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STUDIES ON BEACH CHANGES AT VISAKHAPATNAM

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ABSTRACT

Various factors controlling the coastal processes at 7·5 km long Visakhapatnam beach were investigated in detail. Studies reveal that the depositional and erosional phases differ from place to place along this coast. Major part of the beach experiences erosion during southwest monsoon and deposition during northeast monsoon and calm weather period. The annual sediment loss of about 75,000 cubic metres during the study period indicates the net erosional trend of the Visakhapatnam beach and also the insufficiency of the quantity of sand being pumped by the port authorities to nourish the beach.

INTRODUCTION

Visakhapatnam is one of the important coastal towns along the east coast of India, situated at latitude 17°41′34″ N and longitude 83°17′45″E with natural port as well as newly constructed outer habour. The long stretch of the sandy beach on the northern side of the harbour breakwaters forms a protective barrier for a beautiful township, hotels, etc., and is engaged with intensive fishing and recreational activities. The beach from the north of harbour breakwaters to the Kailasa range hill is about 7·5 kilometres long and is quite interesting to study the beach processes that are controlled by numerous factors. Earlier to the construction of outer harbour, the breakwaters made of two rockfilled sunken ships placed just south of harbour channel, caused erosion along this beach (Lafond and Prasada Rao, 1954). After the completion of the construction of outer harbour in 1975, about 0.45×10^6 cubic metres of sand is being pumped every year from March to October to stabilise the beach.

The characteristics of the annual beach cyclycity and the sediment supply on this beach are discussed and compared with earlier investigations. The mode of accretion and erosion along the Visakhapatnam beach at different months are evaluated. The length of the beach is divided into 3 categories according to the period of erosion and accretion. The changes in beach profiles and the volumetric changes of sediments experienced by the shoreline are also calculated.

Meteorology and oceanography of the coast

The climate of Visakhapatnam is dominated by the monsoons and cyclonic storms which divide the year approximately into four seasons (Ince and Jamieson, 1974).

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a) The northeast monsoon from end November to end of February with predominantly northeasterly winds.

d) The premonsoon period from March to May when the winds shift to southwesterly direction and cyclones are frequent.

c) The southwest monsoon from middle May to middle October with predominantly southwesterly winds.

d) The postmonsoon period from middle October to end November with variable weather and occurrence of frequent cyclones.

In general, waves are from south from March to September and from east from December to February, October and November is the transition period during which the wave direction changes from south to east. From January to April, sea is usually calm with the average wave heights not exceeding one metre. From May to September during southwest monsoon, sea becomes rough, with the average wave heights varying between 1 and 3 metres. From October to December, the sea remains calm other than cyclonic days when the wave heights even exceed 5 metres. Wave periods vary from 6 to 12 seconds. However, for greater part of the year, it persists between 8 and 10 seconds.

Morphology of the coast

North of fishing harbour opposite to nature cure hospital, there is always little intrusion of sea and it is observed that most of the months the waves break over the side wall of the road which is protected by armour stones and concrete blocks. The harbour authorities are pumping the sand at this place to nourish the beach. In between this place and Lion's Club Park, isolated rocky patches are present in shallow waters and part of them are being exposed during low tide level. From Lion's Club Park to Palm Beach, the beach is almost open, exposed to direct wave action. Further north, from Palm Beach to south of Lawson's Bay till Santhi Ashramam, beach is comprised of many rocky outcrops backed with high foreshore and backshore sand dunes. Scattered rocks exist from Santhi Ashramam to Kailasa range, forming a protected and shallow bay called Lawson's Bay. The Kailasa range hill located to the north of the Bay protrudes deep into the sea.

The beach in between fishing harbour and Palm Beach is about 90 metres wide with only foreshore and backshore berms and not with any sand dunes. On the other hand, from Palm Beach to Kailasa range, beach is comparatively wider with foreshore and backshore berms and high sand dunes. Two major sewage drains join the sea in this stretch of the beach, one near the Lion's Club Park and another near to the Santhi Ashramam. The scattered and concentrated rocky outcrops across the littoral zone along this stretch of the beach is found to modify the pattern of sediment movement considerably (Sastry, 1958).

Beach processes prior to outer harbour construction

The studies carried out earlier in this region are confined to the environment that existed before construction of outer harbour. LaFond and Prasada Rao (1954) reported that filling takes place during northeast monsoon and erosion takes

place during southwest monsoon. Sastry (1958) reported that the rocky outcrops across the littoral zone in between Jalaripeta and anchored light modify the sediment transport considerably. Reddy (1962) made a study at eight stations in between Jalaripeta and Palm Beach and discussed the effects of rock outcrops that modify the beach processes. He indicated the insufficiency of sand supply along the northern side of the harbour channel to maintain the equilibrium. After the construction of outer harbour, Sastry, Swamy, Prasada Rao and Vasudev (1979) made a study between Visakhapatnam and Bhimunipatnam beach. They reported that this stretch of the beach undergoes erosion during northeast monsoon and deposition during southwest monsoon. They also indicated the insufficiency of sand supply and the annual net erosion at the southern end of the Visakhapatnam beach.

METHODS OF OBSERVATION AND STUDY

For the present study sixteen base stations were established from north of fishing harbour to Kailasa range to evaluate the comprehensive results on the existing beach processes (Fig. 1). Monthly observations on beach level changes for a period of 14 months, from January 1978 to February 1979, were taken during the lowest low tide level, upto one metre depth into the sea. The base stations for beach studies were so located as to identify the effect of rocky outcrops scattered along the beach.

Surveyor Dumpy level, 4 metres long telescopic wooden levelling staff, 2·5 metres long steel ranging rod and a surveyor magnetic compass were used for beach profile survey. Changes in beach level were recorded for every 5 metres length along the profile section. Same traverses of the beach profiles were maintained every month by fixing the bearing of each profile using surveyor magnetic compass.

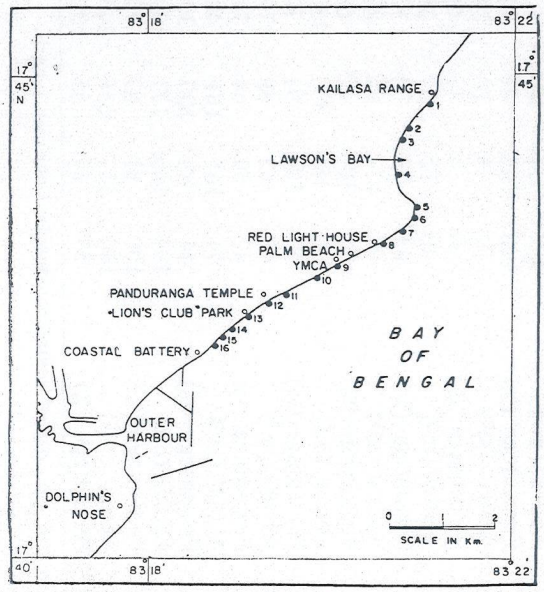

Fig. 1. Location map of Visakhapatnam beach.

The cross sectional beach change till the lowest low tide water line is obtained by using trapezoidal rule along the profiles at each station. From this, the changes in quantity of material for a unit length of beach at each station at different months are calculated. The relative variation of the quantity of the material with respect to the months of minimum beach level are calculated for different months (Table I). Considering the minimum quantity of the year as zero and the maximum quantity of the year as hundred, the percentage of meterial deposited over unit length of the beach at each station for the remaining months is calculated and plotted (Fig. 2). The percentage of material deposited at each station on different months are also plotted

Table I. Actual quantity and percentage of sand deposited per unit length of the beach.

Station Number		Jan 78	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan 79	Feb
1	Actual (m^3)	0	18	38	19	70	15	51	21	66	78	65	29	49	34
	Percentage (%)	0	23	48	24	90	19	65	28	84	100	83	37	63	43
2	Actual (m^3)	84	123	149	124	118	73	69	19	72	0	29	25	70	124
	Percentage (%)	43	82	100	83	79	49	46	13	48	0	19	16	47	83
3	Actual (m^3)	98	102	92	110	107	92	27	0	51	26	37	105	21	2
	Percentage (%)	89	92	84	100	97	83	25	0	46	24	33	19	2	2
4	Actual (m^3)	27	81	96	14	37	42	31	0	8	11	27	32	53	53
	Percentage (%)	28	85	100	15	38	44	33	0	8	12	28	33	55	55
5	Actual (m^3)	28	28	37	30	24	0	33	36	34	31	6	8	18	30
	Percentage (%)	25	74	100	73	64	0	90	98	93	83	15	21	48	80
6	Actual (m^3)	19	0	33	41	42	22	35	27	58	37	30	5	94	49
	Percentage (%)	33	0	57	71	71	37	60	51	100	63	51	9	160	84
7	Actual (m^3)	30	63	51	131	121	78	6	0	33	27	51	19	17	21
	Percentage (%)	23	48	39	100	92	60	5	0	25	20	39	14	13	16
8	Actual (m^3)	121	56	104	13	64	74	35	15	0	31	49	81	49	61
	Percentage (%)	100	46	86	11	53	61	29	12	0	26	40	68	41	50
9	Actual (m^3)	0	3	20	24	61	73	101	123	153	132	69	10	42	43
	Pe centage (%)	0	2	13	16	40	52	66	80	100	86	58	7	28	28
10	Actual (m^3)	46	35	37	38	69	0	52	48	30	45	71	108	41	49
	Percentage (%)	43	32	34	35	64	0	48	44	28	42	66	100	38	45
11	Actual (m^3)	97	117	96	80	105	50	18	8	15	10	0	60	69	91
	Percentage (%)	89	100	82	68	89	43	16	7	13	8	0	51	63	78
12	Actual (m^3)	155	187	171	130	111	107	101	66	47	0	104	112	153	158
	Percentage (%)	83	100	91	70	59	57	53	35	25	0	56	60	81	84
13	Actual (m^3)	44	62	68	77	106	67	73	45	65	51	4	0	14	25
	Percentage (%)	42	59	64	72	100	63	69	42	62	48	4	0	12	23
14	Actual (m^3)	71	141	161	48	10	61	19	10	23	4	16	0	58	57
	Precentage (%)	44	88	100	30	6	38	12	6	14	2	10	0	36	35
15	Actual (m^3)	197	160	171	139	146	111	85	59	47	0	18	91	65	121
	Percentage (%)	100	81	87	70	74	56	43	30	24	0	9	46	33	62
16	Actual (m^3)	140	157	136	245	106	87	9	0	23	21	42	78	128	153
	Percentage (%)	57	64	55	100	43	35	4	0	9	9	17	32	52	58

Actual– Actual quantity of sediment deposited per unit length. *Percentage*–Percentage of sediment deposited per unit length.

(Fig. 3) to indicate the pattern of sediment movement along the beach. Total volumetric changes of meterial all through the beach are calculated by multiplying the changes in area of cross section at each profile with half length of the shoreline between the profiles (Table II).

RESULTS AND DISCUSSION

The plot of percentage of material deposited in different months at a station (Fig.2) is self explanatory. The top most point of the curve corresponds to the month of maximum deposition and the bottom most point corresponds to the month of maximum erosion. This plot clearly shows that the period of deposition and erosion differs from station to station, and the rock outcrops disrupt the regular movements of the longshore ransport.

Referring to Fig. 2 and considering the period of erosion and deposition, the stretch of Visakhapatnam beach can be categorized into three types viz., the part of the beach that

(a) undergoes erosion for both southwest and northeast monsoons (Stations 1, 2, 3, 13 and 14).

(b) undergoes erosion in southwest monsoon and deposition in northeast monsoon (Stations 4, 10, 11, 12, 15 and 16).

(c) undergoes erosion in northeast monsoon and deposition in southwest monsoon (Stations 6 and 9).

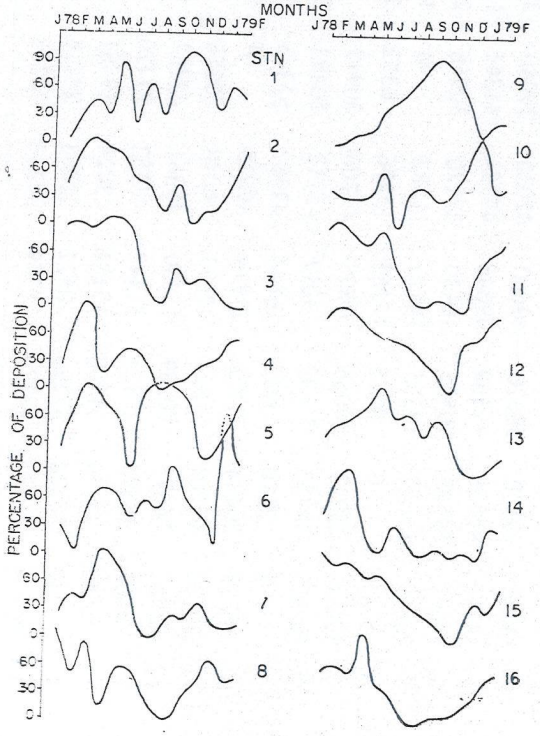

Fig. 2. Percentage of material deposited per unit length of the beach at different stations.

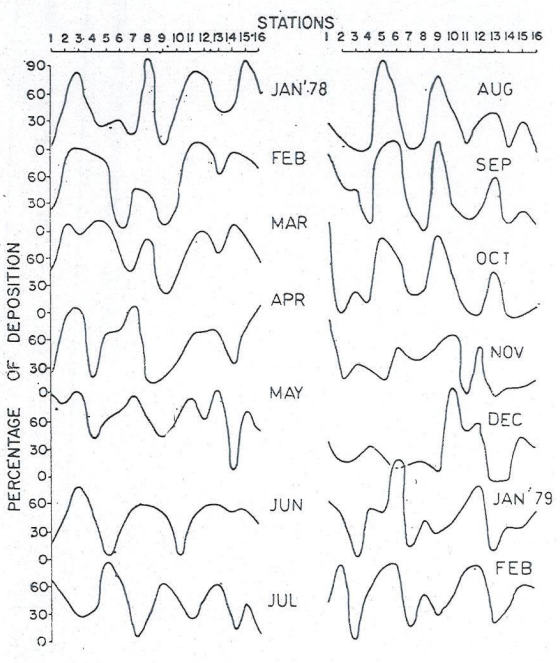

Fig. 3. Percentage of material deposited per unit length of the beach in different months.

Table II. Total valume of sand diposited and different station in cubic metres.

Station Number	Jan 78	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan 79	Feb
1	0	9748	20803	10381	38658	8158	28106	12024	36086	42995	35859	16135	26998	18459
2	33780	49100	59620	49660	47020	29040	27532	7640	28626	0	11420	9840	28160	49540
3	44241	45838	41569	49646	47959	41361	12206	0	22855	11706	16510	47093	9641	861
4	19661	59545	70505	10430	27120	30966	23097	0	5779	8342	19808	23566	38671	38781
5	13669	13637	18335	14813	11682	0	16526	18006	17073	15271	2822	3898	8885	14664
6	5741	0	9775	12165	12276	6372	10336	8817	17239	10945	8820	1600	27583	14547
7	12018	25023	20066	51873	47706	30919	2444	0	12918	10527	20175	7337	6804	8414
8	82585	38257	71437	9017	43712	50493	24138	10027	0	21355	33660	55725	33831	41520
9	0	2170	13712	16844	42482	51345	71042	86022	106987	92417	62169	7079	29392	30057
10	26759	20434	21578	21914	39675	0	30812	27952	17317	26284	41184	62222	23683	28642
11	52122	62601	51821	42873	56048	26656	9898	4420	7945	5176	0	32086	36801	48625
12	63652	76675	70289	53330	45361	43752	41369	27239	19326	0	42676	46058	62684	64580
13	18101	25574	27921	31447	43552	27470	29961	18296	26906	20767	1763	0	5847	10183
14	22552	45156	51308	15184	3024	19581	5928	2856	7416	1076	5020	0	18424	18200
15	43348	35228	37593	30572	32068	24418	18739	12961	10260	0	3913	19915	14270	26642
16	45541	51135	44176	79759	34312	28263	2766	0	7609	6894	13565	25248	41612	49770

The variation of beach levels from January 1978 to December 1978 at stations 13, 11 and 9 are given in Fig 4, 5 and 6 respectively.

According to Sastry, Swamy, Prasada Rao and Vasudev (1979) the beach experiences deposition during southwest monsoon and erosion during northeast monsoon. However, the present study reveals that this may not be true for the whole stretch of beach since the processes differ from place to place.

It is quite unusual to note that a small stretch of the beach little south of Lawson's Bay (Stn. 5) undergoes deposition for both monsoon periods and erosion during more calm weather period. This may be due to rocky barriers being flanked on either side of the station, protecting the beach from strong monsoon wave actions.

It can be inferred from the pattern of the existing beach process that the major rocky outcrops that interfere with longshore transport are, the Kailasa range hill, the intrusion of rocks at the southern end of Lawson's Bay, the patch of rocks at Waltair point, the scattered rocks near Lion's Club Park and the artificial barrier of harbour breakwaters.

The existence and the effect of these rocky barriers are less pronounced during southwest monsoon due to heavy sea state. The more turbulent and complicated littoral zone overcomes the real obstructions caused by the littoral barriers. This is evidenced at the stations just south of each rocky barriers (Stns. 1, 10 and 13). That is, during southwest monsoon when the longshore transport is towards northeast, in spite of accretion that has to take place at those updrift sides, erosion is more predominant. Consequently for northeast monsoon, the rocky barriers are more effective that in all updrift sides just north of barriers (Stn. 4, 8, 12 and 16) considerable amount of deposition takes place.

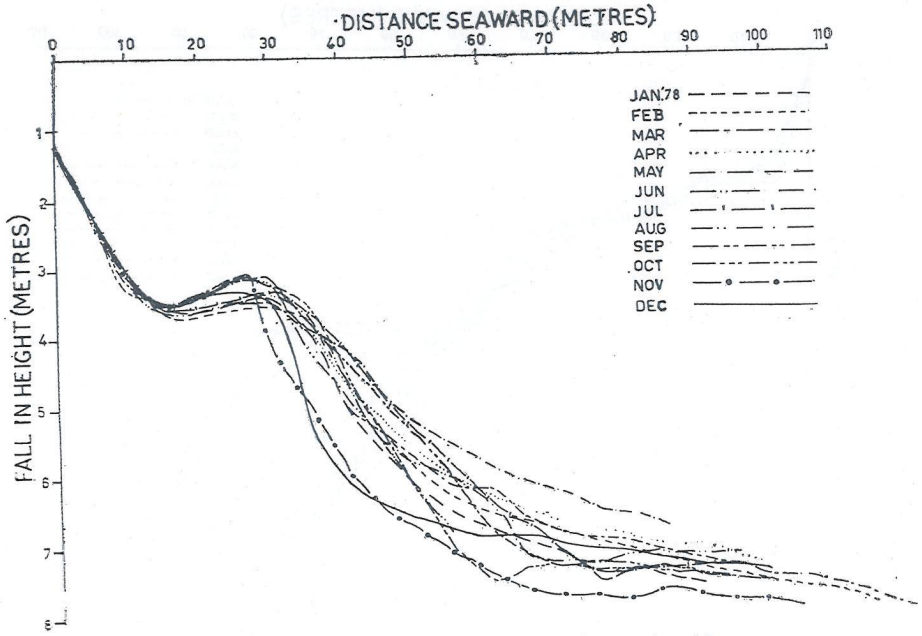

Fig. 4. Changes in beach levels at Station 13.

Near to Santhi Ashramam (Stn. 4), the littoral zone is very shallow with small spills and weak longshore currents for the major parts of the year. This place is considered safe for recreation and swimming.

The quantity of sand deposited per unit length of beach above the level of the month of maximum erosion for different months at different stations is given in Table I. The percentage quantity of sand deposited is also given in the same Table. This Table enables to visualize the quantity of sand that is being subjected to changes in annual beach process and its mode of monthly variations. The quantum of fluctuation is high at station 16, where in fact, the sand is being pumped by the port authorities to nourish the beach. The beach between stations 12 and 15 experiences more quantum changes. The variation of quantity of sand is considerable between Red Light House and Palm Beach (Stn. 7 to 9). Beaches opposite to Pittapuram quarters and near Santhi Ashramam (Stn. 10 and 4) have comparatively less quantum fluctuations. In Fig. 3, alternative peaks and falls indicate, when erosion takes place at some places immediately adjecent to that there exists some depositional environment causing the part of eroded material to deposit nearby. Hence, it is apparent that the stretch of Visakhapatnam beach is entrapped by such coastal features that most of the littoral sediments are being arrested and kept confined within the stretch. In June, fluctuation of the curve is less, indicating that the major part of the beach is in equilibrium with about 50 percent accretion. The curves show similar variation from July to October. This shows that the beach undergoes systematic changes due to the rocky flanks protruding inside, as such some artificial barriers have been constructed along the coast at stations 1, 5, 9, 13 and 15. The process of deposition and erosion during November to January, when the longshore transport is towards southwest, also confirmed this fact.

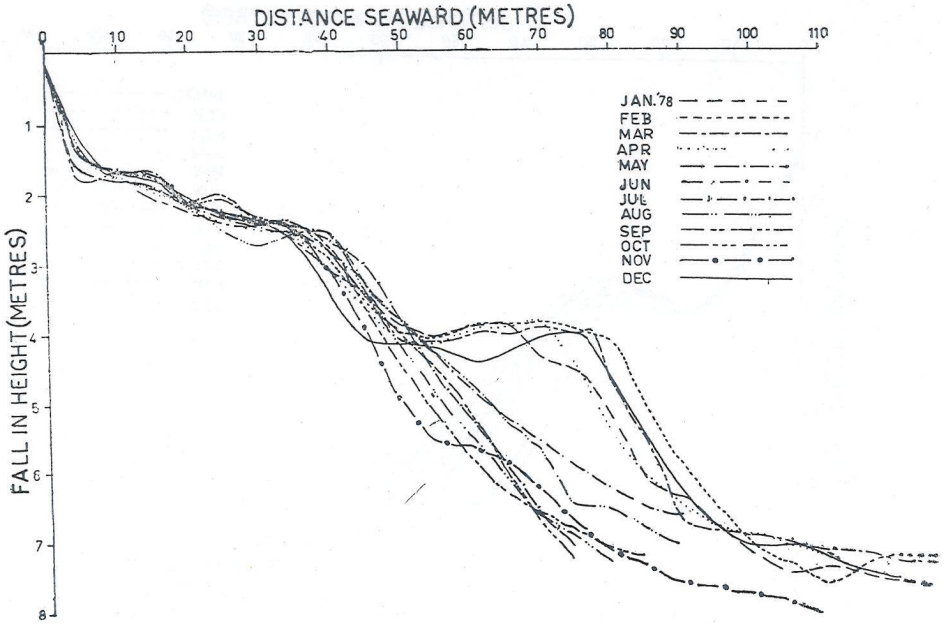

Fig. 5. Changes in beach levels at Station 11.

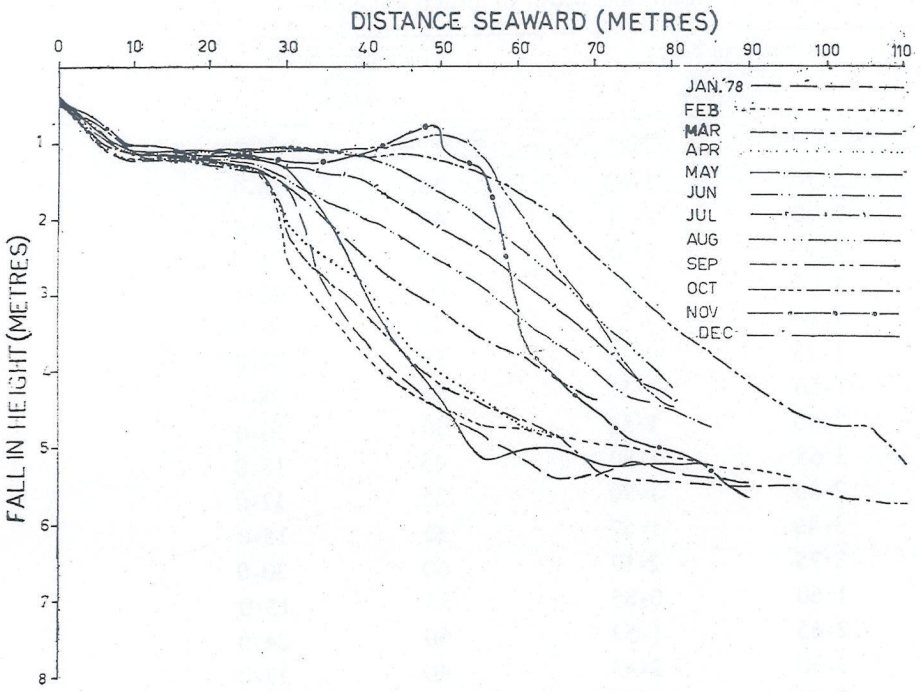

Fig. 6. Changes in beach levels at Station 9.

The total volume of sand subjected to changes in between the fishing harbour and Kailasa Range is 919,250 cubic metres (Table II). However, the net change due to the occurrence of both erosion and accretion along shore, the net volume of sand over the minimum level of the beach is low about 236,260 cubic metres in August. Also an amount of 682,990 cubic metres of sand is washed off from the shore during this month. On the other hand the beach has maximum quantity (630,508 cubic metres) of sand in March.

In many aspects of coastal planning, it is important to know where the loss or addition of sediment occurs across the beach section (Taylor, 1977). Referring to the quantity of net longshore transport along Visakhapatnam beach as $0{\cdot}88 \times 10^6$ cubic metres (Saxena, Viadyaraman and Srinivasan, 1976) greatest change in sediment volume occurs above lowest low tide waterline.

During the study period, it is estimated that the beach experiences a net annual loss of 75,000 cubic metres of sand. The changes in beach width and variation in beach heights at different months are given in Table III.

It is observed from Fig. 2 that near Red Light House and near Panduranga Temple net loss of the beach sediment is about 10 per cent (Stns. 8, 11 and 12). It is very important to note that near Palm Beach and Lion's Club Park (Stns. 9, 13 and 14), the beach is not completed safely its annual cycle. The loss of material at these places are more than 30 per cent. Apart from these, at all other places the beach safely completes its annual cycle with neither net annual erosion nor deposition.

Table III. Height and width of beach changes.

Stn. No.	Change in beach elevation (metres)		Change in beach width (metres)	
	Maximum	Mean	Maximum	Mean
1	2·75	1·32	15	8·0
2	2·70	1·51	40	18·0
3	2·35	1·38	50	24·0
4	1·05	0·51	100	20·0
5	1·60	1·15	20	8·0
6	1·15	0·70	35	14·0
7	1·50	0·58	55	28·0
8	2·60	1·55	60	30·0
9	3·65	1·90	45	18·0
10	2·30	1·80	25	12·0
11	3·40	1·67	35	15·0
12	3·75	2·17	60	30·0
13	1·60	0·85	35	15·0
14	2·65	1·53	60	24·0
15	3·30	2·43	40	22·0
16	2·75	1·66	90	42·0

The rocky barriers present across the littoral zone and the outer harbour break-waters largely influence the depositional and erosional phase that differ from place to place along this coast. In general, major part of the beach undergoes erosion during southwest monsoon and deposition during northeast monsoon and calm weather period. The beach enclosed by Lawson's Bay experiences a safe annual beach process and it is subjected to less sediment quantity fluctuation except at its northern end (Stn. 2). The beach opposite to Santhi Ashramam (Stn. 4) is more safe for swimming and can be developed as a good recreational spot. On an average, the beach in between Red Light House and University Ladies Hostel (Stns. 8 to 14) undergoes minor annual loss of materials. This suggests that the quantity of sand being pumped by the port authorities is inadequate to stabilise the beach. The southern end of Visakhapatnam beach in between Panduranga Temple and Coastal Battery is more sensitive in annual beach process and the quantity of sediment changes are more. Though the Visakhapatnam coast is exposed to high wave energy environment, the presence of rocky outcrops along the shore forms as protective barriers. They interrupt the longshore transport so that considerable quantity of sediments are deposited within its limits.

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