

Littoral Drift along Shoreline between Munambam & Anthakaranazhi, Kerala Coast

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Probable volume of littoral sediment transport at 2 m depth contour along the shoreline between Munambam and Anthakaranazhi has been computed for waves approaching the shore from directions varying from 220° - 300° TN with periods varying from 6 to 14 sec. It is estimated that about $9 \times 10^6 \text{ m}^3$ of material drifts towards south annually between Munambam and Vypin while about $7 \times 10^6 \text{ m}^3$ of material drifts towards south between Fort Cochin and Anthakaranazhi. The drifts are discussed in relation to the availability of sediments and the instability of beaches.

Information on sediment movement, on a long term basis, in the nearshore environs is a pre-requisite for the design of shore protection structures and for navigational purposes. It is known that this movement of sediment, particularly in the surf zone, is governed by complex interplay of waves and the nature of prevailing sediments in addition to morphological features of adjoining beach sections. Broadly, the alongshore component of wave energy together with the intense turbulence associated with breaking waves determine the sediment movement quantitatively. This takes place in 2 ways: in a zig-zag motion on the beach face in swash-backwash zone as beach drift and as suspended/bed-load movement in the surf zone.

Studies on sediment drift based on empirical relationship developed from quantitative estimates of littoral flows through wave refraction studies and field and laboratory experiments on the nature of movement of sediment in the vicinity of natural barriers have been made along various coastlines of the world¹. Along the coastlines of India such quantitative determinations have been made only at few localities²⁻⁵. The present study deals with the quantitative estimations of the sediment drift along the coast of Kerala between Munambam and Anthakaranazhi which has been experiencing severe erosion since few decades.

Materials and Methods

The region under investigation is about 54 km stretch of low, sandy shore, extending from Munambam to Anthakaranazhi (Fig. 1) and forms part of a barrier beach system. Periyar River opens into the Arabian Sea and discharges fresh water along with sediments during southwest monsoon season,

influencing the beach processes along this part of the coast. Off Malipuram and Narakkal, the shore is usually protected by the presence of mudbanks⁶ active during southwest monsoon season. The sediments, in general, beyond 3-4 m depth up to about 140 m are silty-clays or clayey-silts⁷. Sandy sediments in fine to medium size limits prevail in the beach and surf zone⁸.

Data on wave climate for the region from lat. $8^{\circ}30'$ to $11^{\circ}30'N$ and between long. $73^{\circ}30'E$ and the coastline presented in the earlier investigation⁹ were utilized to compute the deep water wave energy and to determine the direction function θ at 2 m depth through construction of wave refraction diagrams. Orientation of shoreline along the Kerala coast is in NNW-SSE direction and so waves approaching the coast between 220° and 300° are of great significance in the littoral processes along the shore under study. Percentages of different periods and heights were calculated for each direction of deep water wave approach to compute the alongshore component of the available wave energy¹⁰(E), assuming that waves from the above directions only occur on any day in any particular month. Here, $E = \gamma \frac{H_0^2 C_0}{16} \cos \theta \sin \theta$ where γ is the specific weight of sea water, H_0 the deepwater wave height, C_0 the deep water wave velocity and θ the angle subtended by the breaking waves with shoreline. The alongshore component of wave energy E (kg-m.m^{-1} wave) calculated at all stations (A to S; Fig. 1) utilizing θ values from the earlier study⁹ are presented in Table 1. While computing E when H_0 exceeds 2 m and the wave further gets amplified due to refraction during its shoreward propagation, a limiting wave height of 2 m only was considered to prevail, for the simple reason $H_b = 0.83 d$ (ref. 11) at the final break point at or close to 2 m depth contour.

Evaluation of the probable littoral sediment drift

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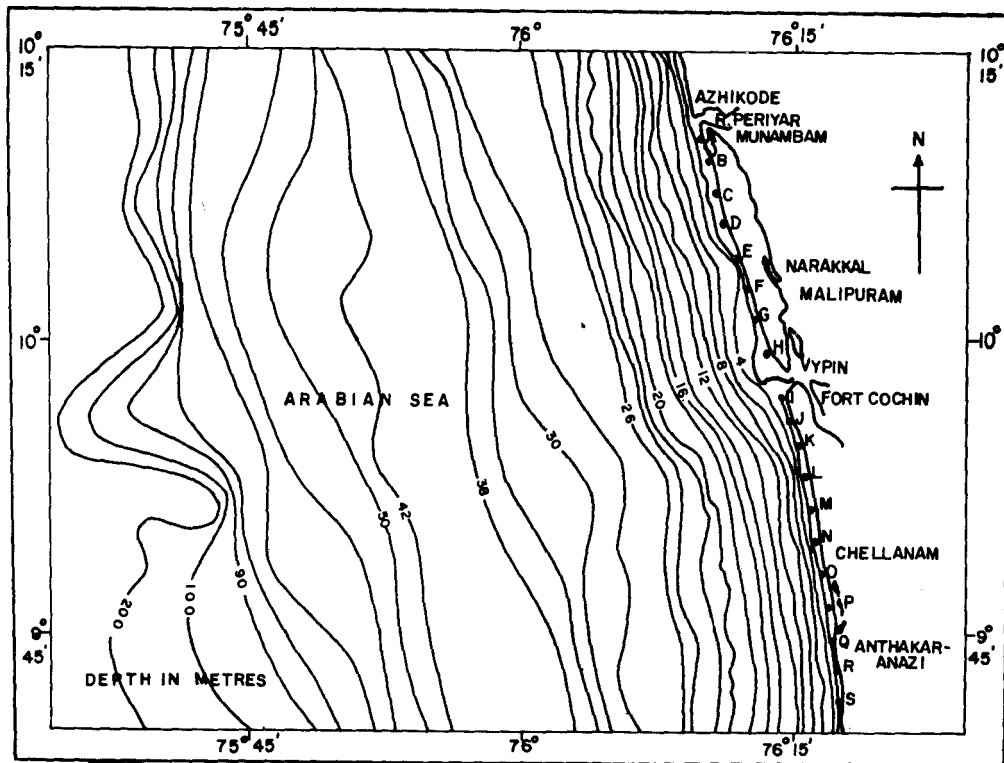


Fig. 1—Location of sts A to S

$Q(m^3)$ has been made, using the empirical relation¹²

$$Q = 210.7 E$$

where E is expressed in $10^6 \text{ kg} \cdot \text{m}^{-1}$ of the wave.

Results and Discussion

Longshore component of wave energy (Table 1) shows considerable variation from month to month at each of the 19 stations. The entire stretch of the shore experiences 2 energy maxima—one during April, and the other during Dec. On an average the longshore energy has a southerly (down coast) component during all the months except November, when the direction reverses to northerly (up coast) at almost all stations.

The quantity of littoral sediments subjected to alongshore drift during rough weather season (April-Sept.) shows an irregular trend (Table 2). The quantity of material in motion is high at st A (377.16 m^3) and st F (380.07 m^3) and low at st D (195.61 m^3). From sts A to D the drift value shows a continuous decrease whereas from sts E to F and further on these values show alternate increase and decrease. During the fair weather season (Oct.-March) the trend remained more or less the same but with lesser magnitude.

The total drift during both seasons is higher north of Fort Cochin than on the south. The observed rate of sediment transport on the mainland beaches along the

west coast of India which are subjected to wave conditions similar to those along the stretch of coast under study is $1.5\text{-}2 \text{ m}^3 \cdot \text{d}^{-1}$ (ref. 13). The computed values in Table 2 (column 1) closely correspond to these values.

The navigational channel of the Cochin harbour consists of 6 km long outer channel and 2 inner channels (inside the backwater system). The approach channel was constructed by cutting the offshore sand bar at a distance of 1.6 km west of the coast. Silting is a severe problem in the harbour's outer channel and nearly $2 \times 10^6 \text{ m}^3$ of the material is dredged every year. Of this quantity about 70% is from the approach channel¹⁴. Present study shows that littoral drift during rough weather season north of Cochin harbour entrance channel is southerly while it is northerly south of the channel. These opposing sediment drifts are likely to be carried into the channel and may, thus, be responsible for the high amount of deposition taking place in the outer channel. The calculated drift is about $0.3 \times 10^6 \text{ m}^3$ during rough weather season and $0.33 \times 10^6 \text{ m}^3$ during fair weather season. The remainder probably reaches the channel either from the offshore or the backwater system by the relatively strong flows associated with the flood and ebb currents. These flows act in a way similar to that of a dynamic barrier preventing any possible by-passing of sediments from one side to the other.

The above computed drift values are to be viewed in

Table 1—Alongshore Component of Wave Energy E ($\text{kg}\cdot\text{m}\cdot\text{m}^{-1}$) of Wave per Day

St	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A	2479.68	8475.84	20545.90	5063.04	9694.08	5011.20	6799.68	12553.92	6013.44	768.96	16692.48
B	2116.80	8484.48	21997.44	5028.48	5944.32	4484.16	6013.44	2401.92	5901.12	17.28	11370.24
C	2090.88	10532.16	19198.08	2860.64	4717.44	2816.64	3533.76	1321.92	5520.96	-267.84	10860.48
D	777.60	5702.40	17288.64	4354.56	3611.52	2064.96	2496.96	1105.92	5676.48	-1356.48	8553.60
E	1572.48	7620.48	19742.40	2384.64	4510.08	1909.44	2471.04	1581.12	4268.16	-864.07	9028.80
F	2903.04	10100.16	19224.00	7205.76	9218.88	7810.56	9426.24	7266.24	7577.28	2669.76	10860.48
G	2885.76	10307.52	26040.96	5235.84	6549.12	5149.44	6713.28	4207.68	5762.88	466.56	11275.20
H	1961.28	8441.28	20252.16	2773.44	4060.80	1235.52	1736.64	2574.72	6030.72	-1753.92	11370.24
I	717.12	3144.96	3758.40	3611.52	-1304.64	-3127.68	-1218.24	-2998.08	-1200.96	-2427.84	8873.28
J	924.48	2522.88	10454.47	-1252.80	-673.92	527.04	-751.68	-1399.68	3274.56	-1598.40	9460.80
K	665.28	3283.20	11335.68	-2289.60	-1546.56	-1235.52	-2177.28	-1183.68	-164.16	-2090.88	7551.36
L	1848.96	5495.04	14627.52	2548.80	9564.48	2980.80	3957.12	2712.96	4276.80	-259.20	9607.68
M	1589.76	6419.52	15621.12	2626.56	5106.24	2462.40	3525.12	2522.88	4034.88	-665.28	9892.80
N	1658.88	6039.36	16104.96	2237.76	2462.40	967.68	2782.08	1105.92	4026.24	-2039.04	1034.08
O	1641.60	6480.00	17418.24	846.72	2246.40	466.56	2021.76	656.64	4760.64	-1779.84	9469.44
P	1356.48	5711.04	13582.08	267.84	423.36	-397.44	293.76	3620.16	2583.36	-4173.12	8873.28
Q	1416.96	4743.36	16588.80	1391.04	2410.56	699.84	2116.80	751.68	5883.84	-1477.44	8069.76
R	1460.16	5097.60	12173.76	803.52	1969.92	259.20	1736.64	155.52	4717.44	-388.80	8069.76
S	1883.52	6143.04	18316.80	1140.48	3283.20	2047.68	3585.60	1598.40	5590.08	-86.40	10152.00

- = northerly; + = southerly

Table 2—Littoral Drift along the Stretch of Beach from Munambam to Anthakaranazhi

[Littoral drift expressed in m^3 per season]

Sts	Littoral drift*	
	April-Sept. (Rough weather)	Oct.-March (Fair weather)
A	377.16	217.63
B	289.99	176.40
C	217.56	181.59
D	195.61	122.33
E	206.11	136.81
F	380.07	215.72
G	340.76	194.15
H	206.44	164.66
I	-8.12	57.62
J	43.58	92.37
K	18.35	58.44
L	230.03	132.44
M	201.52	134.35
N	162.20	126.70
O	149.42	129.98
P	112.39	90.66
Q	151.39	117.69
R	108.13	119.88
S	189.40	149.64

*Total drift (m^3) forsts A to H: April to Sept. = 5.8147×10^6 and Oct. to March = 3.6987×10^6 .sts I to S: April to Sept. = 3.7057×10^6 and Oct. to March = 3.3005×10^6 .

the light of availability of sandy sediments in the surf zone and the adjacent beach sector. Considering the mass balance, a total of about $9.5 \times 10^6 \text{ m}^3$ during rough weather season and $7 \times 10^6 \text{ m}^3$ during fair weather season moving south should be compensated by equal amounts from the north. As sandy sediments in the shore regions are limited to only 3-4 m depth contour and the beaches being low, it is improbable that this quantum of sediment is actually under transit. Moreover, the backwater system extending over the length of the study area traps the otherwise available sand size sediments carried by way of land runoff and, hence, deplete the barrier beach. The computed values reflect only the potential of available energy for sediment drift. In the absence of such large quantities of sediment supply from the north, the littoral flows associated with the wave activity are likely to be undersaturated and give rise to erosion of existing material in the shore zone. The reported failure of the shore structures constructed along this stretch of the coast may partly be due to this imbalance in the sand budget.

Detailed examination of the bathymetric charts shows a progression of shoreline north of Cochin with flat inshore bottom contours and recession of shoreline south of Cochin with steep and close bathymetric contours. This feature indicates depositional nature of the stretch of the beach north of Cochin harbour entrance channel. This progression of the shore corresponds roughly to stations from G to H (Fig. 1). The net southerly drift estimated in the present study indicates that the growth of shoreline near Vypin

takes place at the expense of the sediments eroded from those reaches situated north of st G. The material drifting towards south from st H is blocked at the Harbour entrance and gets either deposited or transported to other reaches depending on the flow conditions. In the region south of Cochin the absence of mass balance could be inferred from this study for the simple reason that $7 \times 10^6 \text{ m}^3$ of sediment is not available for transport towards south. Since there is no supply of sediment to this stretch from the north, the existing material is eroded from this stretch. The eroded material might be getting deposited further south of the area of the present study.

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