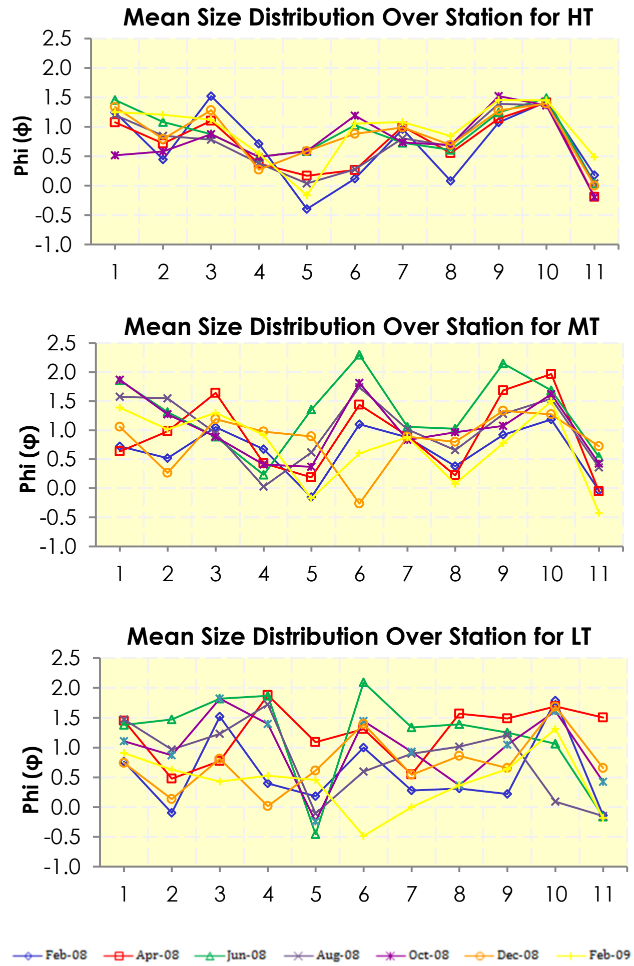


Figure 8 Mean size distribution over station of distinct tidal level

3.2.2 Shore Normal Sorting

In terms of sorting, seven out of eleven stations indicate that the mid-tide samples are generally the most poorly sorted which reflects the tendency of this area to be subjected to relatively more wave action than either the high or mid-tide samples (Figure 9). Sample from station 7 was by far the best sorted at each its tidal level. Sorting can be influenced by either sediment inputs or highly variable transport mechanism. The mid-tide environment is generally subjected to two cycles of breaking waves, swash and backwash action and nearshore current. Therefore, there are both 'normal to shore' and 'shore parallel' components to process operation in the middle region of the beach. The best sorted sediments are generally originated from the high-tide samples. The difference between the sorting values of the mid and low-tide samples is actually quite small compared with high-tide samples. The high-tide samples are subject to wind deflation action and very limited amount of swash action.

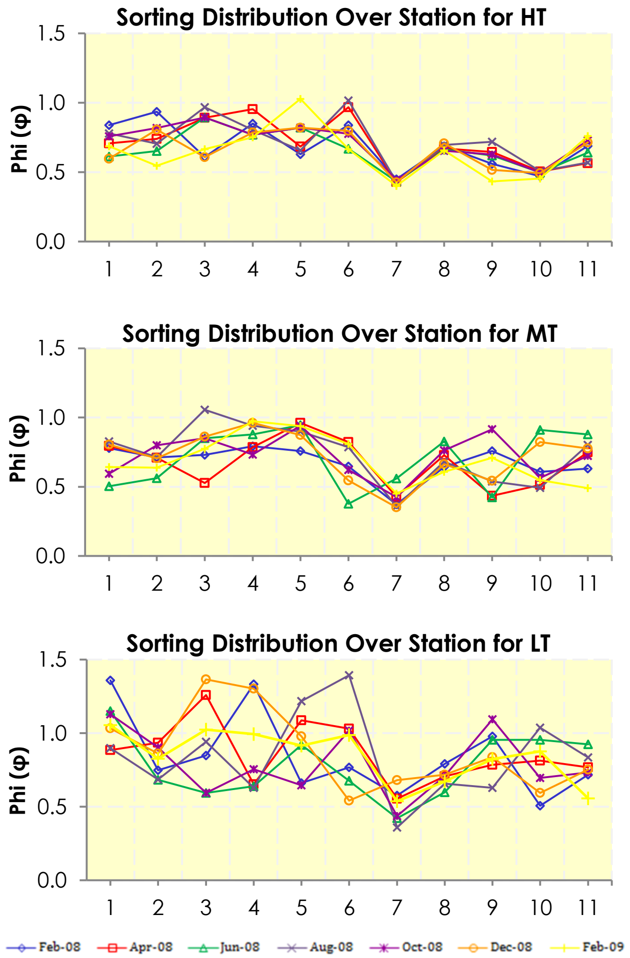


Figure 9 Sorting coefficient distribution over station of distinct tidal level

3.2.3 Shore Normal Skewness

There is no clear trend indicates by the sample suite, the distribution pattern of mid-tide and low-tide is relatively similar compared to high-tide samples (Figure10). Generally, the low-tide samples are more likely to be more negatively skewed than the mid and high-tide samples. This may be due to recent low energy conditions bringing fine material up the beach, while leaving the coarser material on the lower portions as a lag deposit. In addition, the predominance of negatively skewed sediments underpins the process of winnowing of finer particles by tides [50].

The range of the skewness distribution at each tidal levels was founded plunge in a wide range between -1.0 to 1.0. It could be noticed that high-tide samples show the most stable fluctuation, especially at stations 8, 9, 10 and 11. This probably signifies that the high-tide level was less propensity for waves influence as this area is left high and dry for the maximum time, though the wave may run-up to this level during the storm event (i.e. Northeast Monsoon). The main reason for alternate changes of skewness values at this level is might due to the rainfall, wind blows and human activities.

The consequence of inconsistent values of the inter-station plot was clearly found at mid-tide and low-tide levels. This could be due to different levels of energy inputs generated at different stations for particular periods. The mid-tide area, mostly influenced by wave breaking energy while low-tide level is subject to action of tidal current.

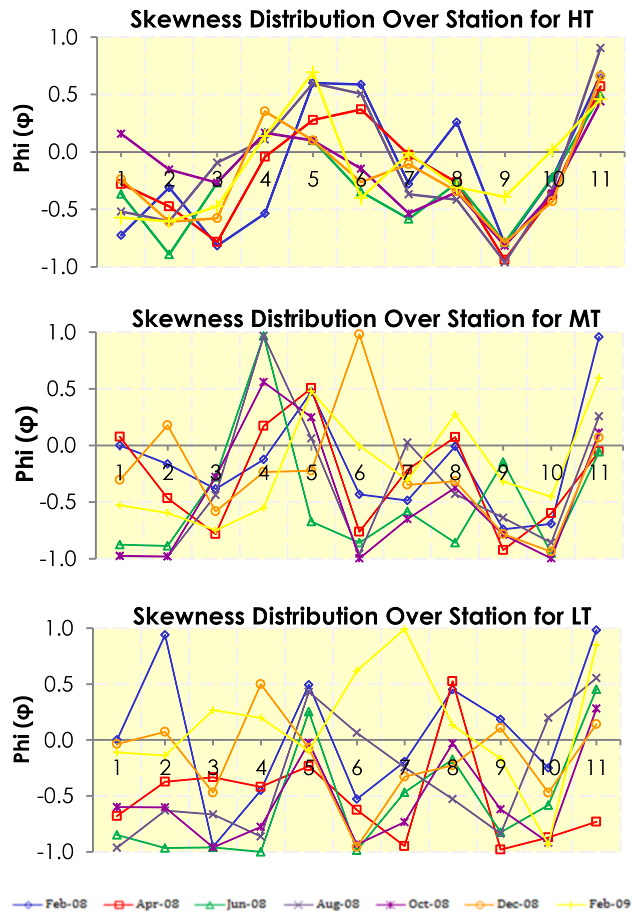


Figure10 Skewness distribution over station of distinct tidal level

3.2.4 Shore Normal Kurtosis

Observation of the individual kurtosis values reveals that the low-tide samples ranged from approximately 1.53 φ to 5.59 φ, mid-tide samples ranged from 1.84 φ to 9.32 φ, and high-tide samples ranged from 1.88 φ to 5.22 φ (Figure 11). The most extremely leptokurtic value was found at mid-tide level at station 6. The high values of kurtosis (a leptokurtic distribution) are indicative of a fairly narrow range of sediment, or can be heavily influenced by a dominant size class [4]. Overall, there is no obvious relationship in these data beyond the fact that high-tide samples have a lower variance in the data than either the mid or low-tide samples.

3.2.5 Shore Normal Kurtosis

On the whole, according to the means data, samples become finer, with position shoreward; they become better sorted in the same direction, negatively skewed, and more leptokurtic (peaky distribution). The poorer sorting at the lower tide levels is not surprising based on the throughput of sediment in these locations, both from wave induced longshore currents, and powerful tidal current that sweep sediments alongshore, particularly close to the tip. The coarsening of sediments towards the high-tide level indicated by means is heavily influenced by two extreme data points, which hide the most common pattern that is a fining of the sediments at the high-tide level. This is most likely due to the preferential movement of finer material up the beach by swash action. An additional factor to consider on at least the high-tide samples is the influence of wind deflation.

4.0 CONCLUSION

The sediment grain size distribution exhibited distinct behaviors at each beaches studied with vast domination of characters from the same class; coarse sand to medium sand. The fractionation of sand particles were also relying with monsoonal activities. The higher energy waves and current during the monsoon season tend to transport finer grain sediments either down-drift or cross-shore, thus leaving behind the coarser fractions. Meanwhile, wide variation of sorting coefficient signifies that the study areas are distributed from well sorted to poorly sorted sediments. However, a lesser variation of the skewness values which indicates a tendency of the data to spread preferentially to the negatively skewed distribution (dominance of coarser fractions).

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References

[1] Rosnan, Y. and Mohd-Lokman, H. 2005. The relationship of sediment texture with coastal environments along the Kuala Terengganu Coast, Malaysia. *Environmental Geology*. 48: 639-645.

[2] Rosnan, Y., Kamaruzzaman Y., Mohd-Lokman, H., Suffian, I. and Subarjo, M. 2002. The Effect of Monsoon to the Beach Morphodynamic and Sediment Distribution along Kuala Terengganu Coastline. *Ultra Scientist International Journal of Physical Sciences.* 14 (3).

[3] Isahak, A. 1992. Coastal Soils of Peninsular Malaysia. In Tjia, H.D. and Mastura, S.S.A. (Eds.), *The coastal zone of Peninsular Malaysia*. Bangi: Universiti Kebangsaan Malaysia.

[4] Nicholas, J. R. J. 2003. Grain Size Analysis of the Sediments of Spun Head, Yorkshire, England. Unpublished doctoral dissertation, University of Cincinnati, England.

[5] Gasim, M. B., Sahib, I. B., Rahim, S. A. and Toriman, E. 2010. Characteristics of history, morphology and landform of the Dungun area, Terengganu, Malaysia with special reference to Bukit Bauk. *Asian Journal of Earth Science*. 3: 213-221.

[6] Wright, L. D. and Thom, B. G. 1977. Coastal depositional landforms: a morphodynamic approach. *Progress in Physical Geography*. 1(3): 412-459.

[7] Short A. D. 1999. *Handbook Of Beach And Shoreface Morphodynamics*. Chichester: John Wiley.

[8] Short, A.D. and Masselink, G. 1999. Embayed and Structurally Controlled Beaches. In Short A. D. (ed), *Handbook of beach and shoreface morphodynamics*. London: John Wiley.

[9] Masselink, G. and Hughes, M. 2003. *Introduction to Coastal Processes and Geomorphology*. London: Arnold.

[10] Jackson, D.W.T., Cooper, J.A.G. and Del Rio, L. 2005. Geological control of beach morphodynamic state. *Marine Geology*. 216(4): 297-314.

[11] Vijayan, V. R. 1993. Marine Geophysical and Sampling Survey: Sand Resources between Mersing and Marang, Eastern Peninsular Malaysia (Report No. 2/1993GM). Geological Survey Department, Malaysia.

[12] Chand, F. 1978. *Geology And Mineral Resources Of The Ulu Paka Area, Terengganu*. Malaysia: Geological Survey of Malaysia.

[13] Bignell, J. D. and Snelling, N. J. 1977. Geochronology of Malaysan granites. *Geol. Mineral Resources*. 47: 71-71.

[14] Azmi, M. A. 1982. Contribution to the knowledge of the soils of the Kedah-Perlis coastal plain, Malaysia. Unpublished doctoral dissertation. University of Ghent, Belgium.

[15] Kanapathy, K. 1976. *Acid Sulphate Soils*. Analytical Services Bulletin No. 6. Malaysia: Ministry of Agriculture.

[16] Roy, S. K., Ramaswamy, S.D. and Aziz, M.A. 1980. Investigation of corrosivity of some soils. *Journal of the Institution of Civil Engineering of Singapore*. 20: 39-47.

[17] Dale, W. L. 1956. Wind and Drift Current in the South China Sea. *Malaysian Journal of Tropical Geography*. 8-31.

[18] Nurul-Hazrina, I. and Mohd-Ibrahim, S. M. 2007. Sea surface current circulation pattern in the South China Sea derived from satellite altimetry. *Proceeding of Asian Conference on Remote Sensing, Kuala Lumpur, Malaysia*. 12-17 November 2007.

[19] Peter, C. C., Nathan, L. E., and Chenwu F. 1999. Dynamical mechanism for the South China Sea seasonal circulation and thermohaline variability. *Journal of Physical Oceanography*. 29: 2971-2989.

[20] Camerlengo, A. L., and Demmler, M. I. 1997. Wind-driven circulation of Peninsular Malaysia's eastern continental shelf. *Scientia Marina*. 66: 203-211.

[21] Fang, W. D., Guo, Z. X., and Huang, Y. T. 1997. Observation and study on the circulation in the southern South China Sea. *Chinese Science Bulletin*. 42: 2264-2271.

[22] Mohd-Lokman, H., A'mali, I. K., and Rosnan, Y. 1995. Short-term Impact of Beach Fest on the Topography, Vegetation Coverage and Sediment Distribution of the Mengabang Telipot Beach, Terengganu. *Pertanika Journal of Science & Technology*. 3 (2): 325-336.

[23] Muzathik, A.M., Wan-Nik, W.B., Ibrahim, M.Z. and Samo, K.B. 2010. Wave Energy Potential of Peninsular Malaysia. *ARPN Journal of Engineering and Applied Sciences*. 5 (7): 11-23.

[24] Mohd-Lokman, H., Rosnan, Y. and Shahbudin, S. 1995. Beach Erosion Variability during a Northeast Monsoon: The Kuala Setiu Coastline, Terengganu, Malaysia. *Pertanika Journal Science and Technology*. 3(2): 337-348.

[25] Hill, R. D. 1966. Changes in beach form at Sri Pantai, north-east Johor. *Journal Tropical Geography*. 23: 20-27.

[26] Philips, R. P. 1985. Long-Shore Transport of Sediment during August and September on the Terengganu Coast. *Pertanika Journal Science and Technology*. 8(2): 273-279.

[27] Hayes, M.O. 1979. *Barrier Island Morphology as Function of Tidal and Wave Regime in Leathermen*. New York: Academic Press.

[28] Rosnan, Y., Kamaruzzaman, Y., Mohd-Azam, M. Y. and Nor-Antonina, A. 2003. A study of beach sediment characteristics and net shore drift direction nearby aquaculture project along Merchang, Terengganu coastline. *Ultra Scientist International Journal of Physical Sciences*. 15(3): 321-334.

[29] Pethick, J. 1984. *Introduction to Coastal Geomorphology.* London: Edward Arnold.

[30] Ishikawa, R. 2008. *Historical Shoreline Change and Beach Morphodynamics at Rapahoe Bay, West Coast, New Zealand.* Christchurch: University of Canterbury.

[31] Krumbein, W.C. and Pettijohn, F. J. 1938. *Manual of Sedimentary Petrography*. New York: Century-Crofts Inc.

[32] Prakash, T.N. and Prithviraj, M. 1988. A study of seasonal longshore transport direction through grain-size trends: An example from the Quilon Coast, Kerala, India. *Ocean and Shoreline Management*. 11: 195-209.

[33] Gale, S. J. and Hoare, P. G. 1991. *Quaternary Sediments: Petrographic Methods for the Study of Unlithified Rocks*. London: Belhaven Press.

[34] Buller A. T. and McManus, J. 1979. Sediment sampling analysis. In Dyer K.R (Ed.), *Estuarine Hydrography and Sedimentation: A Handbook*. Cambridge University Press.

[35] McBride, E. F. 1971. Mathematical treatment of size distribution data. In: R. E. Carver (Eds.), *Procedures in sedimentary petrology*. New York: Wiley Interscience.

[36] Folk, R. L. 1980. Brazos River Bar: A study in the significance of grain size parameters. *Journal of Sedimentary Petrology*. 27(1): 3-26.

[37] Komar, P.D. 1983. Nearshore currents and sand transport on beaches. In: Johns, B. (Ed.) *Coastal and Shelf Dynamical Processes.* New York: Elsevier.

[38] Reeve, D., Chadwick, A. and Fleming, C. 2004. *Coastal Engineering: Processes, Theory and Design Practice*. London, New York: Spon Press.

[39] Singarasubramanian, S. R., Mukesh, M. V., Manohara, K, Murugan, S., Bakkiaraj, D. and John Peter, A. 2006. Sediment characteristics of the M-9 Tsunami event between Rameswaram and Thoothukudi, Gulf of Mannar, Southeast Coast of India. *Science of Tsunami Hazards.* 25(3): 160 – 167.

[40] Visher, G. S. 1969. Grain size distributions and depositional processes. *Journal of Sedimentary Petrology*. 39: 1074–1106.

[41] Briggs, D., Smithson, P., Addison, K. and Atkinson, K. 1997. *Fundamentals of the Physical Environment (2nd Edition).* London: Routledge.

[42] Dyer, K. R. 1985. *Coastal and estuarine sediment dynamics.* Tuaton: Institute of Oceanography Science.

[43] Siti-Waznah, A. 2010. *Geochemical studies of the bottom sediments of Pahang River-Estuary*. Malaysia, Master of Science. International Islamic University Malaysia.

[44] McLaren, P. and Bowles, D. 1985. The Effect of Sediment Transport on Grain size Distributions. *Journal of Sedimentary Petrology*. 55 (4): 447 – 470.

[45] Kamaruzzaman, B.Y., Shazili, N.A.M. and Mohd-Lokman, H. (2002). Particle size distribution in the bottom sediments of the Kemaman river estuarine system, Terengganu, Malaysia. Pertanika. *Journal of Tropical Agriculture Science*. 25(2): 149–155.

[46] Brambati, A. 1969. Stratigraphy and sedimentation of Siwaliks of North Eastern India. *Proc. Inter. Sem. Intermontane Basins: Geology and Resources*, Chiang Mai, Thailand. 427-439.

[47] Friedman, G. M. 1962. On sorting, sorting coefficients and the log normality of the grain-size distributions of sandstones. *Journal Geology*. 70: 737 – 753

[48] Stephenson. R. A. 1970. On the use of grain size analysis in geomorphological studies. *Prof. Geol*. 22: 200 – 203.

[49] Rao, P.A., Anilkumar, V. Rao, Y.R., Ravi, G.S. and Krishnan, S. 2001. Grain size parameters in the interpretation of depositional environments of coastal sediments between Bendi Creek and Vamsadhara river, East Coast, India. *Journal Indian Assoc. Sedimentologists* . 20(1): 106 – 116.

[50] Srivinas, R. and Sajan, K. 2010. Significant of textural analysis in the sediments of Kayamkulam Lake, southwest coast of India. *Indian Journal of Marine Sciences*. 39(1): 92-99.