**Peer Reviewed International Research Journal of Geography**

**Maharashtra Bhugolshastra Sanshodhan Patrika**

ISSN : 0971-6785 {Impact Factor 3.687 (IIFS)} Vol. 34,No.1, Jan-Jun. 2017.pp 87-93

# IDENTIFICATION OF PROCESSES LEADING TO BEACH DUNE FORMATION USING PROBABILITY PLOTS: A CASE STUDY OF AKSHI - REVDANDA BEACH SECTOR, MAHARASHTRA

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***Abstract:***

*The grain-size analysis of the sediment samples usually provides the size frequency spectrum in terms of weight or volume present in a specific size interval. Plotting of the results of single sample analysis on a probability paper no doubt enables us to know about the sediment distribution properties such as mean, median, standard deviation, skewness and kurtosis but it also helps in the identification of processes by which the sediment is deposited. Certain process cannot be interpreted directly from ordinary statistical techniques. This is the advantage of using probability plots especially when it comes to beach and dune sediment samples. In order to identify different processes, segments on probability curve, should be studied separately. Identification of such process segments helps in improving the interpretation of the process dominant in the deposition of the said segment.*

*Three common segments were identified by Moss (1963), on probability plot. Two of these are tails and another is the middle portion of the curve. Tanner (2009) designated these segments as "coarse tail", "central segment", and "fine tail". Important hydrodynamic and process changes could be identified no matter from where the samples are selected from the beach or back-beach,.*

*The cumulative sand grain weight against size of the fine tail on the probability plot corresponds to the sediment load carried in suspension. The coarser tail is considered to represent the movement by surface creep and the central segment, the movement of saltation.*

**Introduction:**

The backshore segment of any beach system is the landward extension of the foreshore and the entire area is directly or indirectly associated with present and past beach processes. It is mainly influenced by the aeolian sand movement.

Development of a variety of coastal sand dunes is a major phenomenon in this backshore zone. Such dunes are different from any other coastal landform as they are mainly the result of the interaction between sand transported by wind and the present vegetation cover of the area. Height of these dunes may vary from 2m to 20m with a steep windward side and gentle leeward side, unlike the desert dunes. Coastal dunes are common along every coast but they are prominent on the back of dissipative beaches with strong onshore winds and plentiful sediment supply. Textural variation over the beach also affects the transport; as smaller particles are more likely to move at a larger distance while the deflations accumulate larger materials on the surface. Sand may be transported a considerable distance inland, however, in most cases deposition occurs within a short distances also. The movement by suspension mostly affects the grains of diameter 0.02mm and less. These grains tend to rise up and get suspended, eventually being blown away from the beach to a long distances to form dunes. The succeeding ones blowing from the beach tend to settle mostly on top of the dunes. Bagnold (1941) showed that these particles are mainly disturbed and moved by vehicles or animals as they kick off the sand particles into dust clouds; and not normally disturbed by the strong winds as they lie below the zero wind velocity zones.

**Study area:**

The beaches on the west coast of India are generally identified as reflective, dissipative or intermediate pocket beaches (Karlekar,2017). Their inconspicuousness is attributed to their smaller north south and even east west extent.

The area of investigation lies between 18°33' N/ 72°55' East and 18°38'N/ 72°53' E on the Middle Konkan region of Maharashtra coast (Fig 1). It covers a 10 km long beach sector from Akshi in the north to Revdanda to the south along the Arabian Sea coast. The backshore area is a relatively flat zone referred to as planation surface, marked by various palaeogeomorphic features and dotted with several low-lying sand dunes.

The spring tide range along the coastal stretch is 2.5 m and the neap tide range is 1.8 m.The average beach width is around 100 m.

The back beach (or intertidal landward portion) behind the berm varies in width and character. The sands on back beach are generally fine grained and well sorted compared to beach face. The backshore is the area of the shoreline above the high water or high tide mark. Permanent vegetation, sand dunes and a berm (flat upper beach) are the main features found in back beach region. The foreshore extends from the low water line to limit of wave up rush at high water. It may have a beach scarp i.e. vertical slope produced by wave erosion and a low tide terrace especially in monsoons (Karlekr, 2017) .

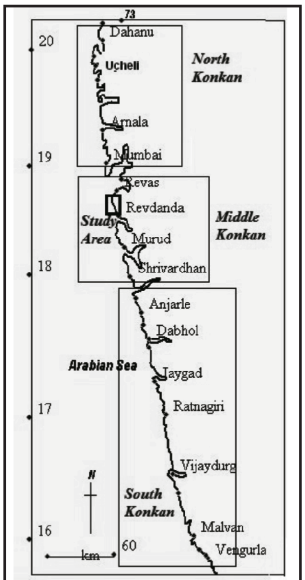



*Fig 1. Study area*

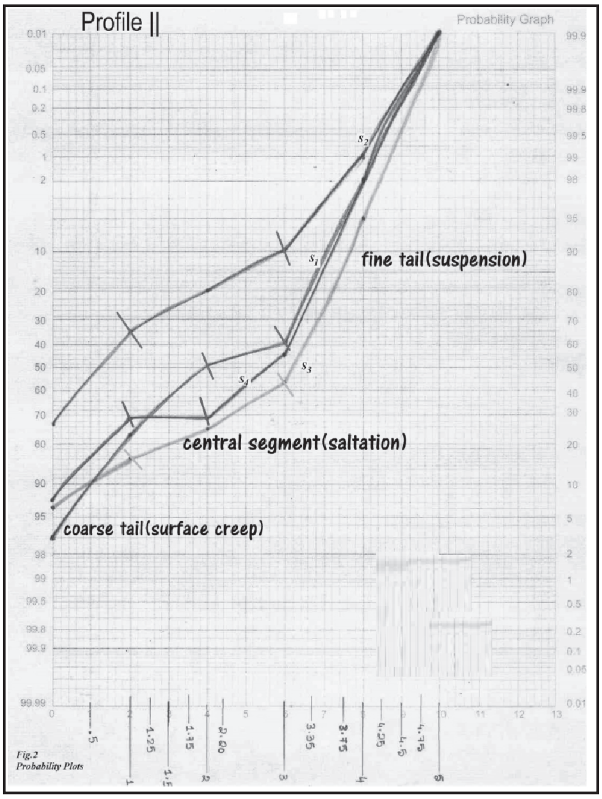
**Methodology:**

The difference in grain texture and size helps in formation of distinct environmentally sensitive sediment population. A number of theoretical and empirical experimental attempts have been made to quantify the grain transport rate, mostly by using sheer wind velocity measurement or sediment traps. However, for many size distributions, the complicated nature of data makes a graphical display always helpful. Taking that into consideration, for the current study probability plots were used to show the size frequency spectrum in terms of weight in a specific size interval because it can be used in identifying the distinctive inflections. It also helps to know about the components where mixing is suspected.

A probability plot is graph that can be used to evaluate the fit of a distribution of the data, estimate percentages, and compare different sample distributions. It is useful for any method of sampling that utilizes some form of random selection.

The advantage of the probability curve is that it creates an estimated cumulative distribution from the samples by plotting the value of each observation against its estimated cumulative occurrences.

The scales are transformed so that the fitted distribution forms a straight line. A good distribution fit is one where the observations are near the fitted line. It also helps in estimating internal sorting of the sediments.




The probability plots were drawn for the entire backshore area stretching between North and South end. Representative probability plots for four samples collected from beach limit S1, berm S2, fore dune S3 and back dune S4 along profile II are shown in Fig 2.A break or change in plot signifies the change in the grain size leading to the change in the movement pattern. The weight of the sediment and their percentage contribution in a particular process became prominent when they were measured separately within each segment between the breaks in the profile, from the probability plot.

All the values from the graph, for a single segment, were collected and statistically interpreted which gave the values of mean, median, standard deviation (sorting), skewness and kurtosis for that particular segment. Such a quantitative analysis was done from all the probability plots. The segment wise statistical calculations were quite useful to know about a particular process that is dominant in that region.Samples collected from near the berm face showed completely different numeric figures than the ones collected from further landward of the backshore. The numerical evidence itself spoke about the morphological features from where the samples were collected. Field truthing with the dumpy level data confirmed the nature of terrain as deposition by sand as dunes, berms etc.

In all nine beach profiles were measured using levelling instrument along 10 km stretch from Akshi to Revdanda approximately at 1km interval each. However, due to the presence of Paulo creek in the middle of the study area, and an increased number of cultivated paddy area in the southern sector, 7 profiles were taken in the northern side of the creek and 2 profiles in the southern side of the creek. Due to such enormous human interference in terms of settlement and cultivation, the south of the creek has highly disturbed backshore.

Samples were collected from each profile considering any textural change seen in the field along the backshore. Although unevenly distributed these samples tell us about the beach system as a whole. Collection of samples ranges from the berm area to the landward extension of backshore consisting of dunes.

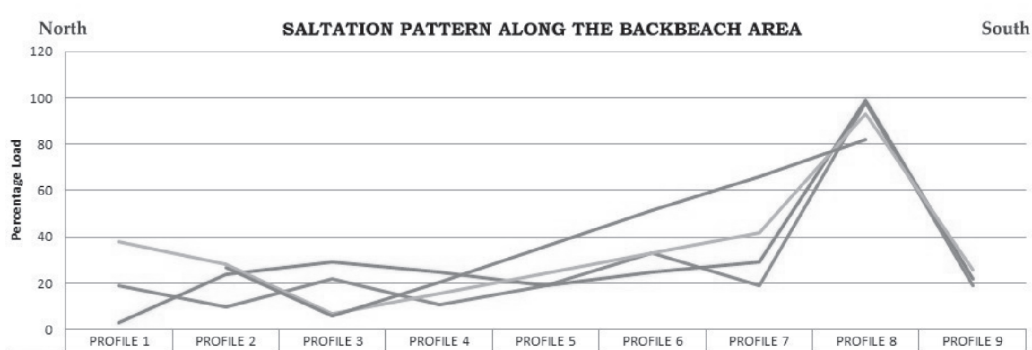
Each of the samples was subjected to grain-size analysis and based on physical characteristics and behaviour the results were plotted in a probability graph.

**Discussion:**

The grain-size analysis of the sediment samples usually provides the size frequency spectrum in terms of weight or volume present in a specific size interval. Plotting of the results of single sample analysis on a probability paper no doubt enables us to know about the sediment distribution properties such as mean, median, standard deviation, skewness and kurtosis but it also helps in the identification of processes by which the sediment is deposited. Certain process cannot be interpreted directly from ordinary statistical techniques. This is the advantage of using probability plots especially when it comes to beach and dune sediment samples. In order to identify different processes, segments on probability curve, should be studied separately. Identification of such process segments helps in improving the interpretation of the process dominant in the deposition of the said segment.

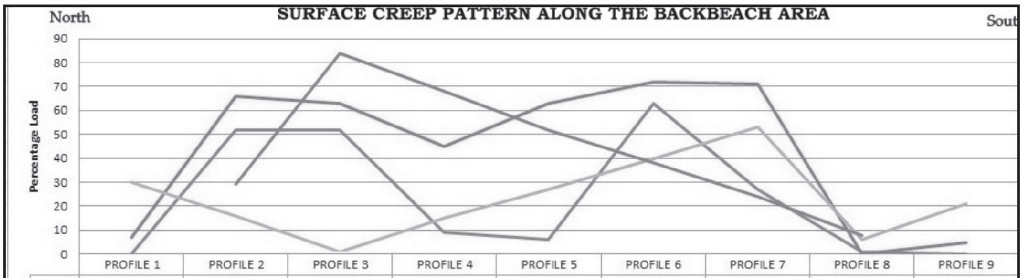
Three common segments were identified by Moss (1962-63), on probability plot. Two of these are tails and another is the middle portion of the curve. Tanner (2009) designated these segments as “coarse tail”, “central segment”, and “fine tail”. Important hydrodynamic and process changes could be identified no matter from where the samples are selected from the beach or back-beach.

The cumulative sand grain weight against size of the fine tail on the probability plot corresponds to the sediment load carried in suspension. The coarser tail is considered to represent the movement by surface creep and the central segment, the movement of saltation.Fig.3, 4 and 5 show the north to south variations in the amount of sand moving by the process of saltation, surface creep and suspension respectively (Table 1). These processes leading to the formation of berm, dune and backdune areas in the northern part of backbeach sector of study area is shown in Fig.6.



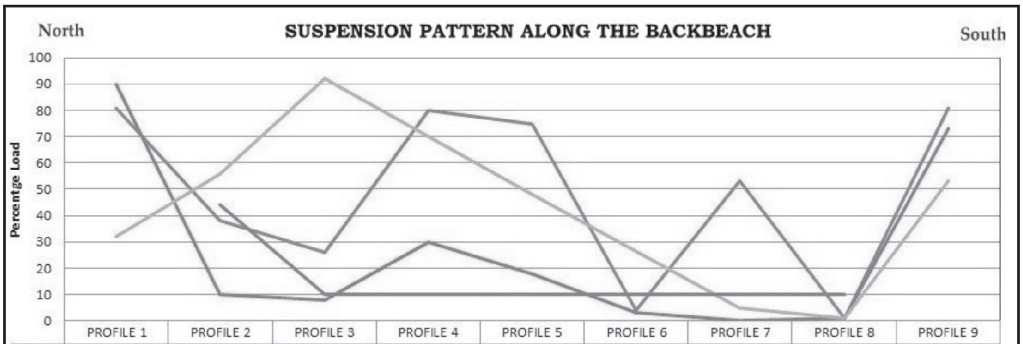

| | PROFILE 1 | PROFILE 2 | PROFILE 3 | PROFILE 4 | PROFILE 5 | PROFILE 6 | PROFILE 7 | PROFILE 8 | PROFILE 9 |
|---|---|---|---|---|---|---|---|---|---|
| s1 | 19 | 10 | 22 | 11 | 19 | 33 | 19 | 98 | 19 |
| s2 | 3 | 24 | 29 | 25 | 19 | 25 | 29 | 99 | 22 |
| s3 | 38 | 28 | 7 | | | | 42 | 93 | 26 |
| s4 | | 27 | 6 | | | | | 82 | |

*Fig. 3*




| | PROFILE 1 | PROFILE 2 | PROFILE 3 | PROFILE 4 | PROFILE 5 | PROFILE 6 | PROFILE 7 | PROFILE 8 | PROFILE 9 |
|---|---|---|---|---|---|---|---|---|---|
| s1 | 0 | 52 | 52 | 9 | 6 | 63 | 27 | 1 | 0 |
| s2 | 7 | 66 | 63 | 45 | 63 | 72 | 71 | 0 | 5 |
| s3 | 30 | 16 | 1 | | | | 53 | 6 | 21 |
| s4 | | 29 | 84 | | | | | 8 | |

*Fig.4*




| | PROFILE 1 | PROFILE 2 | PROFILE 3 | PROFILE 4 | PROFILE 5 | PROFILE 6 | PROFILE 7 | PROFILE 8 | PROFILE 9 |
|---|---|---|---|---|---|---|---|---|---|
| s1 | 81 | 38 | 26 | 80 | 75 | 4 | 53 | 1 | 81 |
| s2 | 90 | 10 | 8 | 30 | 18 | 3 | 0 | 1 | 73 |
| s3 | 32 | 56 | 92 | | | | 5 | 1 | 53 |
| s4 | | 44 | 10 | | | | | 10 | |

*Fig. 5*

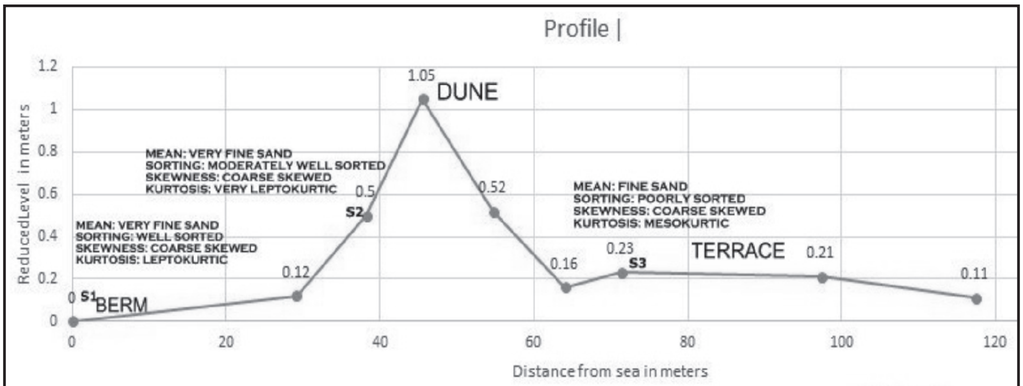



*Fig.6*

| SAMPLES | SURCFACE CREEP(%) | SALTATION(%) | SUSPENSION(%) |
|---|---|---|---|
| PROFILE 1 | | | |
| SAMPLE 1 | 0 | 19 | 81 |
| SAMPLE 2 | 7 | 3 | 90 |
| SAMPLE 3 | 30 | 38 | 32 |
| PROFILE 2 | | | |
| SAMPLE 1 | 52 | 10 | 38 |
| SAMPLE 2 | 66 | 24 | 10 |
| SAMPLE 3 | 16 | 28 | 56 |
| SAMPLE 4 | 29 | 27 | 44 |
| PROFILE 3 | | | |
| SAMPLE 1 | 52 | 22 | 26 |
| SAMPLE 2 | 63 | 29 | 8 |
| SAMPLE 3 | 1 | 7 | 92 |
| SAMPLE 4 | 84 | 6 | 10 |
| PROFILE 4 | | | |
| SAMPLE 1 | 9 | 11 | 80 |
| SAMPLE 2 | 45 | 25 | 30 |
| PROFILE 5 | | | |
| SAMPLE 1 | 6 | 19 | 75 |
| SAMPLE 2 | 63 | 19 | 18 |
| PROFILE 6 | | | |
| SAMPLE 1 | 63 | 33 | 4 |
| SAMPLE 2 | 72 | 25 | 3 |
| PROFILE 7 | | | |
| SAMPLE 1 | 27 | 19 | 53 |
| SAMPLE 2 | 71 | 29 | 0 |
| SAMPLE 3 | 53 | 42 | 5 |
| PROFILE 8 | | | |
| SAMPLE 1 | 1 | 98 | 1 |
| SAMPLE 2 | 0 | 99 | 1 |
| SAMPLE 3 | 6 | 93 | 1 |
| SAMPLE 4 | 8 | 82 | 10 |
| PROFILE 9 | | | |
| SAMPLE 1 | 0 | 19 | 81 |
| SAMPLE 2 | 5 | 22 | 73 |
| SAMPLE 3 | 21 | 26 | 53 |

Table 1. Percentage weight of sediment in each process movement

**Conclusion:**

The study clearly suggests that the probability plots can be very effectively used in the identification of various sediment movement process in the beach and back beach areas along the coastline. Existence of very small, insignificant, low berms and dunes could be ascertained by the processes leading to their formation.

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