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A study of the monsoonal beach processes around Alleppey, Kerala

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Abstract. The responses of a sandy beach to the southwest monsoonal waves are studied based on biweekly observations. The onslaught of the first spell of monsoonal breakers causes maximum erosion in the sub-aerial section of the beach. However, further spells of high breakers do not affect this zone significantly. The erosion in the sub-aerial zone is followed by accretion in the nearshore zone and vice versa. Whereas the sub-aerial zone has a net erosion the total section of the beach including the nearshore zone shows near equilibrium condition. It is concluded that in spite of erosion or accretion of the sub-aerial zone, equilibrium conditions may be found in the total section of the beach.

Keywords. Beach processes; beach erosion; equilibrium beach.

1. Introduction

Studies on beach dynamics assume great importance for a coastline such as that of Kerala, which is of recent geological origin and is constantly threatened by severe erosion. Some literature on the beach processes for a few selected zones of this coastline are available (Moni 1973; Murthy 1977; Murthy and Varadachari 1980; Prasannakumar *et al* 1984, etc.) The present investigation aims at a detailed study of the beach processes in relation to the nearshore processes at Alleppey, which is a coastline about which little information is available in the literature. The study has been carried out during the most dynamic period of the year, viz, the southwest monsoon. Most of the studies on beaches are guided by the conventional definition of beach (CERC 1977) and considers only that portion of the profile which lies above the low water level. The present study has been extended to the nearshore zone, which, according to Komar (1976), is a part of the beach. The inclusion of the nearshore zone in the study is expected to give a more realistic picture of the beach processes and the sedimentation pattern.

2. Location

For the purpose of the study, a small stretch of coastline of 700 m length is selected at Alleppey (figure 1). The area of study is chosen so as to facilitate nearshore observations and measurements from the pier, which projects well into the sea. The coastline is straight, extending in a direction of 350–170° north. The beach upto a distance of about 80 m from the MLW line consists mostly of fine sand and the rest of the nearshore zone is composed of mud. The tide here is semidiurnal with a maximum range of 1 m.

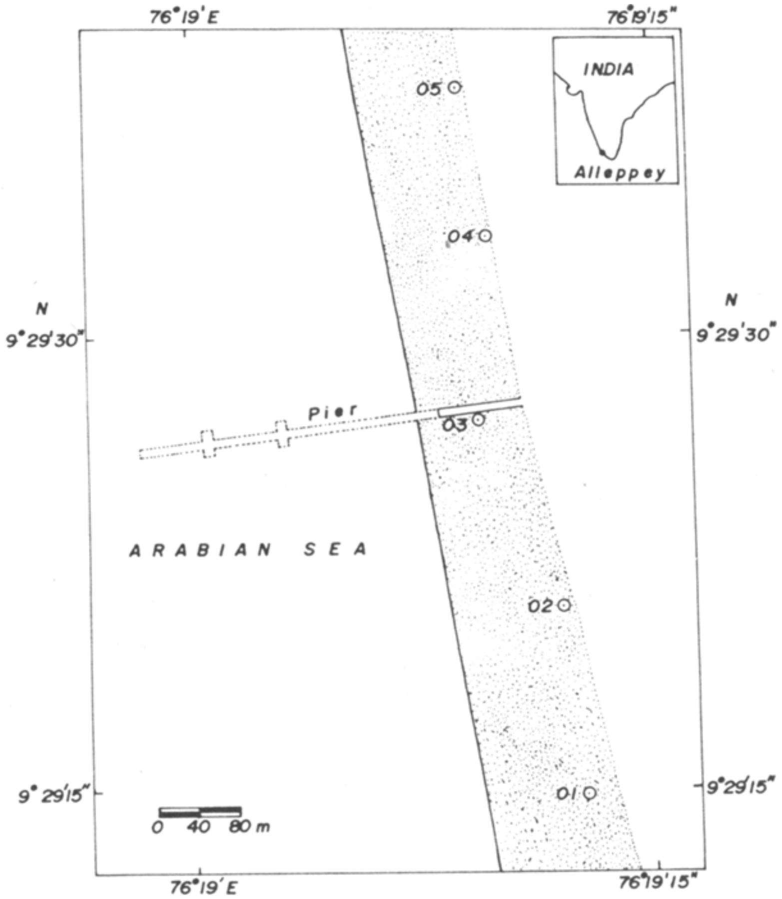

Figure 1. Location map and the area of study.

3. Methodology

The breaker parameters like period, direction and height were determined from the pier following the procedures adopted by Baba *et al* (1983) and Kurian *et al* (1984). Direction and speed of longshore currents were measured by following the trajectories of neutrally buoyant floats deployed in the surf zone. Beach profile measurements were carried out along five selected transects (figure 1) out of which the profile off Station 03 extends into the nearshore zone. The beach profile data have been used to quantify the erosion/accretion at each station and to study the onshore-offshore exchange of material.

4. Results

4.1 *Breaker characteristics*

The characteristics of the breaking waves vary considerably during this period (figure 2). From low initial values around 1·25 m the breaker heights reach high values like

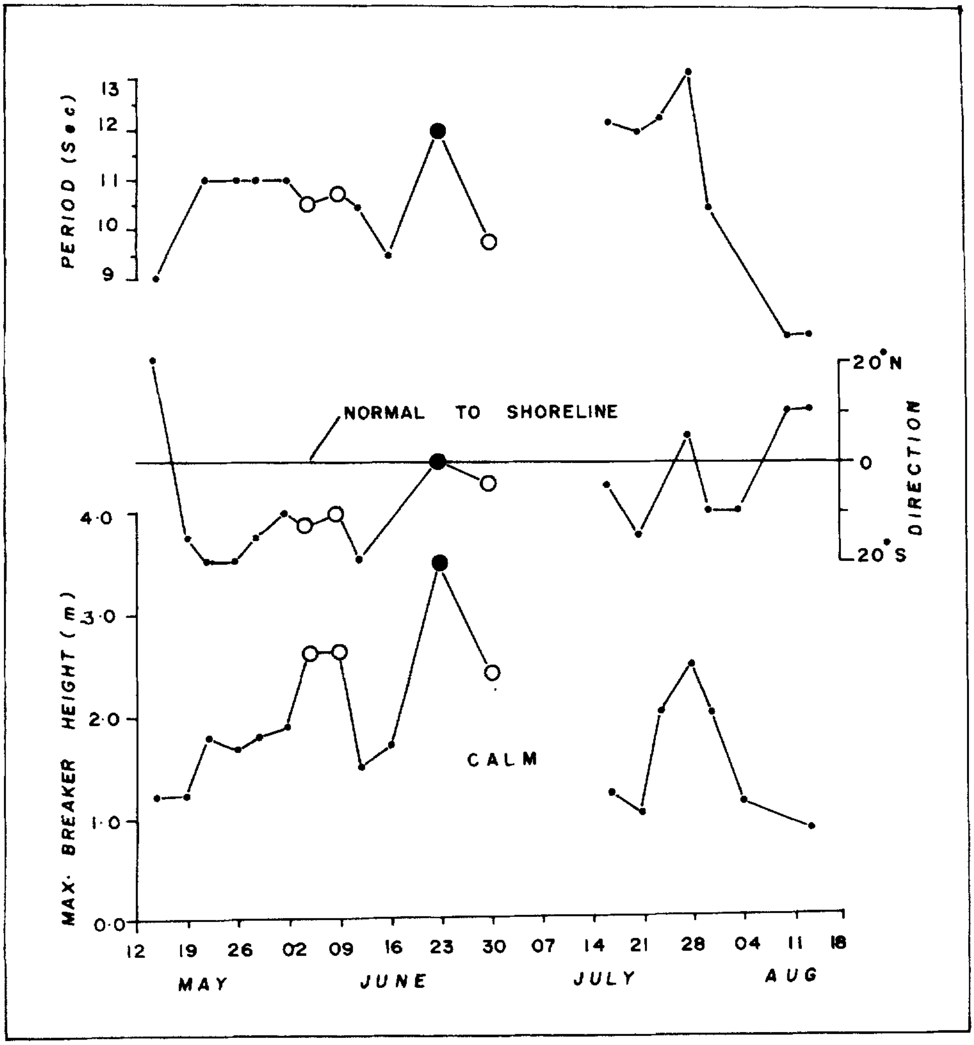

Figure 2. Variation of breaker parameters during the monsoon (•-plunging, O-spilling and plunging, ●-spilling).

2·6 m in the first half of June and after a spell of low values they reach a peak value of 3·5 m in the latter half of June. The distance of the breakers varies between 25 and 55 m from the MLW line. Very calm sea conditions prevail in the first fortnight of July whereas, from visual observations, it is seen that the adjacent nearshore zones have moderate wave conditions. A moderate peak is observed by the end of July. The breaker period is predominant in the range of 10–13 sec. For higher breakers high period values are noted, and vice versa, indicating a direct relationship between these two parameters. However, the relationship is not exactly linear and consequently, the breakers are steepest in June and most gentle in July. The directions of approach of the breakers vary between 20°N and 20°S with respect to the shoreline. The highest breakers are found to be more or less parallel to the shoreline and are of the spilling type.

4.2 *Longshore currents*

The longshore currents vary from day to day as well as from station to station (figure 3). Due to different sets of wave trains from different directions non-persistent current directions are also observed occasionally. In May, the currents are generally sluggish and northerly in direction. However, by June the currents are mostly southerly and relatively strong. During July–August again sluggish currents are mostly observed. Southerly currents are dominant in the study area, both in magnitude and direction, especially on the southern side.

4.3 *Beach profile*

4.3a *Subaerial zone:* Since the pattern of variation in the profile is nearly the same for all stations, only the profile for station 03 (figure 4), which includes the nearshore also, is presented. However, the quantum of erosion/accretion at all stations have been computed and presented. Whereas the backshore of stations 1, 2, 4 and 5 are considerably wide extending upto 100 m, it is restricted to a maximum of 40 m for station 3 due to the base of the pier.

The beach at the start has a fair weather profile with two berms in the beginning of the season. With further advance of the season the recession of the second berm commences and scarps are formed in the foreshore. In the first quarter of June, drastic changes occur in the configuration. This zone undergoes extensive erosion resulting in considerable reduction in its width. However, by the middle of June the process is reversed and deposition is noticed. Again the process is reversed by the end of June and this zone undergoes some erosion till the beginning of July. Accretionary processes set in thereafter and by the third quarter of July this zone is considerably wide with the build-up of new berm. Erosional and accretional processes are alternatively observed in the succeeding weeks till the end of the study period.

From figure 5 it can be seen that all the stations follow more or less the same pattern of erosional or accretional tendency. However, the quantum of erosion/accretion varies from station to station. The two southernmost stations i.e., stations 01 and 02 suffer the maximum loss of about 50 m^3/m during this period. Station 04 is the least affected most of the time in this period and this station alone has a net accretion in the second fortnight of July, though for a brief period.

4.3b *Nearshore profile:* The nearshore profile is smooth in the beginning of the season (figure 4). However, as the season advances further, a break-point bar forms which extends offshore with the intensity of the breakers. With further increase in the intensity of breakers in the first quarter of June, multiple bars are observed extending upto a distance of about 70 m from MLW line and a net deposition as high as 90 m^3/m (figure 5) is found in the nearshore. Erosion of the nearshore zone takes place thereafter and the profile reaches almost the premonsoon position by the third quarter of July. However this process is interrupted by the end of July. In August erosion of the nearshore zone once again takes place, though this process is stopped by the middle of August. Thus this zone has a net accretion of 31 m^3/m during monsoon season.

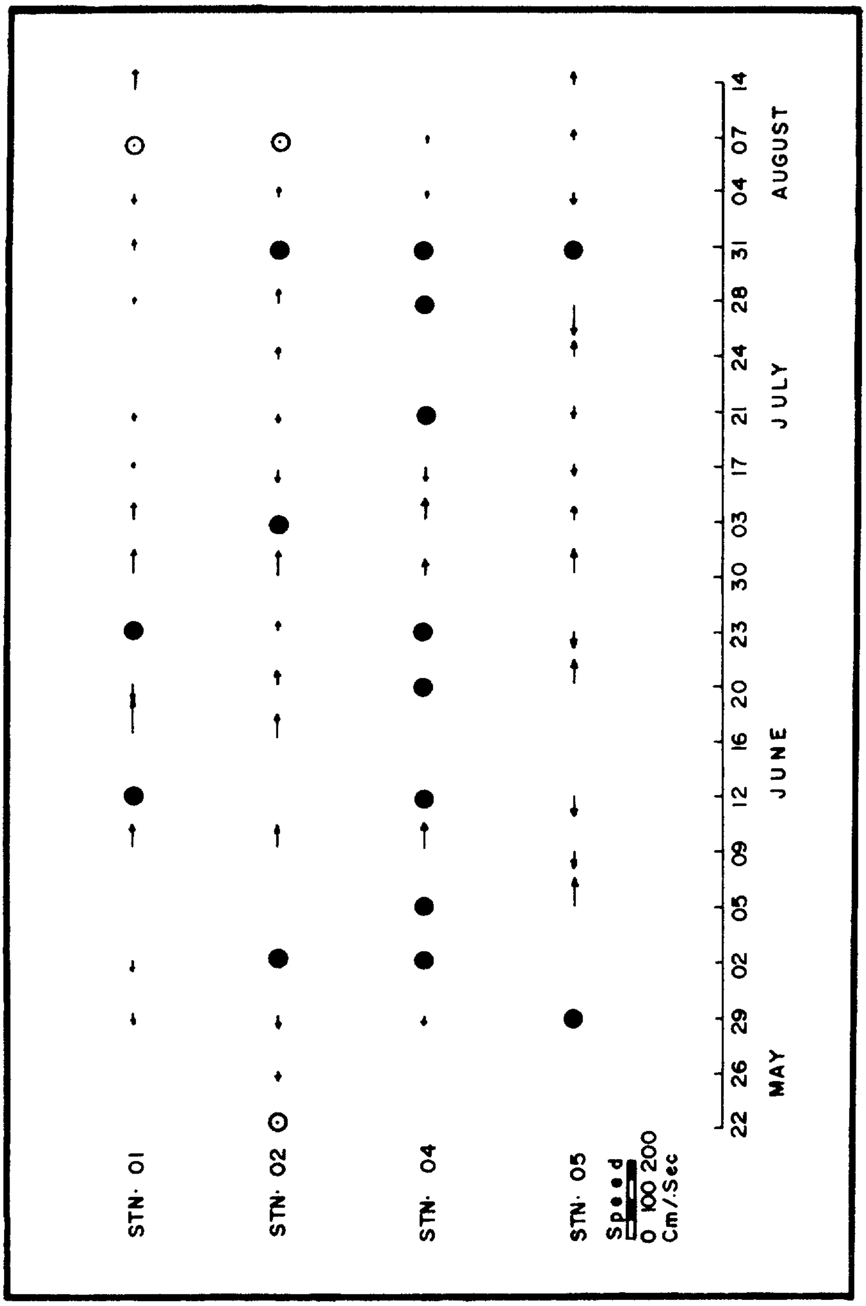

Figure 3. Longshore currents at the different stations (← upcoast (northerly); → downcoast (southerly); ● nonpersistent; ⊙sluggish).

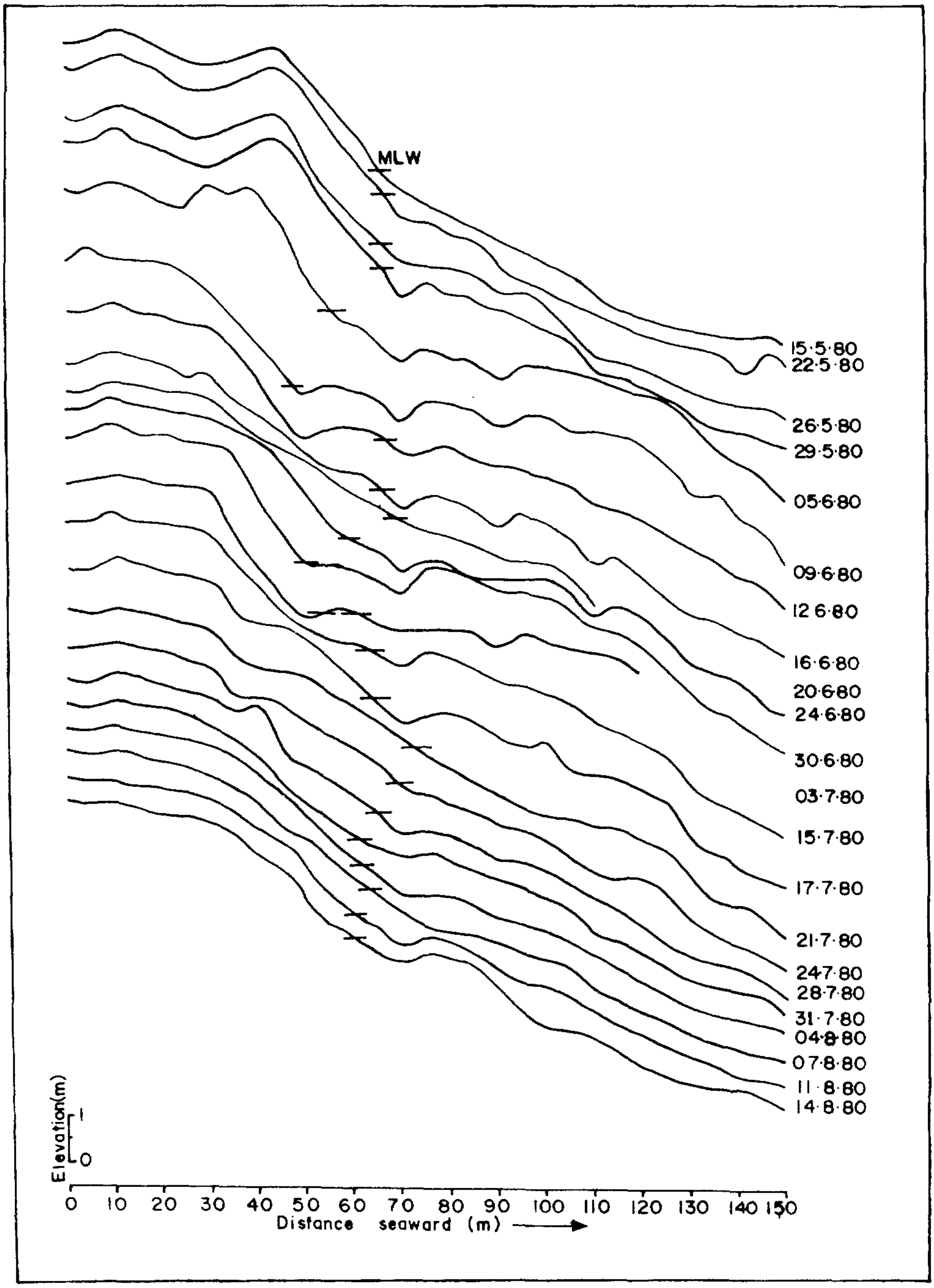

Figure 4. Beach profiles – station: 03.

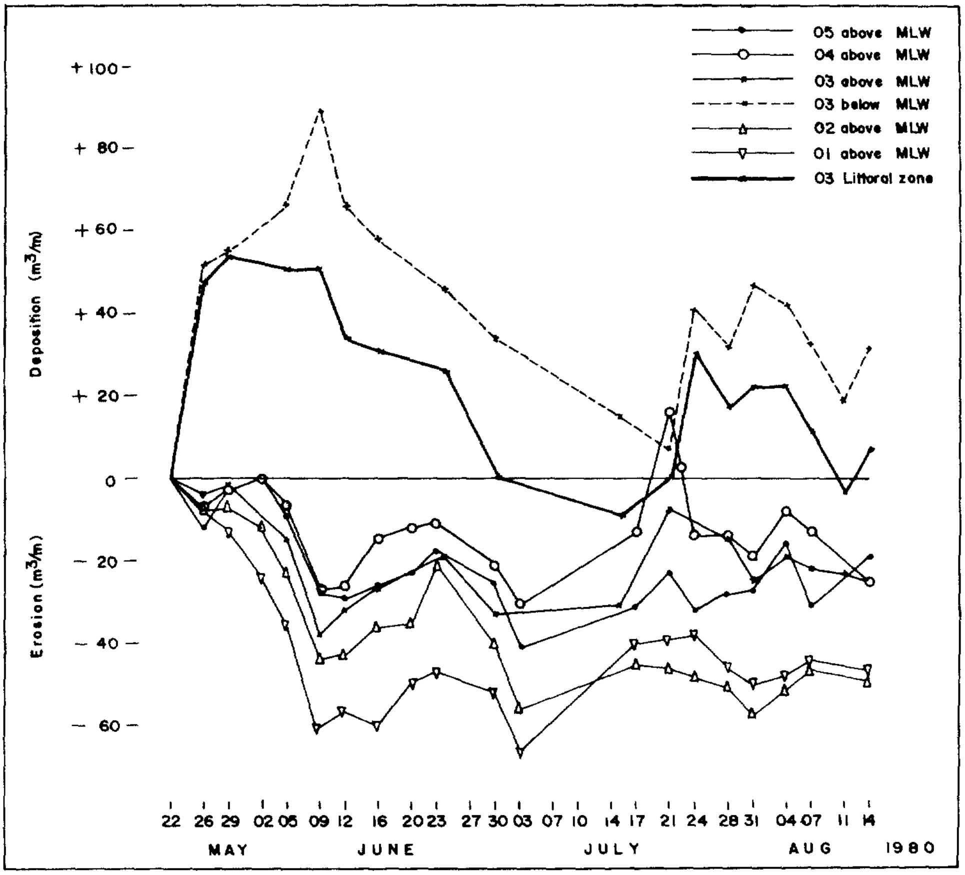

Figure 5. Cumulative erosion/accretion at the different stations.

5. Discussion

With the onset of monsoonal winds, the sea waves pick up and shortcrested steep waves result from the interference of sea waves generated by the local wind and swells generated and transmitted by the general monsoonal winds. The high breakers resulting from these have a disastrous effect on the beach face. The effect of the breakers may be more pronounced owing to the increased wind and wave set-up during this period. The erosion from the beach face is followed by deposition in the inner nearshore reaches and formation of longshore bars and troughs. The continuance of this process leads to a shallow nearshore zone, as is observed by the first quarter of June. As a result, the highest waves break further offshore, in the form of spilling breakers. The widening of the surf zone leads to filtering of the high energy waves far away from the beach. Though the steepest breakers of the season are observed in the last quarter of June, it leads only to a marginal onshore erosion. This filtering effect due to the wide surf zone and its sheltering effect on the onshore is reported by Murthy and Varadachari (1980) based on their studies of the Valiathura beach. The steep wave conditions during this period has a churning action (Komar 1976) on the substratum causing a high quantum of mud in suspension. It is possible that this mud suspension subsequently causes the occurrence of mud banks, which is a phenomena reported off this coast (Kurup 1977). The occurrence of mud banks in the inshore region of the study area is established from the calm conditions in the study area and the moderate wave conditions on either side and offshore of the study area. Erosion observed in the nearshore during this period may be due to the loss of material by way of mud suspension and alongshore transport. By the second week of July the mud bank starts disappearing and wave activity gets intensified. This leads to the onshore transport of material and subsequent accretion of the subaerial zone (figure 4). Once the nearshore profile is reshaped to the fair weather profile, any further intensification of sea conditions, as observed by the end of July, has more access to the subaerial zone resulting in onshore erosion and accretion in the nearshore zone.

A comparative study of the onshore-offshore and alongshore sediment transport could be made from figure 6. It is seen that erosion in the nearshore zone is followed by deposition in the subaerial zone and vice versa in most of the cases. Since the cases examined have more access to the straight line fit, which is indicative of complete onshore-offshore exchange, it could be concluded that the onshore-offshore transport dominates over alongshore transport during this season. That there are cases which depart widely from this straight line fit shows the occasional occurrence of alongshore transport of sediments. The periodic strengthening of the longshore current (figure 3) must be causing this alongshore transport.

The spatial and temporal variations in the quantum of erosion/accretion in the subaerial zone may be explained in relation to the longshore drift. Bowman and Dolan (1982) observed shadow zones due to the groin effect of a research pier. Even though the pier in the present study area is highly permeable as compared to the one examined by the above authors, the pier is found to be interrupting the sediment movement (Hameed *et al* 1984). Thus the higher quantum of erosion observed on the southern side could be due to the dominance of southerly longshore currents coupled with the groin effect of the pier. Due to the same reason, lesser loss of material could be expected on the northern side. But relatively more erosion has been observed at the northern most station (05) as compared to station 04. As no abnormal waves or currents are observed at this station, this erosion may be due to the end effect of the sea wall (CERC 1977), even though it is at a distance of 150 m north of station 05.

6. Conclusion

There is a net erosion in the beach (as per the conventional definition) during the monsoon season. If the nearshore portion alone is considered a net accretion is observed. But, if the beach on the whole is considered, there is more or less an equilibrium condition by the end of the monsoon period. Inspite of erosion or accretion of the subaerial zone, equilibrium conditions may be found in the total section of the beach (including the nearshore zone), as is indicated in the present study. Thus beach dynamics can be fully understood only from a study of the subaerial zone and the nearshore zone. The study underlines the necessity for a more inclusive definition of beach in the investigation of coastal processes as recommended by Komar (1976).

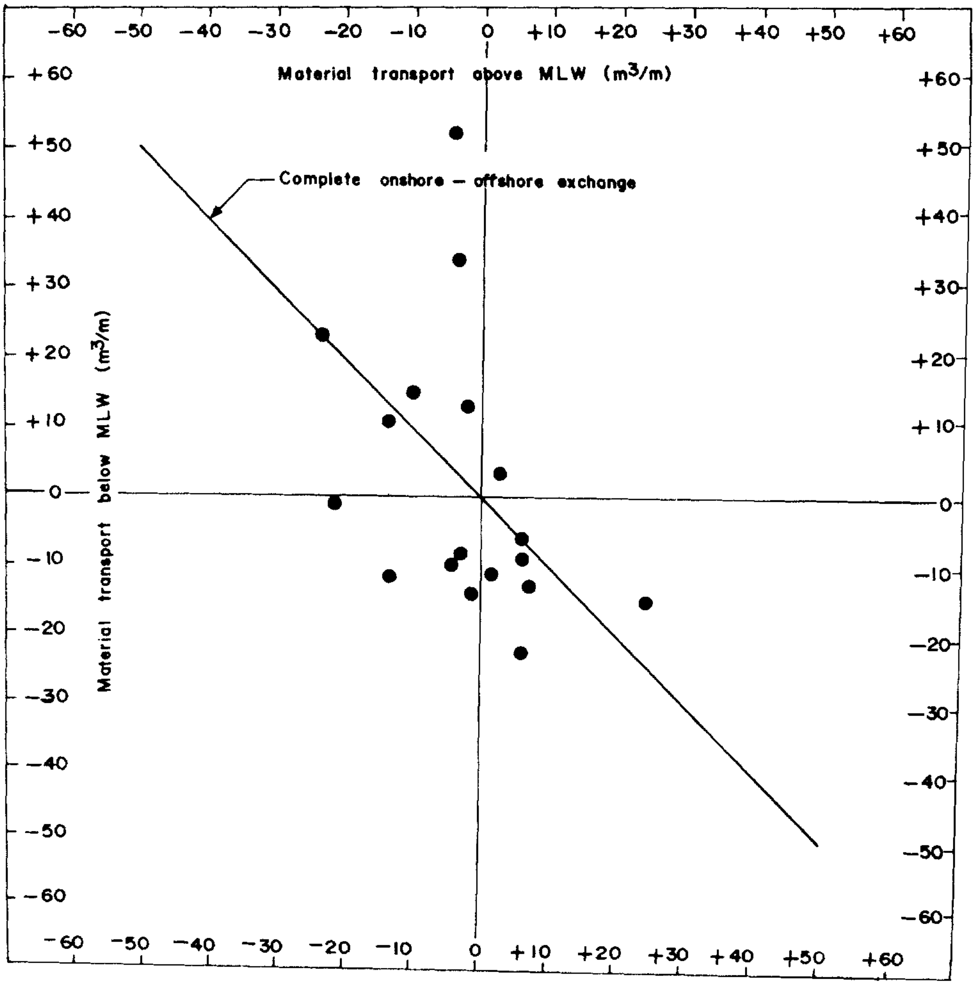

Figure 6. Scatter diagram of onshore-offshore changes.

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