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Stability of the coastline from Manakkodam to Thottappally along the Kerala coast

P. Udaya Varma and V. V. R. Varadachari, F.A.Sc.

National Institute of Oceanography, Dona Paula 403004, *Goa*

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Abstract

Wave refraction studies were undertaken to assess the stability of the coastline from Manakkodam to Thottappally, along the Kerala coast. Refraction diagrams were constructed for waves of different periods and directions of approach and the cumulative effect of the sediment transport was assessed for the particular region under study. The study reveals that the coastline north of Alleppey is on the whole a stable one. The stability of the beaches on the southern side from Alleppey Pier to Thottappally spillway, is more dependent on the changes in offshore relief.

1. Introduction

For any real or hypothetical shoreline, the general configuration of a stable equilibrium beach can be roughly estimated. Beach and offshore zones are altered by wave action and the alterations induce changes in wave conditions in shallow waters. These interrelated factors gradually adjust towards an equilibrium. The interrelationship of longshore transport and the wave characteristics, was studied empirically and analytically by numerous workers (Krumbein,[1] Saville,[2] Eaton,[3] Caldwell,[4]. Bajournes,[5] etc.). The importance of wave refraction studies in the coastal geological setting has been shown by Munk and Traylor.[6] Also Davis,[7] Jennings[8] and Silvester[9,10] have established that predominant swell rather than wind waves, is the major dynamic factor that usually controls the long term pattern of littorals and transport.

2. Methods of Analysis

An attempt has been made to study shoreline changes from Manakkodam to Thottappally through wave refraction diagrams. Waves approaching a coast get refracted as soon as the waves begin to feel the bottom. It results from the change in velocity of the wave crest, which depends on the water depth. The part of the wave in deeper water moves more rapidly than the part in shallower water, causing a bending of the wave front which is known as wave refraction. Due to this refraction there will be convergences and divergences of wave energy at different places along the coastline. At places where convergence takes place, energy will be partly dissipated and utilised in churning up the beach material and keeping it in suspension. This material will be carried alongshore and offshore by littoral currents. This offshore transport of material gives rise to changes in bathymetry in the near shore regions which may in turn affect the pattern of wave refraction.

The zones of convergence and divergence will not remain the same for the different directions and periods of wave approach. Hence in order to assess the stability of a particular coastline wave refraction studies have to be made for all possible periods and directions of approach of waves. With this in view, refraction diagrams have been constructed for this region for waves having periods 4, 6, 8, 10 and 12 sec. approaching the coast from 200°, 220°, 240°, 260°, 280° and 300°.

These directions and periods were chosen because from an analysis of the Indian Daily Weather Reports published by the India Meteorological Department, it was found that these directions and periods cover the major part of the wave climate including that during the S–W monsoon season in the Arabian Sea, which may affect the Kerala coast. For the construction of refraction diagrams the graphical method of Arthur, Munk and Issacs,[11] was used. The bottom topography was obtained from the admiralty chart no. 750. The accuracy of the bottom topography was checked using the recent bathymetric data available (Indian J. Fish., 1962) and the cruise data of INS "KRISHNA". The refraction parameters such as the refraction function $K(f, \theta)$ and the direction function $\alpha(f, \theta)$ were calculated for each of the arbitrarily chosen regions A to U (figure 1) of the coast under study. Each region covers about 2 mile stretch of the beach. An analysis of the refraction parameters was made to arrive at a theoretical estimation of the mechanism of sediment transport along the coast. By correlating the two refraction parameters the areas of accretion and erosion along the coast studied, have been assessed. A decreasing trend between two stations, in the values of both the refraction parameters shows that it is a possible region of accretion and an increasing trend shows that it is a region of possible erosion. Uniform values show that it is a region of uniform transport. The stability or instability of a particular section of the shoreline will depend on the net effect of all the swell waves affecting the area. The effect along the different regions of the coast under

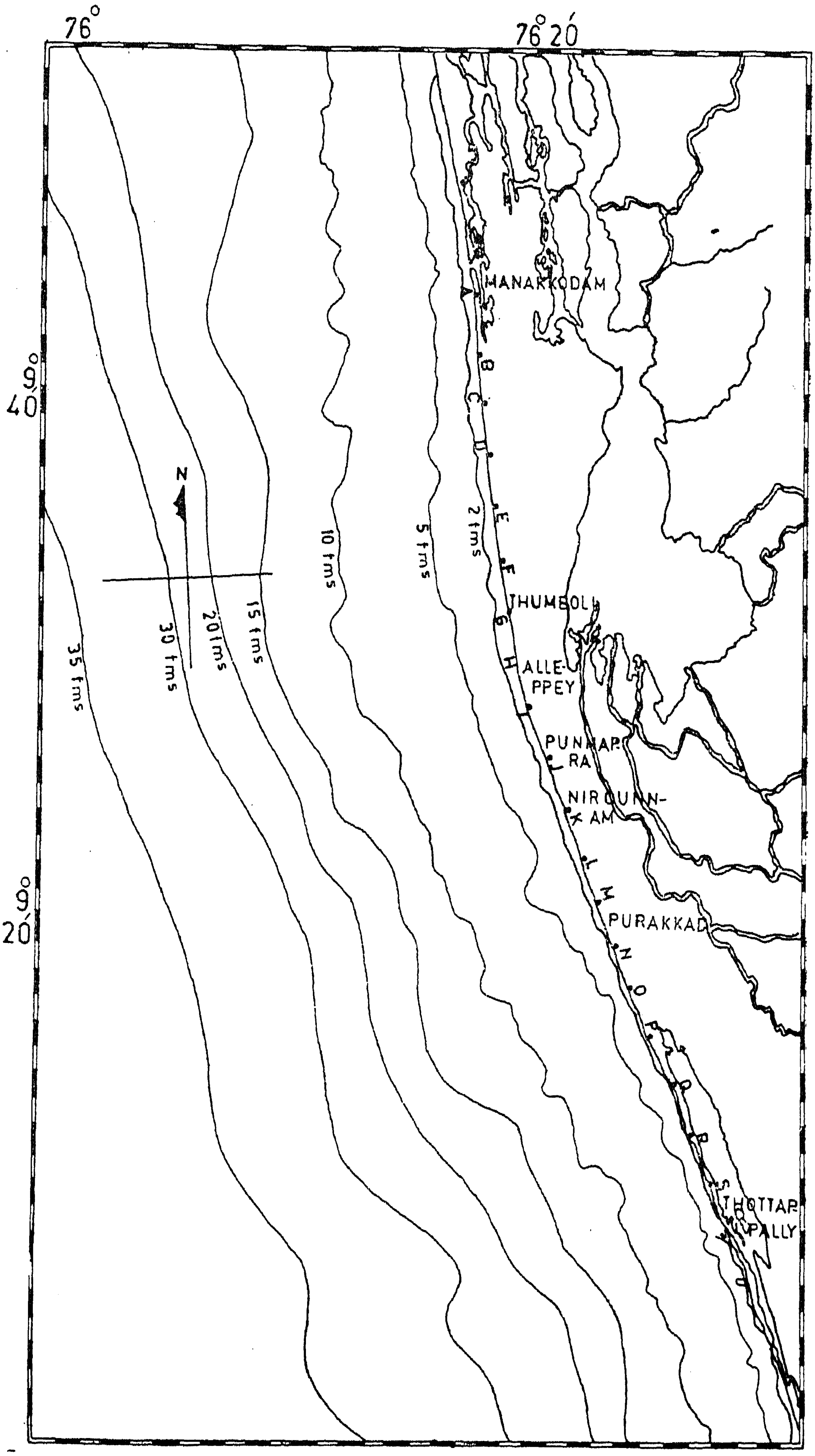

Figure 1. Coastline between Manakkodam and Thottappally showing locations of stations A to U where refraction parameters were evaluated.

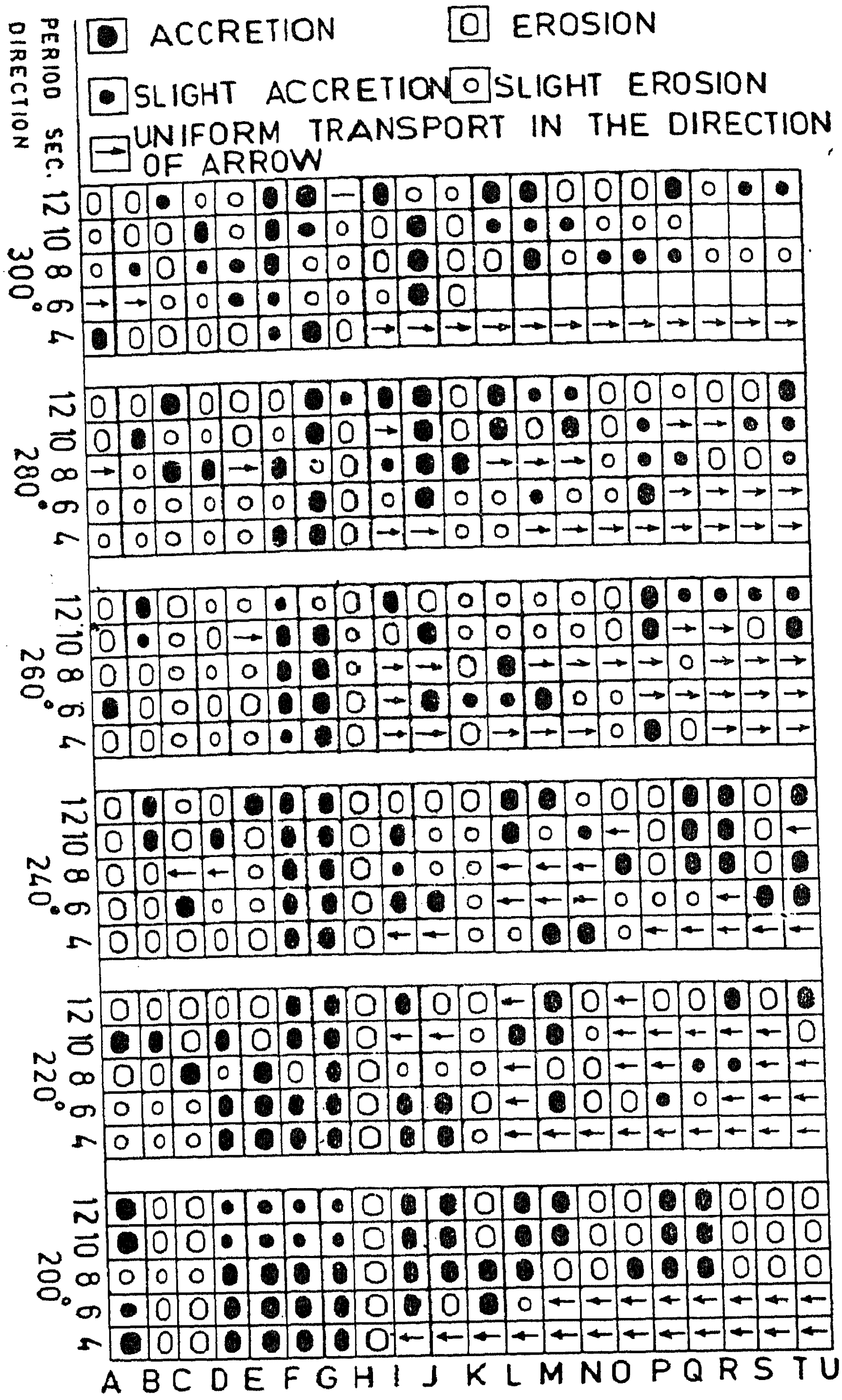

Figure 2. Erosion and accretion patterns at stations A to U between Manakkodam and Thottappally for waves of different periods approaching the region from different directions.

study, due to waves of different periods approaching from different directions has been shown in figure 2. The salient features such as loss or gain of material that could be inferred from this study are discussed below.

3. Results

For waves approaching from 200°, accretion or slight accretion of material takes place in the region between A and B, except for 8 sec waves which cause slight erosion in this region. Similarly accretion or slight accretion takes place also in the region between D and H. Between I and M, the general trend is towards accretion or uniform transport of material, except for some erosion between J and K due to waves of 6 sec and between K and L due to waves of 12 sec and 10 sec. In the region between M and U, 4 and 6 second period waves cause uniform transport towards north. Between P and R, the high period waves (8, 10 and 12 sec) cause accretion.

Waves of all periods under study, approaching from this direction cause either severe or slight erosion in the region between B and D and H and I. Waves of 8 sec period cause erosion between N and P. Severe erosion is to be expected also in the region between R and U for waves of periods 8, 10 and 12 sec.

Accretion of material is to be expected in the regions D–H and I–K for waves of almost all periods approaching from 220°, although high period waves are found to produce erosion in certain parts of these regions. In the region between stations L and N, either accretion or uniform transport of material takes place. Towards south, beyond station O, low period waves cause uniform transport of material and high period waves (12 sec) cause accretion in the regions R–S and T–U.

The region between A and D is a zone of erosion for this angle of approach of waves except in the case of 10 sec and 8 sec period waves which cause accretion in the region A–C. Waves of all periods cause erosion in the region H–I and K–L. High period waves cause erosion and low period waves produce mostly uniform transport towards the north in the regions N–R and S–T.

Accretion is the pronounced trend in the regions F–H, L–Q, Q–S and T–U for waves approaching the coast from 240°. Beyond P, towards the south, 4 sec period waves produce uniform transport of material towards the north. Slight or severe erosion of material is to be expected in the regions A–B, H–I and K–L for waves of all periods. In the region C–D, J–K, P–Q and S–T, erosion is caused by high period waves and uniform transport or accretion by low period waves. In general for this direction of wave approach, erosion predominates accretion except in the regions F–H, L–O, Q–S and T–U.

In the case of waves approaching from 260°, accretion of material takes place between F and H for waves of all periods. Between P and Q either accretion or uniform transport is noticed. Between Q and U, 12 sec period waves cause slight accretion while waves of other periods mostly produce uniform transport of material except in the regions between Q and R and S and T where erosion is caused by waves of periods 4 sec, 8 sec and 10 sec. In the region between I and K accretion or uniform transport predominates erosion. In all the other regions, erosion predominates accretion or uniform transport. The direction of uniform transport is mostly towards the South for waves approaching from 260°. Accretion is very much less compared to erosion for waves approaching from 280° and 300° except in the regions between F and H and J and K where there is more accretion than erosion. For waves from 280°, the regions C–D, I–J, L–O and T–U in general, experience accretion for high period waves and slight erosion or uniform transport for low period waves. For waves from 300°, in the region L–N high period waves cause accretion and low period waves cause either slight erosion or uniform transport. The direction of transport of material for both these directions of wave approach is towards south.

In general, for all the directions of wave approach, the regions, F–H and I–K would be subject to accretion of material, whereas in the regions A–D, H–I and K–L, the net effect would be depletion of material. Beyond L, towards the south, higher period waves cause erosion or accretion depending on the direction of wave approach as discussed in the foregoing paragraphs, and low period waves maintain a uniform transport of material. The direction of transport is also dependent on the direction of wave approach, it being towards the north for waves approaching from directions ranging between 200° and 240° and towards the south for directions lying between 260° and 300°.

4. Conclusions

The coast north of Alleppey up to Manakkodam can be considered on the whole, a stable coast, accretion and erosion taking place every year at the same rate. Each zone is in dynamic equilibrium with the material brought from north or south, depending on the nature of the littoral transport. But the region of the coast between the stations F and H can be considered as a nodal zone where the accretion will be slightly more than the erosion and the net result will be widening of the beaches in the region. Thus the Thumboli beach in the region H–G has widened by about 20 meters during the period 1964–69.

The stability of the beaches on the southern side of Alleppey Pier up to Thottappally spillway, is more dependent on the changes in offshore relief. For all the directions of wave approach the Nircunnam beach located in the region between stations I and K is a seminodal zone and accretion of material predominates erosion in this region. While other regions are temporarily stable, this region has remained stable for many years. Punnappra beach near station J had widened to 210 metres in 1965 and subsequently shrunk to 80 meteres in 1969 (figure 3) while Purakkad beach shrunk from 75 metres in 1964 to 50 metres in 1968 and to zero metres during the monsoon period of 1969.

The wave refraction pattern explains clearly the widening of the Nircunnam beach, which is located in the region between I and K. Since the stability of the beaches along this coast is more dependent on the change in the offshore relief caused by mud banks, the presence of mud banks off Nircunnam is also one of the factors responsible for this stability. Thus even though the beaches of Punnappra and Purakkad have been eroded since the study has been started, Nircunnam beach in between the two, has widened considerably. This shows that the sediment brought from north and south will be deposited in this region.

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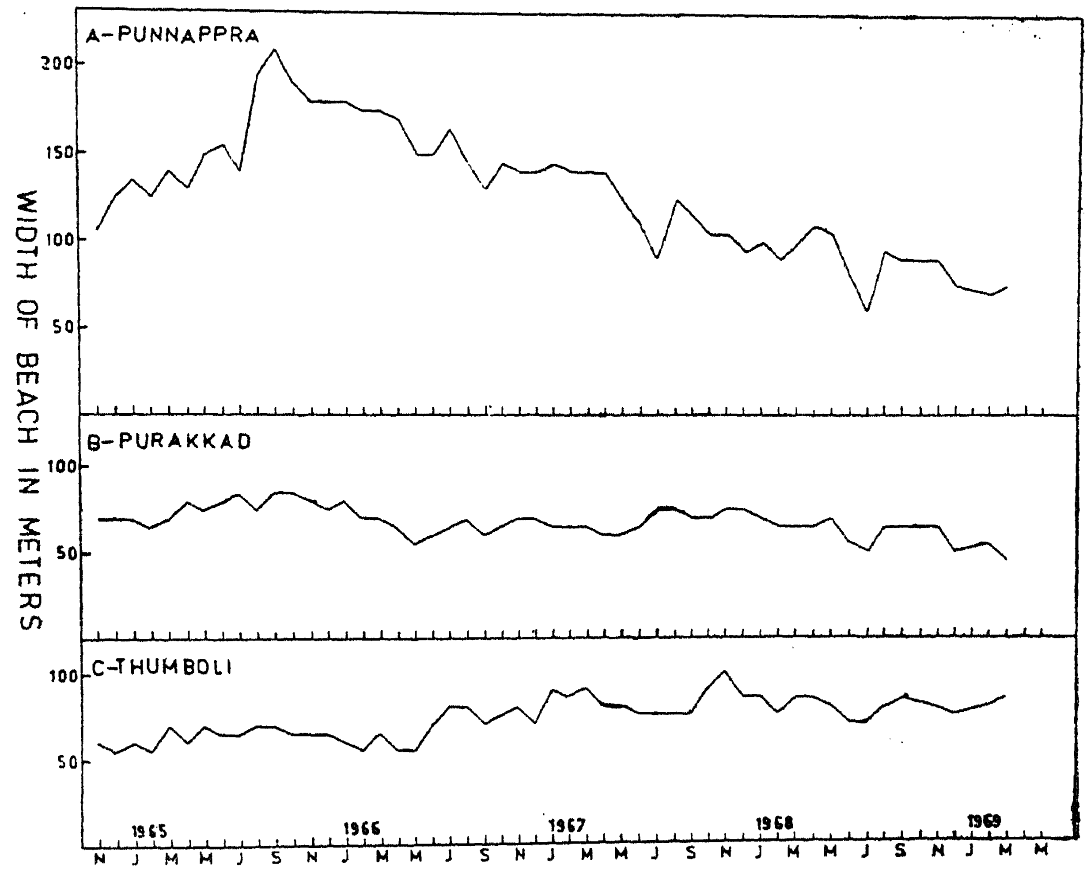

Figure 3. Monthly changes in beach width at A—Punnappra, B—Purakkad and C—Thumboli situated in the region of study.

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