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Deposition of Fluid Mud on beaches and in partially sheltered tidal creeklets on North Konkan Coast, Maharashtra

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Abstract

Deposition of fluid mud is usually significant in quiet, wave free environments such as creeks and estuaries on the coast. This behavior of fluid mud getting deposited only in quiet wave free environments is showing different tendencies and patterns on North Maharashtra coast where the supply of fine grained, silt clay textured sediments is extremely large. Fluid mud with a water content of 65 to 85 % and the bulk density ranging from 1.05 to 1.25 gr / cm ^3, is found covering many lower and upper beach sectors and partially sheltered small creeklets on North Konkan coast of Maharashtra in recent years. Numerous small indentations are getting filled by this mud along rocky shoreline sectors.

Quantum of suspended sediment is found to range from 100 to 800 gr / l. The occurrence also exhibits a significant seasonal and tidal phase variation. The fluid mud reappears at the same location especially in August and September and at low tide phase. The temporal variation component indicates that the massive suspension is followed by rapid deposition in monsoon, post monsoon and ebb conditions. It was also seen that tremendous potential exists for sediment transport in monsoon and high tide waves.

The field study of mud occurrence at Zai, Bordi, Chikhali, Dahanu, Revas , Yelavane, Nagav and Revdanda shows that these areas receive fine grained suspended sediment mainly from land and secondarily from the offshore zone. The bulk of the fine sediment is transported in suspension as diffused sediment plumes. Sediment is dispersed on beaches by complex combinations of waves and currents and the mud is deposited in every small sheltered sector of the shore. In most of the cases the mud deposited is a fluid mud associated with seaward margin of beach and is exposed at low tide as wide mud beach or mud patches scattered on the beach. Mud appears welded to shoreline especially along the coast having meso and macro tidal environment.It is not always easy to ascertain the existence of mud on the sandy beaches by indicators like sediment texture. It is often necessary to employ proxy indicators like plant and animal fossils, bioturbation and cohesion or destruction of flakes. These could be used as 'passive markers'.

The study concludes that fluid mud can accumulate on beaches in moderate wave energy and meso and macro tidal environment. The areas of mud, especially fluid mud with a water content ranging from 65 to 85 % can change rapidly in time and space as a result of amount of suspended sediment carried by waves. Occasionally mud becomes permanently attached to shoreline and is rapidly colonized by mangroves.

Key Words : *Fluid mud, mud flats, tidal creeklets, North Konkan.*

Introduction

Coasts composed predominantly of mud, comprising silt and clay sized sediment, occur in low energy settings, generally sheltered from wave action. Muddy coasts can be part of, or adjacent to, deltaic-estuarine coasts and are usually dominated by tides. Fine sediments are transported to considerable distances in suspension. After deposition, muddy sediments tend to be cohesive, making them more resistant to resuspension, and highly organic supporting a diverse biota.

Mudflats, salt marshes and mangroves are most extensive on macrotidal coasts (Woodroffe, 2002): They are especially associated with large embayments where tidal current are strong and wave action limited. However mud can occur wherever there is a large supply of fine sediment irrespective of tidal range. For instance, extensive mud banks develop downdrift of major deltas and, over time these prograde to form a muddy plain. Coarse sediment is either deposited within deltaic landform or concentrated into narrow shore – parallel ridges, termed 'cheniers' A prograded muddy coastal plain is called a chenier plain where it is composed of mud with intermittent coarse chenier ridges marking former shorelines.

The source of the mud on beaches can be in many cases traced directly to nearby sea. It can also be related with the coastal configuration and the wave climate of the region. Mud can occur in a number of different coastal settings. Many a times, no single coastal or combination process can be used to explain the existence of all mud patches. (Wells ,1981)

The mud patches are not always fixed and rigid and can move seasonally. The mud can be veneered by a thin layer of sand in fair weather and can be eventually scored in stormy season on beaches; it can be deposited at different depths alternated with sand shingles. The mud in tidal inlets, creeks and creeklets can be rolled by tidal waves and by sea waves to produce mud balls on beach that are then armored by sand and shingles. Distinct erosion, acieration cycle on the beaches along the Konkan coast of Maharashtra, supplemented with minor fall in sea level or scouring of shelf may be responsible for recent appearance of mud on the Konkan beaches.

The occurrence of mud on beach is quite a significant phenomenon on Maharashtra coast. The properties of cohesive sediments usually combine with the hydraulic phenomena to form complex transport patterns. The hydraulic phenomena in tidal channels and along coast are a continually varying interaction between the intrusion of salt water from the sea, tidal oscillation, ocean currents and waves.

The term tidal mud pertains to mixtures of fine solid material and water, the solid material generally being of the granulometric ranges called clay (>8 phi) and silt (4 to 8 phi). It may contain some organic matter and sand also.

Mineralogically, the most important constituents of tidal mud are clay minerals which occur in crystalline particles of various characteristic shapes. The particles are light and as a consequence flocculation in suspension of these sediments and cohesion is a characteristic property of deposits. The water component of mud can either be

natural fresh water or sea water. When bulk density is excessive the mud becomes a hard soil and the consolidation process is even slower than in the fluid mud.

When the supply of fine grained sediments is very large the mud can accumulate even in wave dominated environments and can be found even on beaches. The only requisite for fluid mud formation is high suspended sediment concentration and rapid sedimentation (Wells, 1981). Fluid mud formation along the coasts is a rapid and dynamic process. The estuarine fluid muds are suspended and redeposited at tidal frequency and produce thicker accumulations as current velocities decrease. Once formed fluid mud consolidates slowly. Stirring by waves slows down the process of consolidation and unless such muds are exposed subaerially for several days consolidation is interrupted by newly formed fluid muds. It has been reported that the fluid mud reappears at the same location periodically.

Semi liquid mud also described as soft silt or fluid mud represents a unique state between suspension and consolidation. Much still remains to be learnt about this type of mud occurring on beaches and creeks. The mud occurs in specific coastal settings such as low and high tide beaches, creeks and estuaries.

Sediment water interface in these muds is usually poorly defined. The muddy bottom on beaches often becomes a time varying surface and hence very difficult to measure. Fluid mud on beaches and mud flats is exposed at low tides and covered by water at high tide.

Fluid mud is a sediment water mixture with sediment concentrations greater than 10,000 mg / l, sediment water density of 1.03 g /cm cube at salinity 35 per thousand. Fluid mud periodically becomes welded to the shoreline where Avicennia mangroves start colonizing the area. In many areas in the world the fluid muds are characterized by extremely fine sediment size, high organic content and show very low strength. The exact combination of properties that govern their behavior is complex and controversial. A detailed study of fluid muds at Surinam,South America, shows following properties (Wells, 1981).

Bulk density 1.03 to 1.25 g / cubic cm , Water content 64 to 96 %, Median particle size 0.5 to 1.0 microns , Organic content 1.5 to 2.2 %. The mineralogical analysis shows that the content of kaolinite is 10 to 30 %, illite 10 to 30 %, smectite 5 to 20 % and Quartz 15 to 40 %.

Study Area

A 500 km long coastline and a narrow coastal plain stretching from north to south along the western boundary, is a distinct physiographic region of Maharashtra. The region is traditionally known as Konkan and is a land of plateaus, plains and hills. It is separated from upland Maharashtra by a west-facing escarpment of Sahyadri Mountains. Konkan extends from Damanganga River in the north to the Terekhol River in the south. The width of this coastal belt is not uniform and varies between 40 and 50 km all along the region. Administratively it comprises of Thane, Raigad, Ratnagiri and Sindhudurg districts and Mumbai.

Konkan is dotted with innumerable, small, sandy pocket beaches.Sandy beaches

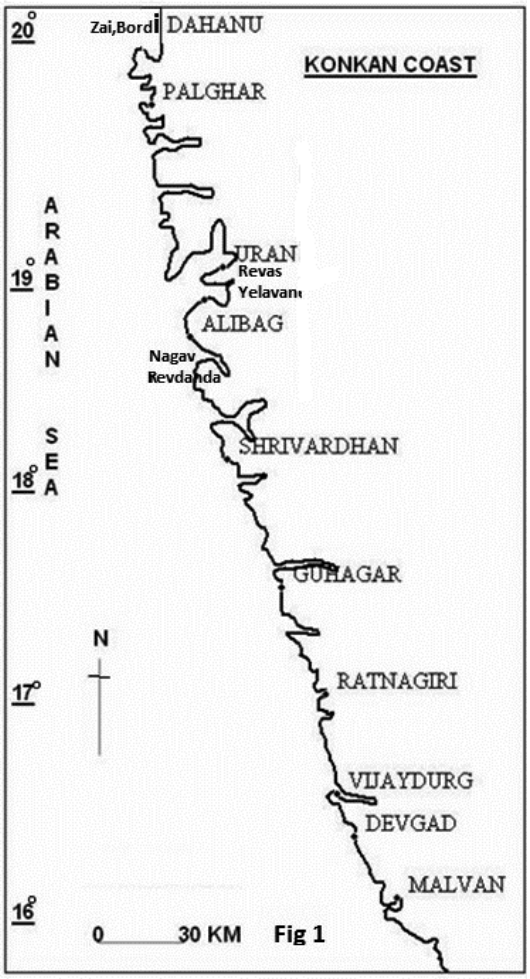

Fig 1 : Study Area

predominate the shoreline, but there are few mud beaches such as at Zai, Bordi,Chikhali, Dahanu and Rewas (Fig 1). The sediment characteristics and the morphodynamics of these beaches are controlled mainly by specific wave and tide environment related to seasons and tidal range. Wide beaches with a well-developed berm and beach face are characteristic of fair weather period. Most beach sediments are well sorted and major differences in grain size reflect differences in wave energy levels. Tides are the main force in macro and meso tidal environment, in north Konkan. Decrease in the velocity of tidal currents at ebb, results in the sediment deposition in swash zone. The flood tide currents, on the contrary, induce erosion and cutting of beach profiles. In addition to these daily changes, Konkan beaches also undergo periodic changes related to seasons. Low, flat, swell waves during fair weather build up the berm or beach face and high, steep, storm waves in monsoon cut the beach face (Karlekar, 2014). Flat beaches in Konkan are usually associated with low and spilling breakers of fair weather whereas plunging breakers front steep beaches. Most of the beaches on Konkan coast are sandy beaches. Mud beaches are confined to macrotidal sectors of the coast to the north. The occurrence of mud and especially fluid mud on many beaches is a recent phenomenon on this coast.

Objectives

The main objective of this work is to study the occurrence and seasonality of fluid mud and its various properties and behavior on the beaches of Maharashtra coast.

Materials And Methods

The beaches and small creeklets in the study area where fluid mud deposition was seen were identified and periodically visited to confirm the occurrence of fluid mud in monsoon and fair weather seasons. Samples of fluid mud deposits collected from representative beaches from meso and macrotidal environment namely, Zai, Bordi, Chikhali, Dahanu, Revas, Yelavane, Nagav and Revdanda were analyzed using wet and dry sieving techniques. In

addition to textural properties chemical and mineralogical composition of the mud samples was determined. Water content, bulk density, organic matter content and IR spectroscopy results were used to determine the fluid character of the mud. On the basis of this an attempt is made to ascertain the geomorphic significance and behaviour of fluid mud on this coast.

Discussion

The field study of mud occurrence at Zai, Bordi, Chikhali, Dahanu, Revas , Yelavane, Nagav and Revdanda shows that these areas receive fine grained suspended sediment mainly from land and secondarily from the offshore zone. The bulk of the fine sediment is transported in suspension as diffused sediment plumes. Sediment is dispersed on beaches by complex combinations of waves and currents and the mud is deposited in every small sheltered sector of the shore. The table below shows that in most of the cases the mud deposited is a fluid mud. It is associated with seaward margin of beach and is exposed at low tide as wide mud beach or mud patches scattered on the beach. Mud appears welded to shoreline in few cases.(Fig2)

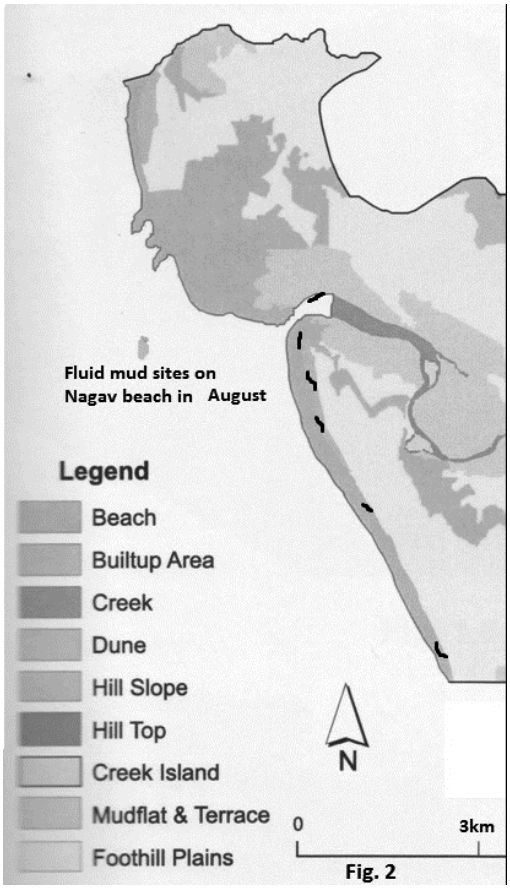

Fig.2: Fluid mud appears welded to backshore at few places like Nagav

Table showing properties of fluid mud in the study area

Beach	Suspended Matter in waves (gr / l)	Water content (%)	Bulk Density (gr/ cm cub)	Liquid density (gr/cm cub)	Organic matter (%)	Median particle size (Phi)	sorting	skewness	kurtosis
Zai 20 ,08 / 72, 44	320	65	1.2	0.98	1.8	6.06	2.2	.65	1.2
Bordi 20 ,07/ 72, 44	650	85	1.3	0.99	2.3	6.9	1.6	.62	0.6

Chikhali 20 ,03 / 72,42	600	78	1.25	0.97	1.8	6.0	2.1	.7	1.1
Dahanu 19 ,58 / 72,437	580	70	1.1	0.96	2.7	6.2	1.6	0.6	0.7
Revas 18, 49 / 72, 57	550	72	1.25	0.98	2.1	6.6	2.2	0.2	0.6
Yelavane 18, 47 / 72, 54	620	82	1.25	0.8	2.3	2.3	1.5	0.2	0.6
Nagav 18, 36 / 72, 53	610	80	1.15	0.7	2.0	6.4	2.0	0.5	0.5
Revadanda 18, 33 / 72, 56	450	72	1.1	0.8	1.7	6.3	2.0	0.6	0.5

The areas bordering most of the beaches are 200 to 500 m wide littoral terraces bounded by hill slopes which provide weathered material that moves downslope. Where the amount of fine grained suspended sediments in waves is greater than 400 gr / l the fluid mud can be seen accumulated even in wave dominated environments and can be found even on beaches and within partially sheltered creeklets. The only requisite for fluid mud formation is high suspended sediment concentration and rapid sedimentation (Wells, 1981). Fluid mud formation along this coast appears to be a rapid and dynamic process. The fluid mud is suspended and redeposited at tidal frequency and produce thicker accumulations as current velocities decrease. Once formed fluid mud consolidates slowly. Stirring by waves slows down the process of consolidation and unless such mud is exposed sub aerially for several days consolidation is interrupted by newly formed fluid mud.

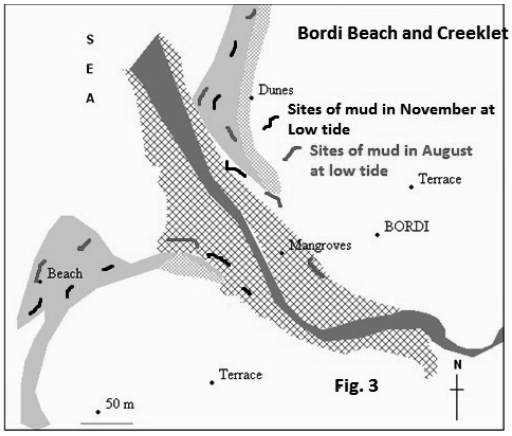

Fig.3 : Fluid mud patches keep on shifting seasonally.

The mud patches are not always fixed and rigid and can be seen moving seasonally (Fig 3). The mud in few cases can be seen veneered by a thin layer of sand in fair weather and can be eventually scored in stormy season on beaches. The bulk of the fine sediment is transported in suspension

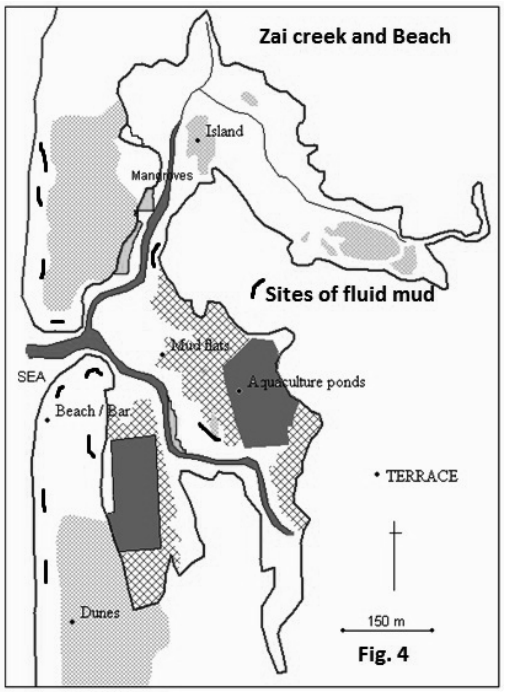

Fig 4: Fluid mud is deposited in every small concavity and open area on the coast.

as diffused sediment plumes. Sediment is dispersed on beaches by complex combinations of waves and currents and the mud is deposited in every small sheltered sector of the shore. (Fig 4)

In most of the cases the mud deposited is associated with seaward margin of beach and is exposed at low tide as wide mud beach or mud patches scattered on the beach. The mud on the lower and upper beach sectors dries due to desiccation in post monsoon and big mud chunks are developed especially at Bordi,Yelavane, Nagav and Revadanda (Fig 5, see page 187). The chunks are triangular to polygonal in shape 2 to 4 cm wide and 4 to 5 cm deep cracks in mud chunks widen by swash backwash and tidal currents. Fluid mud in creeklets is always sticky, moist and does not crack due to dessication. Fluid Mud also appears welded to shoreline especially at Zai, Bordi and Dahanu.

It is not always easy to ascertain the existence of fluid mud on the sandy beaches by indicators like sediment texture. It is often necessary to employ proxy indicators like plant and animal fossils, bioturbation and cohesion or destruction of flakes. These could be used as 'passive markers' to recognize fluid nature of mud on beaches. The mineralogical analysis of samples collected indicates predominance of montmorillionite group of clays in fluid mud which is responsible for shrinkage due to dessication.Montmorillionite-Kaolinite-Illite shows 3:2:1 proportion in most of the samples collected.

Conclusion

Most fluid mud beach sediments are well sorted and differences in median grain size reflect differences in wave energy levels. Decrease in the velocity of tidal currents at ebb, results in the sediment deposition in swash zone. Sediment is dispersed on beaches by complex combinations of waves and currents and the mud is deposited in every small sheltered sector of the shore. Sediment water interface in these mud is usually poorly defined. The only requisite for fluid mud formation on sample beaches is found to be high suspended sediment concentration which is to the tune of 300 to 700 gr / l. The occurrence also exhibits a significant seasonal and tidal phase variation. The fluid mud reappears at the same location especially in August and September and at

low tide phase. The study shows that fluid mud can accumulate on beaches in moderate wave energy and meso and macro tidal environment. The areas of fluid mud, with a water content ranging from 65 to 85 % can change rapidly in time and space as a result of amount of suspended sediment carried by waves. Occasionally mud becomes permanently attached to shoreline and is rapidly colonized by mangroves.

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Fig 5 (see page 185 for the text) : Big mud chunks on Bordi beach

Plate 1 : See text on page 193

Plate 2 : See text on page 193

Plate 3 : See text on page 196

Plate 4 : See text on page 196

Plate 5 : See text on page 196

Plate 6 : See text ----------