International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 8, Issue 2, February 2019)

# Sedimentary Textural Characteristics of Digha Coastal Beach, a Part of Kanthi Coast, West Bengal, India

Nayan Dey[1], Dr. Purnima Shukla[2]

[1]*Research Scholar, Pt. R.S.U., Raipur, Chhattisgarh, India*
[2]*Head of the Department, Department of Geography, Durga Mahavidyalaya, Raipur, Chhattisgarh, India*

***Abstract--*** **The present research has been discussed on the sediment textural characteristics of the coastal beach. Sediment plays a role of document landform formation. Various statistical parameters such as Graphical Mean Grain Size (Mz), Standard Deviation ($\sigma_1$), Skewness (Sk) and Kurtosis (kG) are used to evacuate the aforesaid concern. The mean grain size (Mz) is being used to find out the dominance grain size. Standard deviation ($\sigma_1$) shows the sorting nature of soil or sediment. Skewness (Sk) measures the costiveness of skewed and also kurtosis (kG) quantifies the sediments nature are mesokurtic to very leptokurtic. In addition, Linear Discriminant Analysis (LDA) is used to analyse the environment of deposition.**

***Keyword:*** **Coastal Beach, Mean Grain Size, Standard Deviation, Skewness, Kurtosis, Linear Discriminant Analysis.**

## I. INTRODUCTION

Grain size is one of the most significant physical property of sediment and commonly used parameter for understanding the processes involved in transportation and deposition of sediments (Inman 1952; Folk and Ward 1957; Mason and Folk 1958; Friedman 1961; Krumbein and Sloss 1963; Nordstrom 1977; Parthasarathy et al., 2016). The environmental interpretation of grain-size distributions found in sedimentary deposits has been, and still is, a fundamental goal of sedimentology (Patric and Donald 1985). The grain size distribution is a simple yet informative test routinely performed in soil mechanics to classify soils (Fredlund et al., 2000). Thus, the knowledge of sediment size and textural parameters is one of the better tools to differentiate various depositional environments of recent as well as ancient sediments (Inman 1952; Dyer 1986; Folk 1974; Mason and Folk, 1958; Friedman 1961; Nordstorn 1977, Kumar et al. 2010). Beach sediment textual distributions and waves control beach profile and shape and, ultimately, it's dynamic behavior (Trindade et al., 2009).

Frequency distributions of sediment grain size (namely mean, sorting, skewness, and kurtosis) were used frequently to interpret the precipitation of sediment when they re-enter the natural environment (Folk and Robles, 1964; Dyer 1986; Weltje and Von Eynatten, 2004; Wachecka-Kotkowska and Kotkowski, 2011). Since nineties sedimentologists are using grain size data for the interpretation of sedimentary processes. An earliest effort for the systematic analysis of grain size data was made by Udden (1898, 1914), Wentworth (1922) (Devi 2014). Present investigation was carried out in the Digha coastal beach, a part of Kanthi Coast to understand the sediment textural characteristics and depositional environment.

## II. STUDY AREA

The sedimentary geology of the great Bengal basin has been totally controlled by regional tectonic activities, quaternary as well as Holocene sea-level fluctuation and sedimentation history (Banerji 1984; Hutchison 1989; Achharyya et al. 2000; Goodbred and Kuehl 2000; Morley 2002; Alam et al. 2003; Sikder et al. 2003; Mukharjee, et al. 2009; Jana, et al. 2018). The study area, Digha is an important tourist destination of West Bengal. The 7 km long beach is a part of Kanthi coast. The Digha coast stretches from the mouth of the tidal river Champa in the east to Udaipur (West Bengal, Odisha Border). Digha coastal beach is also divided into 15 beaches, viz. from west, beaches are Udaypur (80.32m), Jatranala (1632.9m), Police Holiday Home (304.73m), Larika (656.42m), Hospital (368.90m), Jagannath Temple (170.00m), Aparajita Cottage (342.00m), Blue View (161.60m), 1st Gate (260.30m), Saikatabas (154.51m), Hotel (362.57), Breack (260.00m), Digha Mohana (1662.60m) (Dey and Shukla 2017; Mondal and Shukla 2018).

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 8, Issue 2, February 2019)

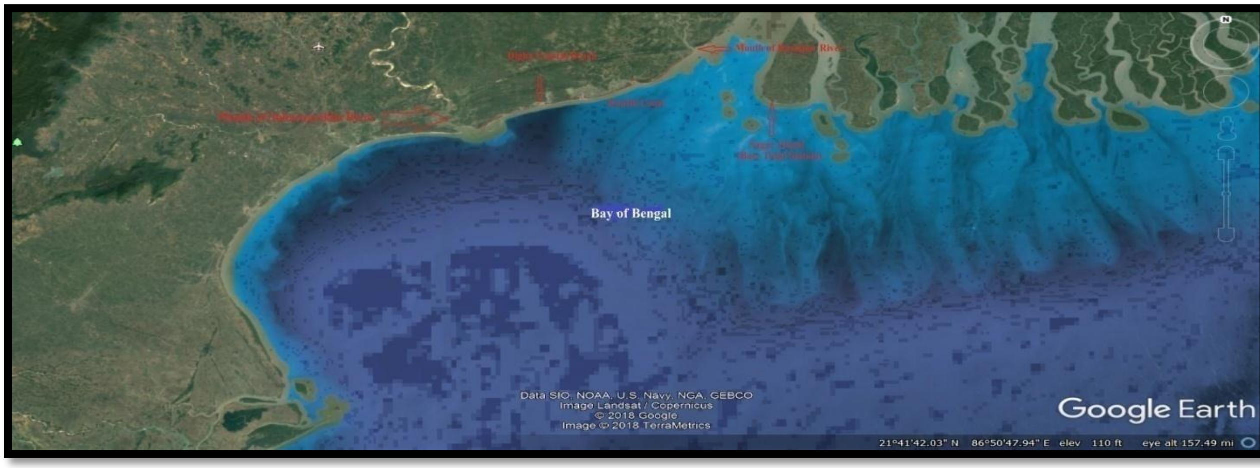


**Figure 1: Kanthi Coastal Beach (Source: Google Map)**

## III. Methodology

According to Boggs (1995), the research work has three main aspects, viz. (a) the method for measuring grain size and representing it in terms of grade scale, (b) techniques for quantifying grain size data and presenting them in a statistical or graphical form and (c) the genetic significance of the data (Baiyegunhi, Liu and Gwavava 2017), on Digha coastal beach. The said research paper has been analysed by using primary data. The methods of study broadly confined to field investigation (Parthasarathy et al. 2016). The soil samples are collected along with longitudinal profile of Digha coastal beach. To classify the collected sediment Samples into different grain size, ASTM sieves has been used. Various statistical methods have been used to evacuate the main objective of the paper, viz. Mean Grain size (Mz) after Inman (1952) and after Folk and Ward (1957), Standard Deviation ($\sigma_1$) after Krumbein (1938), after Otto (1939) and after Folk and Ward (1957), Skewness (Sk) after Folk and Ward (1957), Kurtosis (kG) after Duane (1964) and after Mason and Folk (1958), Linear Discriminant Functions after Sahu (1962, 1964).

## IV. Result And Discussion

*Textural Parameters:*

Grain size is a fundamental physical property of sediment.

The parameters employed to describe the grain size distribution are categorised into four main groups that include, the mean, standard deviation, skewness, and kurtosis (Baiyegunhi et al. 2017). Grain size analysis is a classical tool and provides additional information regarding sediment transport, energy conditions and depositional environment (Udden 1914; Srivastava et al. 2008). Textural parameters such as graphic mean, standard deviation (sorting), skewness and kurtosis have environmental significance and are useful for understanding synsedimentary hydrodynamic factors of transportation and deposition in a basin (Folk and Ward 1957; Friedman 1979; Passega 1964). Its importance in the classification of sediments has been recognized since the end of the 19$^{th}$ century by workers like Udden (1898), Wentworth (1922), Krumbein (1938) and others (Ghosh et al. 1994). A number of formulas have been proposed by different workers to calculate four main statistical parameters viz. graphic mean, graphic standard deviation, graphic skewness and graphic kurtosis (Wentworth 1922; Friedman 1961; Passega 1964; Sahu 1964; Venkatesan et al., 2017). The formula for calculating graphic mean, standard deviation, skewness and kurtosis is depicted (Baiyegunhi et al. 2017) in Table 1 and Table 2.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 8, Issue 2, February 2019)

**Table 1**
**Graphic measures from the grain size analysis of sediments at Digha Coastal Beach (Part of Kanthi Coast)**

| Station Name | Mean Grain Size (Mz) in $\phi$ | Standard Deviation ($\sigma_1$) | Skewness (Sk) | Kurtosis (kG) | Remark | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mz | $\sigma_1$ | Sk | kG |
| A | 2.633 | 0.633 | -0.265 | 1.061 | FS | MWS | CS | MK |
| $A_1$ | 2.950 | 0.505 | -0.732 | 1.009 | FS | MWS | VCS | MK |
| $A_2$ | 3.133 | 0.340 | -1.233 | 5.738 | VFS | VWS | VCS | ELK |
| $A_3$ | 3.283 | 0.216 | -0.941 | 3.484 | VFS | VWS | VCS | ELK |
| $A_4$ | 3.167 | 0.129 | 0.020 | 1.161 | VFS | VWS | NS | LK |
| $A_5$ | 3.083 | 0.395 | -0.436 | 1.080 | VFS | WS | VCS | MK |
| $A_6$ | 2.833 | 0.530 | -0.371 | 0.820 | FS | MWS | VCS | PK |
| $A_7$ | 3.083 | 0.415 | -0.566 | 1.230 | VFS | WS | VCS | LK |
| $A_8$ | 2.817 | 0.563 | -0.267 | 0.615 | FS | MWS | CS | VP |
| $A_9$ | 2.667 | 0.575 | -0.084 | 0.751 | FS | MWS | NS | PK |
| $A_{10}$ | 2.983 | 0.480 | -0.465 | 1.093 | FS | WS | VCS | MK |
| $A_{11}$ | 2.983 | 0.480 | -0.465 | 1.192 | FS | WS | VCS | LK |
| $A_{12}$ | 2.950 | 0.480 | -0.298 | 1.311 | FS | WS | CS | LK |
| $A_{13}$ | 3.083 | 0.450 | -0.691 | 2.705 | VFS | WS | VCS | VLK |
| $A_{14}$ | 3.100 | 0.491 | -0.7 | 2.342 | VFS | WS | VCS | VLK |
| $A_{15}$ | 2.750 | 0.648 | -0.239 | 0.840 | FS | MWS | CS | PK |
| $A_{16}$ | 2.750 | 0.555 | -0.154 | 0.820 | FS | MWS | CS | PK |
| $A_{17}$ | 3.050 | 0.440 | -0.598 | 1.025 | VFS | WS | VCS | MK |
| $A_{18}$ | 2.967 | 0.427 | -0.008 | 1.025 | FS | WS | NS | MK |

**Note: FS** = Fine Sand, **VFS** = Very coarse Sand, **VWS** = Very Well Sorted, **WS** = Well Sorted, **MWS** = Moderately Well Sorted, **CS** = Coarse Skewed, **VCS** = Very Coarse Skewed, **NS** = Nearly Symmetrical, **MK** = Mesokurtic, **ELK** = Extremely Leptokurtic, **LK** = Leptokurtic, **PK** = Platykurtic, **VPK** = Very Platykurtic, **VLK**=Very Leptokurtic.

**Table 2**
**Showing Grain Size Parameter from Digha Coastal Beach (Part of Kanthi Coast)**

| Item | Mean (Mz) in Phi | Standard Deviation ($\sigma_1$) | Skewness (Sk) | Kurtosis (kG) | Remark | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Mz | $\sigma_1$ | Sk | kG |
| **Min** | 2.633 | 0.129 | -1.233 | 0.615 | FS | VWS | VCS | VPK |
| **Max** | 3.283 | 0.648 | 0.020 | 5.738 | VFS | MWS | NS | ELK |
| **Average** | 2.961 | 0.461 | -0.447 | 1.542 | FS | WS | VCS | VLK |

*1. Graphic Mean (Mz)*

Mean grain size (*MZ*) is a descriptive parameter of grain-size that measures the arithmetic average size of all the particles in a sample (Baiyegunhi et al. 2017). Graphic Mean (Mz) is a measure of central Tendency (Suganraj et al. 2013).

Mean size of the sediments are influenced by the source of supply, transporting medium, and the energy conditions of the depositing environment (Folk and Ward 1957). The variation in mean size is a reflection of the changes in energy condition of the depositing media and indicates average kinetic energy of the depositing agent (Sahu 1964).

**International Journal of Recent Development in Engineering and Technology**
**Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 8, Issue 2, February 2019)**

Graphic Mean (Mz) is calculated by $\mathrm{Mz}\,(\phi) = (\phi 16 + \phi 50 + \phi 84)/3$, after Folk and Ward 1957. The dominant fine grained nature of sediment indicates the moderately wave energy condition on Digha coastal beach. Fine grained sediment predicts the winnowing action on beach.

*2. Standard Deviation ($\sigma_1$)*

Standard deviation or grain-size sorting is a measure of a range of grain sizes present and the degree of spread or scatter of these sizes around the average or mean size (Baiyegunhi et al. 2017). Standard deviation measures the sorting of sediments and indicates the fluctuations in the kinetic energy or velocity conditions of the depositing agent (Sahu 1964).The inclusive graphic standard deviation is the mathematically expression for sorting (Baiyegunhi et al. 2017). Sorting has an inverse relation with standard deviation (Venkatesan et al. 2017). The graphic standard deviation ($\sigma_1$) is the measure of sorting or uniformity of particles size distribution and it is calculated by the formula, $\text{Standard Deviation}\,(\sigma 1) = ((\phi 84 - \phi 16))/4 + ((\phi 95 - \phi 5))/6.6$ (Suganraj et al. 2013), after Folk and Ward (1957). The values obtained range from 0.129 (very well sorted) to 0.648 (moderately well sorted) and average value is 0.461. Thus, Digha beach platform is considered as well sorted platform.

*3. Skewness (Sk)*

Skewness measures the asymmetry of a frequency distribution (Venkatesan et al. 2017). The graphic skewness (Sk) measures the systematic of the distribution or predominance of coarse or fine sediments (Suganraj et al. 2013) and it is quantified by the following formula, $\text{Graphic Skewness (Sk)} = ((\phi 16 + \phi 84 - 2\phi 50))/(2\,(\phi 84 - \phi 16)) + ((\phi 95 - \phi 5))/(2\,(\phi 95 - \phi 5))$, after Folk and Ward (1957). The negative value denotes coarse skewed material, whereas, the positive value represents more material in the fine-tail i.e. fine skewed (Suganraj et al. 2013). The skewness value ranges of collected samples from -1.233 (Very Coarse Skewed) to 0.020 (Nearly Symmetrical). Mean skewness value is -0.447 (Very Coarse Skewed) which indicates winnowing action of fine particles with high wave energy.

*4. Graphic Kurtosis (kG)*

The graphic kurtosis (KG) is the peakedness of the distribution and measures the ratio between the sorting in the tails and central portion of the curve (Parthasarathy et al. 2016).

If the tails are better sorted than the central portions, then it is termed as platykurtic, whereas, leptokurtic, if the central portion is better sorted (Suganraj et al. 2013). If both are equally sorted then mesokurtic condition prevails (Parthasarathy et al. 2016). The Kurtosis (kG) is being measured by following formula$\text{Graphic Kurtosis (kG)} = (\phi 95 - \phi 5)/(2.44\,(\phi 75 - \phi 25))$, after Folk and Ward (1957). The values of collected sediment samples range from 0.615 (Very Platykurtic) to 5.738 (Extremely Leptokurtic). Mean value of Kurtosis is 1.542 (Leptokurtic) which indicates multiple processes are engaged to winnowing action of very fine particles in Digha beach.

## V. Linear Discriminate Function (LDF)

Variations in the energy and fluidity factors seem to have excellent correlation with the different processes and the environment of deposition (Sahu 1964). Sahu (1964) introduced the linear discriminate functions for environmental interpretation and the method uses all the grain size parameters in the form of a single linear equation, in which Y1 (Aeolian: beach), Y2 (fluvial: turbidity), Y3 (shallow marine: fluvial) and Y4 (beach: shallow marine) values were analyzed (Venkatesan et al. 2017). We are using the Y1, Y3 and Y4 discriminate functions for the aforesaid work. The aforesaid discriminant has been employed to bring out the relation between aeolian, beach, shallow marine environment and shallow agitated water process through the statistical analysis of mean, standard deviation, skewness and kurtosis, by the following formulas-

$$\begin{aligned}\text{Y1 (Aeolian : Beach)} &= -3.5688\,(\mathrm{Mz}) \\ &\quad + 3.7016\,(\mathrm{SD})2 - 0.0766\,(\mathrm{SK}) \\ &\quad + 3.1135\,(\mathrm{kG})\end{aligned}$$

$$\text{Y3 (Sh. Marine : Sh. Agitated)} = 0.2852\,(\mathrm{Mz}) - 8.7604\,(\mathrm{SD})2 - 4.893\,(\mathrm{SK}) + 0.0482\,(\mathrm{kG})$$

$$\begin{aligned}\text{Y4 (Beach : Sh. marine)} &= 15.6534\,(\mathrm{Mz}) \\ &\quad - 8.7604\,(\mathrm{SD})2 - 4.8932\,(\mathrm{SK}) \\ &\quad + 18.5043\,(\mathrm{kG})\end{aligned}$$

The following table number 3 is deals with classification of the different depositional environment.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 8, Issue 2, February 2019)

**Table 3**
**Different Depositional Environment (Sahu 1962, 1964)**

| Y | Depositional Environment | Value | Linear Discriminant Function (LDF) |
|---|---|---|---|
| **Y1** | Aeolian : Beach | < -2.7411 | Aeolian Environment |
| | | >-2.7411 | Beach Environment |
| **Y3** | Sh. Marine : Sh. Agitated | >-7.4190 | Shallow Marine Environment |
| | | <-7.4190 | Shallow agitated water process |
| **Y4** | Beach : Sh. marine | <65.3650 | Beach Environment |
| | | >65.3650 | Shallow Marine Environment |

**Table 3**
**Linear discriminate function (LDF) values and depositional environments for Digha Coastal Beach calculated after Sahu 1964**

| Station Name | Y1 | Y3 | Y4 | Remark | | |
|---|---|---|---|---|---|---|
| | | | | Y1 | Y3 | Y4 |
| A | -4.590 | -1.412 | 44.332 | Aeolian | Sh. Marine | Beach |
| $A_1$ | -6.386 | 2.238 | 66.196 | Aeolian | Sh. Marine | Sh. Marine |
| $A_2$ | 7.217 | 6.190 | 160.179 | Beach | Sh. Marine | Sh. Marine |
| $A_3$ | -0.624 | 5.300 | 120.055 | Beach | Sh. Marine | Sh. Marine |
| $A_4$ | -7.673 | 0.716 | 70.814 | Aeolian | Sh. Marine | Sh. Marine |
| $A_5$ | -7.029 | 1.702 | 70.510 | Aeolian | Sh. Marine | Sh. Marine |
| $A_6$ | -6.489 | 0.217 | 58.874 | Aeolian | Sh. Marine | Beach |
| $A_7$ | -6.492 | 2.199 | 72.281 | Aeolian | Sh. Marine | Sh. Marine |
| $A_8$ | -6.945 | -0.637 | 54.005 | Aeolian | Sh. Marine | Beach |
| $A_9$ | -5.950 | -1.689 | 53.159 | Aeolian | Sh. Marine | Beach |
| $A_{10}$ | -6.354 | 1.160 | 67.176 | Aeolian | Sh. Marine | Sh. Marine |
| $A_{11}$ | -5.725 | 1.165 | 67.599 | Aeolian | Sh. Marine | Sh. Marine |
| $A_{12}$ | -4.135 | 0.344 | 69.876 | Aeolian | Sh. Marine | Sh. Marine |
| $A_{13}$ | -1.778 | 2.617 | 99.921 | Beach | Sh. Marine | Sh. Marine |
| $A_{14}$ | -2.825 | 2.310 | 93.176 | Aeolian | Sh. Marine | Sh. Marine |
| $A_{15}$ | -5.626 | -1.684 | 56.081 | Aeolian | Sh. Marine | Beach |
| $A_{16}$ | -6.109 | -1.073 | 56.276 | Aeolian | Sh. Marine | Beach |
| $A_{17}$ | -6.931 | 2.184 | 67.940 | Aeolian | Sh. Marine | Sh. Marine |
| $A_{18}$ | -6.722 | -0.663 | 63.852 | Aeolian | Sh. Marine | Beach |

With reference to Y1 value, aeolian process contributes 84.21% and 15.79% by beach at Digha coastal beach. With reference to Y3 value, shallow marine environment is dominant with 100%.

Y4 values show that about 63.16% of the samples were deposited under shallow marine environment and about 36.84% were deposited under shallow marine agitated environment (Table 3). From the calculation of Y1, Y3 and Y4, it has been evacuated that the maximum portion of Digha beach was occurred under the shallow marine environment.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 8, Issue 2, February 2019)

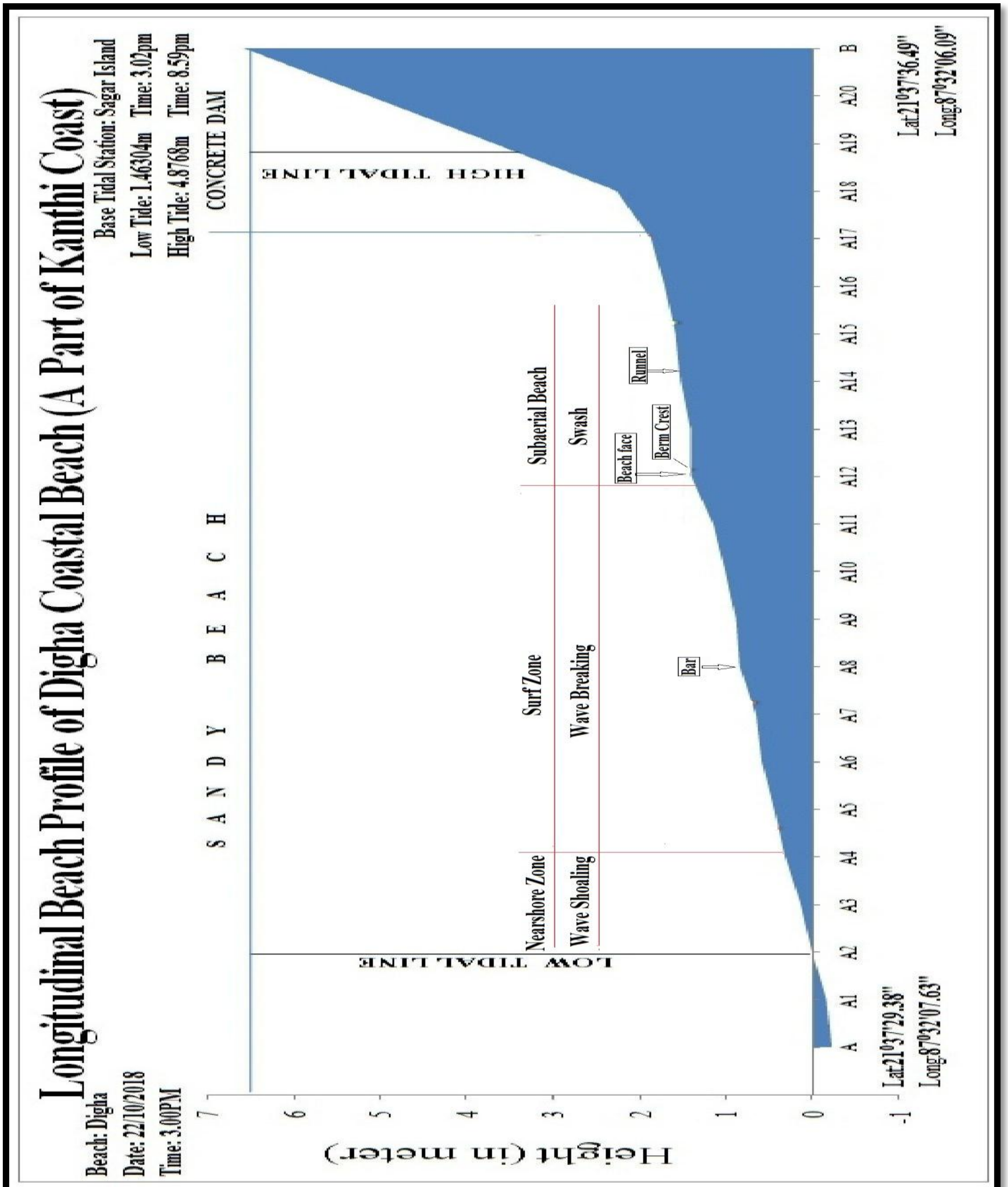


**Figure. 2: Longitudinal Beach Profile of Digha Coastal Beach**

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 8, Issue 2, February 2019)

## VI. Conclusion

From the above discussion sedimentary textural context is measured which help to conclude about the nature, formation and future prediction of Digha beach. The investigation of the textural characteristics revealed that the size distributions of the mean values are indicates the dominance of fine grained nature (Parthasarathy et al. 2016) and also well sorted platform. According to the energy variation model (Mean Wave Height vs. Mean Tidal Range) after M. O. Hayes (1979); Davis and Hayes (1984); Paul (2002), Digha is under moderate to high energy section. Consequently, in Digha coast winnowing action is being acted by removing fine particles. In addition very low percolation rate also influence to erosional work. Thus the beach shape is changing from flat to concave (Fig 2).

## References

[1] Acharyya, S.K., et al., (2000): Arsenic toxicity of ground water in parts of the Bengal basin in India and Bangladesh: the role of Quaternary Stratigraphy and Holocene sea-level fluctuation, Environmental Geology, vol. 39, Iss. 10, 1127-1137.

[2] Alam, M., et al., (2003): An overview of the sedimentary geology of the Bengal basin in relation to the regional tectonic framework and basin-fill history, Sedimentary Geology, vol. 155, Iss.3, 179-208.

[3] Banerji, R.K., (1984): Post-Eocene biofacies, palaeoenvironments and palaeogeography of the Bengal basin, India; Palaeogeography, Palaeoclimatology, Palaecology, vol. 45, Iss. 1, 49-73.

[4] Baiyegunhi, C., Liu, K, Gwavava, O., (2017): Grain size statistics and depositional pattern of the Ecca Group sandstones, Karoo Super group in the Eastern Cape Province, South Africa; De Gruyter Open, vol. 9, 554-576.

[5] Devi, T.D., (2014): Textual Characteristics and Depositional Environment of Olistostromal Sandstone of Ukhrul, Manipur; International Journal of Recent Development in Engineering and Technology, vol. 2, Iss. 1, 92-100.

[6] Dey, N., Shukla, P., (2017): Physical carrying capacity assessment in coastal tourist destination – a case study in igha, West Bengal; Economic Development & Environment (Edited book Volume), Vasundhara Publication, Gorakhpur, 102-106.

[7] Dyer, K.R., (1986): Coastal and estuarine sediment dynamics, Wiley, London, p.342.

[8] Folk, R.L., Robbles, R., (1964): Carbonate sediments of Isla Perez. Alacran reef complex, Yucatan; Journal of Geology, vol. 72, 255-292.

[9] Folk, R.L., Ward, W.C., (1957): Brazos River bar: a study in the significance of grain size parameters, Journal of sedimentary Geology, vol. 27, 3-26.

[10] Fredlund, M.D., Fredlund, D. G., Ward Wilson, G., (2000): An equation to represent grain size distribution, Can. Geotech J., vol.37, 817-827.

[11] Friedman, G.M., (1961): Distinction between dune, beach and river sands from textural characteristics, Jour. Sed. Petrology, vol. 31, 514-529.

[12] Friedman, G.M., (1979): Address of the retiring President of the International Association of Sedimentologists: Differences in size distributions of populations of particles among sands of various origins, Sedimentology, vol. 26, 3–32.

[13] Goodbred, S.L., Kuehl, S.A., (2000): The significance of large sediment supply, active tectonism, and eustasy on margin sequence development: Late Quaternary stratigraphy and evolution of the Ganges-Brahmaputra delta, Sedimentary Geology, vol. 133, Iss. 3, 227-248.

[14] Hutchison, C.S., (1989): Geological Evolution of South-east Asia; Oxford: Clarendon Press, vol. 13, p. 368.

[15] Inman, D.L., (1952): Measures for describing the size distribution of sediments, Jour. Sedimentary Petrology, vol. 22, 125-145.

[16] Jana, S., Paul, A.K., (2018): Genetical Classification of Deltaic and Non Deltaic Sequences of Landforms of Subarnarekha Middle Course and Lower Course Sections in Odisha and Parts of West Bengal with Application of Geospatial Technology, Journal of Coastal Sciences, vol. 5, Iss.1, 16-26.

[17] Krumbein, W.C., (1934): Size frequency distribution of sediments, Jour. Sedimentary Petrology, vol. 4, 65-77.

[18] Krumbein, W.C., (1938): Size frequency distribution of sediments and the normal phi curve, J. Sediment. Petrol., vol. 18, 84-90.

[19] Krumbein, W.C., Sloss, L., (1963): Stratigraphy and Sedimentation, Ch. 4, Properties of Sedimentary Rocks, 93-149.

[20] Kumar, G., Ramanathan, A.L., Rajkumar, K., (2010): Textural characteristics of the surface sediments of a Tropical mangrove ecosystem Gulf of Kutch, Gujarat, India; Indian Journal of Marine Science, vol.39, 415-422.

[21] Mason, C.C., Folk, R.L., (1958): Differentiation of beach, dune and aeolian flat environment by size analysis, Mustang Island, Texas, Jour. Sed. Pet., vol. 28, 211-226.

[22] Mondal, C., Dey, N., (2018): Carrying capacity assessment in coastal tourism center: a case study in Digha, West Bengal; Sustainable Development: A Dynamic Perspective (Edited Book Volume), Anjan Publisher, Kolkata, vol. 1, 175-182.

[23] Morley, C.K., (2002): A tectonic model for the Tertiary evolution of strike-slip faults and rift basins in SE Asia, Tectonophysics, vol. 347, Iss.4, 189-215.

[24] Mukherjee, A., et al., (2009): Geologic, geomorphic and hydrologic framework and evolution of Bengal basin, India and Bangladesh; Journal of Asian Earth Sciences, vol. 34, Iss.3, 227-244.

[25] Nordstrom, K.F., (1977): Bay side beach dynamics: Implications for simulation modeling on eroding sheltered tidal beaches. Marine Geology, vol. 25, 333-342.

[26] Parthasarathy, P., et al., (2016): Sediment dynamics and depositional environment of Coleroon river sediments, Tamilnadu, Southeast coast of India; Journal of Coastal Science, vol.3, Iss.2, 1-7.

[27] Patric, M., Donald, B., (1985): The effects of sediment transport on grain size distribution, Journal of Sedimentary Petology, vol. 55, Iss. 4, 0457- 0470.

[28] Passega, R., (1964): Grain size representation by CM patterns as a geological tool, Journal of Sedimentary Petrology, vol. 34, 830–847.

[29] Sahu, B.K., (1964): Depositional mechanism from the size analysis of clastic sediments, J. Sediment Petrol, vol. 34, Iss. 1, 73-83.

[30] Sikder, A.M., Alam, M.M., (2003): 2-D modelling of the anticlinal structures and structural development of the eastern fold belt of the Bengal Basin, Bangladesh; Sedimentary Geology, vol. 155, Iss.3, 209-226.

[31] Srivastav, A.K., Mankar, S.R., (2008): Grain Size Analysis and depositional pattern of Upper Gondwana sediments (early Crataceous) of Salbardi area, distt. Amravati, Maharashtra and Betul, Madhya Pradesh; Journal of Geological Society of India, vol. 73, 393 - 404.

[32] Suganraj, K., et al., (February, 2013): Grain size statistical parameters of coastal sediments at Kameswaram Nagapattinam District, east coast of Tamilnadu, India, International Journal of Recent Scintific Research, vol. 4, Iss.2, 102-106.

[33] Trindade, J., Ramos-Pereira, A., (2009): Sediment textual distribution on beach profiles in a rocky coast (Estremadura - Portugal), Journal of Coastal Research, SI56.

[34] Udden, J.A., (1898): Mechanical composition of wind deposits, Augustana Library Publications, vol. 1, 69.

[35] Udden, J.A. (1914): Mechanical composition of clastic sediments. Geol. Soc. Am. Bull. Vol. 25 p. 655-744.

[36] Venkatesan, S., et al., (2017): Depositional mechanism of sediments through size analysis from the core of Arasalar river near Karaikkal, east coast of India; Indian Journal of Geo Marine Sciences, vol. 46, Iss. 10, 2122-2131.

[37] Wachecka-Kotkowska, L., Górska-Zabielska, M., (2011): Extent of the Middle Polish Glaciations (Saalian, MIS 6) in central Poland on the basis of petrographic analysis; Abstracts IAG/AIG Regional Conference ‘Geomorphology for Human Adaptation to Changing Tropical Environments; p. 161.

[38] Weltje, G.J., Von Eynatten, H., (2004): Quantitative provenance analysis of sediments: review and outlook, Sedimentary Geology, vol.171, 1-11.

[39] Wentworth, C.K., (1922): A scale of grade and class terms for clastic sediments, Journal of Geology, vol. 30, 377-392.