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FINAL REPORT

S-KU/OCEAN. (4)/1

Shore Erosion Studies of Pakistan Coast in the Vicinity of Karachi

Sponsored by:

PAKISTAN SCIENCE FOUNDATION

Principal Investigator: Dr. S. M. A. Tirmizi
Professor of Physics

DEPARTMENT OF PHYSICS
UNIVERSITY OF KARACHI

DECEMBER, 1983

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SUMMARY

This research work was undertaken to study the process of shore erosion along the coast of Karachi.

The area under investigation is the coastline from Manora Island to Cape Monze. Six different locations in this area were selected for taking observations and collections of samples.

Due to the limitations regarding instruments and sea-going facilities, the study was carried out near the shore only. The observations from the six fixed reference points along the coast were taken after every fortnight, including the recording of visual wave data, wind data and samples of sediments and sea water. In order to track the offshore movement of suspended load, satellite imageries were visually interpretated.

In the laboratory the sediment samples were dried and sieved for the determination of variations in grain size in surf zone at each station for diffferent seasons. From the visual wave data an attempt is made to work out the longshore energy flux in surf zone due to breaking waves.

It is observed that during SW-monsoon the dissipation of wave energy causes considerable changes on the beaches and surf zone, and large amount of sediment are brought into suspension by the collapsing waves. During this season of high wave energy the waves predominantly approach the coast line

obliquely resulting transport of sediment along the coast and "on and Off" shore. It is observed that during the post-monsoon and pre-monsoon period the beaches and nearshore zone, are subjected to only moderate to low wave energy conditions and rebuilding of beaches takes place in these periods.

However it is observed that the beach material removed due to erosion is greater than the beach material deposited back and thus there is a net loss of beach material in the area. At station No.2 near Paradise Point erosion is quite severe as the waves attack causes landslides. On the other-hand at sandspit the most crucial area is near station No.6 where sea water is observed to cross the sandspit on several occasions. Protective measure must be taken here immediately to protect the sandspit.

CHAPTER -I

1.1. INTRODUCTION

Along the coast-line of Karachi several areas are under constant threat of erosion.Waves generated during SW-monsoon by the south westerly winds are very high and strong enough to erode the beaches.

Wave commonly approach the beaches obliquely and on breaking generates" on & off" shore current and longshore currents. Turbulance generated by breaking of waves stirs up the bed material and brings them into suspension.Currents associated with the waves and tides transport these suspended and rolling sediments parallel to the coast and causes problems of erosion and siltation.

Shore erosion arises when more material is eroded than deposited.Usually there are two types of erosion, natural erosion due to storm, tides and rise in the sea-level and man made erosion resulting from improperly designed and incorrectly located coastal structures. Natural erosion is usually a very slow process mainly due to littoral currents. Sometimes this process may be accelerated by sudden storms.Man made erosion is caused by man's interference such as dredging or construction of jetties which blocks the natural movement of sediments along the shore.

Predominent waves in Karachi and vicinity during south-west monsoon (May to September) are from south-west having a long fetch over the Arabian sea. Consequently, waves are built to a height of 2-3 meters.They generally approach the coast at an angle that gives a large component of longshore current in the direction of Manora Break water.

The erosion of coastline at Manora Island, Sandspit and Paradise Point is not only depriving this area from beautiful beaches having tourist attraction but is also a cause of danger to the harbour in case theopen sea water enters the harbour after the erosion of Manora Island by the waves. Several incidents have shown that during high tide in SW-monsoon the waves have crossed the Manora Island across Sandspit area. As a result of erosion at Manora and other places, the eroded sea bed material is deposited in the navigational channel of Karachi Harbour. This deposition of sediment decreases the depth of harbour and as a result of which the movement of ships is restricted. In order to maintain the standard depth of the harbou a large amount of money is spent on annual dredging after every SW-monsoon season.

A large coastal area of Hawk's bay and Paradise Point is also under going erosion and under cutting of rocks due to waves and tidal action, KANUPP, our only Nuclear Power Station, is also situated on such a coastal feature and as such it has to be kept under constant observations.

In view of the above mentioned facts it is quite necessary to study the coast line and beaches of Karachi so that necessary steps may be taken in time to prevent them from erosion and subsequent siltation of the harbour.

Unfortunately no record of such study in the past could be found for the coast line of Karachi.It seems that the present research work is the first attempt to study the process of erosion along Karachi coast.Due to lack of proper equipment and sea going facilities the research work was confined along the coast line.

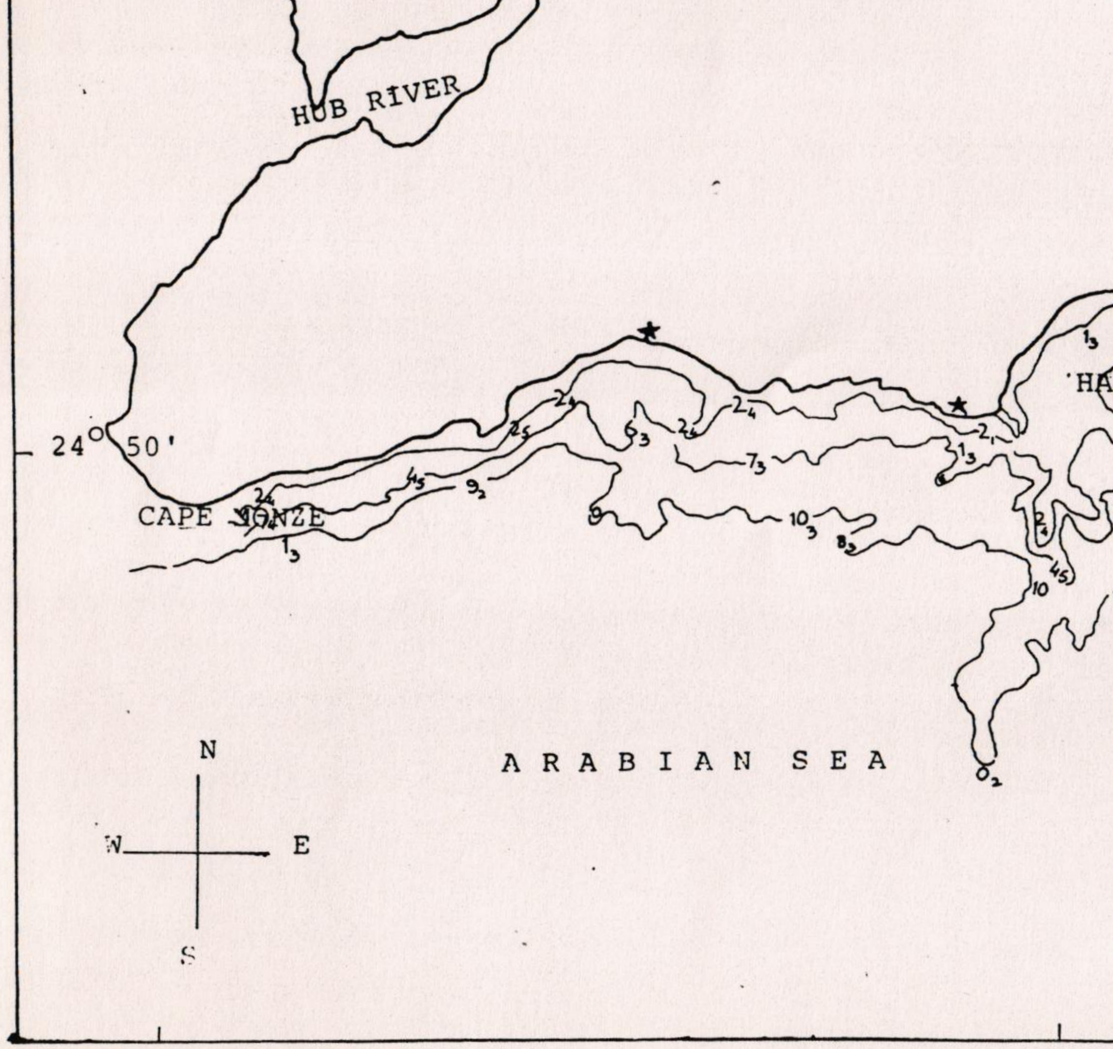
1.2. AREA UNDER INVESTIGATION :

In the south of Karachi is the coastline where the waters of Arabian Sea washes the shores of Karachi. The coast line at Karachi, which runs about 37 miles, can be divided into two parts, one lying on the west side of the navigational channel ofKarachi Harbour, starting from Manora Island and upto cape Manze .The other part of coast line is on the eastern side of navigational channel and is known as Clifton and Korangi creek areas.

The area situated between Cape Monze and point Yousuf Ali is constituted by hill ranges which run for 3½ miles parallel to the coast and then gradually turn towards North and North east .At Cape Monze the rocks are formed by sandstone with interbedded shale and limestone.They are of marine origin and some of the limestone beds are of highly fossiliferous. There are sufficient indications of raised and depressed shore lines. Close to the Cape Monze, a few traces of former shore-lines, now raised to varying heights, above the present sea-level and the presence of fresh shell -beds give a clear proof that the elevation of land has taken place.

From the eastern end of Haw's bay a narrow belt of sandspit run over a distance of about five miles until it got a foot-hold onthe hard conglomerates of Manora Island. The coastal area situated between south of Maurypur and north to Shamps Pir Island is utilised for the extraction of salt. Sea water is admitted during high tide in this area through south-eastern creek and salt is obtained mainly fromthe sea brine solar evaporation.On the west of salt-works is the Lyari delta which is well protected from the direct influence of the ocean surf by the belt of Sandspit.The area between sandspit and the mouth of Lyari river has been filled by a few lagoons and mud banks, which by silting became tidal swamps overgrown by mangroves. Numerous tidal channels exist between sandspit and lagoons which are used when the tide is high.

The rocks of Manora Island are composed of Manchar sandstone and arenaceous clays capped by the hard conglomerates. On the seaward side of the cliff owing to the soft Manchar rocks at the base shallow caves are formed by the action of waves. The climate of Karachi coast is mainly determined by the southwesterly monsoons in summer and by northereasterly monsoon in winter.The entire sea in front of Karachi is also influenced by the prevailing monsoon wind system. The south west monsoons (i.e. mid May to mid September) produce heavy swell in sea water


HUB RIVER
24° 50'
CAPE MONZE
ARABIAN SEA
N
W
E
S

and put a temporary stop to fishing operations in summer. During SW-monsoon easterly and south easterly littoral drift and long off shore currents are set in motion along the coast.The wave action in this period is generally very strong causing turbulance along the coast. The SW-monsoon is followed by a transitional period of two months (October-November) during which the winds are variable.During December,January and February north easterly winter monsoon sets in and the sea remains comparatively clam.March and April are again transitional months during which winds are variable.

The coast is mostly barren due to semi-desert conditions.The only vegetation found near the shorelines of Karachi is bushes, succulent and low trees. The scrub is stunted and thorny. It does not grow above a foot in height and mostly die due to lack of water.On the back of Sandspit there is an abundant growth of mangroves on the swamps and mud banks.

1.3. SITE FOR OBSERVATIONS:

Since the dominant direction of wave attack from Arabian Sea is from the southwest and the resultant littoral drift is in eastward direction, the coast line from Manora and upto Cape Monze was selected for the study.Another important reason for the selection of this area for investigation was its importance as a protection of Karachi Harbour from waves attack.

Seven different locations in this area were selected for taking observations and they were named as station No.1 to station No.7(map).Station No.1 which was established near Cape Manze had to be abondoned due to restriction on entry in this area by the Naval Authorities.

The major part of the coast line at station No.2 (two miles ahead od Paradise Point in West) is considerably high(about 10 to 14 meters) and the land falls sharply below and extends towards low water marks with variable slopes at many places. The coast at station No.2 is a rocky shore line with sporadic sandy beaches. The rocks in the area are mostly of sand-stone type and mixed at some place with conglomerate.Station No.3 is situated on the West side of Buleji and about a mile east of KANUPP. Most of the coast line at this area is rocky with small pockets of sandy beaches.The incoming wave energy converges on the protruded rocks of Buleji Point. These protruded rocks also provide a shelltering to Hawk's bay from waves coming from southwest. Station No.4 is situated at about the centre of the long arc of Hawks bay.This station is comparatively in sheltered area (i.e. the area which is not very much affected by the wave from southwest).This sheltering from waves is achieved due to the protruded rocky Buleji point towards sea.

Station No.5 and 6 are situated at Sandspit which is a narrow ridge protecting the Karachi Harbour from the wave attack from the open sea.Here intense wave action occurs along the coast because of its exposure to the entire open sea front.Station No.7 is situated at Manora near breakwater. Just few hundred meters towards east from Station No.7 is the navigational channel going to the Karachi harbour . Between station No.6 and station No.7 concrete cubes are dumped on the beach by the Pakistan Navy.As a result of dumping of these cubes on the beach some sand accumulation has taken place near the old temple(MUNDIR) of manora which was previously observed as eroding due to the attack of waves.

The off shore depth contours along the coast from Manora and upto Cape Monze are at random distances from shore at different places.At some places they are parallel to each other and to the coast line and at other places, they are not.The offshore depths are steep at off station 2 and 3 while at station 4,5,6 and 7 its is comparatively shallow. The depth contour of 9 fathoms is at about 1.5 miles from the coast at Station No.2 and 3, where as the same depth contour is about 5 miles from the coast at Sandspit. At the front of Sandspit(i.e. facing towards Arabian Sea) the depth contours are almost parallel to each other and they are also parallel to the coast. If a normal is drawn at Sandspit towards sea it would point almost in southwest direction. Thus the orthogonals of waves coming from SW-direction would hit the coast line almost perpendicularly and there would be very little refraction of waves. But a wave coming from south would certainly experience refraction because its eastern end will enter in shallow water first .Thus the waves from south would swing towards northeast and, on reaching the coast line, will hit the coastline from soutwest direction.

CHAPTER II

METHODS AND MATERIAL

The process of shore erosion and accretion is usually a very slow process except when the coastline is subject to things like storm surge and hurricanes. The rate at which the sea can erode the coast line depends on many factors such as offshore relief, sea-level changes, wave climate and the nearshore currents, degree of exposure of coast line to wave attack, coastal type and effects of man-made structures. Therefore in order to study the problem of shore erosion of any area it is necessary not only to be well equipped with proper instrument but also to have some past record of that area. In case of present study we had limitation for both. Due to these limitation the study was carried out only from shore which includes the collection of visual wave data, wind data and samples of sediment and water from the six reference points fixed along the coast line. However an attempt is made to track the offshore movement of suspended load with the help of satellite imageries.

The observation from the six fixed reference points along the coast were taken after every fortnight.But on many occasions this interval could not be kept constant due to non-availability of transport in time.However this is compensated by sufficient number of observations taken from 1978-1982. More than fourty five observations were taken from each station.

2.2. SEDIMENT SAMPLING AND ANALYSIS:

Samples of sediment were collected from all six stations after every fortnight. From every station samples were used to be collected on each visit from the near shore surf zone.In each case the sample was collected from the surface layer of sea-bed. The samples were collected in polythene bages marked with date and location of sample collection. In the laboratory sediment samples were dried by two methods. The sample were either dried in the oven or they were left in cloth bags to dry up by evaporation in sun heat. However, there was no effect on the grain size of the sediment by any of the two methods.

After drying, samples were analysed to measure the percentage of grain size distribution.For this purpose dry-sieving was carried out with the help of electrical sieve shaker using cone and quartering method.Grain size analysis was classified in the following four categories according to their diameter.

(1) Fine sand (diameter $< 250\mu m$)

(2) Medium sand ($250\mu m <$ dia < 0.5 mm)

(3) Coarse sand ($0.5mm <$ dia $< 1mm$)

(4) Very coarse sand (diameter $> 1mm$)

The percentage of grain size distribution was measured by weight.

2.3. REMOTE SENSING TECHNIQUES USED FOR STUDY

To detect the movement and extend of suspended load in the sea and the changesin coast line, landsat imageries were procured from SUPARCO.

Because in band 4(.54-.58μm) the spectral response pattern of the suspended material is distinct from that of the clear sea water, these two materials can be readily distinguished on the satellite imagery.Therefore imageries in band 4 were used to delineate the extend of suspended load on different dates.A set of three imageries of 1977 were used to measure the extend of suspended load from shore during the start, mid and at the end of south west monsoon.

To detect any change in coast line two imageries in band 7 were interpretated. Band 7(0.660-0.70μ m) gives a clear demacration between land and water and therefore it is possible to detect the shifting of coast line by comparing the two imageries of same area having sufficient interval between their time of scanning.

From the available imageries from SUPARCO two imageries were selected for the detection of changes in the coast line,one of 1972 and the other of 1978.
The imageries used for the study of suspended load were of the scale of 1: 1000,00 where as the two imageries interpretate

for the detection of coastal changes were of the scale of 1:250,000. The imageries were visually interpretated using magnifying glass and overlays were drawn to delineate the different feature.During the visual interpretation all the image characteristics such as shape, size, tone, texture shadow, pattern, location and association were very carefully studied.

Imageries of 1978-82, the period of study, could not be interpretated because during the south-west monsoon the area under investigation remained cloudy and satellite imageries were of more than 45% cloud covered. No."ground truth" procedure was carried out because it was not possible to go offshore with the available facilities.

2.4. WAVE DATA

Wave data was recorded visually by the observer from the beaches in area under investigation. Wave data was recorded for the waveheight in breaker zone, waves period and the direction of waves.

The period of waves was was recorded by noting down the time for ten waves to pass a fixed point(like rock) and then taking the mean of time for one wave.

The direction of waves was recorded after the waves had entered the breaker zone, but before their breaking.For direction mariner compass was used. The angles between waves crests and shore lines were measured clockwise from shore line by observer looking sea-ward perpendicular to shore line.

2.5. PHOTOGRAPHIC RECORD:

Photographs of coast line were taken at each station after every fortnight to see the variations and coastal changes at the area under investigation. Due to the restriction by the naval authorities photographs at station No.7 could not be taken.

In the beginning black and white film was used for photography but afterward it was felt that a colour film would record more information than the black & white one.Therefore later on, colour photography was done for recording the information regarding the beach conditions and the extent of surf zone. For this purpose two photographs at each station were taken, one covering the left hand side of the coastline and other the right hand side.

2.6. THEORY FOR CALCULATION:

ENERGY FLUX METHOD

This method is based on the assumption that longshore transport rate depends on thelong shore component of energy flux in the surf zone.The long shore energy flux in the surf zone is approximated by assuming conservation of energy flux in the shoaling waves, using small amptitude theory and then evaluating the energy flux relation at the breaking position.

The energy flux per unit length of wave crest is given as

$$\bar{P} = - \frac{g}{8} H^2 \quad C_g \qquad .... \ (2.1)$$

where = mass density = 2.0 slugs/ft^3 for sea water

g = gravity

C_g = group velocity of waves.

If the wave crests make an angle withthe shore line, the energy flux in the direction of wave advance per unit length of beach is given as

$$\bar{P}\cos\alpha = \frac{\rho g}{8} H^2 \cos\alpha \qquad .... \ (2.2.)$$

and the longsjore component is given by $P = \bar{P}_\ell \cos \sin = \bar{P}\frac{1}{2} \sin 2\alpha$

$$\therefore \quad P_\ell = \frac{\rho g}{16} H_b^2 \ C_g \ \sin 2\ \alpha_b \qquad .... \ (2.3)$$

The surf zone approximation of P_l is written as $P_{\ell s}$

$$P_{\ell s} = \frac{\rho g}{16} H_b^2 \ C_g \ \sin 2\alpha_b$$

H_b = wave height at breaking

α_b = Angle of crest with coast line at wave breaking.

Group velocity equals wave speed at breaking and breaking speed is given by solitary wave theory according to approximation.

$$C_g = C = (2g\ H_b)^{\frac{1}{2}} = 8.02\ (H_b)^{\frac{1}{2}}$$

Substituting the value of C_g in Eqn(2.3) and replacing α by α_b

$$P_{1s} = 32.1\ H_b^{5/2}\ \sin 2\,\alpha_b \quad \ldots\ldots.. \quad (2.4)$$

(units of P_{1s} : ft-Lbs/sec/ft of beach front).

Equation (2.4) is applied to the data collected because it requires wave height at breaking and the angle between the coastline and the wave crest, the two parameters which we have recorded.

Angle between wave crest and shore line is measured clockwise from shore line by observer looking sea ward perpendicular to shoreline.

The observatins of wave data are divided into three periods i.e.pre-monsoon, monsoon and post-monsoon.Pre-monsoon is the period from mid January till the end of April.From the beginnning of May and upto the mid of September is the monsoon period and post-monsoon is the period from mid September till mid January.The word monsoon is used for SW-monsoon until and unless otherwise mentioned.

Four average values of P_{1s} are calculated for each period in the following manner.

(i) $\bar{P}_{1s}$ (gross) is the average of sum of all the longshore energy components in the surf-zone.

$$\bar{P}_{1sg}(\text{gross}) = \frac{\text{sum of all observations}}{\text{No. of observation.}}$$

(ii) $\bar{P}_{1sn}$(net) is the average of difference of longshore energy components in the East and West Direction.

$$\bar{P}_{ls}(\text{net}) = \frac{\bar{P}_{lsg}(\text{East}) - \bar{P}_{lsg}\ (\text{West})}{\text{Total No.of observations.}}$$

where subscript l & s denotes longshore and g and n denotes gross and net flux respectively. Whereas $\bar{P}_{ls}$ (East) and $\bar{P}_{ls}$ (West) are the average of P_{ls} in the east and west direction respectively. The negative values of P_{ls} indicates east ward direction of longshore energy components in the surf zone.

DATA

Table-1

Station No.	SE	South	SSW	SW
2	30^{o}	75^{o}	97.5^{o}	120^{o}
3	20	65	87.5	110
4	53	98	120.5	143
5	7	52	74.5	97
6	6	51	73.5	96
7	6	51	73.5	96

Direction function (α_b) of waves approach for six stations.

onsoon,78	105.45	75.66	71.10	58.48	164.67	150.99
nsoon 79	115.12	205.01	64.56	184.62	313.38	157.44
onsoon 80	651.70	668.58	345.56	467.4	476.50	471.42
nsoon 81	496.38	283.49	361.30	239.23	239.71	195.52
n 81	2878.1	2803.33	1087.01	2343.29	3380.05	2760.92
onsoon 81	231.26	188.81	28.31	188.35	648.70	288.54
nsoon 81	451.93	453.56	54.24	277.84	903.51	1129.29
n 82	2828.23	2753.05	1243.59	2059.81	4384.13	3227.45

e longshore energy flux component $\bar{P}_{ls}$, entering the surf zone and
ing transport of beach material (i.e.Eastward transport plus Westward transport).

soon,78	93.21	-61.90	-53.93	28.67	60.45	24.39
oon,79	-89.67	-186.89	-54.96	-119.29	201.36	-98.66
soon,80	-295.86	-247.13	-254.18	330.86	- 7.8	48.14
oon,81	-489.96	-281.26	-361.30	-226.77	-43.93	183.24
81	-2878.1	-2803.33	-1087.01	-2343.29	-3380.05	-2760.92
soon,81	137.17	166.78	5.71	188.35	648.70	288.54
oon,82	-298.60	-177.04	-51.77	-242.65	-612.11	-837.89
82	-2828.23	-2701.95	-1243.59	-1908.65	-3943.66	-3227.45

Longshore Energy flux component $\bar{P}_{ls}$ entering the surf zone, resulting

ansport of beach material i.e. either east or westward.

gn indicates eastward movement.

$\bar{P}_{ls}$ (East)

Table-4

Period	St.No.2	St.No.3	St.No.4	St.No.5	St.No.6	St.No.7
Post-monsoon,78	-6.12	-68.78	-62.51	-14.90	-122.11	63.30
Pre-monsoon,79	-102.39	-195.95	-59.76	-151.96	-257.37	-128.06
Post-monsoon,80	-473.78	-467.86	-299.87	- 68.27	-242.15	-211.64
Pre-monsoon,81	-493.17	-282.38	-361.30	-233.00	-141.82	-189.50
Monsoon,81	-2878.1	-2803.33	-1087.01	-2343.29	-3380.05	-2760.92
Post-monsoon,81	- 47.0	-11.02	- 11.30	0	0	0
Pre-monsoon,81	-375.27	-315.3	-53.01	-260.25	- 757.81	-983.59
Monsoon,81	-2828.23	-2727.5	-1243.59	-1984.23	-4163.9	-3227.45

Average Energy flux component $\bar{P}_{ls}$, entering the surf zone,resulting Eastward transport of beach material. Minus sign indicate eastward transport.

$\bar{P}_{ls}$ (West) Table-5

Period	St.No.2	St.No.3	St.No.4	St.No.5	St.No.6	St.No.7
Post-monsoon,78.	99.63	6.88	8.59	43.58	62.11	87.69
Pre-monsoon,79	12.73	9.06	4.8	32.67	56.01	29.39
Post-monsoon,80	177.92	220.72	45.69	399.13	234.35	259.78
Pre-monsoon,81	3.21	1.11	0	6.23	97.89	6.28
Monsoon,81	0	0	0	0	0	0
Post-monsoon,81	184.21	177.79	17.01	188.35	648.70	288.54
Pre-monsoon,82	76.66	138.26	1.23	17.59	145.7	140.7
Monsoon,82.	0	25.55	0	75.58	220.24	0

Long energy flux component $\bar{P}_{ls}$ entering the surf zone and resulting westward transport of Beach material.

.207	-	74.614	1.8519	-	-
2.5962	1.1432	82.7752	3.1388	0.2152	0.0652
5.0841	52.4722	93.5869	77.4511	2.3935	27.9591
.6931	69.4715	90.0147	57.0685	47.0715	18.6861
2.158	68.1926	35.1798	88.1523	76.376	-
3.3681	44.9223	-	83.3456	30.9965	17.6048
.4505	51.0676	47.128	72.2956	50.2947	12.0511
3.0327	72.7478	38.6715	63.0105	84.2971	60.754
.1873	62.1433	65.9097	79.6491	80.3898	15.8385
.6835	11.8515	83.6296	4.9149	7.1048	4.9491
3.4007	85.1032	67.5147	7.5683	2.3037	3.1027
.3667	50.4242	-	16.0817	2.0043	2.2992
-	35.9112	53.1118	21.8567	7.9002	1.8875
.5057	11.7243	63.1212	1.4955	-	-
.1661	1.4507	46.7507	-	0.3782	1.1335
9.1613	84.0142	23.7012	52.0512	31.9922	88.4772

Contd/-

8.8867	73.2186	98.3222	59.3572	17.6028	38.5612
42.3805	46.3037	54.7105	77.8641	94.6525	84.3745
43.307	82.4162	38.9822	64.9478	96.284	84.8005
24.6565	89.248	53.688	82.001	46.5925	81.608
91.2665	86.6928	62.969	70.3134	82.0757	21.0312
20.489	70.9094	38.9075	74.7407	57.0982	16.0707
58.9912	45.2205	53.6738	55.9671	1.452	4.2505
35.1955	76.3547	21.1523	90.8289	29.1269	12.0265
27.1074	7.1975	-	-	-	-
30.3379	24.7514	81.1022	64.808	9.2719	2.9616
-	-	49.893	15.717	3.8227	15.717
0.2500	1.7632	3.4500	6.5101	2.7611	0.0123
11.5802	5.0895	3.4594	5.8357	1.509	0.1922
-	-	-	21.1454	0.6738	0.5284
0.6102	0.5440	9.1759	22.6410	8.6934	-
3.5035	15.3560	21.9155	18.5580	1.4202	0.0617

56.5952	-	11.2432	5.2532	0.0082	-
53.6218	28.7984	12.5162	6.3537	7.2234	7.3796
45.1753	44.5837	4.7711	18.3872	13.2767	32.6549
15.2955	26.2663	6.2615	12.9845	8.6160	46.3295
45.8468	26.6967	7.9042	2.9765	16.3175	-
50.0912	45.0528	-	11.5427	32.0256	38.4468
18.6899	29.6813	14.9768	17.2600	34.324	25.6091
32.8642	21.0232	16.6376	10.6216	10.2598	21.1737
9.5838	33.8523	4.7936	13.1519	12.5357	30.6316
65.0181	74.0499	31.5078	15.6317	51.3386	48.3862
40.6767	62.3645	26.4487	18.1265	33.3343	66.6357
7.3907	45.1677	-	45.975	36.299	73.9587
-	61.5812	20.6712	51.2662	64.6985	56.4812
50.0607	38.6907	19.4965	29.3837	-	-
68.9053	29.7669	12.1520	-	13.5927	30.0487
36.6328	9.9622	6.0287	20.4702	51.8934	11.1127
21.7662	16.1685	1.0912	12.1337	38.5652	45.2969

Contd/

Table-7

PERCENTAGE OF MEDIUM SAND (% of weight)

Date	St.No.2	St.No.3	St.No.4	St.No.5	St.No.6	St.No.7
10.12.81	48.8805	45.1575	6.0037	10.9355	4.6438	14.783
22.12.81	49.1265	58.389	8.942	17.0782	3.533	9.605
6.1.82	47.378	51.544	4.9615	9.554	15.138	16.3367
3.2.82	7.823	10.6765	4.875	13.9735	9.1642	41.3195
17.2.82	10.6407	25.6967	4.5342	13.6075	24.7727	33.1337
17.3.82	23.1615	34.596	2.913	28.4035	3.4905	24.9073
30.3.82	16.9886	18.3457	4.9188	5.791	30.2683	48.942
12.4.82	57.0654	38.9521	-	-	-	-
31.5.82	53.3022	61.7136	3.7687	26.331	28.4431	38.734
13.6.82	-	-	10.2181	27.5778	32.7123	79.801
30.6.82	4.9666	14.5822	27.8218	37.3498	26.5291	8.395
14.7.82	33.2002	52.4183	11.9241	30.6062	23.233	21.8348
5.8.82	-	-	-	55.152	11.3723	19.6422
26.8.82	7.0465	13.1087	23.7148	69.778	30.2407	-
9.9.82	31.1448	54.6942	11.7165	56.9594	18.6648	23.5281

St.No.2	St.No.3	St.No.4	St.No.5	St.No.6	St.No.7
33.7822	-	4.407	21.1077	0.8338	-
21.3288	58.4002	2.7952	33.8897	58.6596	79.4487
8.0514	2.7503	1.0219	6.1625	56.7673	31.4995
3.0177	3.8398	2.1631	13.1715	3.5325	26.1815
7.0705	4.4078	19.453	2.9095	6.1833	-
5.0934	9.4211	-	4.2151	22.6730	37.8023
4.1602	14.0122	11.1363	6.3039	12.0048	53.6743
26.102	5.3356	15.0767	8.2332	4.1245	14.1645
1.6805	3.7063	6.0519	4.7737	5.449	42.663
15.3284	13.5452	31.2331	53.7323	40.9923	45.1822
20.7053	2.2664	5.1007	57.1458	54.3381	29.9852
7.1637	4.205	-	30.6925	52.7862	23.4563
-	2.4379	3.1777	26.2532	26.0912	40.7126
22.4897	48.649	6.2582	64.6197	-	-
21.1015	57.3237	7.8922	-	56.9007	60.3039
7.4869	4.0537	20.3312	17.9622	14.8812	0.2752

16.5422	7.2212	0.0612	17.3272	30.4495	14.7632
6.4455	8.0605	6.0015	6.4945	0.4445	0.5625
6.5260	8.424	11.3083	11.9675	0.0905	1.523
9.42	8.362	5.4255	4.233	22.185	1.398
0.759	2.4545	4.879	9.712	1.9675	29.9309
8.1987	3.0347	6.4428	8.0222	12.8542	36.7642
8.0693	16.9585	10.8425	18.7418	9.1645	64.3925
4.7128	4.3099	10.6035	2.0614	27.4469	36.9301
13.8719	53.0663	-	-	-	-
14.0018	13.2366	3.7687	7.318	44.9299	58.5815
-	-	10.2181	42.7204	58.4398	4.4500
51.6226	43.2684	27.8218	51.0886	56.8043	63.4817
25.7587	30.829	11.9241	60.1598	34.0817	68.6576
-	-	-	20.0376	58.8608	68.8329
19.3952	55.2103	23.7148	7.3255	50.483	-
33.5725	26.8988	11.7165	18.6276	38.394	63.2825

.0552	-	9.497	71.6559	99.1072	-
2.3052	11.5092	1.7287	56.5035	33.8475	13.0195
.5718	0.0392	0.4494	2.7945	27.5583	7.8641
5.7525	0.3781	1.2785	16.6369	40.6693	8.7015
.8977	0.6761	37.3499	5.8668	1.053	-
5.4275	0.5859	-	0.8276	14.2718	6.0953
2.6672	5.1784	26.7481	4.0904	3.3421	8.6305
7.905	0.7447	29.5922	17.6935	1.3041	3.744
4.4403	0.2633	23.2311	2.3683	1.5843	10.7375
4.696	0.4556	3.4849	25.7149	0.5468	1.4824
5.1007	0.0933	0.8587	16.9869	9.9547	0.2627
4.0367	0.068	-	7.1112	8.8372	0.1907
-	0.0171	23.0482	0.5582	1.2701	0.8526
2.9407	0.9457	11.143	4.4907	-	-
.7717	11.3977	33.185	-	29.0997	8.4717
6.6012	1.9148	49.3671	9.4677	1.1148	0.0392
2.7292	3.3316	0.3902	11.1012	13.2147	1.2247

Contd/2

Table-9

PERCENTAGE OF VERY COARSE SAND (% by weight)

Date	St.No.2	ST.No.3	St.No.4	St.No.5	St.No.6	St.No.7
10.12.81	2.2565	0.417	33.2035	4.6705	0.2615	0.248
22.12.81	1.0265	0.7852	40.8025	5.9723	0.0205	4.078
6.1.82	18.179	0.445	35.3818	3.8935	15.723	0.332
3.2.82	0.193	0.1895	27.2857	5.9815	6.7825	7.6814
17.2.82	60.6693	0.4107	50.0252	3.6042	5.2807	14.0277
17.3.82	9.6605	2.9965	32.582	1.8285	85.8881	6.4235
30.3.82	43.0323	0.742	63.2479	1.1108	13.1310	2.0191
12.4.82	1.9051	0.6704	-	-	-	-
31.5.82	2.358	0.2983	11.9294	0.6916	17.3456	0.606
13.6.82	-	-	18.1622	13.6002	5.0144	0.031
30.6.82	43.0449	40.371	65.4934	5.0515	13.8787	28.0029
14.7.82	29.4121	11.6632	78.7651	3.3886	41.1639	9.2932
5.8.82	-	-	-	3.6436	29.0913	10.9585
26.8.82	72.9438	31.137	53.6922	0.192	10.5829	-
9.9.82	31.7353	3.0083	60.0594	5.8549	41.5092	12.6820

DATA FROM STATION NO. 2

STATION No.2

WAVE DATA

Table -10

Date	Wave period (sec)	Wave height at breaking (feet)	Wave Direction	Angle of breaking waves.	Longshore wave energy flux in surf-zone.P_{ls}
29.9.80	7.5	5-6	SW	120	-1972.16
28.10.80	7,8	4	SE	30	889.58
17.11.80	CALM SEA			0	0
18.12.80	12.0	2	SW	120	-157.26
18.1.81	CALM SEA	-	-	-	0
2.3.81	9.0	1	S	75	16.06
19.3.81	10.0	2-3	SW	120	-274.72
2.4.81	10.0	3-4	SW	120	-637.10
20.4.81	7.0	5	SW	120	-1554.03
7.5.81	8.4	3-4	SW	120	-637.10
30.5.81	8.0	5-6	240SW	135	-2277.02
22.6.81	9.0	5-6	210SW	105	-1138.63
9.7.81	10.0	8-10	210SW	105	-3900.15
23.7.81	9.5	10-12	210SW	105	-6441.05
27.10.81	12.0	2-3	210SW	105	-158.61
17.11.81	7.5	4	South	75	513.6
10.12.81	6.0	2	SE	30	157.26

Contd/-

STATION No.2

Table-10

WAVE DATA

Date	Wave period (sec)	Wave height at breaking (feet)	Wave Direction.	Angle of breaking waves.	longshore wave energy flux in surf-zone. P_{ls}
25.9.78	7.5	2-3	200^{o}S	95	-55.08
2.10.78	6.8	3-4	South	75	+367.83
9.10.78	10	2-3	South	75	+158.61
25.10.78	9.0	2-3	South	75	+158.61
8.11.78	12.0	1-2	SE	30	+76.61
22.11.78	5.5	1-2	190S	85	+15.36
2.12.78	5.0	1-2	170SE	65	+67.76
9.12.78	10.0	1	170SE	65	+24.59
31.12.78	3.5	1	170SE	65	+24.59
21.7.79	10.0	1	SE	30	+27.80
5.2.79	10.0	1-1.5	SE	30	+48.56
7.3.79	10.0	1-	SW	120	-27.799
21.3.79	4.0	1-2	SW	120	-76.61
3.4.79	6.0	1-2	SW	120	-76.61
18.4.79	5.5	3	SW	120	-433.35
16.9.80	8.5	4-5	200S	95	-239.46

12	1.5	SW	120	-76.61
13.0	3	S	75	250.20
9.0	3.0	170SE	65	383.32
8.0	2.0	SW	120	-157.26
6.0	2-3	SW	120	-274.72
9.7	3	210S	105	-250.19
4.0	4-5	225SW	120	-1194.17
8.0	4-5	200S	95	-239.45
9.0	8	200S	95	-1009.02
8.0	8	SW	120	-5032.23
8.5	8	SW	120	-5032.23
7.2	6	195S	90	0

ngshore energy flux in surf zone (units: ft-lbs/sec/ft of beach)

nus sign indicates eastward movement.

nsoon,78.	105.45	93.21	-6.12	99.33
soon,79.	115.12	-89.67	-102.39	12.73
nsoon 80.	651.70	-295.86	-473.78	177.92
soon 81.	496.38	-489.96	-493.17	3.21
81.	2878.1	-2878.1	-2878.1	0
nsoon 81.	231.26	137.17	- 47.0	184.21
soon 82.	451.93	-298.60	-375.27	77.66
82	2828.23	-2828.23	-2828.23	0

STATION No.2

DISTRIBUTION OF GRAIN SIZE IN NEAR SHORE SURF-ZONE
(Percentage by Weight)

Table-12

Date	Fine sand	Medium sand	Coarse Sand	V.Coarse. sand
16.9.80	4.207	56.5952	33.7822	5.0552
29.9.80	12.5962	53.6218	21.3288	12.3052
28.10.80	46.0841	45.1753	8.0514	0.5718
17.11.80	74.6931	15.2955	3.0177	6.7525
18.12.80	42.158	45.8468	7.0705	4.8977
19.1.81	38.3687	50.0912	5.0934	6.4275
2.3.81	64.4505	18.6899	4.1602	12.6672
19.3.81	13.0327	32.8642	26.102	27.905
2.4.81	84.1873	9.5838	1.6805	4.4403
20.4.81	14.6835	65.0181	15.3284	4.696
7.5.81	33.4007	40.6767	20.7053	5.1007
30.5.81	1.3667	7.3907	7.1637	84.0367
9.7.81	4.5057	50.0607	22.4897	22.9407
23.7.81	4.1661	68.9053	21.1015	5.7717
27.10.81	39.1613	36.6328	7.4869	16.6012
17.11.81	8.8867	21.7662	16.5422	52.7292
10.12.81	42.3805	48.8805	6.4455	2.2565
22.12.81	43.307	49.1265	6.526	1.0265
6.1.82	24.6565	47.378	9.420	18.1790
3.2.82	91.2665	7.823	0.759	0.193

Contd/-

STATION-2

Date	Fine Sand	Medium Sand	Coarse Sand	V.coarse san
17.2.82	20.489	10.6407	8.1987	60.6693
17.3.82	58.9912	23.1615	8.0693	9.6605
30.3.82	35.1955	16.9886	4.7128	43.0323
12.4.82	27.1074	57.0654	13.8719	1.9051
31.5.82	30.3379	53.3022	14.0018	2.3580
30.6.82	0.250	4.9666	51.6226	43.0449
14.7.82	11.5802	33.2002	25.7587	29.4121
26.8.82	0.6102	7.0465	19.3952	72.9438
9.9.82	3.5035	31.1448	33.5725	31.7353

DATA FROM STATION NO.3

25.9.78	6.0	2-3	210SW
2.10.78	8.0	3-4	SW
9.10.78	6.0	2-3	105S
25.10.78	9.8	2-3	210S
8.11.78	3.5	1	SE
22.11.78	5.5	1-2	200SW
2.12.78	9.0	1	SE
9.12.78	8.0	1	SW
31.12.78	12.0	1	SE
21.1.79	9.0	1-1.5	SE
5.2.79	12.0	1	SE
19.2.79	5.5	4-5	SW
7.3.79	12.0	1	SW
21.3.79	3.5	1-2	SW
3.4.79	5.0	2-3	SW
18.4.79	5.2	2-3	SW
16.9.80	8.0	6-7	SW
29.9.80	9.0	4-5	200S

.0	4	SE	20	660.27
1.0	2-3	SE	20	203.9
2.0	2	SW	110	-1167.2
CALM SEA			-	0
2.0	1	200S	85	5.57
0.0	2-3	SW	110	-203.9
.0	3	SW	110	-321.64
5.5	4-5	SW	110	-886.35
.6	3-4	SW	110	-472.87
.5	5	240SW	125	-1686.23
.5	6-7	SW	110	-2222.57
.0.0	8-10	210SW	95	-1354.51
.5	10-12	SW	110	-8280.46
.2.0	2-3	210SW	95	-55.08
.0.0	4	S	65	786.88
.2.0	1-2	SE	20	56.86

Contd/-

STATION No.3

Table-13

WAVE DATA

Date	Wave period (sec)	Wave height at breaking (feet)	Wave Direction	Angle of breaking waves	Longshore wave energy flux in surf-zone. P_{1s}
22.12.81	6.2	1	South	65	24.59
6.1.82	14.0	1	SE	20	20.63
3.2.82	9.5	3-4	170SE	55	691.29
17.2.82	8.0	4	SW	110	-660.27
17.3.82	6.5	2-3	SW	110	-203.90
30.3.82	7.5	4-5	210SW	95	-239.45
12.4.82	6.0	3-4	SW	110	-472.87
31.5.82	7.0	3-4	200S	85	127.75
30.6.82	8.0	8	SW	110	-3735.06
14.7.82	9.0	8-10	SW	110	-5013.94
26.8.82	8.5	8	SW	110	-3735.06
9.9.82	7.5	5	SW	110	-1153.45

P_{1s} = Longshore energy flux in surf zone.(units:ft-lbs/sec/ft of beach)

Minus sign indicates eastward movement.

STATION No.3

Table-14

Period	$\bar{P}_{ls}$(gross)	$\bar{P}_{ls}$(net)	$\bar{P}_{ls}$(east)	P_{ls}(west)
Post-monsoon 78	75.66	-61.90	-68.78	6.88
Premonsoon 79	205.01	-186.89	-195.95	9.06
Post-monsoon 80	688.58	-247.13	-467.86	220.72
Premonsoon 81	283.49	-281.26	-282.38	1.11
Monsoon 81	2803.33	-2803.33	-2803.33	0
Post-monsoon 81	188.81	166.78	- 11.02	177.79
Premonsoon 82	453.56	- 177.04	315.3	138.26
Monsoon 82	2753.05	-2701.95	-2727.5	25.55

STATION No.3

DISTRIBUTION OF GRAIN SIZE IN NEAR SHORE SURF-ZONE

(Percentage by Weight)

Table-15

Date	Fine sand	Medium sand	Coarse sand	V.coarse sand
29.9.80	1.1432	28.7984	58.4002	11.5092
28.10.80	52.4722	44.5837	2.7503	0.0392
17.11.80	69.4715	26.2663	3.8398	0.3781
18.12.80	68.1926	26.6967	4.4078	0.6761
19.1.81	44.9223	45.0528	9.4211	0.5859
2.3.81	51.0676	29.6813	14.0122	5.1784
19.3.81	72.7478	21.0232	5.3356	0.7447
2.4.81	62.1433	33.8523	3.7063	0.2633
20.4.81	11.8515	74.0499	13.5452	0.4556
7.5.81	35.1032	62.3645	2.2664	0.0933
30.5.81	50.4242	45.1677	4.2050	0.0680
22.6.81	35.9112	61.5812	2.4379	0.0171
9.7.81	11.7243	38.6907	48.6490	0.9457
23.7.81	1.4507	29.7669	57.3237	11.3977
27.10.81	84.0142	9.9622	4.0537	1.9148
17.11.81	73.2186	16.1685	7.2212	3.3316
10.12.81	46.3037	45.1575	8.0605	0.4170
22.12.81	32.4162	58.389	8.424	0.7852
6.1.82	39.248	51.544	8.362	0.445
3.2.82	86.6928	10.6765	2.4545	0.1895

Contd/-

STATION No.3

Date	Fine sand	Medium sand	coarse sand	V.coarse sand
17.2.82	70.9094	25.6967	3.0347	0.4107
17.3.82	45.2205	34.596	16.9585	2.9965
30.3.82	76.3547	18.3457	4.3099	0.742
12.4.82	7.1975	38.9521	53.0663	0.6704
31.5.82	24.7514	61.7136	13.2366	0.2983
30.6.82	1.7632	14.5822	43.2684	40.371
14.7.82	5.0895	52.4183	30.829	11.6632
26.8.82	0.544	13.1087	55.2103	31.137
9.9.82	15.356	54.6942	26.8988	3.0083

DATA FROM STATION NO.4

sec)	at breaking (feet)	Direction	breaking waves		energy flux in surf-zone P_{ls}
7.5	1-2	230SW	148		-79.5
5.9	1-2	SW	143	1	-85.03
8.0	2-3	SW	143		-304.93
7.5	1	210SW	128		-31.15
3.4	1	ESE	75.5		15.56
4.0	1	SW	143		-30.86
3.5	1	SE	53		30.86
4.0	1	210SW	128		-31.15
3.5	1	SE	53		-30.86
2.9	1	SE	53		30.86
6.0	1	ESE	75.5		2.75
5.0	2	230SW	148		163.2
CALM SEA					0
4.2	1-2	SW	143		-85.03
4.0	1-2	SW	143		-85.03
6.5	1-2	SW	143		-85.03

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6.8	3-4	SW	143	-707.16
5.0	3-4	SW	143	-707.16
4.5	2	SE	53	174.55
8.0	1-1.5	SE	53	53.9
12.0	1.5	SW	143	- 85.03
CALM SEA				0
CALM SEA				0
CALM SEA				0
5.6	3	SW	143	-481.00
8.0	4-5	SW	143	-1325.49
7.8	3-4	SW	143	-707.16
8.0	4-5	240SW	158	-957.87
6.5	3-4	SW	143	-707.16
8.0	4-5	210SW	128	-1337.95
8.5	4-6	SW	143	-1724.93
÷	1	210SW	128	-5.51
10.0	1-1.5	S	98	-24.38

	(feet)		waves	surf-zone P_{l_s}
13.0	1.5	SE	53	85.03
CALM SEA				0
14.0	1	200S	118	-26.61
7.0	1-2	170SW	88	6.17
-	1	SW	143	-5.45
5.0	2	SW	143	-174.55
CALM SEA				0
3.0	1-2	SW	143	-85.03
5.9	3	S	98	-137.93
4.0	4-5	S	98	-380.08
3.0	5-6	200S	118	-1887.93
3.0	6	SW	143	-20720.98
7.0	4-5	210SW	128	-1337.95
3.0	4	210SW	128	-996.69

ore energy flux in surf zone.(units: ft.lbs/sec/ft.of beach)

indicates eastward movement

		$\bar{P}_{1s}$(gross)	$\bar{P}_{1s}$(net)	$\bar{P}_{1s}$(east)	$\bar{P}_{1s}$(west)
nsoon	78	71.1	-53.93	52.51	8.59
soon	79	64.56	-54.96	-59.76	4.8
onsoon	80	345.56	-254.18	-299.87	45.69
nsoon	81	361.30	-361.30	-361.30	0
n	81	1087.01	-1087.01	-1087.01	0
onsoon	81	28.31	5.71	- 11.30	17.01
nsoon	82	54.24	-51.77	- 53.01	1.23
n	82	1243.59	-1243.59	-1243.59	0

STATION No.4

DISTRIBUTION OF GRAIN SIZE IN NEAR SHORE SURF- ZONE
(Percentage by Weight)

Table-18

Date	Fine sand	Medium sand	Coarse sand	V.course sand
16.9.80	74.614	11.2432	4.407	9.497
29.9.80	82.7752	12.5162	2.7952	1.7287
28.10.80	93.5869	4.7711	1.0219	0.4494
17.11.80	90.0147	6.2615	2.1631	1.2785
18.12.80	35.1798	7.9042	19.453	37.3499
2.3.81	47.128	14.9768	11.1363	26.7481
19.3.81	38.6715	16.6376	15.0767	29.5922
2 .4.81	65.9097	4.7936	6.0519	23.2311
20.4.81	33.6296	31.5078	31.2331	3.4849
7.5.81	67.5147	26.4487	5.1007	0.8587
22.6.81	53.1118	20.6712	3.1777	23.0482
9.7.81	63.1212	19.4965	6.2582	11.143
23.7.81	46.7507	12.152	7.8922	33.185
27.10.81	23.7012	6.0287	20.3312	49.3671
17.11.81	98.3222	1.0912	0.0612	0.3902
10.12.81	54.7105	6.0037	6.0015	33.2035
22.12.81	38.9822	8.942	11.3083	40.8025
6.1.82	53.688	4.9615	5.4255	35.3818
3.2.82	62.969	4.875	4.879	27.2857

Contd/-

STATION-4

Date	Fine sand	Medium sand	Coarse sand	V.coarse sane
17.2.82	38.9075	4.5342	6.4428	50.0252
17.3.82	53.6738	2.913	10.8425	32.582
30.3.82	21.1523	4.9188	10.6035	63.2479
31.5.82	81.1022	3.1997	3.7687	11.9294
13.6.82	49.893	21.7762	10.2181	18.1622
30.6.82	3.45	3.1238	27.8218	65.4934
14.7.82	3.4594	5.8388	11.9241	78.7651
26.8.82	9.1759	13.4077	23.7148	53.6922
9.9.82	21.9155	6.2994	11.7165	60.0594

DATA FROM STATION No.5

(sec)	at breaking (feet)	Direction	breaking waves	energy flux in surf-zone $.P_{1s}$
7.5	2-3	SW	97	-76.74
6.2	2-3	21-SW	82	87.44
7.0	2-3	200S	72	186.45
6.4	1-2	230SW	102	-35.98
8.0	1-1.5	S	52	54.41
4.0	1-2	SW	97	-21.40
3.5	1	SSE	29.5	27.52
10.0	1	210SW	82	8.85
13.0	1	SSE	29.5	27.52
8.0	1-1.5	SSE	29.5	48.07
15.0	2	170SE	42	180.59
5.5	3-4	260SW	132	-731.63
6.0	1-1.5	SW	97	-13.57
4.5	1-2	SW	97	-21.40
5.5	2-3	SW	97	-76.74
4.5	2-3	240SW	112	-220.36

c)	at breaking (feet)	Direction	breaking waves.	energy flux in surf -zone. P_{ls}
7.5	4-5	SW	97	-333.59
6.0	2	SSE	29.5	155.65
8.0	2	S	52	176.19
2.0	1	SW	97	-7.77
7.0	1-1.5	SW	97	-21.40
1.0	1	S	52	31.15
8.0	1	SW	97	7.77
5.6	3-4	SW	97	-177.97
8.0	4-5	240SW	112	-957.87
6.0	3-4	SW	97	-177.97
7.8	3	240SW	112	-347.60
9.0	6-7	SW	97	-836.50
8.0	8	SW	97	-1405.74
9.0	10-12	240SW	112	-8948.66
8.0	2	210SW	82	50.05
9.0	3	210SW	82	485.53

ec)	at breaking (feet)	Direction	breaking waves.	surf-zone $.P_{l_s}$
15.0	1.5	S	52	79.5
14.0	1	200S	72	18.87
7.0	1-2	170SE	42	87.97
6.0	4	SW	97	-248.40
6.0	2	SW	97	-43.93
5.3	4	255SW)	127	-987.4
3.0	1-2	SW	97	-21.40
5.3	4-5	240SW	112	-957.87
6.5	4	SSW	74.5	529.05
8.0	6	SW	97	-684.79
9.0	8	250WSW	122	-5222.64
8.0	8	240SW	112	-4036.64
8.0	8	SW	97	-1405.74

hore energy flux in surf zone.(units:ft.Lbs/sec/ft.of beach)

ign indicates eastward movement.

STATION NO.5 Table-20

Period		$\bar{P}_{ls}$(gross)	$\bar{P}_{ls}$(net)	$\bar{P}_{ls}$(east)	$\bar{P}_{ls}$(west)
Post-monsoon	78	58.48	28.67	-14.90	43.58
Pre-monsoon	79	184.62	-119.29	-151.96	32.67
Post-monsoon	80	467.40	330.86	- 68.27	399.13
Pre-monsoon	81	239.23	-226.77	-233.00	6.23
Monsoon	81	2343.29	-2343.29	-2343.29	0
Post-monsoon	81	188.35	188.35	0	188.35
Pre-monsoon	82	277.84	242.65	- 260.25	17.59
Monsoon	82	2059.88	-1908.65	-1984.02	75.58

STATION No.5

DISTRIBUTION OF GRAIN SIZE IN NEAR SHORE SURF-ZONE

(Percentage by Weight) Table -21

Date	Fine sand	Medium sand	Coarse sand	V.coarse sand
16.9.80	1.8519	5.2532	21.1077	71.6559
29.9.80	3.1388	6.3537	33.8897	56.5035
28.10.80	77.4511	13.3872	6.1625	2.7945
17.11.80	57.0685	12.9845	13.1715	16.6369
18.12.80	88.1523	2.9765	2.9095	5.8668
19.1.81	83.3456	11.5427	4.2151	0.8276
2.3.81	72.2956	17.260	6.3039	4.0904
19.3.81	63.0105	10.6216	8.2332	17.6935
2.4.81	79.6491	13.1591	4.7737	2.3683
20.4.81	4.9149	15.6317	53.7323	25.7149
7.5.81	7.5683	18.1265	57.1458	16.9869
30.5.81	16.0817	45.975	30.6925	7.1112
22.6.81	21.8567	51.2662	26.2532	0.5582
9.7.81	1.4955	29.3837	54.6197	4.4907
27.10.81	52.0512	20.4702	17.9622	9.4677
17.11.81	59.3572	12.1337	17.3272	11.1012
10.12.81	77.8641	10.9355	6.4945	4.6705
22.12.81	64.9478	17.0782	11.9675	5.9723
6.1.82	82.001	9.554	4.233	3.8935
3.2.82	70.3134	13.9735	9.712	5.9815

Contd/-

STATION No.5

Date	Fine sand	Medium sand	Coarse sand	V.Coarse sand
17.2.82	74.7407	13.6075	8.0222	3.6042
17.3.82	55.9671	28.4035	13.7418	1.8285
30.3.82	90.8289	5.791	2.0614	1.1108
31.5.82	64.808	26.331	7.318	0.6916
13.6.82	15,717	27.5778	42.7204	13.6002
30.6.82	6.5101	37.3498	51.0886	5.0515
14.7.82	5.8357	30.6062	60.1598	3.3886
5.8.82	21.1454	55.152	20.0376	3.6436
26.8.82	22.6410	69.778	7.3255	0.192
9.9.82	18.5580	56.9594	18.6276	5.8549

DATA FROM STATION NO.6

period ec)	Wave height at breaking (feet)	Wave Direction	Angle of breaking waves.	Longshore wave energy flux in surf-zone. P_{l_s}
8.2	3-4	SW	96	-152.95
6.7	3-4	SW	96	-152.95
5.5	3-4	SW	96	-152.95
6.0	3-4	230SW	110	-472.87
6.0	2-3	SSE	28.5	266.04
4.4	3-4	SW	96	-152.95
7.5	1	SSE	28.5	26.92
12.0	1-2	SW	96	-18.39
10.0	2-3	SSE	28.5	266.04
9.0	2-3	150SE	21	212.26
15.0	2	170SE	41	179.82
4.5	4-5	250SW	121	-1217.51
5.0	2-3	SW	96	-65.95
4.5	3-4	SW	96	-152.95
6.0	2-3	240SW	111	-212.26
5.0	3-4	SW	96	-152.95

(sec)	at breaking (feet)	Direction	breaking waves.	energy flux in surf-zone. P_{l_s}
6.8	6-7	SW	96	-718.90
7.5	5-6	SW	96	-473.47
5.2	4	SSE	28.5	861.48
7.5	2-3	S	51	310.28
13.0	1-5	SW	96	-18.39
7.0	1.5	SW	96	-18.39
11.0	3	S	51	489.45
7.0	3	SW	96	-104.04
7.0	4	SW	96	-213.57
6.5	5	SW	96	-373.09
5.8	4	SW	96	-213.57
8.0	3-4	240SW	111	-492.25
8.0	7-8	SW	96	-1028.10
9.5	10-12	240SW	111	-8619.81
8.0	2	210SW	81	56.11
9.0	5	S	51	1755.23
[illegible]	3	S	51	489.45

sec)	at breaking (feet)	Direction.	Breaking Waves	energy flux in surf-zone. P_{l_s}
-	2-3	S	51	310.28
11.0	4	200S	71	632.41
9.0	3-4	170SE	41	728.50
8.0	6	SW	96	-88.52
6.0	3-4	SW	96	-152.95
6.0	5-6	240SW	111	-1523.78
3.0	5-6	240SW	111	-1523.78
5.3	4-5	240SW	111	-922.67
7.5	6	SSW	73.5	1541.67
6.5	10	SW	96	-211.49
8.0	10	270W	141	-9929.09
10.0	10-12	250SWW	121	-11374.22
6.0	8	240SW	111	-3888.13

shore energy flux in surf -zone.(units ft.Lbs/sec/ft.of beach)

sign indicates eastward movement.

	P_{ls} (gross)	P_{ls} (net)	P_{ls}(east)	P_{ls} (west)
nsoon 78	184.67	60.45	-122.11	62.11
soon 79	313.38	201.36	-257.37	56.01
nsoon 80	476.50	- 7.8	-242.15	234.35
soon 81	239.71	-43.93	-140.82	97.89
81	3380.05	-3380.05	-3380.05	0
nsoon 81	648.70	648.70	0	648.70
soon 82	903.51	-612.11	-757.81	-145.70
82	4384.13	-3943.66	-4163.90	220.24

STATION No.6

DISTRIBUTION OF GRAIN SIZE IN NEAR SHORE SURF-ZONE

(Percentage by Weight) Table-24

Date	Fine sand	Medium sand	coarse sand	V.coarse sand
16.9.80	0.000	0.0082	0.8338	99.1072
29.9.80	0.2152	7.2234	58.6596	33.8475
28.10.80	2.3935	13.2767	56.7673	27.5583
17.11.80	47.0715	8.616	3.5325	40.6693
18.12.80	76.376	16.3175	6.1833	1.053
19.1.81	30.9965	32.0256	22.673	14.2718
2.3.81	50.2947	34.324	12.0048	3.3421
19.3.81	84.2971	10.2598	4.1245	1.3041
2.4.81	80.3898	12.5357	5.449	1.5843
20.4.81	7.1048	51.3386	40.9923	0.5468
7.5.81	2.3037	33.3343	54.3381	9.9547
30.5.81	2.0043	36.299	52.7862	8.8372
22.6.81	7.9002	64.6085	26.0912	1.2705
23.7.81	0.3782	13.5927	56.9007	29.0997
27.10.81	31.9922	51.8934	14.8812	1.1148
17.11.81	17.6028	38.5652	30.4497	13.2147
10.12.81	94.6525	4.6438	0.4445	0.2615
22.12.81	96.284	3.533	0.0905	0.0205
6.1.82	46.5925	15.138	22.185	15.723
3.2.82	82.0757	9.1642	1.9675	6.7825

Contd/-

STATION No.6

Date	Fine sand	Medium sand	Coarse sand	V.Coarse sand
17.2.82	57.0982	24.7727	12.8542	5.2807
17.3.82	1.452	3.4905	9.1645	85.8881
30.3.82	29.1269	30.2683	27.4469	13.1310
31.5.82	9.2719	28.4431	44.9299	17.3456
13.6.82	3.8227	32.7123	58.4398	5.0144
30.6.82	2.7611	26.5291	56.8043	13.8787
14.7.82	1.509	23.233	34.0817	41.1639
5.8.82	0.6738	11.3723	58.8608	59.0913
26.8.82	8.6934	30.2407	50.483	10.5829
9.9.82	1.4202	18.6648	38,394	41.5209

DATA FROM STATION No.7

	(feet)		waves	surf-zone, P_{l_s}
7.0	3-4	SW	96	-152.95
6.4	2-3	SW	96	-.65.95
9.0	3-4	SW	96	-152.95
9.0	3-4	SW	96	-152.95
5.0	2-3	210SW	81	·88.03
6.5	3-4	SSE	28.5	616.97
5.5	2-3	SW	96	-65.95
10.0	1-2	SSE	28.5	74.19
10-0	2-3	SW	96	-55.95
8.0	2-3	SSE	28.5	65.95
11.0	2	150SW	21	121.50
5.0	1-1.5	S	51	54.85
4.0	4-5	SW	96	-286.69
5.0	1-2	SW	96	-18.39
4.5	2-3	W	141	-310.28
5.2	3-4	SW	96	-152.95
		SW	96	- 473.47

Wave Period (sec)	Wave height at breaking (feet)	Wave Direction.	Angle of breaking waves	Long shore wave energy Flux in surf-zone, P_{l_s}
6.5	5	SW	96	-373.09
7.0	4	SSE	28.5	861.48
10.0	2	S	51	177.62
6.5	1-2	SW	96	-18.390
11-0	1	S	51	31.400
7.0	3	SW	96	-104.04
5.0	3-4	SW	96	-152.95
7.0	5	230SW	101	-672.21
6.0	4	SW	96	-213.57
9.0	6	SW	96	-588.52
7.0	8-10	SW	96	-1621.77
9.0	10-12	240SW	111	-8619.81
7.0	2	210SW	81	56.11
7.0	2-3	200S	71	195.30
-	1.5	South	51	86.52

1	CALM	-	-	-	0
	11.0	5	200S	71	1104.77
	9.0	3-4	170SE	41	728.5
	8.4	6	SW	96	-588.52
	5.5	3-4	SW	96	-152.95
	6.0	5-6	250SW	121	-2010.69
	4.5	5-6	255SWW	126	-2165.80
2	6.2	5-6	240SW	111	-1523.78
	8.0	6-7	240SW	111	-2313.66
	6.0	6-7	SW	96	-718.90
2	8.0	10	SW	96	-2110.49
	8.0	10	270W	141	-9929.08
	9.0	6	270W	141	-2768.77

Long shore energy surf -zone. (Units: ft-lbs/sec/ft of beach)

	$\bar{P}_{1s}$ (gross)	$\bar{P}_{1s}$(net)	$\bar{P}_{1s}$(east)	P_{1s}(west)
soon 78	150.99	24.39	-63.30	87.69
oon 79	157.44	-98.66	-128.06	29.39
soon 80	471.42	48.14	-211.64	259.78
oon 81	195.52	-183.24	-189.50	6.28
81	2760.92	-2760.92	-2760.92	0
soon 81	288.54	288.54	0	288.54
oon 82	1129.29	-837. 89	- 983.59	145.7
82	3227.45	- 3227.45	-3227.45	0

STATION No.7

DISTRIBUTION OF GRAIN SIZE IN NEAR SHORE SURF-ZONE

(Percentage by Weight)

Table -27

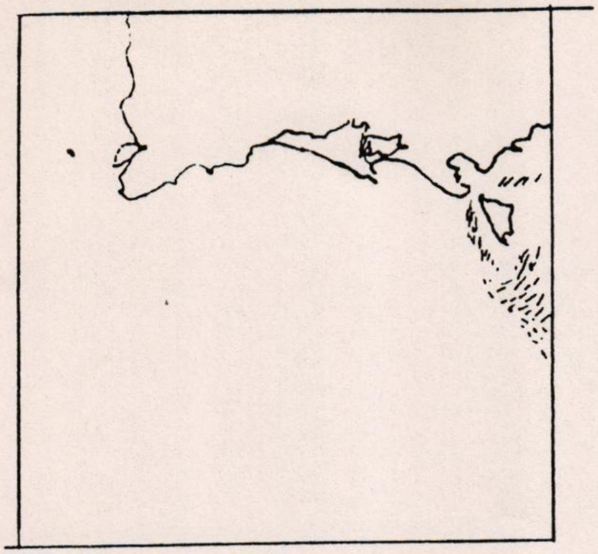
Date	Fine sand	Medium sand	Coarse sand	V.Coarse sand
29.9.80	0.0652	7.3796	79.4487	13.0195
28.10.80	27.9591	32.6549	31.4995	7.8641
17.11.80	18.6861	46.3295	26.1815	8.7015
19.1.81	17.6048	38.4468	37.8023	6.0953
2.3.81	12.0511	25.6091	53.6743	8.6305
19.3.81	60.754	21.1737	14.1645	3.744
2.4.81	15.8385	30.6316	42.663	10.7375
20.4.81	4.9491	48.3862	45.1822	1.4824
7.5.81	3.1027	66.6357	29.9852	0.2627
30.5.81	2.2992	73.9587	23.4563	0.1907
22.6.81	1.8875	56.4812	40.7126	0.8526
23.7.81	1.1335	30.0487	60.3039	8.4717
27.10.81	88.4772	11.1127	0.2752	0.0392
17.11.81	38.5612	45.2969	14.7632	1.2247
10.12.81	84.3745	14.783	0.5625	0.248
22.12.81	84.8005	9.605	1.523	4.078
6.1.82	81.608	16.3367	1.398	0.332
3.2.82	21.0312	41.3195	29.9309	7.6814

Contd/-

STATION NO.7

Date	Fine sand	Medium sand	Coarse sand	V.Coarse sand
17.2.82	16.0707	33.1337	36.7642	14.0277
17.3.82	4.2505	24.9073	64.3925	6.4235
30.3.82	12.0265	48.942	36.9301	2.0191
31.5.82	2.9616	38.734	58.5815	0.606
13.6.82	15.717	79.801	4.45	0.031
30.6.82	0.0123	8.395	63.4817	28.0029
14.7.82	0.1922	21.8348	68.6576	9.2932
5.8.82	0.5284	19.6422	68.8329	10.9585
9.9.82	0.0617	23.5281	53.2825	12.682

OVERLAY OF LANDSAT IMAGERIES (BAND 4)



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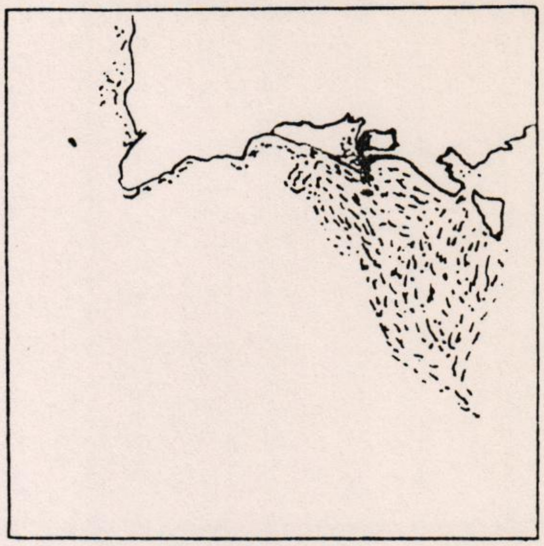

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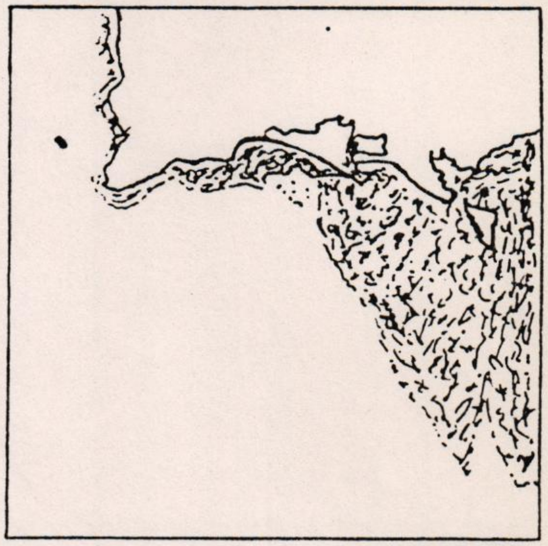

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DISCUSSION AND CONCLUSIONS

DISCUSSION

The direction of the littoral currents, resulting from the waves approaching the coastline from different directions at each station, is expressed in term of a direction function (α_b) given in Table-1. The direction function is only for breaking waves which have already been refracted while entering into surf-zone.From Table-1 it can be seen that waves approaching from southwest result in an eastward (i.e.towards Manora Island) littoral drift.As the wave approach predominantl from a soutwest direction in the area, the longshore current is likely to be generated which flows towards the Manora Island For the purpose of calculation it is assumed that the off-shore depth contours of the area under investigation are straig and parallel to the shoreline.Whereas in fact the off-shore dep contours are neither straight nor parallel to the coastline.Bu since we confined our calculations only upto the near-shore surf-zone and wave data was collected for the breaking waves, the results are in a fairly good approximation for drawing some basic conclusions about the direction of longshore wave energy flux in surf zone and the resulting direction of littoral drift

Table-2, which shows the gross longshore energy flux in the surf-zone, indicates that the maximum energy flux is in the period of southwest monsoon.In general, the energy dissipating at station No.2,3 & 6 is higher than at other stations.This means that at these stations the coastline remains under more severe attacks of waves.Large amount of wave energy arriving at station No.2 and Station No.3 can be attributed to the fact that at these stations the off shore slope is quite steep as compared to other stations and thus the surfzone is usually not as wide as at other places.Same reasons cannot be applied to the large energy dissipation at station No.6 because, as shown in the admarity chart (1976) of Pakistan Navy, the off shore slope at this station is not as steep as that of station No.2 and Station No.3. However the large amount of energy dissipation at station No.6 is also evident fromthe sieve analysis of sediment collected from near-shore surf-zone at this station.The sieve analysis (tables No.6-9) show that highest percent of very coarse sand is found at station No.6. This clearly shows that there is severe erosion at station No.6. It is thus likely that off-shore slope has become steep and a fresh bathymetry of this area would be useful to clarify this point. In the southwest monsoon of 1982 higher values for longshore energy flux (Table-2) are observed for station No.7 also.One possible explanation, for increase in longshore energy flux in pre-monsoon 82, and monsoon 82, at station No.7 could be the dredging and extension of navigational channel into deep waters. It is possible that as a result of this dredging, the sea-bed material from this station and Manora might have drifted towards the navigational channel.

The lowest gross value of longshore energy flux in surf-zone is found to be at station No.4 .This could be due to the fact that station No.4 is situated at the centre of long arc of Hawk's Bay and the incoming energy of waves is spread along the whole arc of the bay.This may also be due to the sheltering of this area from waves attack by the protruded land at Buleji Point.

Table No.3 shows the net longshore energy flux in near shore surf-zone.(The net longshore energy flux is the difference of longshore energy flux components in eastward and westward directions, and thus it represents the effective energy delivered for removal of beach material). It is seen that the longshore energy flux component in eastward direction prevails for most ofthe time and the westward component appears to be very low.It can also be noted from Table -3 that the net longshore energy flux (surf=zone) during the period of SW-monsoon is equal to gross longshore energy flux and it is directed towards east. This could mean that there is almost no movement of beach material in west direction during SW-monsoon and all the littoral drift is towards Manora Island in the east.Since the longshore energy flux component in eastward direction is much greater than its counterpart component, it can be inferred that the erosion during soutwest monsoon is more than the accretion of the beaches in the pre-monsoon and post-monsoon period and hence there is a net loss of beach materi This could lead to a severe erosion problem over a number of years.

Tables No.4 and 5 show the eastward and westward average component of longshore energy flux in surf-zone during different seasons.From Table-4 it can be seen that the eastward component of longshore energy flux (surf zone) during southwest monsoons provides the destructive force due to its higher values and it brings large amount of sediment in suspension and thus results erosion of beaches.Table -5 shows that in pre-monsoon and post-monsoon periods the longshore wave energy flux gives a westward component in surf-zone and dissipating energy is low to moderate During these periods the building up of beches is observed.

The grain analysis of sediment samples collected from the near shore surf-zone of the area under investigation is divided,as mentioned in Chapter 2, into four categories.Viz.fine sand, medium sand, coarse sand and very coarse sand.The distributions of sand in these four categories during different seasons at different stations are given in Tables 6 to 9.

Table No.6 , which shows the distribution of fine sand, indicate that during post-monsoon and pre-monsoon periods fine sand progressively increases towards Buleji Point and Paradise Point (station 2 & 3), indicating a probable deposition of fine sand inthese regions.During the transitional periods between post-monsoon and pre-monsoon, there is a drop in the percentage of fine sand at station No.4(Hawk's Bay) is noted, which may be due to movement of fine sand in western direction along the coast. The possibility of transportation of sand in western direction is supported from the fact that the eastern end of

Hawk's Bay is relatively open for incoming wave energy from south east direction as compared to western end where some sheltering from wave attack from soutwest is provided by the protruded rocky Buleji Point. High percentage of fine sand is also observed to be present at stations No.5,6 and 7 during the post-monsoon and pre-monsoon periods.This could be due to constructive wave action during these periods.

A sharp decrease in the percentage of fine sand is observed at all stations(Table No.6) during the monsoon period.This is in agreement with the calculations for longshore energy flux in surf-zone for southwest monsoon period when wave energy is found to be high enough to erode the shoreline and to bring a large amount of beach material into suspension.

Table No.7 shows the distribution of medium sand in the near sho surf-zone at different locations.The medium sand is the most dominating grain size along the coastline under investigation and is observed to be present in significant percentage througho the year.A slight increase in thepercentage of medium sand is observed during monsoon period, especially at station No.3 (Buleji Point) where it is found to be highest.From this it can be inferred that the increase in medium sand couldbe due to under cutting and shattering of rocks at the protruded head lan of Buleji Point.

Tables 8 and 9 show the distribution of coarse sand and very coarse sand, respectively, at each location during different seasons.The percentage of coarse sand in the near shore surf-zone is observed to increase with the progress of monsoon and then to decrease in the calm season. This is in agreement with seasonal changes on the beaches indicating removal of fine and medium sands during soutwest monsoon and deposition during post-monsoon and pre-monsoon.

Since the presence of very coarse sand can be used as an indicator of severe erosion, the samples of the sea-bed material from near shore surf-zone were analysed for determining the percentage of very coarse sand. Although significant percent of very coarse sand was observed along the whole area under investivation, it was very pronounced along the beaches of sandspit. Some exceptionally high values for percentage of very coarse sand were also noted. For example at stations No.5 and 6 it was observed that the percentages of very coarse sand were 71% and 99% respectively, just after the southwest monsoon of 1980. This indicates that the wave-energy during monsoon of 1980 was very high and there could be significant erosion at these stations,(No.observations were carried out during the SW-monsoon of 1980).

High percentage of very coarse sand appeared at station No.2 during the SW-monsoon of 1981 and 1982, indicating the possible erosion and undercutting of rocks at this region.

Since the movement of sediment along the coast is the resul
of many individual littoral drifts acting on discrete coastal segments, it will be informative to consider the da
from each station separately.

STATION NO.2

Tables No.10 to 12 give details about station No.2. It represents a typical example of coastline from Paradise Poi
to Cape Monze.The coastline in this area is rocky and the land rises sharply to varying heights . Here the land rises to a height of about 15 meters. It is observed that during SW-monsoon the high waves attack the foot of high land causing landslides. Since the land is generally composed of clay and sandstone, it is possible that these landslides ar
one of the sources of fine material in the area, where as th
undercutting of rocks in the area could be the source of coarse material.

Further very high values of longshore energy flux in surf-zo
are also observed here especially during SW-monsoon. This could be due to the fact that at this station the surf-zone not so wide.Table No.11 shows that $\bar{P}_{ls}$ (east) remained highe
than $\bar{P}_{ls}$ (west) during the whole period of study except duri
the post-monsoon of 1981.The $\bar{P}_{ls}$(net) values show that there
was more transportation of sediment in east direction than t

west and very little reversed littoral drift occured during the period of study.This could mean that the eroded material is not completely replaced back.

The sieve analysis of beach material (Table No.12) shows that in general the percentages of fine sand and medium sand are higher in post-monsoon and pre-monsoon seasons, indicating possible accretion of beach.Whereas the percentage of coarse sand and very coarse sand are observed to be high during SW-monsoon periods, possibly due to erosion.

STATION NO.3

Tables No.13 to 15 give details about station No.3 which is situated at Buleji Point.It is a rocky coastline with small pockets of beaches. Table No.14 shows the longshore energy flux in surf-zone which is in the eastward direction for most of the time.Here the values of wave energy dissipation is quite high during all the seasons and especially during the SW-monsoon. This can be attributed to the fact that Buleji Point is a protruded head land in sea and the incoming wave energy may converge at this point.From Table-15 it can be seen that the fine to medium sand is usually in higher percentage than the coarse sand and very coarse sand.Very coarse sand is observed to be present in very little percentage except during the SW-monsoon of 1982 when it was as high as about 40%. But by the end of monsoon period it had dropped back to about 3%.

Since station No.3 is situated in a pocket beach, it can be inferred that the high percentage of fine sand at this station could be due to trapping of fine and medium sand coming from Paradise Point and Cape Monze.

STATION NO.4

The longshore energy flux in surf-zone at station No.4 was found to be relatively lower than other stations (Table 16 to 18). Thus the station No.4 can be said to be comparatively calm than the other stations. Here the lower wave energy condition can be attributed to the fact that this station is situated at the centre of long arc of Hawk's Bay and the incoming energy of waves is spread along the whole arc of bay. Another factor could be the sheltering of this area from the waves by the protruded land at Buleji Point. In this case the dominant direc ion of longshore energy flux in surf-zone is observed to be suc that it results in eastward littoral drift.

The most dominant grain size is found to be that of fine sand (Table 18) .The percentage of fine sand is observed to vary throughout the year, but during post-monsoon periods it is foun to be present in very high percentage. This may be due to deposition of sand during the post-monsoon period. The percentag of very coarse sand is also significant during SW-monsoon, indicating erosion and washing out of fine and medium sand from Hawk's Bay area in monsoon season.

STATION -5

Tables No.19 to 21 give details about station No.5 .This station is situated at the western end of Sandspit. The extended rocks of Goth Jaffer(Jaffer Village) in the sea act like a barrier to the littoral drift towards west and provide a little sheltering effect to this station . Here the longshore energy flux in surf-zone was observed to be lower than at any other point on Sandspit. The sieve analysis of sea bed material from near shore surf-zone (Table No.21) reveals that the percentage of fine sand remains quite high during post-monsoon and pre-monsoon periods indicating deposition of beach material during these periods.A sharp decreases in fine sand and increase in coarse sand is observed during the SW-monsoon periods.The percentage of very coarse sand remained very low during most of the time except at the end of SW-monsoon of 1980, when it was found to be about 71% indicating erosion due to strong wave action in monsoon of 1980. Later it was observed that during the post-monsoon of 1980 the percentage of very coarse sand dropped down and the percentage of fine sand increased indicating the rebuilding of beach. On the whole it can be said that at station No.5 the erosion is least as compared to other stations.

STATION No.6

The sandspit at station No.6 is very narrow and this area is observed to be most vulnerable to wave attacks.The calculation for longshore energy flux in surf-zone (Table 23) also indicates that dissipation of wave energy is very high at this point. Here the intensive wave activity could be due to its exposure to open sea front and its orientation, because of which waves from southwest attack without much refraction. On several occasions it is observed that, during high tide in SW-monsoon periods, high waves cross the Spit and affect the Sandspit road, blocking the traffic. On the basis of these observations it is recommended that some measures for coastal protection be taken in this area otherwise if once a channel is made by the waves crossing the Sandspit it will be widened very quickly by the tidal currents and the whole belt of Sandpit, a natural protection to Karachi Harbour, might be eroded away.Sieve analysis of sediment from surf-zone(Table 24) shows that the percentage of fine sand decreases with the progress of SW-monsoon and increases during the post-monsoon and pre-monsoon periods. This shows the seasonal erosion and accretion of beach. The presence of coarse sand in significant percentage during all the seasons could be attributed to the high wave energy dissipation.

STATION No.7

Station No.7 situated near the break water of Manora Island. Table No.26 shows that the station is also zone of high wave energy dissipation and the magnitude of longshore energy flux in surf-zone resulting eastward littoral drift is much higher than in westward direction. As compared to monsoon of 1981 an increase in wave energy dissipation during the monsoon of 1982 was observed at station No.7 only. This increase in energy may be due to the increase in the slope of beach caused by the dredging and extension of navigational channel, which is just a few hundred meters away, and subsequently shifting of bed-material towards greater depth of navigational channel.

From the results of sieve analysis of sediment it is observed that in the post-monsoon of 1980 and premonsoon of 1981 the percentage of coarse sand was high in nearshore surf zone and it gradually decreased. In the SW-monsoon of 1981 the percentage of medium sand was observed to be the highest which indicates that the sea bed material eroded at Sandspit and Hawk's Bay is being deposited at station No.7. This shows that the material eroded on the west side of navigational channel is silting the entrance of the Karachi Harbour near station No.7. The sharp increase in the percentage of coarse sand during the SW-monsoon of 1982 is in confirmation with the increase observed in dissipation of wave energy at station No.7.

SATELLITE IMAGERIES:

To measure the extent of suspended load in coastal zone satellite imageries (band 4) for different seasons were studied. Figure shows the overlays drawn to delineate the extent of suspended load in front of area under investigation.From the study of satellite imageries it is observed that during SW-monsoon large amount of sediment is brought into suspension.In the coastal water of Cape Monze and Paradise Point the suspended load is observed to be extended about 1 to 2 kilometers from shore whereas in fron of Sandspit and Manora it is extended fr about 5km to 8km, spreading over an area of about 80 sq.km. (over lay no.4).This could be due to rocky coastline at Cape Monze and Paradise Point and sandy beaches at Sandspit and Manora.This could also mean thatthe surf-zone during SW-monsoon at Cape Monze and Paradise Point is comparatively narrower than at Sandspit and Manora and thus the shore line from Cape Monze to Paradise Point is subjected to more wave en in SW-monsoon. The shape of the plumes on satellite imageries indicate an eastward drift of suspended load.

Imageries in Band No.7 were studied to detect the changes in coastline due to erosion. No significant change could be obser due to low resolution of imageries, which in case of Landsat i 80 meters.However, the shoreline from Sandspit to Manora looks bright and straight on theimagery.According to the Shore Protection Manual Vol.1,U.S.Army Coastal Engineering Research Centre (pp.4-50) the brightness is usually evidence of sand and the straightness often indicate transport of sediment.Therefor we can say that Sandspit is a zone of littoral transport.

The minor changes such as small landslides and exposure of rocks due to waves actionwere recorded by photographs taken after every fortnight along the coastline.

Thus it is observed that high wave energy conditions prevailing during southwest monsoon in the region cause considerable changes on the beaches and surf-zone. Large amount of sediment are brought into suspension by the collapsing waves during this period of high wave energy. The two most significant roles play by southwest monsoon waves, probably, is to bring great quantities of suspended sedient in surf-zone and to generate littoral currents as the waves predominantly approach the coatline obliquely. As a result of these wave activities transport of sediment, along the coast and "on & off" shore, take place. During the post-monsoon and pre-monsoon periods (i.e. from October to April) the beaches and near shore zones are observed to be subjected to only moderate to low wave energy conditions. During these periods waves produce a net transport of sediment in a landward direction which probably give rise to the building up of the beaches.

CONCLUSIONS

From the above discussion the following conclusions may be drawn:

(1) The dominant direction of waves approach in thearea under investigation is from southwest which results littoral drift in eastward direction i.e. towards Manora Island.

(2) Dissipation of wave energy at stations No.2,3 and 6 is higher than at other stations.

(3) During the SW-monsoon beaches are eroded whereas the post-monsoon and pre-monsoon are the periods of the rebuilding of beaches.

(4) The beach material removed due to erosion is greater than the beach material deposited back, thus there is a net loss of beach material in the area.

(5) Near Paradise Point, erosion at station No.2 is more severe as the waves attack causes landslides.

(6) On Sandspit the most crucial area is near station No.6 where sea water is observed to cross the Sandspit on several occasions.Protective measure must be taken here immediately to protect the Sandspit from erosion.

(7) As compared to other stations, an increase in thedissipation of wave energy at station No.7 was observed.

NEED FOR ADDITIONAL RESEARCH:

Since the process of coastal erosion is influenced by several factors it is essential that the present study should be extended to cover the following aspects.

(1) The observations should be extended from coast to deeper water to track the offshore forces and their influence in the near shore region.For this purpose large boats equipped with appropriate winches will have to be hired and instruments such as current meter, STD, turbidity meter, wave recorder should be used.

(2) Mean sea level oscillation extend the intertidal zone and expose a wider band of beach line to storm action,thus affectin coastal erosion and sediment transport processes. Therefore long period meteorological and tidal records together with short period measurement of currents should be analysed to assess the coastal erosion.

(3) Extensive measureemnt at several locations should be carried out before proper quantitative conclusions may be drawn.

LIST OF PUBLICATIONS AND THESIS:

PUBLICATIONS

(1) S.M.A.Tirmizi and Ziauddin Ahmed: Distribution of Seabed Material along the Coastal Area of Karachi during the Southwest Monsoon.
Pakistan J.Sci.Ind.Res.Vol.26,No.2,April 1983.

THESIS

A thesis entitled "A Study of Shore Erosion Along the Coast of Karachi" submitted by Mr.Ziauddin Ahmed to the Faculty of Science, in fulfilment of the requirements for the degree of Master of Philosophy in Physics.

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