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ECOLOGY AND PRODUCTION OF INTERTIDAL MACROFAUNA DURING MONSOON IN A SANDY BEACH AT CALANGUTE, GOA

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Abstract

Observations were made on a sandy beach at Calangute Goa, during the monsoon months of 1971. Prevailing unstable conditions caused dynamic changes in the beach ecology. The average spread of the intertidal region was 19 m with a gradient of 1 in 10. The sand was predominantly coarse and the diameter of particle size varied between 450 and 900 μ. Organic carbon in the sand ranged from 38 to 732 μg/gm. The temperature regime of the sea water and interstitial water was 23.9 to 25.9° C, whereas on the sand surface, values upto 32.5°C were observed. Salinity of the surface sea water varied from 22.05 to 34.56‰. The average biomass during the period was 11.86 g/m^2. Polychaetes, mainly, *Pisionidens indica* occurred at mid and low tide levels. Pelycypods *Donax incarnatus*, *Donax apperitus*, and mole crab *Emerita holthuisi* accompanied by amphipods and isopods were abundant in the wash zone.

Introduction

This study is a part of the project "Ecology of some sandy beaches along the Goa coast". Earlier studies on the beach ecology have been confined to some sandy beaches of the south-west coast of India, (Trevallion *et. al.*, 1970) Central West Coast (Dwivedi *et. al.*, 1972) and along the East Coast, studies were carried out by Ganapati and Rao (1959) and McIntyre (1968). This paper presents an account of the beach ecology during the monsoon months in relation to certain physico-chemical changes at an open sea sandy beach which is influenced by the outflow of estuarine waters of the Mandovi and the Zuari. Fig. 1 shows the location of Calangute beach and the position of the Mandovi and Zuari estuaries.

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Material and Methods

Fortnightly observations were made during the monsoon period (June to September 1971). From a fixed reference point, a transect was taken at right angles to the wash zone, and starting from the high tide level, stations, were fixed, 5 m apart. Beach expanse and profiles were observed and are shown in Fig. 2. At every station, samples for macrofauna were taken with a 0.1 m^2 metallic quadrant forced into the sand upto 15 cm. The enclosed sand was scooped and washed in a sieve of mesh size 0.5 mm (Birkett and Mc Intyre, 1971) and the animals retainee were preserved in formalin, their wet weight was taken as the biomass. Fig. d shows the changes in biomass at different tide levels. Methods adopted for th3

*Present Address: Department of Zoology, The New College, Madras—600014 collection of interstitial oxygen and salinity samples were similar to those as suggested by Pamatmat (1968). The oxygen analysis was carried out by the modified Winkler procedure and the salinity by the Mohr's method. However, difficulties in collecting

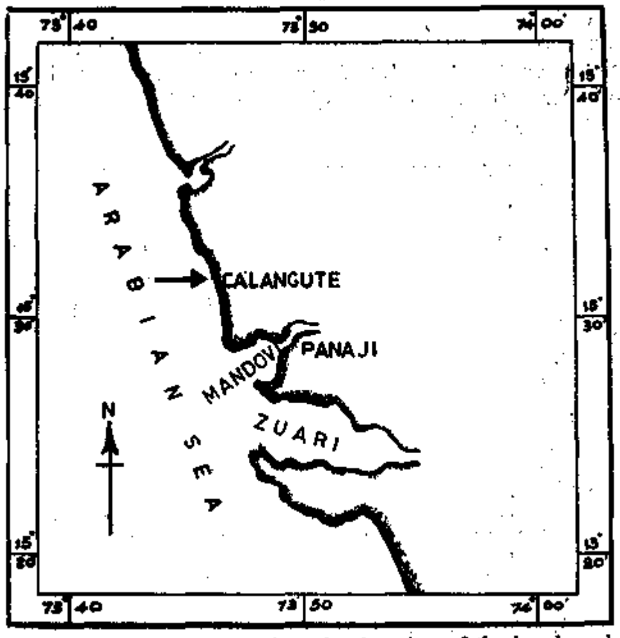

Fig. 1. Map of Goa showing the location of the beach and the position of the Mandovi and Zuari estuaries.

water samples at the high tide levels were solved by digging the sand upto a level of the water table, care being taken not to expose the water level to the atmospherer Sand samples were taken at each station upto a depth of 15 cm by a plastic core fo.

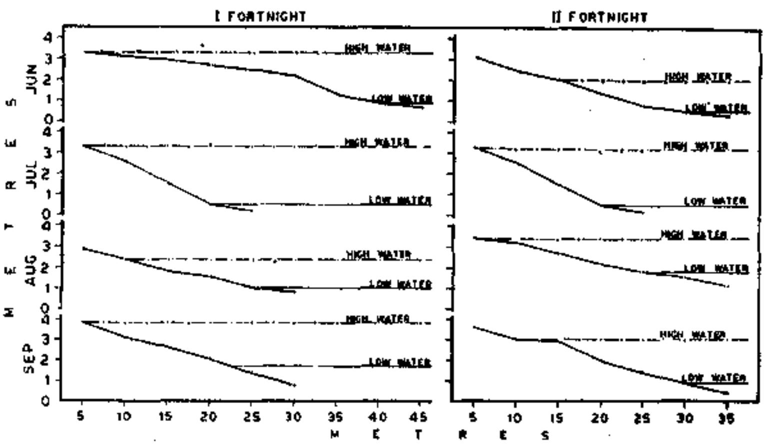

Fig. 2. Fortnightly beach profiles from June to September.

analysing organic carbon and sand grain size. Organic carbon in the beach sand was analysed by the method of El Wakeel and Riley (1957). Fig. 4 shows the fluctuations of organic carbon, in the sand at different tidal levels. Inman's (1952) classification was adopted for sand grain size analysis.

PHYSICAL AND CHEMICAL FEATURES

The expanse of the intertidal region varied considerably during monsoon. The exposure of the beach and intertidal expanse are given in Table 1. The mean spread of the intertidal region was 18.3$\pm$ 2.3 m and the CV was 36.2. This was determined after Mayr (1969).

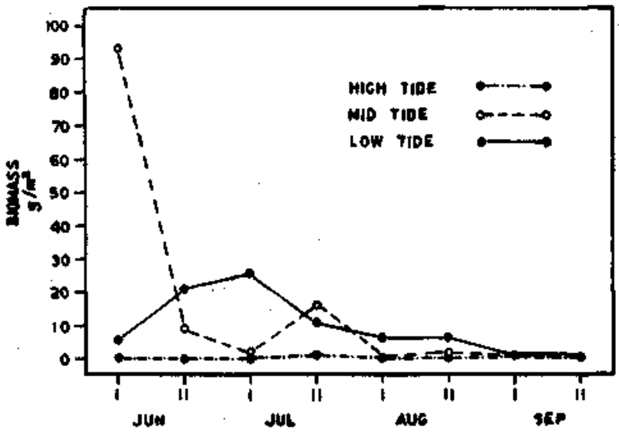

Fig. 3. Changes in the biomass (in g/m^2) at different tide levels.

The texture of sand and the interstitial space were found to affect the ecology (Trevallion *et. al.*, 1970; Dwivedi *et. al.*, 1972). Therefore the sand grain size was studied at low, mid and high tide levels and their cumulative curves were plotted (Fig. 5), the median diameters are shown in Table 2. Throughout the season at all the tidal levels, the sand was predominantly coarse. During July, at the low water mark the very coarse sand of the size range 610-900 μ was observed. Again in September, at the high tide mark very coarse sand in the range of 570-875 μ was found. Evidently during the monsoon months, two processes, erosion and accretion, bring about changes in the grain size at different tide levels and these could give rise to changes in the beach gradient and intertidal expanse.

TABLE 1. *Fortnightly changes in the spread of intertidal and total beach with gradients*

Fortnight		INTERTIDAL		TOTAL BEACH	
		Spread in m	Gradient	Spread in m	Gradient
June	I	35	1:11	40	1:14
	II	15	1:5.5	30	1:11
July	I	15	1:4	25	1:7.5
	II	15	1:4.5	20	1:7.5
August	I	15	1:7	20	1:11
	II	20	1:8	25	1:10
September	I	20	1:5	20	1:8
	II	15	2:5	20	1:10

TABLE 2. *Median diameter of sand grain size (in microns)*

Fortnight		Low water mark	Mid water mark	High water mark
June	I	620	600	500
	II	450	525	600
July	I	900	600	480
	II	610	600	500
August	I	750	780	550
	II	620	550	600
September	I	755	800	570
	II	625	775	875

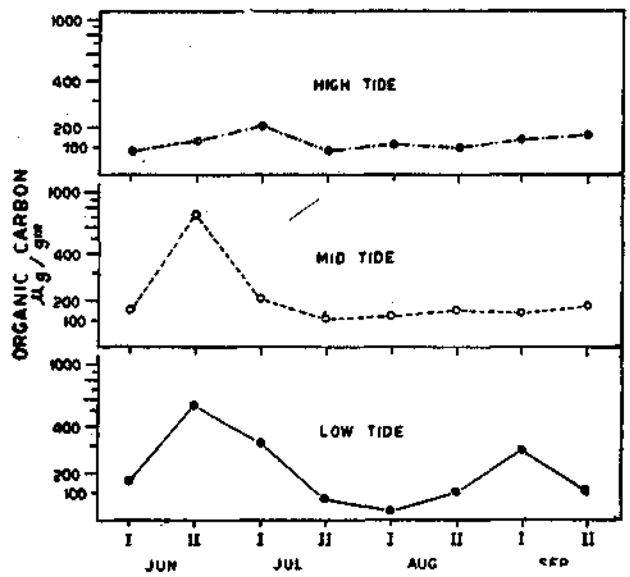

Fig. 4. Fluctuations of organic carbon in the sand at different tidal levels.

Temperature

The observed temperature of the substratum (1 cm below the surface) was as high as 32.5°C. The temperature of the surf and of interstitial water varied from 23.9°C to 25.9°C (Fig. 6). Though most of the observations were made at low tides in the morning, the tidal range and solar radiation including weather conditions *viz.*, humidity and rainfall had pronounced effects on the temperature observed. The general pattern observed was a slight increase in temperature from low tide to high tide mark; but variations were pronounced particularly when it was raining or the sky was overcast. Pollock and Hummon (1971) had also found similar effects.

Salinity

The beach is influenced by the outflow of fresh water from the adjoining Mandovi and Zuari estuaries. The salinity of the surface water varied between

22.05‰ and 34.56‰ (Fig. 6). The highest values were recorded during the first fortnight of June. Later, with the onset of heavy monsoon during the second fortnight of June, the salinity decreased to 22.5‰. The interstitial salinity also followed a similar pattern and it varied from 22.5 to 33.58‰. A gradual increase in the values was observed towards the end of September. It is thus seen that the rainfall had a pronounced influence on salinity for a short duration only.

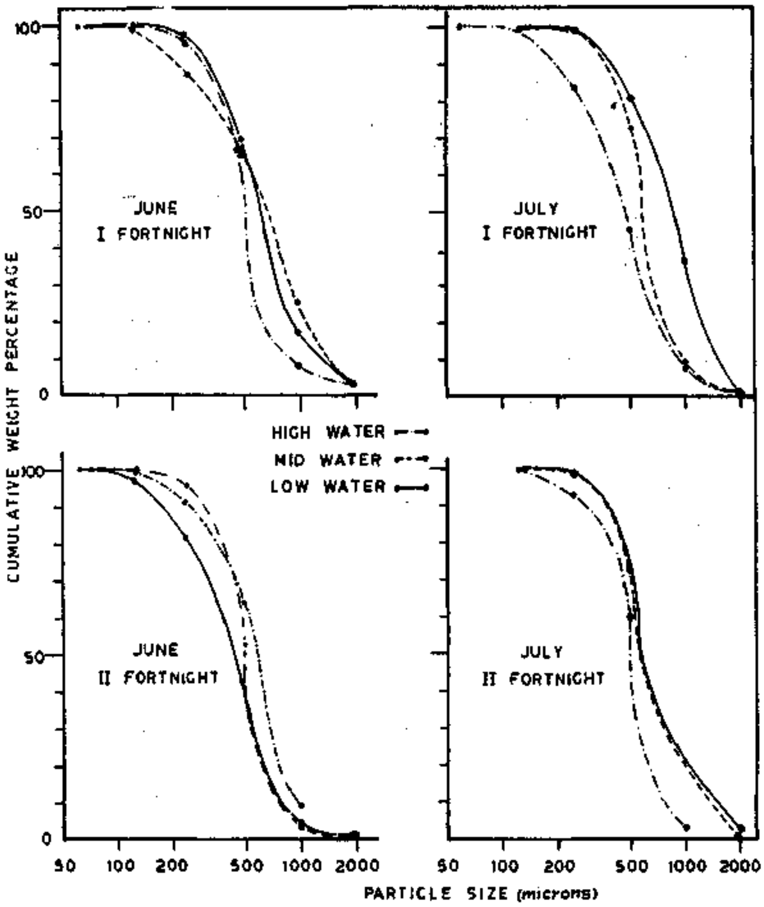

Fig. 5a. Cumulative curves of sand particle size from different tide marks.

Oxygen

The oxygen contents of the interstitial water varied between 2.1 to 5.5 ml/L The values decreased from low to high tide levels (Fig. 6). The oxygen values of the surface water ranged between 4.2 to 5.5 ml/L as compared to the lower values of the interstitial water (Fig. 5). A general pattern of high oxygen values at low water mark and low values at high water mark was evident.

Water Table

The porosity, atmospheric exposure and temperature are some of the factors known to limit the water contents in sandy beaches. The interstitial water in the beach and the possible inter-relations between the beach characteristics and changing water levels were discussed by Emery and Foster (1948). During the period under observation the beach underwent considerable changes in its profile, and the gradient varied from 1:7.5 to 1:15. The water table was seen to vary with the gradient; when the gradient was steep the water table became low and vice versa.

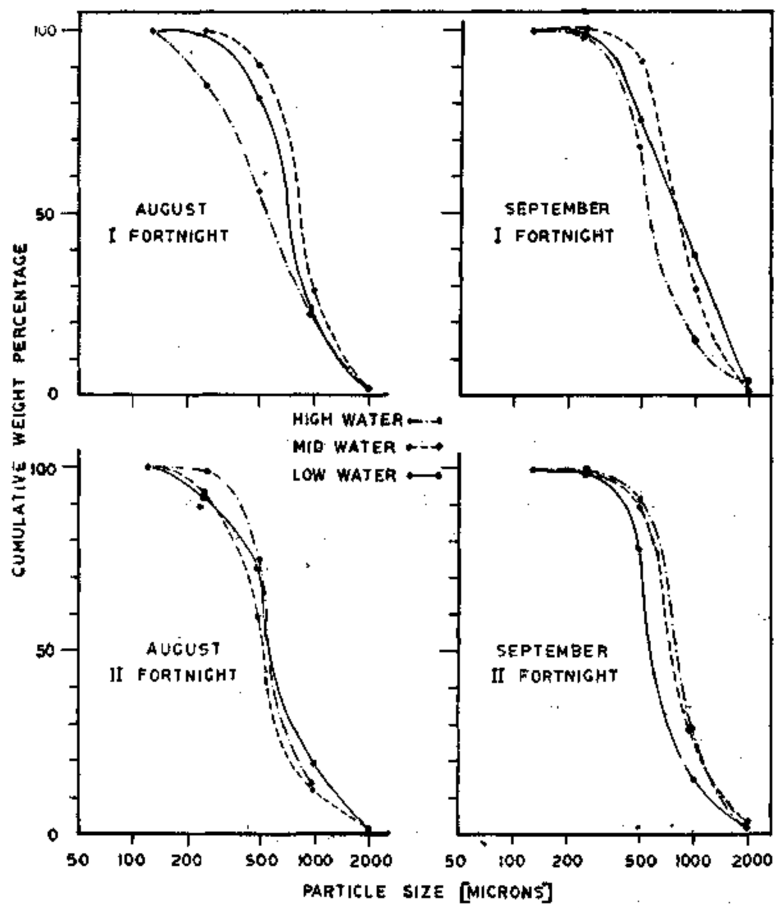

Fig. 5 b. Cumulative curves of sand particles size from different tide marks.

Organic carbon

Organic carbon content in the sand ranged from 38 to 732 $\mu g/g$ (Fig. 4). At the two beaches studied near Cochin and Shertallai (Trevallion *et. al.*, 1970) the values obtained were between 210 to 630 $\mu g/g$. Thus the range in the values of organic carbon is wider at Calangute than at Cochin and Shertallai.

Biomass

Thirty eight stations were sampled at different tidal levels and of these, macrofauna was present only at 21 stations. These 21 stations are hereafter called as positive stations. At the low water mark, out of the 17 stations sampled, 13 were positive. At the mid tide level out of 12 stations sampled, macrofauna occurred at 9 stations whereas at the high tide level out of 9 stations sampled only 2 were positive. It is thus evident that the low tide level had a higher percentage of positive stations as compared to the mid and high tide levels.

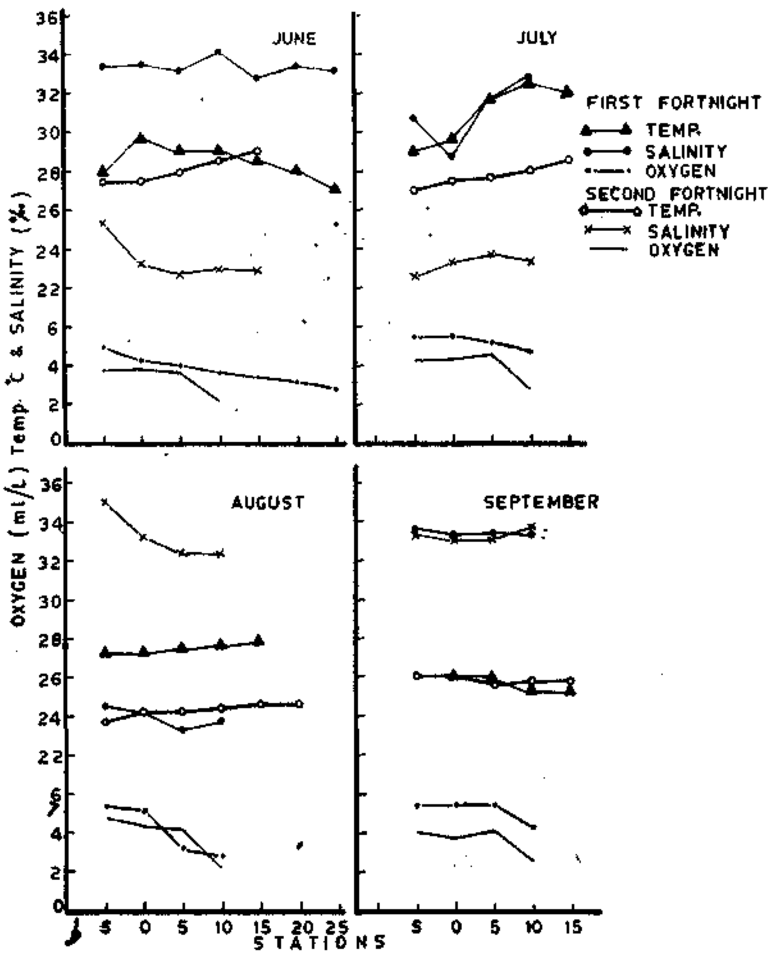

Fig. 6. Environmental factors during the monsoon (June-September).

Monthly variation

Initially in June (Fig. 3) the biomass was high, but it gradually declined and in September, at all the tide levels it was almost negligible. The low and the mid-tide level had been the principal zones for macrobenthic biomass and the fluctuations in standing crop at low tide levels were of much narrower range (0.85 to 25.6 g/m^2) compared to the mid-tide level (0.5 to 92.9 g/m^2). In general the biomass (0.06 to 0.53 g/m^2) at the high tide level was practically negligible. The faunal composition at different tide levels is given in Table 3.

BIOMASS AT DIFFERENT TIDE LEVELS

Low Tide level: A slight increase was observed in the standing crop from June to the first fortnight of July and then a gradual decrease from 25.60 g/m² to almost nil was noticed till the end of monsoon.

Mid Tide level: During the first fortnight of June standing crop was 92.90 g/m² (Fig. 3) and by the second fortnight it decreased to 8.40 g/m². In September the average values found were only 0.85 g/m² suggesting the prevalence of unfavourable environmental conditions.

High Tide Level: Negligible standing crop in the range of 0.53 and 0.06 g/m² were observed in July second fortnight and in August first fortnight (Fig. 3), otherwise the standing crop was nil throughout. Absence of macrofauna may be due to several adverse factors like longer atmospheric exposure and the deeper water table, accompanied by low oxygen in the interstitial water.

ECOLOGICAL NOTES

The distribution of fauna in relation to median sand grain size has been show in Table 3. The existence of a relationship between sand grain size to the different groups is evident. Some features of the faunal groups represented are given below:

PELYCYPODS

Pelycypods were represented by mainly two active tidal migrants, *Donax incarnatus* and *Donax apperitus* which were distributed at the mid and low tide levels. It was observed that the latter was particularly abundant in the wash zone of the surf associated with coarse sand texture.

CRUSTACEA

This group was represented by mainly the mole crab *Emerita holthuisi* in the wash zone. The range in the sand grain size in which they were present was 450 to 900μ.

The ghost crabs which were found above the high tide mark at the area of collection were *Ocypode ceraptothalma* and *Ocypode cordimana*. The burrows of these crabs were mainly observed well above the high tide mark upto the berm of the beach. The other crab found in the wash zone is the *Philyra* sp.

Mysids were observed in August and September in the sand grain size range between 625 to 755 μ.

POLYCHAETES

Polychaetes generally occurred in the low tide level with only one species *Pisionidens indica* having a uniform pattern of distribution, and these were abundant at all the tide levels. The association of this species to different sand grain sizes is an evidence of its adaptability to a wide range. The decline in the total number of this species was seen by the last month of monsoon (September). The other Polychaete species represented are shown in Table 3. They included *Lumbriconereis latreilli*, *Onuphis* sp., *Nereis* sp. and few Talitrids.

TABLE 3. *Distribution of fauna at different tide levels in relation to median sand grain size*

Tide Level	Animals present	Median sand grain size in μ	Animals present	Median sand grain size in μ	Animals present	Median sand grain size in μ	Animals present	Median sand grain size in μ
Low	*Donax incarnatus* *Donax apperitus* *Emerita holthuisi* *Lumbriconereis latrailli* *Pisionidens indica* *Caprella* sp.	450 to 620	*Donax incarnatus* *Onuphis* sp. *Pisionidens indica* *Emerita holthuisi* *Philyra* sp.	610 to 900	*Donax incarnatus* *Donax apperitus* *Pisionidens indica* *Emerita holthuisi* *Eurydice* sp. *Mysis* sp.	620 to 750	*Donax apperitus* *Pisionidens indica* *Mysis* sp. *Philyra* sp.	625 to 755
Mid	*Donax incarnatus* *Donax apperitus* *Onuphis* sp. *Talitrid* sp. *Pisionidens indica* *Eurydica* sp.	525 to 600	*Donax incarnatus* *Donax apperitus* *Pisionidens indica* *Eurydice* sp.	600	*Emerita holthuisi* *Nereis* sp. *Mysis* sp.	550 to 780	*Pisionidens indica*	775 to 800
High	*Pisionidens indica*	500 to 600	*Pisionidens indica*	480 to 500	*Pisionidens indica*	550 to 600	....	570 to 875

The Cirrolanid isopods were represented by *Eurydice* sp. only and their occurrence was confined to the low tide level in the surf zone. It was recorded in the mid tide levels in June and July in very few numbers. Amphipod *Carprella* sp. were observed in June at the wash zone associated with the sand grain size range of 450 to 620 μ.

DISCUSSION

The Calangute beach was characterised by narrow intertidal range and steep gradient which underwent considerable variation during monsoon. The sand was coarse throughout the period of observation and the mean sand grain size varied from 450 to 900μ. Variations in the mean sand grain size were observed at different tide levels indicating continuous shifting of the sand resulting in an unstable substratum for macrofauna. These parameters apart from resulting in low biomass, also influenced the distribution and diversity of the macrofauna. Five major groups *viz.*, Pelycypods, Polychaetes, Crustaceans, Amphipods and Isopods were recorded during the study period (Table 3). As observed earlier (Dwivedi *et. al.,* 1972). the estuarine beaches of Goa, during monsoon, were comparatively more stable and the diversity of species was also more, however, the mean biomass values during the monsoon months was 4.1 g/m^2.

The sand grain size, beach gradient, accretion and erosion process are at least partly responsible for the ecological changes. One of the important effects of steep gardient is deeper water table. In the present study, at the mid and high water mark, the water table was deep and the biomass was negligible. Oxygen content in the water also appears to be influenced by the gradient as the oxygen values were very low at mid and high tide levels.

The organic carbon ranged from 38 to 732 μg/g and it showed variations at different tide levels. Sand at low water mark was rich in carbon and showed two peaks, first in the second fortnight of June with a value of 630 μg/g and a secondary minor but well pronounced peak during first fortnight of September. At the mid tide level there was only one peak which also occurred in the second fortnight of June. During the rest of the period values fluctuated between 100-200 μg/g. At the mid tide level the values remained mostly around 100 μg/g with slight increase during the first fortnight of July. Thus it is seen that organic carbon was rich at low tide level and its values decreased from low to high water mark, except during the second fort- night of June when peak concentration was observed both at the low and high water mark.

The biomass at the high tide level throughout the monsoon was low and almost negligible, whereas at the mid tide level, it ranged from 0.05 to 92.9 g/m^2 and at low tide level the range was from 0.8 to 25.6 g/m^2. From the beaches near Porto Novo macrofauna biomass ranging from 0.21 g/m^2 at the high water level to values around 3.53 g/m^2 at mid tide level were reported by Mc Intyre (1968). Similarly from the west coast, Trevallion *et. al.,* (1970) reported biomass values which were comparable to the values obtained on the east coast (Mc Intyre, 1968). Apart from the environmental parameters discussed above, major differences in biomass at these beaches may also be due to the seasonal difference, because the other two beaches were investigated during non-monsoon months. During monsoon months when erosion occurs in the intertidal region, the beach material alongwith the macrofauna is washed away at least partially. A possible reason for this destruction of the shore fauna during the South West monsoon period along the west coast of India has also been attributed to the prevailing unstable conditions (Panikkar, 1970). The accretion and erosion processes vigorously agitate the substratum between the tide levels due to the severe wave action resulting in absence of macrofauna at high tide level. The deposition of fresh tar lumps of various sizes, at different tide levels were also observed (Nair *et. al.*, 1972), but its influence on the intertidal macrofauna was not apparent.

It is thus evident that at Calangute, during the monsoon months erosion and accretion processes and estuarine influence modify the beach ecology and production of the intertidal macrofauna.

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