GEOMORPHOLOGY AND MINERAL ANALYSIS OF TELUK LIPAT BEACH: MONSOONAL EFFECT TO THE OPEN COASTAL SYSTEM

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ABSTRACT

The northeast monsoon brings a significant physical change to the shores of Terengganu, east coast Peninsular Malaysia. The change in wave magnitude is thought to be the main agent for this change. Though this naturally occurring phenomenon brings changes to the coastal area, this is somehow compensated naturally in the following southwest monsoon season change. The point of interest that triggered this study is the presence and effect of human-made structures in the vicinity of the coastal area that brings further deterioration to these areas. The methods used to identify the erosional process at the coastal areas are mainly the total station method; measuring the width of beach at different tide levels as well as the grain size distribution of sediments washed onto the beach. This method was done to classify the mean, sorting and skewness of the sediments deposited. With this data, obtained at the start of monsoon season and during the occurrence, the difference between these two timelines can be graphed to depict a clearer picture. The positive trend of deposition can be observed to almost all the stations with an exception to a few stations due to the presence of the groin. Result obtained indicates that Teluk Lipat beaches mainly dominated by very coarse to coarse-grained based on the calculation of the mean. The skewness holds a positive trend before the monsoon and negatively skewed during the pre-monsoon. Through heavy mineral analysis, there are variants of minerals that were identified within all samples point in Teluk Lipat Beach. Quartz mainly dominates the majority minerals found in the sample, followed by other minerals that have shown its presence in previous stations, such as tourmaline, iron oxide and andalusite. This analysis was carried out to highlight the mineral origin before it was deposited in the coastal area.

Keywords: density, mean, panning, quartz, skewness, sorting, total station

INTRODUCTION

Coastal erosion is defined as the process whereby the coastal sediments swept away due to longshore currents, strong waves or even winds. Coastal erosion happens on a regular cycle and is considered a natural phenomenon [1]. It can cause lots of adverse effects on the surrounding area, such as unstable land foundation and shortening of shorelines. The coastal area of the east coast section of Peninsular Malaysia faces heavy weathering and reshaping due to the Eastern Monsoon. The beaches in this area are wave-dominated and faced severe erosion [2]. However, over the years, human activities have facilitated this process, causing it to become more vigorous. The east coast shoreline level has deteriorated over the years due to the annual monsoonal season. he construction of man-made structures such as beach groin and barriers caused an even faster rate of erosion of the shoreline. These structures bring unfortunate effect to the civilization nearby, endangering their daily livelihood in the process. It would also cause a massive loss in terms of maintenance expenditures of the locality. Besides, the sedimentology of the area also will be analysed for further understanding of the type of sedimentary materials distribution in the east coast of Peninsular Malaysia during the monsoonal season. This study also emphasised the physical aspects, such as the beach length and width, to determine its impact on beach morphology.

Teluk Lipat Beach in Dungun experiencing severe erosion and the effects of erosion can be seen through the difference in the elevation of the beach. Therefore, the main objectives of this study are to understand the changes in the beach morphology and how it affects the erosion in that area by using the total station method. On the other hand, the sedimentology and mineral analysis, is targeted to identify the characteristics and the possible provenance of the sediments by identifying the grain texture, minerals and trace minerals present in the beach sediments.

Cause of Coastal Erosion

Coastal erosion as a form of landward erosion that occurs in the shoreline due to the excessive wave force acting on the beachfront. Other causes also included, 1) heavy winds that blow at the beachfront, 2) high tide range, 3) human activities buildup of groins and breakwaters. Coastal erosion is an ongoing natural process that would only be of serious danger once it occurs without control, or when its natural flow is affected by any other external, non-natural causes. An article published by a team of researchers from the University of Southampton [3] concluded that human activities are the most significant contributors to erosional activities compared to natural occurrences. The presence of man-made structures along the beachfront such as groins and breakwaters are very common these days. However so, it proves to be detrimental to the coastline in the long term. These man-made groins interfere with the longshore currents that move parallel to the beachfront. These longshore currents deposit sand and other sediments along the beach. When these currents get disrupted, there is an irregular deposition of sediments on the beachfront. The change in wave strength also causes a reduction of sediments in the downdrift area [4].

Effect of the coastal erosion also highly related the heavy winds that blow at the beachfront. This erosion causes the sands to be deposited elsewhere, causing the water level of the sea to increase landward every time the tide changes. This changes would alter the beach morphology at the area, causing it to be deteriorative to the locality. According to Wong [5], the primary characteristic of a monsoonal coastline is that the beach would be essentially erosional.

Study Area

Teluk Lipat Beach (Transect II) in this study focuses on the deterioration of shoreline and its direct effect on the community, especially to the infrastructure build near to the beach. Transect II is proposed to be in the beach located near to the Kampung Pantai area, stretching for about 1 km long (Figure 1). The study would take place here to see the level of beach changes before the monsoon season, as well as the pre-monsoon season (within September and October). With this set of data, a basic deduction on the effect of the monsoon can be concluded.

Figure 1 (a) and (b) location of the area of interest, Teluk Lipat Beach in Dungun, (c) area of interest denoted as Transect II located near to the Kampung Pantai area, stretching for about 1 km length, (d) the study area stretches for 1 km long and is sub-divided into 11 stations (ST) of 100 m intervals and were further divided into three main regions: namely the low tide, mid-tide & high tide areas

SAMPLING METHODS AND ANALYSIS

Total Station Method

The study area stretches for 1 km long and is sub-divided into 11 stations of 100 m intervals (Figure 1). The sequence of the stations started from the most northwest and ends with the most southeast station. Beach profiling activity was conducted at each of the stations, respectively. This survey was carried out in September (before monsoon) and October (pre-monsoon). The total station method was used to measure the width of the coastline at these stations (Figure 2). Besides that, these stations were further divided into three main regions, namely the low tide, midtide & high tide areas. The collected readings were categorized accordingly. The sampling of sediments from the beach was taken at different tide levels and was sent for particle size analysis. The method used here was the sieving method [6]. This method incorporated a manual sieving and shaker method. Approximately 300 g samples collected from each station at different tide levels was placed in the sieve pan with different sieve mesh size (2.00 mm, 1.18 mm, 600 µm, 425 µm, 300 µm, 212 µm, 150 µm, 63 µm and empty pan). Before that, the empty sieve pans were weighed. Once the samples were placed in the pan, the pan was then left in the mechanical sieve shaker to shake for at least 5-10 minutes to ensure thorough filtering of the sediments. Then, new weights of the pans were measured with the assumption that the samples collected at each tray were segregated according to the mesh size. The difference and percentage of samples compared to the total weight of samples tested were calculated and then used for further calculation of mean, sorting and skewness of sand.

Next, Formula 2 to calculate the sorting. This parameter is pertinent in segregating the degree of sorting for the sand samples; ergo may understanding the pattern of the sand deposited.

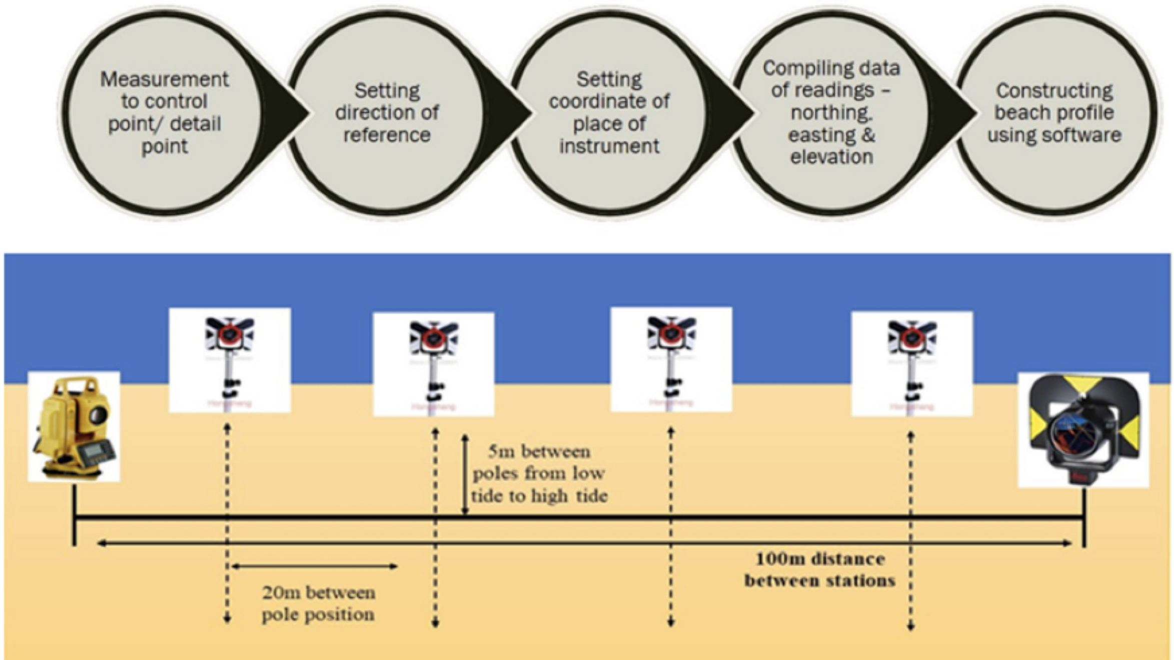

Figure 2 The workflow for a total station method.

Mean, Sorting and Skewness

The mean was calculated to define the average particle size in the tested sample. Formula 1 used to estimate the sample's grain size distribution for each taken from the station before and during the monsoon, where the classifications range from gravel (denote as -1 Φ) to clay (denote as ∞ Φ) [7]. Moreover, all data calculated may assist in identifying the force applied in to transport the grains, also known as the energy state of the particles. This was carried out from September to October that within the time range of before and after the monsoon.

$$\text{Mean}=\frac{\Phi16+\Phi50+\Phi84}{3} \tag{1}$$

$$\text{Sorting}=\frac{\Phi84-\Phi16}{4}+\frac{\Phi95-\Phi5}{6.6} \tag{2}$$

Lastly, from the data curve of the particle size distribution of the sand samples, skewness was determined by measuring the degree of asymmetry of the frequency or cumulative curve via the formula skewness. The classifications are based on ranges of values (+1.00 to -0.30) and through graphically skew of the data curve. Consequently, the analysis was to delineate or tabulate the distribution of grain sizes of samples sand at each station within before and during the monsoon season.

$$\text{Skewness}=\frac{\Phi84+\Phi16-2(\Phi50)}{2(\Phi84-\Phi16)}+\frac{\Phi95+\Phi5-2(\Phi50)}{2(\Phi95-\Phi5)} \tag{3}$$

Mineral Analysis

This analysis was conducted to portray all the minerals and the trace elements present in the sediments selected along with this selected coastline sampling. One of the methods used in the analysis was manual separation via panning to remove the larger sized grains and other compounds. Following that, the samples were further separated via the density separation using Bromoform to separate the light and heavy minerals roughly. It was placed in a U-shaped tube filled with the Bromoform and kept until the lighter materials separated from heavier ones. After that, the magnetic separation conducted to separate the heavy minerals from the light mineral's residue and separate in according to each mineral magnetic value.

RESULTS AND DISCUSSION

Beach Profiling

From the gathered data, the profile illustrates the same pattern throughout the course of the project observed from Station 1 (ST 1) at 0 m and Station 2 (ST 2) at 100 m (Figure 3). Since both stations located in the low energy area, the lack of significant activities and factors that may influence the trend of the beach profile neither before nor the pre-monsoon. The sediment transportation varies over time throughout a particular year due to its being controlled by different factors such as wind climate, tidal climate and wave climate that significantly linked to monsoon seasons [8]. However, in this case, the location of Station 1 (ST 1) and Station 2 (ST 2) situated at southwards of the first groin transect nullifies all the factors, resulting in a similar pattern of beach profiles during both visits.

Based on the beach morphology studied from total station data collection revealed that there are more signs of deposition compared to erosion (Figure 4). This deposition is arguably affected by the morphology of Teluk Lipat Beach itself and the presence of man-made defence structure. The groin structure's function as protection when beaches and dunes are not enough; it is used to retard the longshore transport of littoral drift and keep the coast from eroding [9].

A positive trend of deposition can be observed almost at all stations (with exceptional of ST 5). A significant increase in the profile elevation signifies that the occurrence of sediment deposition throughout the affected stations (Figure 3). The findings arguably linked with longshore sediment transport. Tung [8] proposed that longshore is the transportation of sediments in which parallel to the direction of the shoreline. The longshore currents flow parallel to the coastline within the zone of the shoreline and location of incipient breaking waves (the surf zone).

On the contrary, Station 5 (ST 5) that covers 400 m length of the transect exhibits a significant decrease in elevation during the second visit (pre-monsoon). This trend would very much highlight the occurrence of erosion in that area (Figure 3). This coastal erosion occurred from the consequences of the monsoon seasons. Coastal Engineering Research Center [9] stated that it is a coastal response to storm conditions by sacrificing an extensive amount of the beach due to large waves and storm surges that carry a huge amount of energy which not dissipated in the surf zone. Further argued that a storm is a short-term erosional event that creates an elevated water level, a storm surge, which floods the land and damages the coast. The flood from the storm conditions also yields high wave energy that would damage upland developments likely occurred during the monsoon season of October.

Nonetheless, this would likely occur at all other stations, yet only Station 5 (ST 5) undergone coastal erosion. This station lagoon-like feature with its shoreline orientates northeast seems to make it more vulnerable to monsoon seasons. A storm that hits the coast can do much damage, as, during storms, the wind is stronger than average weather and generates higher, steeper waves that gradually create a storm surge. This surge will break the higher part of the beach by eroding and carrying the material offshore [10].

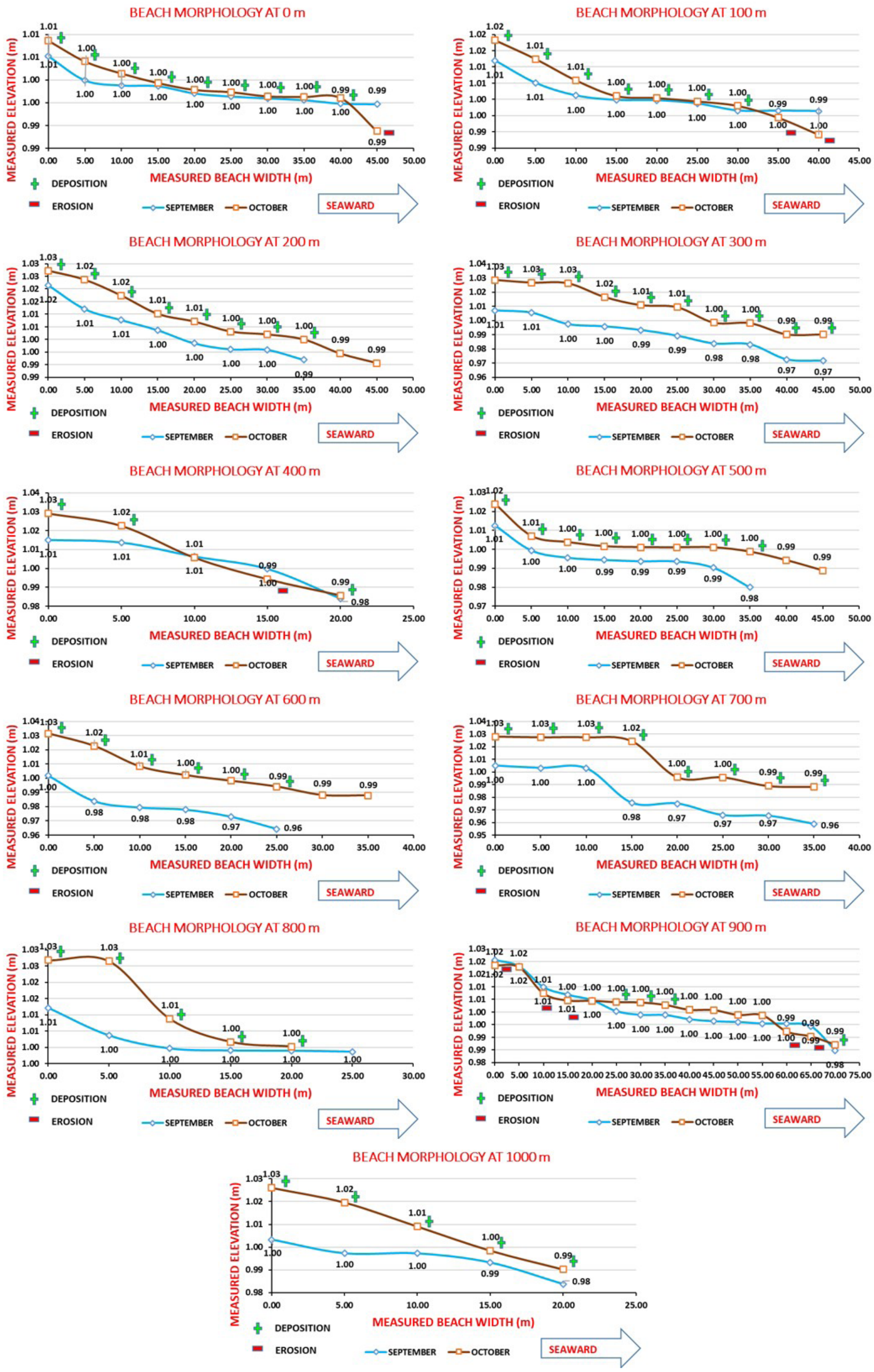

Figure 3 Series of profiles that illustrate the trend of Teluk Lipat Beach from Station 1 (ST 1) (0 m) until Station 11 (ST 11) (1000 m). The trends would very much highlight the occurrence of erosion or accretion at that area during before (First visit) or during the pre-monsoon (Second visit) due to influence of different factors such as wind climate, tidal climate and wave climate

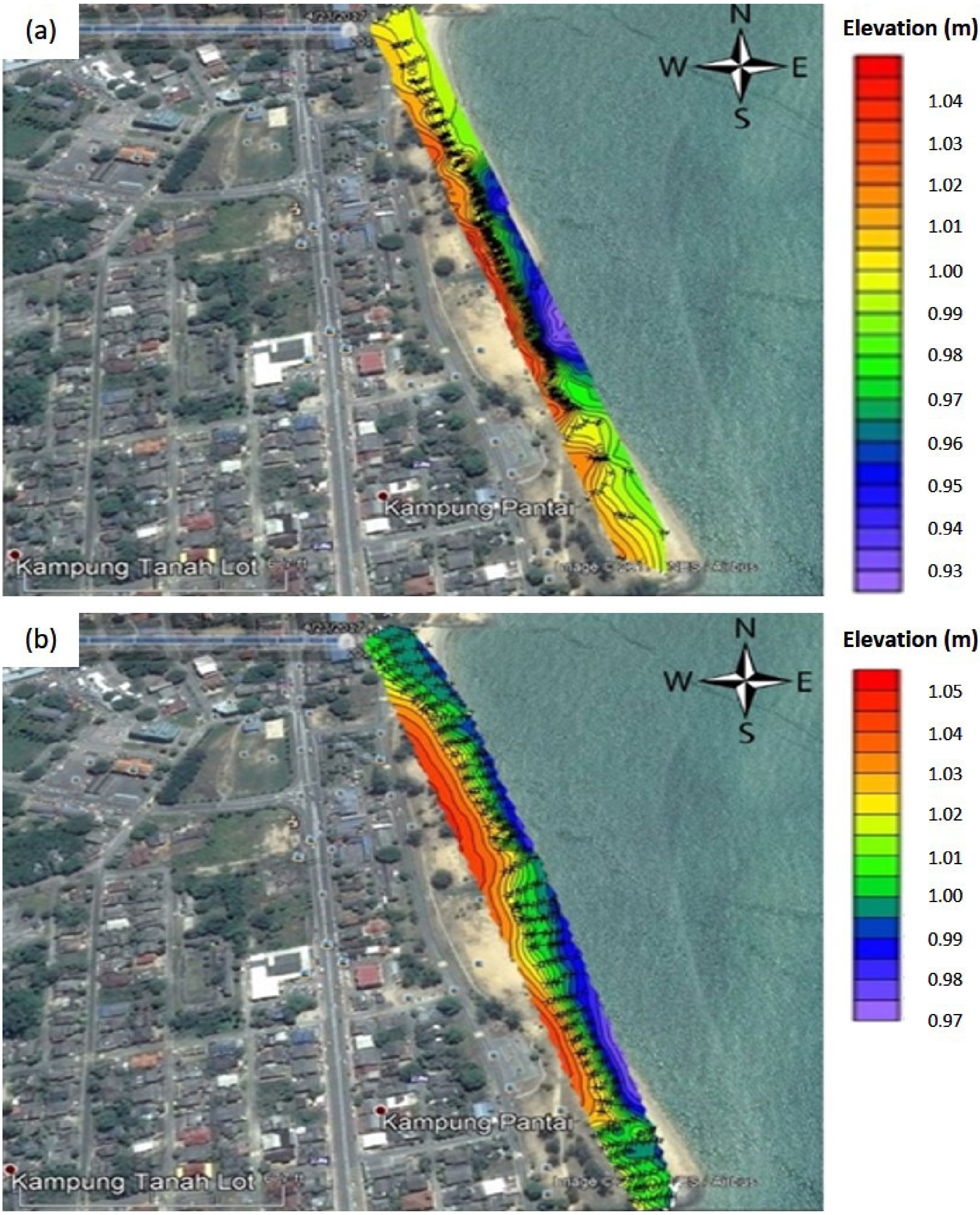

Figure 4 Beach profile (a) before monsoon and (b) during pre-monsoon

Mean, Sorting and Skewness

The data gathered tabulated in Tables 1 and 2, and Figure 5 plotted a series of bar charts to illustrate the stations' mean value before and during the pre-monsoon. Analysis of mean value was used in this study to determine the average grain size of sediment [11]. The result of before the monsoon reveals that the largest value of mean lies within the range of coarse grain size (0.92 Φ). A similar pattern can be observed for the mean value during the pre-monsoon data, which approximately less than 1.00 Φ in value. Both data confirm that mostly the grain size of Teluk Lipat Beach is between very coarse to coarse-grained; however, the data (pre-monsoon) also shows the deposition of gravel-sized sediment at Station 6 (ST 6) & Station 7 (ST 7) that is located beyond the groin.

The presence of the groin seems likely to promote larger-sized sediment to be deposited around its vicinity. The groin acts as a barrier whereby the sediment deposited at the banks of the groin with ease, as the longshore current hitting the beach from the southwest direction. Besides, these factors are caused by the difference in sea level, wave energy and a nearby source of alongshore sand between the two visits. Sediment size is important in the interaction of the sand particle with the oscillatory flow in the wave bottom boundary layer where most morphological changes happened [12]. Findings by Abuodha [13] reported that during northeast monsoon majority of beaches were dominated with smaller phi (coarser sediment). Besides, all the results conclude that the east coast of Malaysia was dominated by coarse and

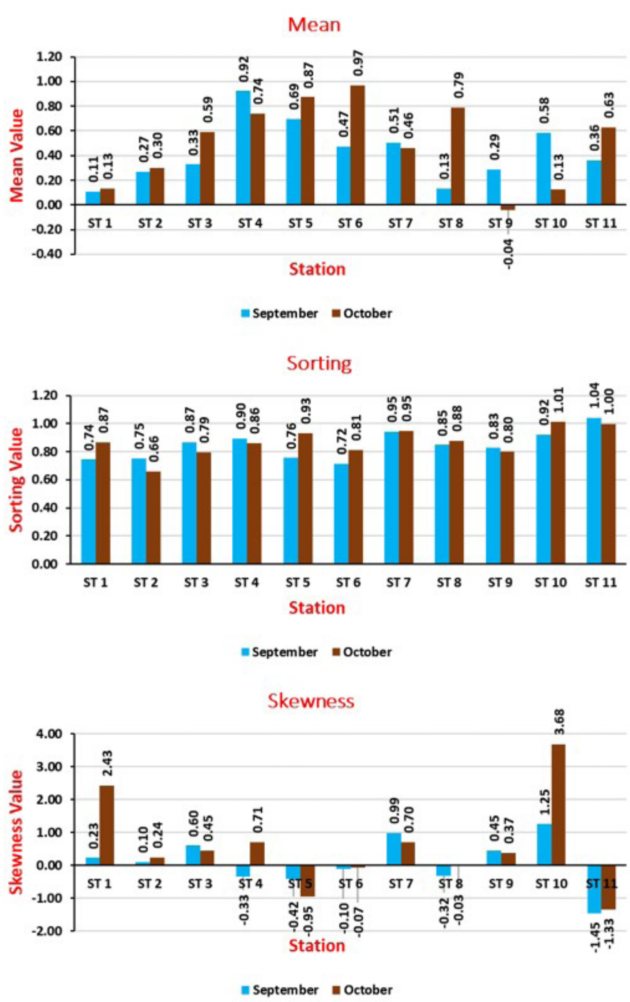

Figure 5 Series of bar charts which delineates the grain size distribution from the sampling point along Teluk Lipat Beach before the monsoon (September) to during the pre-monsoon (October)

medium sediment due to high energy wave and the presence of the longshore current [12].

Next, the determination of sorting is important to delineate the indication of erosion and accretion of coastal interest area. Most of the samples taken indicate sorting values within the range of 0.65 Φ to 1.0 Φ for both before and during the pre-monsoon (Table 1 & 2).

Ergo, the sieving analysis results confirm that the sorting of Teluk Lipat Beach lies in the domain of moderately sorted to moderately sorted. Yaacob et al. [14] argued that poorly sorted sediment indicates the process of erosion, while fine sorted sediment shows the accretion occurred in that area. Hence, for the sake of argument, the sorting of Teluk Lipat Beach may indicate sediment accretion in overall with a certain degree of erosion during the annual circle of both monitoring period.

Table 1 Sedimentological characteristic value before the monsoon (September)

Station	Mean	Sorting	Skewness
ST 1	0.11	0.74	0.23
ST 2	0.27	0.75	0.10
ST 3	0.33	0.87	0.60
ST 4	0.92	0.90	-0.33
ST 5	0.69	0.76	-0.42
ST 6	0.47	0.72	-0.10
ST 7	0.51	0.95	0.99
ST 8	0.13	0.85	-0.32
ST 9	0..29	0.83	0.45
ST 10	0.58	0.92	1.25
ST 11	0.36	1.04	-1.45

Table 2 Sedimentological characteristic value during the pre-monsoon (October)

Station	Mean	Sorting	Skewness
ST 1	0.13	0.87	2.43
ST 2	0.30	0.66	0.24
ST 3	0.59	0.79	0.45
ST 4	0.74	0.86	0.71
ST 5	0.87	0.93	-0.95
ST 6	0.97	0.81	-0.07
ST 7	0.46	0.95	0.70
ST 8	0.79	0.88	-0.03
ST 9	-0.04	0.80	0.37
ST 10	0.13	1.01	3.68
ST 11	0.63	0.1	-1.33

Skewness refers to the symmetrical distribution of the sediment samples that composed of the fine or coarse fraction. The positive skewness mainly associates with fine particles while the negative skewness indicates coarser particle [14]. Results from the first sampling denote that skewness values for all stations range from 0.40 to 3.00. Positive values illustrate that the grain-size distribution was influenced by coarse particles [14]. The author further stated that skewness values were noted to decrease as the grain size increased. Although it is before the actual monsoon season, Teluk Lipat Beach may be affected to a certain degree during this month as the factors that contribute to sediment deposition yield for transportation of coarse sediment.

On the other hand, the bar chart shows the skewness of particles in the second sampling was tabulated in Figure 5. A significant difference can be observed between the data, especially in between Station 9 (ST 9) and the rest of the stations. The skewness of the sample obtained in this area shows a very low value, suggesting that sand particles here are finer particles compared to other parts. These fine particles are possible to happen due to the presence of groin structure that has dampened the wave energy, causing only fine particles to be deposited at the mouth of the groin. The fact that this beach faces longshore current that moves parallel to the shoreline also is a factor for this occurrence. The wave travels further in displacement when it propagates parallel to the shoreline compared to hitting the beach perpendicularly. This extend is displacement causes the energy in the waves to be weaker, hence only allowing lighter particles to be deposited.

On the contrary, the depositional side of the groin indicates a much higher concentration of coarser particles. These coarse particles are because this side of the groin does not face a flow of parallel wave movement. The flow is now blocked by the groin, hence causing low mobility in this area. As such, it is observed that in Station 1 (ST 1) and Station 9 (ST 9) the skewness is of high value, proving that the particles there are positively skewed. The data obtained for all the composite coastal sediments are summarized in Table 1. The mean, sorting and skewness are significantly linked with one another which benefit in highlighting the morphology of the Teluk Lipat Beach before and after the monsoon.

Mineral Contents

This analysis may provide a further understanding of the properties of the minerals and their provenance. It was observed here that in the first low tide sample sent for the mineral analysis, only quartz collected. A common and highly resistance mineral does not get easily dissolved nor destroy along the transportation processes. Moving further southwards, the samples tested show traces of other metallic elements such as iron oxide and andalusite. These minerals are also common minerals that associated with the weathering of parent igneous rock located in the Eastern Belt granitic body. Even though most of the minerals can share their origin with sedimentary and metamorphic rocks, however, it is evident that the igneous origin does play a significant role in this case. The supporting evidence is by the radiometric dating, which was done on the granitic body Kemaman area, which dates the biotite to be 253-275 Ma and muscovite to be 271 Ma [15]. More traces of minerals that can be correlated to the igneous parent rock in the Eastern Belt can be identified from the samples collected. There are variants of minerals mixing off the light and heavy minerals observed within all sampling points which is located further southwards (Figure 6). Quartz still dominates the majority minerals found from the samples collected, followed by other minerals that have shown its presence in smaller but significant percentages in previous stations, such as tourmaline, iron oxide and andalusite. A similar finding was discovered by Ariffin et al. [16] from his studies on the sediments collected from selected estuaries and coastal environments along the Terengganu coastline. From all the 11 stations, the author manages to be identified assemblage of anatase-blue (rutile), andalusite, ilmenite, leucoxene, magnetite, monazite, siderite, tourmaline, spinel, topaz and zircon. The study speculated that sediment movement at estuaries and coastal of Terengganu was suspected from Kenyir Lake to river and estuaries, and lastly to coastal, which similar cases may occur at Teluk Lipat Beach. The minerals were initially transported from the origin to the estuaries, which was later re - transported out by the wave-current (longshore current) before deposited at the coast.

be a craft in a way to minimize the coastal erosion effect on the study area. Besides the coastal erosion issues that being the highlighted for this study, other aspects that also should be given a fair judgment

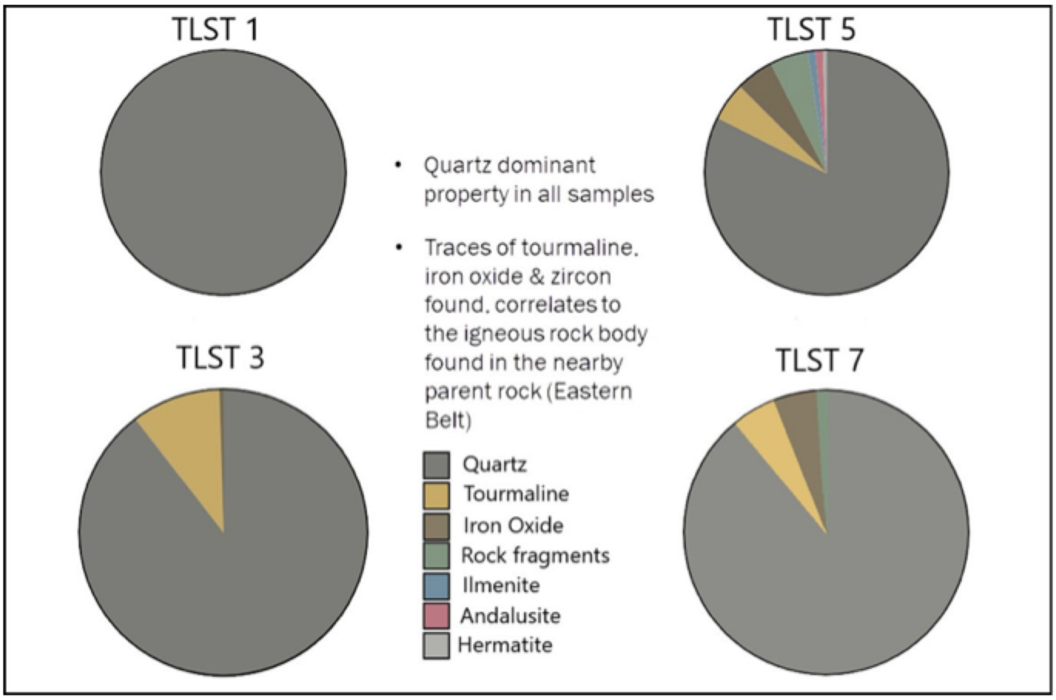

Figure 6 Minerals (light & heavy minerals) found in the samples taken from the study area through the panning method, mineral separation method (Bromoform technique) and heavy mineral analysis using a magnetic separator. This analysis may provide further understanding on properties of the heavy minerals and their provenance

CONCLUSION

Geomorphology and sedimentological data collected from this short period monitoring proved that coastal areas such as Teluk Lipat Beach is considered as an open type of coastal area experience rough and extreme changes due to diverse natures and human activities. The beach profile changes rapidly, especially in the beach gradient and width based on the observation and measurement done during both sampling period even though the duration were considered short. The construction of groin as one of the coastal protection systems in a way bring both positive and negative effect to the coastal area. Further analysis needs to is on the source and type of the sediments that are deposited on the coastal area as the sediment supply play a crucial role in intensifying the erosional effect to the coastal area as the decrease in the sediment supply will always end up with more critical erosion. The abundance of quartz from the collected samples is a good indicator of high resistance sediments being deposited on the study area but further to that, the physical characteristic of quartz as a light mineral in terms of its specific density will always turn the coastal area as a vulnerable area to erosion. The observation and results taken from the study area can always be a reference for any area that similar sage properties.

RECOMMENDATION

The recommendation that is put forth for the efficiency and further accuracy of this research project is a long time for research tenure. The timeline set for this research does not permit its full completion to cover the monsoon season. The initial study that can be carried out only covers the duration of before and during the pre-monsoon. However, the data to be obtained at the end of the monsoon season cannot be justified and compared to see a whole pattern of sediment movements and the proper geomorphology of the transect. As such, further extension of studies by a different team should be done to obtain an appropriate closure for this topic.

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