

Effect of Artificially Dumped Material on the Configuration of Baina Beach, Goa

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The changes in beach topographic features along with variations in particle size distribution of beach sediments from Baina, at three selected stations, with special emphasis on the effects of dumping of dredged material from Mormugao Harbour on the beach, have been studied. The study has revealed that at station 1, located at the dumping point of the dredged material, (i) the berm, originally located at about 45 m from the sea wall, has prograded by about 70 m due to the dumping operations, and (ii) a runnel extending up to 250 m on either side of the dumped spot has formed. In general, the beach experiences cut from May to July and fill from September to March. Before dumping operations, the sediments of the beach at all the 3 stations had their mean grain size in medium sand class and moderately well sorted to moderately sorted with symmetrical or negatively skewed distribution. After the dumping operations, the sediments at stations 2 and 3 remain in the same class limits, whereas the samples at station 1 are in fine sand class, poorly sorted and very negatively skewed. These findings indicate that there is very slow littoral movement existing along the beach. Further, if any foreign material with different textural characteristics is dumped on this beach, the material is not likely to move appreciably along the beach nor does it influence the neighbourhood much.

AS a part of a detailed and continuing study on the composition, distribution and movement of sediments of the beaches (Calangute, Colva, Baina, Palolim) and nearshore regions along the Goa coast, a preliminary account of the seasonal variations in textural characteristics of Calangute beach sediments has been presented earlier¹. The present paper deals with (i) the changes in the beach topographic features of Baina, recorded during May 1972 to March 1973, and (ii) the variations in particle size distribution of the beach sediments with particular reference to the effects of dumping of dredged material from Mormugao Harbour area on this beach.

It is pertinent to mention that in connection with the development of Mormugao Harbour by deepening the harbour area and the approach channel, a pipeline (65 cm internal diam. and 2 km in length) connecting the harbour at one end and the nearby Baina beach at the other end was laid down. The material, dredged from the harbour area, was first discharged on to the then existing beach foreshore in the form of slurry (sediment + water mixture) through this pipeline, on 7 July 1972. This operation (at the rate of 450 m³/hr) lasted till the middle of September 1972.

Materials and Methods

Study area -The area investigated is a small sandy beach located at lat. 15°23'25"N and long. 73°48'27"E on the coast of Goa (Fig. 1). Unlike the other beaches (Calangute, Colva) which are exposed to the waves of the sea, the beach under study is a partly protected one. Mormugao headland and Kambariem Island in the north and Peken Island in the south protect the beach from the waves approaching the

shore from north-west and south-west directions respectively. On the landward region, the southern half of the beach is backed by sand dunes, the central part is protected by semi-consolidated beach rock, while most of the northern sector is protected by a sea wall.

Three reference points were fixed along this strip of beach for observations, taking into consideration the physiography of the beach. One of the three reference points (station 1, Fig. 1) is situated at the northern end of the sea wall. The sediment discharge pipeline was laid down at station 1, projecting on to the foreshore. (Fig. 2, point A, station 1).

Beach profiles were measured using graduated pole and measuring tape, and these together with observations of relevant meteorological and oceanographic parameters were recorded from May 1972 to March 1973. The profiles were measured at fortnightly intervals in the beginning (during May 1972) and about once a month later on (from July 1972 to March 1973). Sediment samples from the beach before and after the discharge of dredged material were collected, then dried and sieved at 1/2 ϕ intervals. Among the samples collected after the discharge of the dredged material, some were composed of sand, silt and clay components and hence these were analysed for particle size distribution by a combination of sieving and pipette method². A composite sample of approximately 1000 ml of dredged material was collected from the discharge pipeline while dumping was going on and this was also subjected to particle size analysis in the conventional manner². Grain size parameters of the sediments were calculated using the formulae of Folk and Ward³.

Results

The changes in beach topographic features at stations 1 to 3 are shown in Fig. 2. Frequency distribution curves of samples giving distribution of material in different size grades before and after the operations of dumping are shown in Fig. 3. The percentage values of the fractions >0.50 mm, 0.50-0.25 mm and <0.25 mm of each sample, plotted on a triangular diagram⁴, are shown in Fig. 4. The results of the particle size analysis are given in Table 1.

Beach topographic changes — Fig. 2 (station 1) shows the topographic changes which have occurred from May 1972 to March 1973. The 10 May 1972 survey, herein referred to as the base survey, was made prior to dumping; the July 1972 survey, just after the beginning of the dumping; the September survey, after all the dumping had been completed; and the October to March surveys, after the dumped material was at the observation site for periods ranging from 11/2 to 61/2 months. In May, the berm was about 45 to 50 m away from the sea wall and by July it practically disappeared. The beach profile

TABLE 1 — RESULTS OF PARTICLE SIZE ANALYSIS

Location	Grain size parameters,					
	Mean size ($Mz \phi$)		St. deviation (σI)		Skewness (Ski)	
	A'	B'	A'	B'	A'	B'
Station 1	1.5130	2.3200	0.8060	1.0311	-0.1680	-0.4997
Station 2	1.5260	1.4300	0.6009	0.9030	0.0962	-0.0852
Station 3	1.7240	1.6210	0.6235	0.6854	-0.0805	0.0167
DP*	4.5900		3.0955		+0.4813	

A' and B' = Samples collected before and after the discharge of the dredged material respectively.
 *Sample collected from the discharge pipeline.

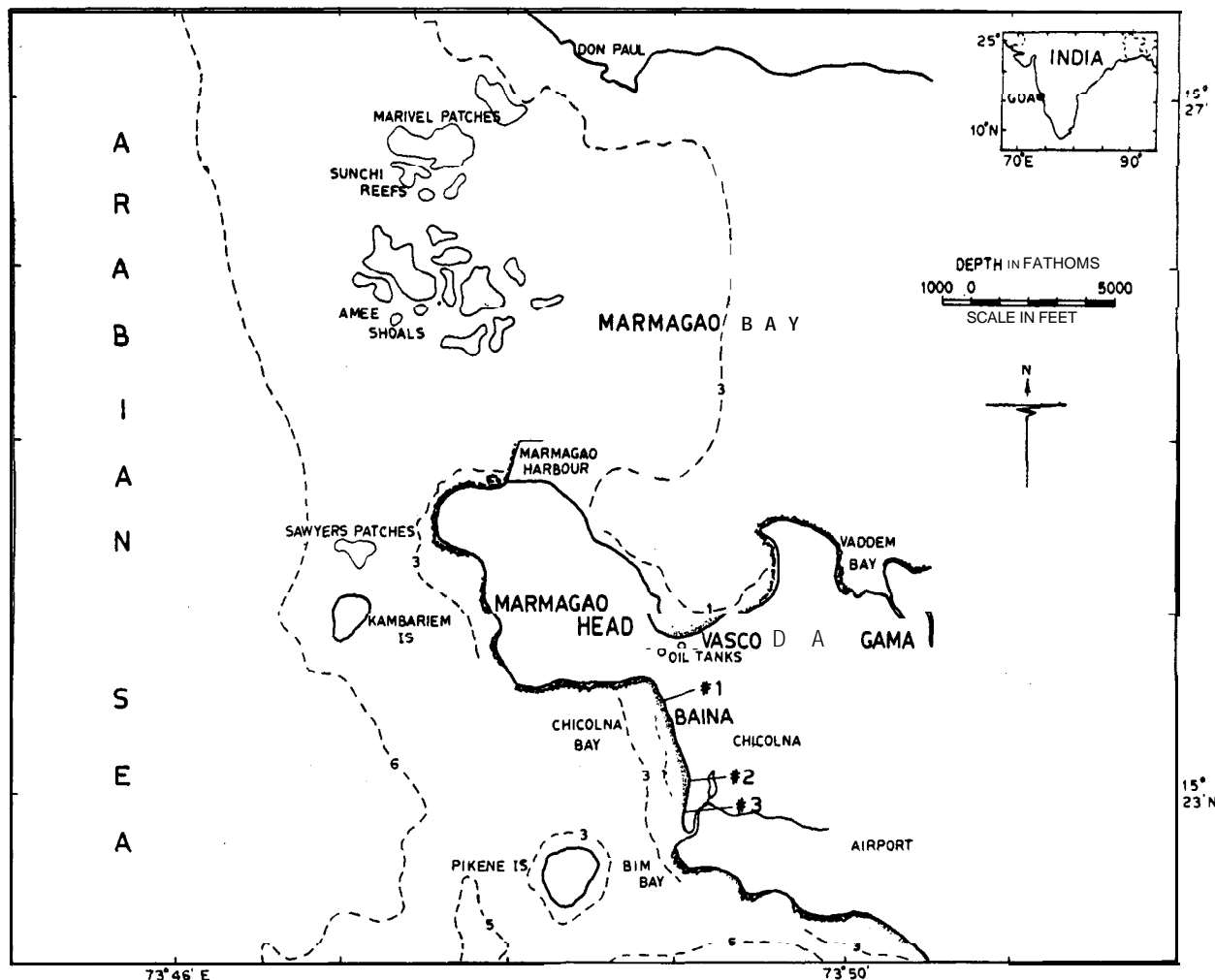


Fig. 1 — Location of the investigated area [Bathymetric contours are indicated in fathoms, e.g. - - - 3 indicates 3 fathoms, . . . 6 indicates 6 fathoms, etc.]

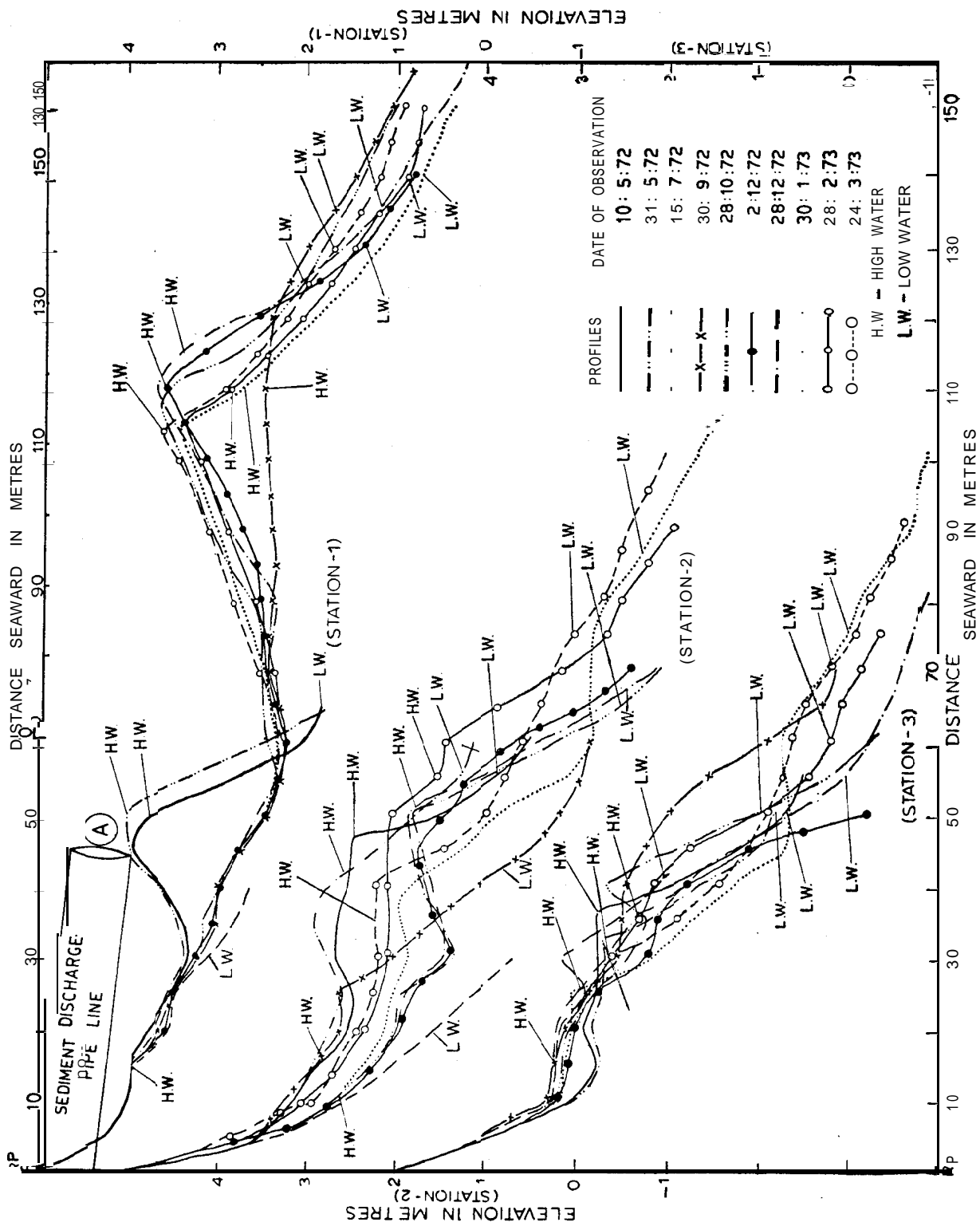


Fig. 2 — Beach profiles for stations 1 to 3 and location of dumping of the dredged material

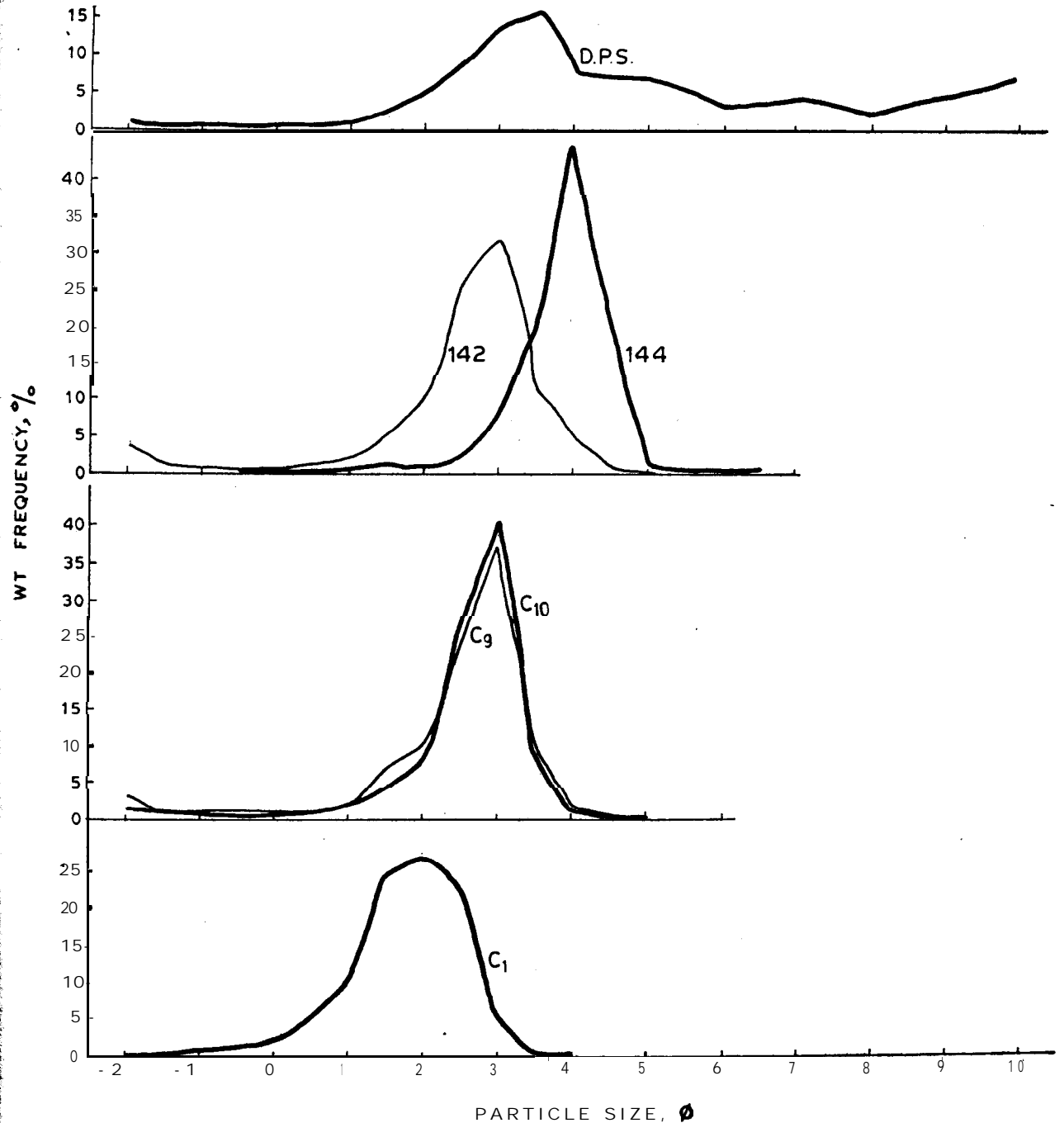


Fig. 3 — Frequency distribution curves of sediment samples giving distribution of material in different size grades before and after the dumping operations [C_1 , beach sample collected at station 1, before dumping operations; C_9, C_{10} , beach samples collected at station 1, after dumping operations; 142, 144, underwater samples (1.25 m depth) collected near station 1 in January 1973; and D.P.S., discharge pipeline sample]

observations from September 1972 to March 1973 show gradual build up of the beach, with minor variations after October. The berm formed again in October and it was located at a distance of about 115 m from the sea wall with a runnel in between. In general, the beach experienced cut from May to July and ml from September through March.

Particle size distribution -Table 1 shows that at the time of initial survey the mean grain size of the beach material at all the stations was in medium sand class (ϕ values lying between 1 and 2), the mean sorting was in moderately well sorted (σ_I values lying between 0.5 and 0.71) to moderately sorted (σ_I values

lying between 0.71 and 1.0) class with either symmetrical or negatively skewed distribution. After the dumping of the dredged material, the samples collected from stations 2 and 3 were also in the same class limits. The samples from station 1 were in fine sand class (ϕ values lying between 2 and 3), poorly sorted (σ_I values lying between 1 and 2) and in very negatively skewed class. Further, the results of grain size analysis (Fig. 3) reveal that samples from station 1, before and after the dumping of the dredged material, are strikingly different in their texture. Prior to the operations of dumping, the sediment samples were unimodal with the

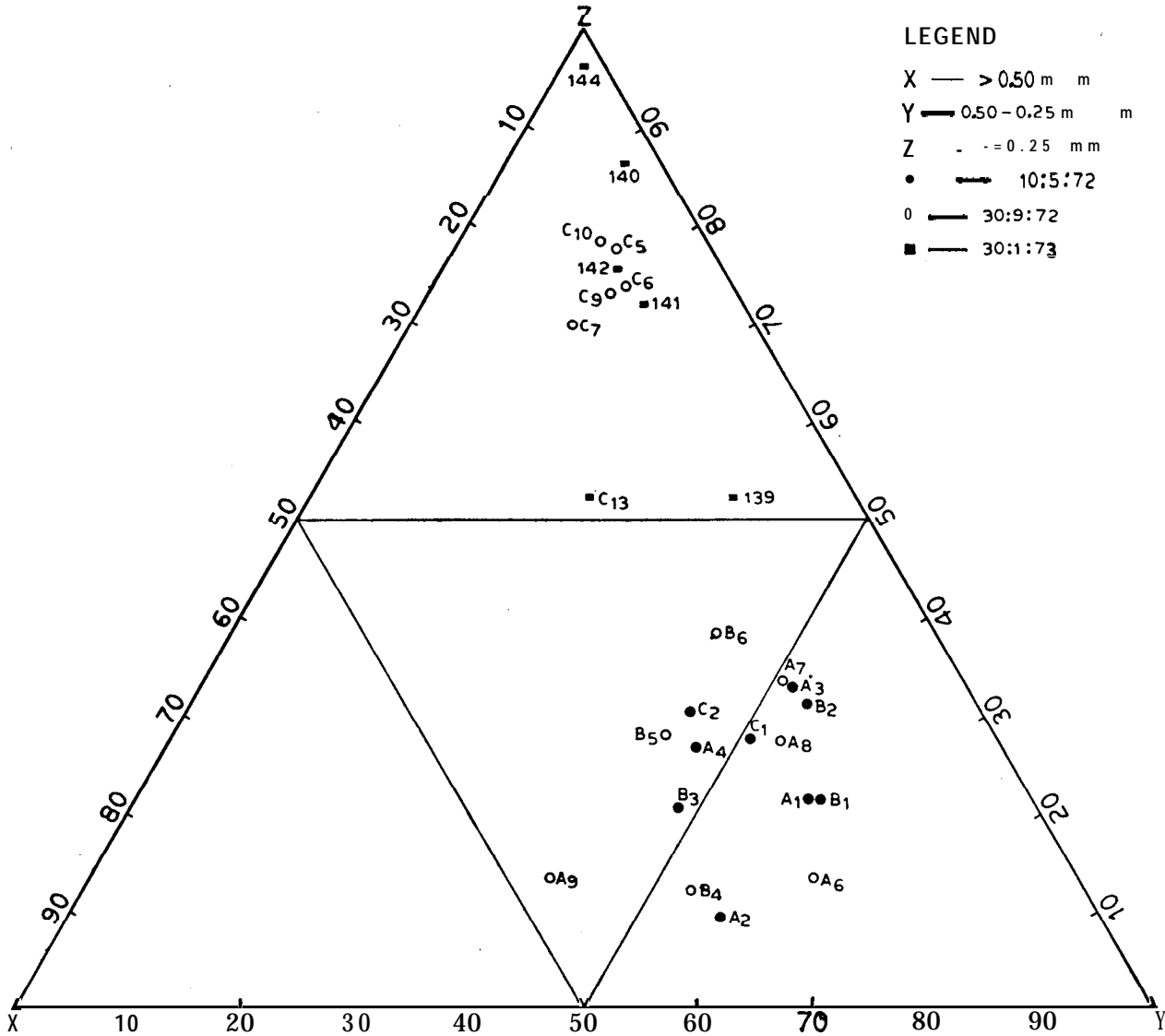


Fig. 4 — Triangular diagram showing percentage values of fractions of each sample [X, coarse sand; Y, medium sand; and Z, fine sand and silt. C₁, C₂, C₃, . . . C₁₃, samples at station 1; B₁, B₂, B₃, . . . B₆, samples at station 2; and A₁, A₂, A₃, . . . A₇, samples at station 3]

mode at 2ϕ , while after dumping, bimodality developed, the modes being at 3ϕ and -2ϕ . Besides the presence of coarse size material, a shift in the major peak towards the higher ϕ values indicates the presence of abundance of fine size material. The grain size analysis of the sample collected from the discharge pipeline indicates a fairly good percentage of very fine sand, silt and clay size class material (Fig. 3). The significant percentages of fine sand, very fine sand and silt material in samples collected after dumping operations reflect the change in gross texture of the beach sediments. This is clearly indicated in Fig. 4, wherein samples from all the 3 stations? before dumping of dredged material fall in one field. After the dumping operations, samples from stations 2 and 3 also fall in the same field, whereas the samples from station 1 fall separately in a different field (closer to Z), in the triangular diagram. This shows that before the dumping of the dredged material, in general, were strikingly uniform at all the 3 stations (Table 1) and after the dumping, the

samples from station 1 markedly differed in their characteristics from those of the other stations.

Discussion

The variations in the beach topographic features in the present case are partly due to the changes in the related meteorological and oceanographic factors, such as winds, waves, tides, etc., responsible for the movement of the material on the beach, and the resultant form of the beach⁵. An account of such factors affecting the coast of Goa has been given earlier in some detail¹. In general, the erosion of the beach from May to July is due to the high and steep waves affecting the coast during the south-west monsoon season and accretion of the beach is attributed to long period, low swell waves during the fair weather season.

The dredged material dumped on the beach fore-shore (Fig. 2, point A, station 1) during the monsoon season was transported mainly offshore (as evidenced by the dye observations conducted by the authors. -data unpublished) by the strong offshore com-

ponent of the littoral currents. The present location of the sand component of the material at about 50 to 60 m from the release spot is mainly due to the littoral current pattern which prevailed in the monsoon season and carried the material offshore. Subsequently, as the south-west monsoon conditions receded, long period, low swell waves, which cause net shoreward transport, brought back the material (sand fraction) to the beach foreshore. This indicates that the waves and littoral currents sorted out the sand size material from the discharged sediment composed of gravel, sand, silt and clay and supplied the coarse size material for the building up of the beach at station 1. Moreover, by October, a runnel had formed near the dumping site and at present it extends to about 250 m on either side of point A (Fig. 2, station 1). This was possible because the material dumped at station 1 might have formed a ridge in the nearshore zone leading to movement of water towards station 1 from either side of the ridge. The sediments of the new foreshore area at station 1 show markedly different textural characteristics (discussed below) as compared to the other stations. This may be the reason why the seasonal cycle of the erosional/accretional features in the beach profile here has deviated from its earlier mode whereas this is not the case when one considers stations 2 and 3 (Fig. 2, stations 2 and 3).

The departure in gross texture of the beach sediments (Figs. 3 and 4) from station 1 and the resulting changes in grain size parameters (Table 1) reflect the overall texture of the gravel and sand component of the sediment discharged on to the beach. Besides this, the presence of considerable percentage of very fine sand and silt component in the samples (Nos. 139 to 144) collected in January 1973 at about 1.25

m depth below low water level off station 1 supports the observation that the dumped material was in and around the site of release point and was responsible for the changes in configuration of the beach at this station.

The persistent uniformity observed in the texture of the sediments at the adjacent stations 2 and 3 in contrast to that of station 1 (even after the completion of dumping operations) and the lateral spread of the material on the beach up to about 250 m on either side of station 1 over a span of 6½ months indicate very slow littoral movement along the beach.

This is evidently a case where a large-scale interference by artificial means in the natural environment has altered the normal erosional/accretional features occurring on a beach.

The study shows that, if any foreign material with different textural characteristics is dumped on this beach, the material is unlikely to move appreciably along-shore or to influence the neighbouring regions.

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