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COASTAL EROSION IN TAKALAR BEACH SOUTHERN MAKASSAR, INDONESIA

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ABSTRACT: One methods to identify the coastal erosion is carried out by identification of characteristic grain size sediment. Geologists and sedimentologists use information on sediment grain size to study trends in surface processes related to the dynamic conditions of transportation and deposition; while engineers use grain size distribution to understand the physical properties of sediment such as permeability and stability sediment under. A statistical description that adequately characterizes the sample sediment from the study area used Gradistat (Blott and Pye, 2001) and Grandplot. The characteristic grain size distribution at Popo beach during the end of rainy season were dominated by medium sand (83, 33%), moderately well sorted (50%), moderately sorted (33,33%) the skewness are symmetrical (58,33%), and coarse skewed (25%) the kurtosis are mesokurtic (41,67%), very leptokurtic (25%), leptokurtic (25%). The dominantly negatively skewed related process dynamic transportation along a beach were high energy, high wave, generate a long shore current and indication coastal erosion and non-depositional influence wining. The cumulative curve Gaussian all samples of the study area show grain size depositional type tidal segment with subsurface creep population, and sediment were deposited by wind, and formed eolian process segment. Fluvial sediment which was supplied by river, was eroded by coastal hydrodynamic along the coastal area.

Keywords: Erosion, Grain size sedimet, Gradistat, Takalar South Sulawesi, Indonesia

INTRODUCTION

Waves and tidal currents act on sediments transported and deposited on the coast. Variations in the size, elevation and position of coastal environments reflect differences in wave and tide processes and sediment supply in constructing shorelines. For example, windward shorelines tend to be steeper and composed of coarser sand and gravel than leeward coastlines, which tend to have shallower gradients and be composed of fine sand-size material.

Grain size distribution is an important characteristic of sediment, because the grain size can be used as a powerful tool to describe the condition of geomorphology, interpretation of geomorphic significance from fluid dynamics in the natural environment, and sediment transport mechanisms distinguish local versus regional. Characterization of physical properties of sediments is important to learn history of transportation and deposition conditions (Folk and Ward, 1957; Friedman, 1979; Bui et al., 1990). The rapid analysis of grain size statistics from any of standard measuring techniques used computer program, Gradistat, and the result

indicate that Folk and Ward measures, expressed in metric units, appear to provide the most robust basis for routine comparisons of compositionally variable sediments, has been written by Blott and Pye, 2001. A statistical analysis of beach sediments is relevant to identify the sedimentary environments. Mean size, sorting and skewness are the most useful parameters to describe the sediments (Carranza-Edwards, 2001; Friedman, 1961).

In this paper, we investigate this short-term process on some typical sand beaches in Takalar, the southern of Makassar, especially in the open-beaches of Popo beach. The specific aims of this paper are: 1) To investigate the characteristic of grain size sand beach, and 2) To document the relationship between coastal erosion and grain size distribution.

Coastal Retreat Rates

Long term records of coastal erosion in Takalar beach are generally scarce; by comparison, researchers in Makassar. The change of coastline in this area have been mapped by using GPS differential type Trimble, and historical data from Google Earth.

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Coastal erosion in Makassar happened as the removal of material from the coast by wave action, tidal currents and/or the activities of man, typically causing a landward retreat of the coastline (Langkoke, R., 2006, 2010, Rochmanto, B., Sakka, 2012). The coastal change at Makassar coast could be seen by Landsat and Ikonos or image from google earth data history. From these images the coastal change of Makassar have maintained yearly measurements of shoreline position at several locations for decades at Makassar. The change of coastline of Tanjung Bunga beach in 19 years varied between 10 m to 124 m (Langkoke, R., 2010., Sakka, 2012). Those most directly at risk from coastal erosion are those living in coastal lowland areas or along 'soft' sediment coastlines where coastal erosion can cause flooding, loss of land and damage to infrastructure. The development activities of construction of Makassar coastal area have been doing and of course it will have a negative impact or coastal erosion on surrounding of Makassar coast, especially on the Takalar coastal area which located on the southern of Makassar. Besides that the coastal retreat rates is caused also by

global warming which cause of changing on mean sea level rise.

Mean Sea Level Rise

The global mean sea level is one of the most important indicators of climate change. It incorporates the reactions from several different components of the climate system. Precise monitoring of changes in the mean sea level, particularly through the use of altimetry satellites, is vitally important, for understanding not only the climate but also the socioeconomic consequences of any rise in sea level (AVISO+). In Figure 1. Altimetric MSL J2, with the satellite altimetry missions, the mean sea level (Jason-2) since July 2008 until February 2014 is calculated after removing the annual and semi-annual signals. A 2-month filter is applied to the blue points while a 6-month filter is used on the red curve. The rise in mean sea level has thus been estimated as 3.67 mm/year (mean slope of the plotted data) (Credits CLS/Cnes/Legos).

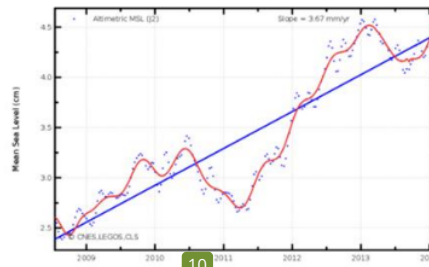
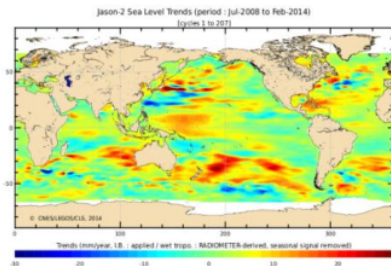


Figure 1. Altimetric MSL J2, satellite mission since 2008 until 2014, the rise in mean sea level has thus been estimated as 3.26 mm/year.

The focus of the study area is Popo Beach (119°20'00" - 119°25'00" N; 5°20'00" - 5°23'00" W), Takalar Distric, located approximately 20 Km southern of Makassar, Indonesia. The length of the shoreline is about 4.5 kilometers. (Figure 2.). Topography of this area is characterized by straight coast with maximum elevation of 10 m asl. Litology of this area is composed mainly of coastal and river alluvial deposits. The coastal typology of the area is sand beach. The coastal sediment is composed of sand, silt, clay, and mud which is resulted from older rocks of the area, the sediment can be found along the Valley of Jeneberang River, and along the Makassar and Takalar coastal areas. (Sukamto and Supriatna, 1982).

There are two river mouths in this area. These river supply sediment from the land to the coastal area. The oceanographic condition of Takalar coastal area is affected by sea of Makassar Strait, the westward and Flores Sea of the southward. As the seasonal and alongshore variation in textural characteristics depend upon the local wind, wave, tide and current patterns, a basic knowledge in these parameters of that particular area helps to further appropriate identification of sedimentary environments.

The coast is exposed to seasonally reversing monsoon winds, blowing from the southwest direction during the southwest (summer) monsoon period and from the northeast during the northeast

(winter) monsoon period. Tides in the region are mixed and predominantly semidiurnal, and the tidal range slightly increase from north to south. Off the study region, the significant wave height 0.498 m. The distribution of sea level rise in Takalar approximately between 6 – 6.5 mm/year. The sea level rise of the Galesong coast relatively between 6.203 – 6.274 mm/year. On the southern part of Takalar coast, Mappakasungu – Mangarabombang, the mean sea level rise relatively higher than its in the northern part of Takalar coast. The sea level rise in Takalar is classified high, comparing with the sea level rise in Java Island which is about 4 – 5 mm/year.

The simulation result of coastline change in 10 years of Takalar coast showed an accretion process about 0,045 – 5.6 m/year. The change of coastline about 5,6 m/year has happened around Biringkassi, Mappakasungu Sector. The abrasion process has also happened at this place about 0.5 – 4.5 m/year. The erosion process (abrasion) also has happened at Bontocinde village, Mangarabombang. The beach slopes were changing spatially and temporally along the study area due to the beach erosion and accretion, observed during the sampling time.

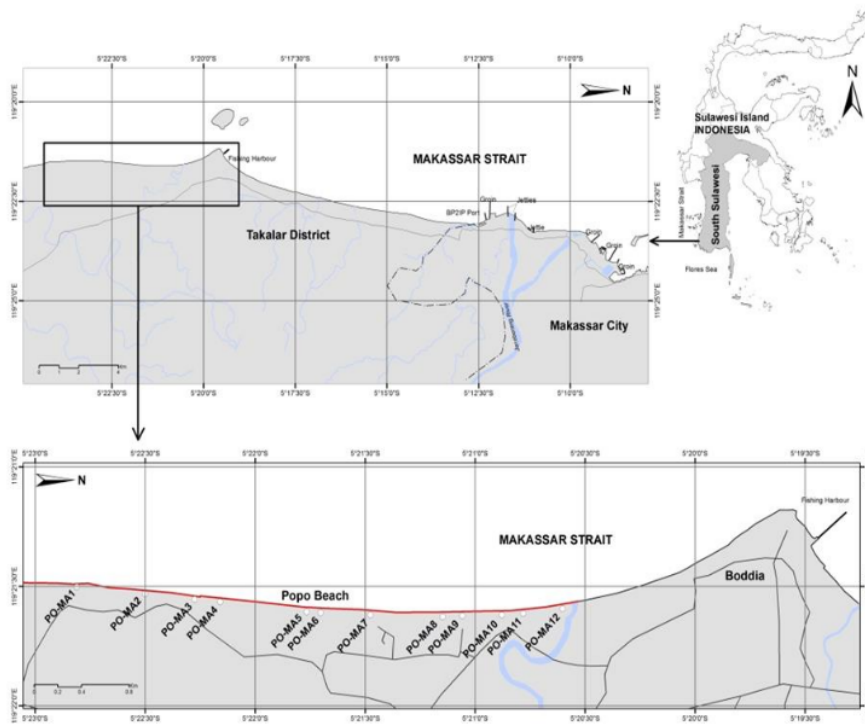


Figure 2. Popo beach location in the southern Makassar city. Top right hand inset: toponymy of the South Sulawesi area, Sulawesi Island, Indonesia.

2 Transport of Sediment

Sediment transport is very important to explain erosion or accretion processes. It takes place in near shore environments by waves and generated currents. The bed load grain size related to the characteristics of hydrodynamic parameters such as energy, and the geomorphology of the coastal area. The coastal hydrodynamics such as waves dominantly come from the southwestern generate long shore currents of

north-south direction, from Popo Beach to south of Takalar Beach. These currents provide alongshore sediment transport, especially behind the spit of Sanrobone. They concentrate behind Sanrobengi Island and generate two branches of long shore currents having opposite directions. The first branch directed to North Galesong along a SE-NW direction. The second branch directed to Sanrobone, a NE-SW direction. The dominant waves come from the north southern generate currents upstream South Galesong.

Method and Data Used

The sediment samples represents a population of sediment grains. The sediment data were collected along Popo beach during the end of rainy season, and take a representative sample of the sediment from 12 locations PO-MA₂ to PO-MA₁₂ along the shoreline on March 2014. The geographical coordinates of the sampling sites were obtained using a handheld GPS. In the laboratory, samples were dried in an oven at a temperature of 50 °C. The grain size distribution was carried out using sieve shaker consisting of 7 sieves having mesh sizes 2, 1, 0.5, 0.425, 0.212, 0.125 and 0.075 mm. The sediment distribution is presented graphically as cumulative curve with phi (φ) scale and the statistical parameters: inclusive graphical mean grain size, standard deviation/ sorting, skewness and kurtosis. They were calculated by Folk and Ward (1957). Statistical analysis of the results and the graphical presentation of the data were performed computational method using GRADISTAT (Blott and Pye, 2001). At Popo beach, south of the Popo river mouth, the study area covered ~4.5 km along the shoreline.

Result and Discussion

Grain size Characteristic of the sand beach the GRADISTAT program is written in Microsoft Visual Basic, and integrated into a Microsoft Excel spreadsheet, allowing both tabular and graphical output. It has been operated by required to input the percentage of sediment present in a number of grain size fractions. The sediment analyzes were carried

out by putting the weight retained on a series of sieves. The following sample statistics are then calculated: mean, mode(s), sorting (standard deviation), skewness, kurtosis, and a range of cumulative percentile values (the grain size at specified percentage of the grains), namely D₁₀, D₅₀, D₉₀, D₉₀/D₁₀, D₁₆, D₁₀, D₇₅/D₂₅ and D₇₅ –D₂₅.

The program provides a physical description of the textural class (such as ‘muddy sandy gray after Folk (1954). Also including a table giving the percentage of grains falling into each size fraction. For sieving results, the program warns the user if a significant amount (>2 per cent) of sediment has been lost during analysis. In terms of graphical output, the program provides graphs of the grain size distribution and cumulative distribution of the data in both micrometer and phi units, and displays the sample grain size on gravel–sand–mud and sand–silt–clay triangular diagrams (Blott and Pye, 2001).

The result of statistic data in analyzed individually at Popo beach (Figure 3), shows variation data from sample of PO-MA₁ to PO-MA₁₂. The histogram graph of all the samples show a peakness, sediment is unimodal, textural group slightly gravelly sand, the grain size medium sand and coarse sand. In Table 1, the grain size distribution of collected sediment samples are presented by statistic parameter of sediment used Graphical Method by Folk and Ward, 1957. Along the study area, the mean values varied from 0.384φ to 1.566φ, the sortation value from 0.430φ to 0.775φ, the skewness value from -0.008φ to 0.178φ, and the kurtosis value from 0.821φ to 1.946φ.

Table 1. Result analysis the comparison between graphical method and the method of moment parameters statistic by Gradistat program.

SAMPLE NO	METHOD OF MOMENTS Logarithmic (φ)				FOLK AND WARD METHOD (φ)			
	Mean (\bar{x}_g):	Sortasi (σ_g):	Skewness (Sk_g):	Kurtosis (K_g):	Mean (M_z):	Sortasi (σ_z):	Skewness (Sk_z):	Kurtosis (K_z):
PO-MA1	1,623	0,993	2,685	1,46	1,566	0,693	0,077	1,094
PO-MA2	1,511	0,779	1,593	1,42	1,530	0,717	-0,014	1,283
PO-MA3	0,371	0,466	0,490	0,878	0,384	0,529	-0,001	1,049
PO-MA4	0,745	0,718	0,821	0,792	0,728	0,775	-0,124	1,094
PO-MA5	1,520	0,516	1,707	2,08	1,511	0,479	0,149	1,607
PO-MA6	2,101	1,018	2,909	1,37	1,974	0,542	-0,070	0,821
PO-MA7	1,200	0,779	1,781	1,39	1,146	0,712	-0,008	1,304
PO-MA8	1,222	0,620	-0,605	0,844	1,258	0,567	-0,157	1,525
PO-MA9	1,086	0,453	0,132	1,10	1,130	0,430	-0,032	1,244
PO-MA10	1,542	0,553	2,047	2,21	1,544	0,502	0,175	1,581
PO-MA11	1,445	0,541	1,571	1,96	1,401	0,464	0,018	1,461
PO-MA12	1,441	0,583	0,814	1,34	1,434	0,571	-0,070	1,946

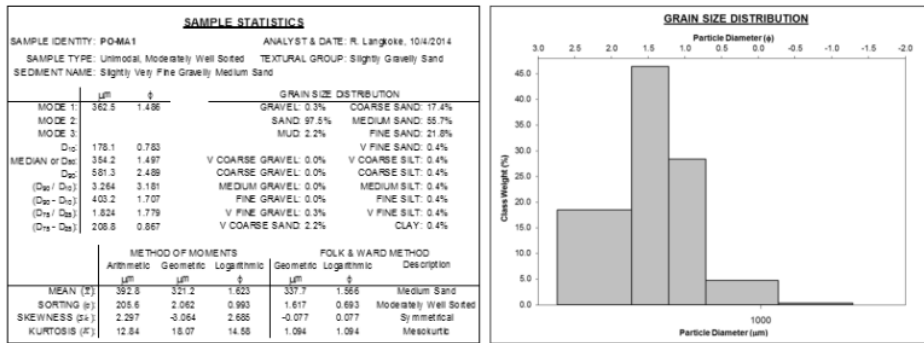


Figure 3. An example calculated statistical parameter using Gradistat program.

Sample analyses of Popo beach, comparison of the Folk and Ward graphical method and the method of moments indicated that both methods are drawbacks. Figure 4, shows the graph and moments methods in unit phi (ϕ) are relatively insensitive to sediments containing a large particle size range in the tails of the distribution. The mean

grain size and sorting values are required, produce similar results, however, the skewness or kurtosis are to be determined, in our experience the Folk and Ward measures provide the most robust basis for routine comparisons of compositionally variable sediments

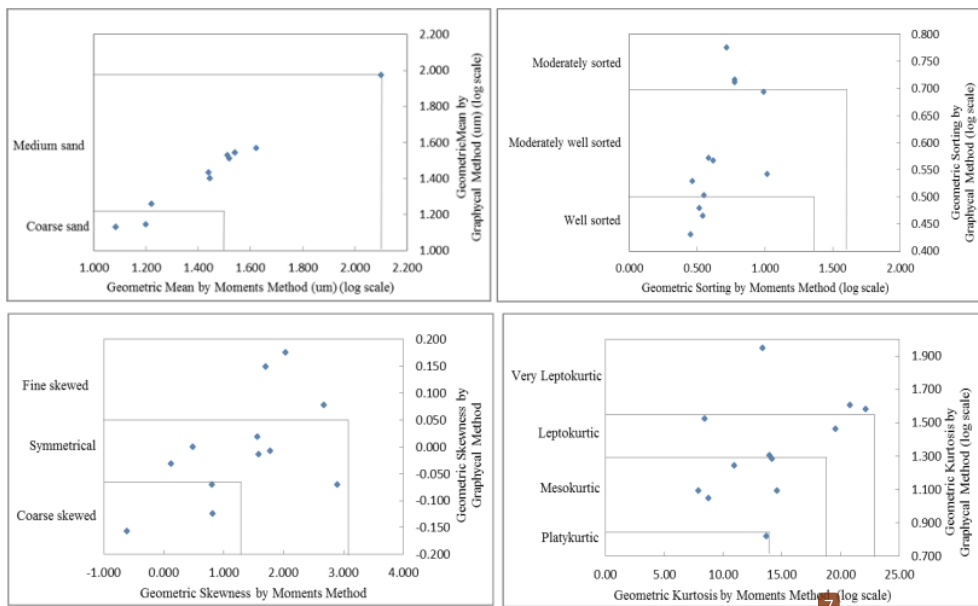


Figure 4. Comparison of statistical parameters calculated using the the geometric method of moments and Folk and Ward (1957) graphical method of Popo beach samples

Distribution of Grain Size Sediments

Characteristic of grain size distribution along the beach have sediment type unimodal with textural group slightly very fine gravel sand, reveals a majority sediment sands of the sample. Sorting represent rather moderately well sorted (MWS),

moderately sorted (MS) and well sorted (WS) of the sample. Skewness represent rather symmetrical, coarse skewed and fine skewed of the coarse and medium fractions of constitutive grains. Kurtosis rather mesokurtic, leptokurtic, very leptokurtic and platykurtic of the samples (Table 2).

Table 2. Characteristic of grain size sediment distribution of sample along Popo beach.

SAMPLE NUM.	PO-MA1	PO-MA2	PO-MA3	PO-MA4	PO-MA5	PO-MA6	PO-MA7	PO-MA8	PO-MA9	PO-MA10	PO-MA11	PO-MA12
MEAN	1.566	1.530	0.384	0.728	1.511	1.974	1.146	1.258	1.130	1.544	1.401	1.434
SORTASI	0.693	0.717	0.529	0.775	0.479	0.542	0.712	0.567	0.430	0.502	0.464	0.571
SKEWNESS	0.077	-0.014	-0.001	-0.124	0.149	-0.070	-0.008	-0.157	-0.032	0.175	0.018	-0.070
KURTOSIS	1.094	1.283	1.049	1.094	1.695	0.821	1.304	1.525	1.244	1.581	1.461	1.946
SEDIMENT NAME	23 ^{um} Sand	Medium Sand	Coarse Sand	Coarse Sand	27 ^{um} Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand	Medium Sand
SORTASI TYPE	MWS	MS	MWS	MS	WS	MWS	MS	MWS	MS	MWS	WS	MWS
SKEWNESS TYPE	Symetrical	Coarse Skewed	Symetrical	Coarse Skewed	Fine Skewed	Symetrical	Symetrical	Coarse Skewed	Symetrical	Fine Skewed	Symetrical	Symetrical
KURTOSIS TYPE	Mesocurtic	Mesocurtic	Mesocurtic	Mesocurtic	Mesocurtic	Platycurtic	Leptocurtic	Very Leptocurtic	Leptocurtic	Very Leptocurtic	Leptocurtic	Very Leptocurtic

Mean (Mz)

The mean value suggest that most of the sediment along Popo beach varied in between medium sand and coarse sand. The beach is dominated by medium sand in 83, 33% with a few amount of coarse sand in 16, 67%, the beach is under the action of relatively low waves and hence the size of the sediment (Figure 5).

The sediment size at PO-MA3 and PO-MA4 are coarse sand. These show that the location have high energy comparing with other locations which are composed of medium sand. The case during the remaining period due to the combined effect of wave activity and beach slope. The unimodal character of

sediment samples were identified towards gently beach slope with less wave activity.

Sorting ($\sigma\phi$)

Standard deviation ($\sigma\phi$) measures the sorting of sediments and indicates the fluctuations in the kinetic energy or velocity conditions of the depositing agent. Standard deviation values reveal that the beach sediments were well sorted, moderately well sorted to well sorted. Along the study area, sorting distribution are shown in Figure 6 with dominantly, moderately well sorted (MWS) in 50%, moderately sorted (MS) in 33,33% and well sorted (WS) in 16,67% of the samples.

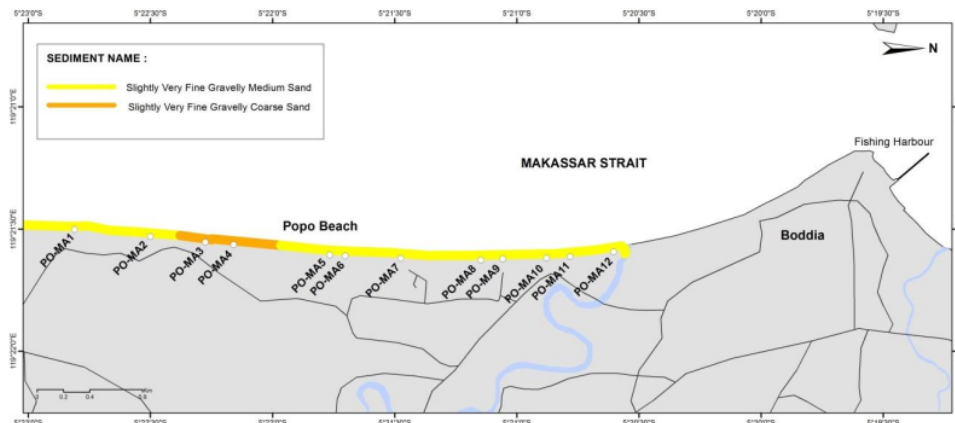


Figure 5. Distribution of sand beach sediment at Popo beach, dominantly medium sand, sediment type Unimodal, textural Slightly Very Fine Gravelly Sand.

The change of sorting formed along the beach is affected by seasonal and wave energy formed at every sample locations. The well sorted sediment samples were identified relatively more along beach during actual or the end of wet monsoon period with low

wave energy, and sediment samples were identified as moderately sorted and moderately well sorted with the influence of relatively high wave energy condition.

1 **Skewness and Kurtosis**

Skewness measures the asymmetrical curve of the frequency distribution. While kurtosis is the measure of peakedness or flatness of samples related to normal distribution. Along the study area sediments varied in between coarse skewed, symmetrical to fine skewed (Figure 7). Along the beach of the samples varied in between symmetrical in 58,33%, coarse skewed in 25% and fine skewed in

1 16,63%. The percentage of positive skewed samples were relatively less where negative skewed were relatively more, indicates that the beach was undergoing erosion or non-deposition (Duane, 1964). Distribution skewness of the sample indicate that about in 66,67% of total sediment samples at the beaches were negatively skewed (symmetrical skewed and coarse skewed) whereas the positively skewed (fine skewed) samples were in 33,33%.

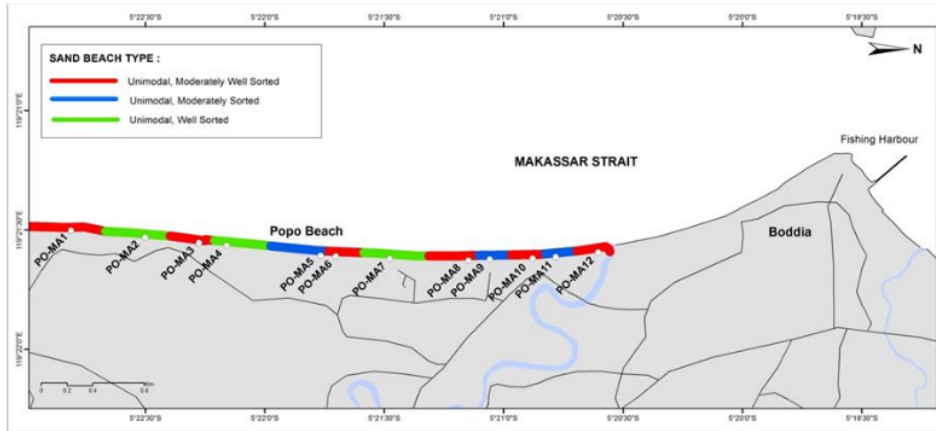


Figure 6. Distribution the sorting of sediment sand at the beach.

1 Along the beach, the fine sand is winnowed away by waves causing the sand to be coarse (negative) skewed. The fine skewed sediments

generally imply the introduction of fine material or removal of coarser fraction (Friedman, 1961) or winnowing of sediments (Duane, 1964).

SAMPLE NO.	SKEWNESS(S_k):	SEDIMENT NAME
PO-MA1	Symetrical	SVFG Medium Sand
PO-MA2	Coarse Skewed	SVFG Medium Sand
PO-MA3	Symetrical	SVFG Coarse Sand
PO-MA4	Coarse Skewed	SVFG Coarse Sand
PO-MA5	Fine Skewed	SVFG Medium Sand
PO-MA6	Symetrical	SVFG Medium Sand
PO-MA7	Symetrical	SVFG Medium Sand
PO-MA8	Coarse Skewed	SVFG Medium Sand
PO-MA9	Symetrical	SVFG Medium Sand
PO-MA10	Fine Skewed	SVFG Medium Sand
PO-MA11	Symetrical	SVFG Medium Sand
PO-MA12	Symetrical	SVFG Medium Sand

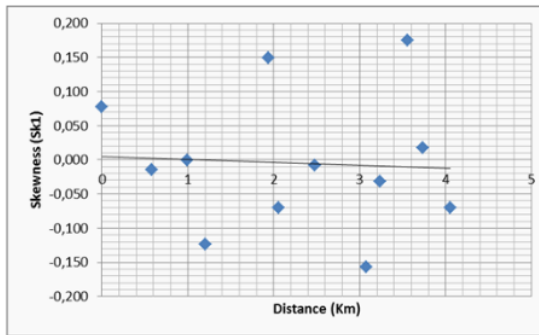


Figure 7. Comparative negative skewed and positive skewed of the sample at Popo beach.

1 Characteristic of sediment distribution type along the shoreline all the samples varied in between very platykurtic to very leptokurtic (Table 2). Most of the samples were shown as mesokurtic in 41,67%, very leptokurtic in 25%, leptokurtic in 25%), and platykurtic in 8,33%. Characteristics of kurtosis were very leptokurtic range varies between 1.525 and

1.946, mesokurtic range varies between 1.094 and 1.607, leptokurtic range varies between 1.244 and 1.461, and platykurtic 0,821 (Blott and Pye, 2001). Data collected during end of the rainy season. 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 above result shows that the skewness was highly influenced by wave action at Popo beach. More variation were found in mesocurtic and negative skewed characters which were linearly related ($Y = 0.5886 * X + 1.3371$) to each other with $r^2=0.036$.

Mean (Mφ) versus Sorting

Result from the scatter plot of the mean versus sorting of beach sediment samples show the variation in sorting character with mean grain size. Dominantly sample were medium sand and coarse sand with well sorted, moderately well sorted to moderately sorted characters. Along the study area the sorting character of sediment samples were negatively correlated, and found in medium sorted and moderately well sorted end of rainy season, which were linearly related ($Y = -0.039 * X + 0.6341$) and with correlation coefficient $r^2 = -0.0211$ (Figure 8). The low value of correlation coefficient indicates that the correlation between these parameters is not significant.

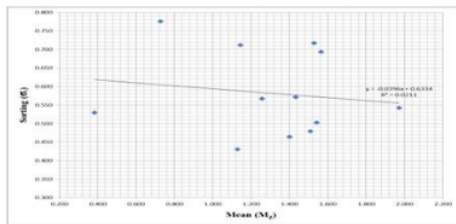


Figure 8. Graphic mean vs sorting.

Coastal Erosion

Grain size is the most fundamental physical property of sediment. As has been mentioned above, geologists and sedimentologists use information on sediment grain size to study trends in surface processes related to the dynamic conditions of transportation and deposition. Cumulative curve in algorithm probability paper showed population transport three type of grain size were surface creep, saltation and suspension. Granplots program of textural pattern determination of transport – depositional agencies in description of granulometric interpretation distribution along Popo beach were sand type tidal segment. Subsurface creep population varies between in 0.1% and 10%, moderately well sorted to well sorted, coarse truncated point varies in -0, 5 and -1, 5. This segment is term the fluvial tails, were indicated eolian processes with termed relative to fine truncated point (segment eolian hump. The Gaussian distribution plots as a straight line on probability paper showed tail represents fluvial energy has a steep slope. The greater the slope the higher the energy level, indicated eolian process with point is termed relative to the eolian hump (Figure 9). Relation of sediment transport to grain size distribution along the beach to analysis comparison of grain size curves and the interpretation of separate populations. Comparison between negatively skewed indication of erosion – non depositional and histogram grain size distribution at Popo beach (Figure 10).

PO-MA1

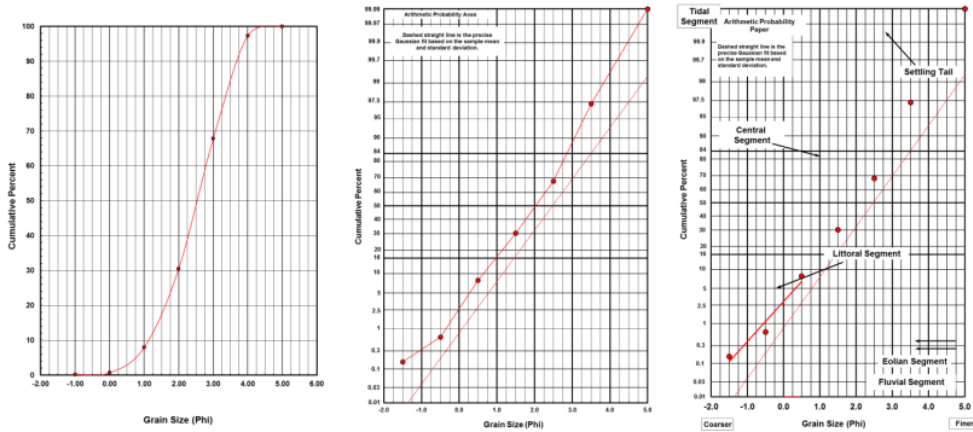


Figure 9. The Gaussian distribution plots showed the fluvial tails, eolian processes has a steep slope were indicated in segment coastal erosion.

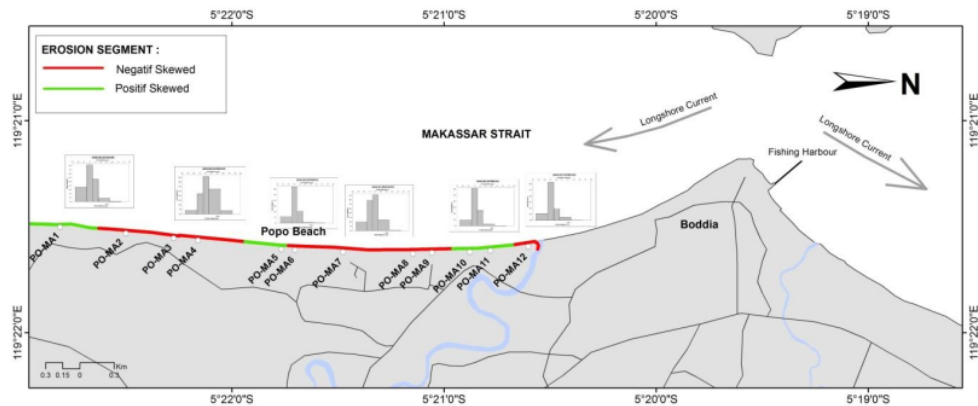


Figure 10. Negatively skewed indication of erosion – non depositional compare with histogram grain size distribution.

CONCLUSION

1. Characteristic grain size distribution along the beach have sediment type unimodal with textural group slightly **20**y fine gravel sand. Sortation represent rather **moderately well sorted (MWS)** , **moderately sorted (MS)** and **well sorted (WS)**, **Skewness** represent rather **symmetrical, coarse skewed** and fine **skewed**, and Kurtosis rather mesocurtic, leptocurtic, very leptocurtic and platycurtic of the samples.

2. Calculate a statistical description that adequately characterizes the sample used Gradistat along the study area, sediment type Unimodal, the mean values varied from 0.384 ϕ to 1.566 ϕ , the sortation value from 0.430 ϕ to 0.775 ϕ , the skewness value from -0.008 ϕ to 0.178 ϕ , and the kurtosis value from 0.821 ϕ to 1.946 ϕ .

3. Data collected during end of the **19**ny season. Kurtosis extreme high or low values **of the sediment achieved its sorting elsewhere in a high energy environment, skewness** was highly influenced by wave action, **negatively skewed** indication of erosion – non depositional. **17**

4. The Gaussian distribution **plots as a straight line on probability paper** showed tail represents fluvial energy has a steep slope. The greater the slope the higher the energy level.

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- 1** G. Udhaba DORA, V. Sanil KUMAR, C. Sajiv PHILIP, Glejin JOHNSON, P. VINAYARAJ, R. GOWTHAMAN. "Textural characteristics of foreshore sediments along Karnataka shoreline, west coast of India", International Journal of Sediment Research, 2011
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- 3** Lantuit, H.. "Fifty years of coastal erosion and retrogressive thaw slump activity on Herschel Island, southern Beaufort Sea, Yukon Territory, Canada", Geomorphology, 20080301
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- 4** Valentina Sattarova, Kirill Aksentov, Alexander Alatortsev, Le DucLuong, Renat Shakirov, Maxim Ivanov, Alexey Legkodimov. **2%**

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