

HETEROTROPHIC BACTERIAL POPULATION IN TROPICAL SANDY BEACHES

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ABSTRACT

Distribution pattern of heterotrophic bacterial flora of three sandy beaches of the west coast of India was studied. The population in these beaches was microbiologically different. Population peaks of halotolerant and limnotolerant forms were attained at different magnitude in different months. Influence of environmental factors on the bacterial distribution are discussed.

INTRODUCTION

Sandy beach ecosystem has been recognized as cleansing filters of sea water (Pugh, 1975). Although some information is available on the isolation and enumeration of microorganisms of the temperate sandy beaches (Litchfield, Rake, Zindulis, Watanabe and Stein, 1975; Rheinheimer, 1977; Boeye, Wayenbergh and Aerts, 1975), little is known about the interaction of microorganisms with sediment properties except for the work of Dale (1974) and Meyer-Reil, Dawson, Liebezeit and Tiedge (1978). In Goa, studies have been carried out on different sandy beaches to understand the complex ecological processes influencing their biological productivity (Achuthankutty, Stirling, Nair, Bharathi and Menezes, 1978; Wafar, Rajagopal, Menezes and Stirling, 1980).

The present investigation was undertaken to enumerate the heterotrophic population of the sandy beaches and their interaction with the sediment properties. Bawal, Colva and Arambol sandy beaches were studied for a period of one year. The topography, ecology and energy inputs of these beaches have been described by Wafar, Rajagopal, Menezes and Stirling (1980).

MATERIALS AND METHODS

Compound samples were taken for bacteriological analysis at monthly intervals from each 10 m station between the high and low marks. Samples were collected using a sterile spatula upto a depth of 1 cm and brought to the laboratory in ice. They were dispersed in 100 ml of aged sterilised sea water and shaken on a shaker. After serial dilution, plating was carried out in ZoEell 2216 E medium (halotolerant) and in nutrient medium (limnotolerant (Krumbein, 1971). Counts were taken after 48 hours incubation at $28 \pm 2^\circ\text{C}$ and expressed as number per gram of dry weight sediment. Particulate carbon of the sediment was determined by the wet oxidation method and expressed as percentage.

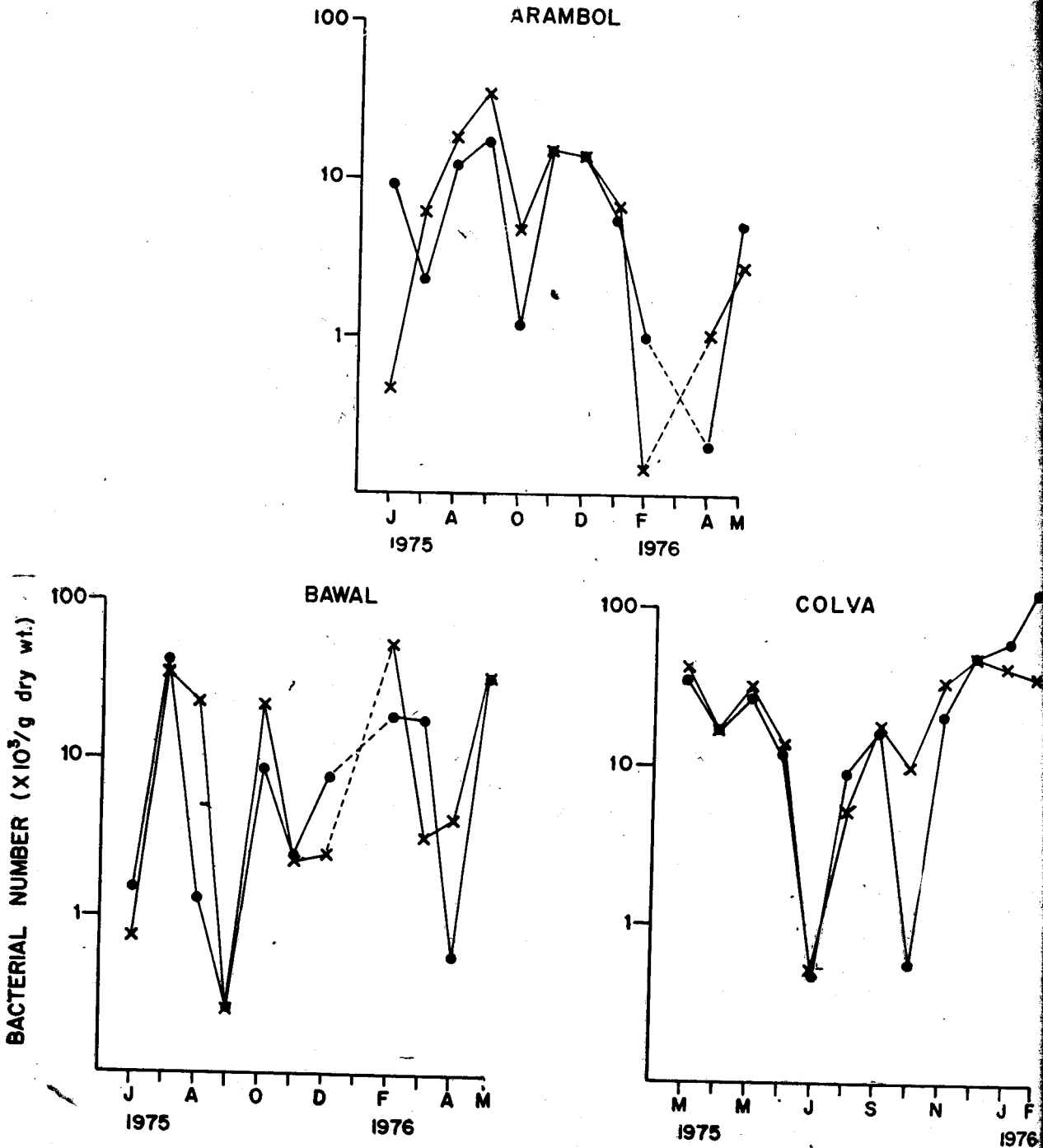


Fig. 1. Distribution of heterotrophic bacterial population in different months in the sandy beaches. (closed circles indicate halotolerant forms; crosses indicate limnotolerant forms).

RESULTS AND DISCUSSION

Distribution of heterotrophic flora

The distribution of halotolerant and limnotolerant bacteria in the 3 beaches are given in Fig. 1. At Colva both the forms had more or less a similar pattern of distribution and a balance was found to exist among the two populations. Halotolerant population was very high in February ($138.46 \times 10^3/\text{g}$) and was minimum in July and October (0.47×10^3 and $0.58 \times 10^3/\text{g}$ respectively) whereas the limnotolerant forms were high in December ($50.42 \times 10^3/\text{g}$) and low in July ($0.63 \times 10^3/\text{g}$). The overall bacterial content of this beach was very poor in July. During the one year study, it was seen that the halotolerant and limnotolerant populations almost had an equal distribution for four months on this beach.

At Bawal also the trend in their distribution was more or less similar to that of Colva but the peak population was different. Halotolerant forms were maximum in July ($41.72 \times 10^3/\text{g}$) and minimum in September ($0.26 \times 10^3/\text{g}$) and the limnotolerant forms were high in February ($54.55 \times 10^3/\text{g}$) and minimum in September ($0.24 \times 10^3/\text{g}$). The bacterial load was very low in September.

At Arambol, on the other hand both halotolerant and limnotolerant flora exhibited peak abundance in September ($17.21 \times 10^3/\text{g}$ and $34.42 \times 10^3/\text{g}$ respectively). The former showed very poor population in April ($0.41 \times 10^3/\text{g}$) and the latter in February ($0.21 \times 10^3/\text{g}$). Unlike the other two beaches the total bacterial load at this beach was not very low in any month. Among the 3 beaches, Colva, in general, had a high population of both the forms. Bacterial population, however, in these three tropical beaches fluctuated widely and peak abundance varied considerably from one beach to the other. It was seen that very good correlation exists between the two forms in these beaches ($r = 0.913$).

Seasonal fluctuation in distribution

The data on halotolerant and limnotolerant forms of these beaches were pooled according to seasons and these are presented in Fig. 2. At Colva, the seasonal fluctuation in halotolerant and limnotolerant forms followed a similar trend. Monsoon season (June–September) recorded a minimum population of $8.67 \times 10^3/\text{g}$ of halotolerant forms. Limnotolerant forms were $11.21 \times 10^3/\text{g}$ during the monsoon. Maximum density of halotolerant was during the postmonsoon season (October–January, $66.672 \times 10^3/\text{g}$) and of limnotolerant form it was $42.27 \times 10^3/\text{g}$.

The two populations followed a similar trend of distribution in Arambol. Minimum population occurred during the premonsoon period (February–May) and maximum during the monsoon period ($10.24 \times 10^3/\text{g}$ of halotolerant and $14.94 \times 10^3/\text{g}$ of limnotolerant forms) (Fig. 2).

Unlike the other two beaches, in Bawal the halotolerant flora was recorded maximum during the pre-monsoon period ($17.54 \times 10^3/\text{g}$) and minimum during the postmonsoon period ($9.68 \times 10^3/\text{g}$). Limnotolerant forms were minimum during the premonsoon period and increased as the season progressed to attain the peak during the postmonsoon period ($20.39 \times 10^3/\text{g}$) (Fig. 2).

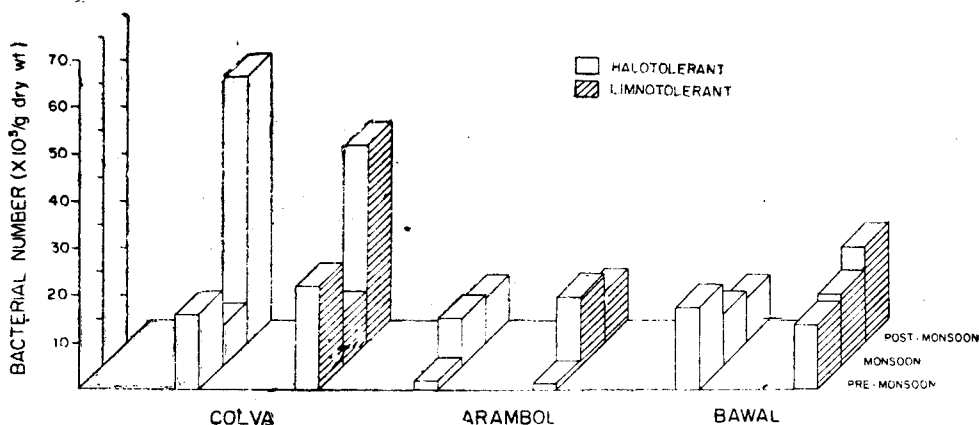


Fig. 2. Seasonal distribution of heterotrophic bacterial population in the sandy beaches.

The heterotrophic bacterial flora and their seasonal fluctuation of the three tropical beaches under investigation though situated close to each other on the west coast of India suggests that the factors responsible for the proliferation of bacterial population in the three beaches may be different from each other as observed by Pugh, Andrews, Gibbs, Davis and Floodgate (1974). Moistening of the beach by rainwater (Rheinheimer, 1977), land run-off, river influence and human activity may be some of the factors responsible for the distribution of limnotolerant forms over halotolerant forms in these beaches.

Bacterial biomass in relation to ecological factors

Chemical variables in the three beaches such as pH, PO_4 -P, NO_3 -N and NH_4^+ (Wafar, Rajagopal, Menezes, and Stirling, 1980) when subjected to computer analysis showed no relationship with the population of bacteria. The mean salinity (‰) ranged from 24.25 to 30.75, 24.35 to 33.11 and 23.89 to 33.98 in Bawal, Colva and Arambol beaches respectively. Only halotolerant bacteria of the postmonsoon and premonsoon seasons showed significant correlation with salinity ($r = 0.59$ and 0.58 respectively). Lack of correlation of bacterial number with their chemical characteristics may be because the system may not be simply controlled by an equilibrium level of nutrients (Pugh, Andrews, Gibbs, Davis and Floodgate, 1974).

The effect of temperature on micro-organisms is well known (Morita, 1974). The sand temperature of the 3 beaches ranged from 20.5 – $35.7^\circ C$ with a peak in premonsoon and that the temperature is influenced by time of sampling and also subjected to semidiurnal temperature changes (Wafar, Rajagopal, Menezes and Stirling, 1980). ZoBell and Conn (1940) feel that a single incubation may not recover all sections of population. Since the minimum growth temperature of bacteria is few degrees above environment temperature, the incubation at $28 \pm 2^\circ C$ is optimum. Various species are known to be adopted to seasonal temperature (Susan and Riley, 1967) and that the adaptation of mixed bacterial population could play an important part in the ecology of the sediment (Nedwell and Floodgate, 1971). No correlation was noted between heterotrophic flora and sand

temperature in the present study. Hence it appears that the heterotrophic distribution of tropical sandy beaches, to some extent, is independent of sand temperature.

Surface sand grain is a well defined habitat for microorganisms (Meadows and Anderson, 1968). The grain size of the 3 beaches ranged from 135–245 μm with mean values at Colva, Arambol and Bawal being 203 μm , 178 μm and 218 μm respectively (Wafar, Rajagopal, Menezes and Stirling, 1980). In the present investigation no correlation could be seen between grain size and population either for the whole year or seasonally. While Dale (1974) showed significant negative correlation between grain size and bacteria, Anderson and Meadows (1969) were not able to establish any such relationship. This may, as pointed out by Meyer-Reil, Dawson, Liebezeit and Tiedge (1978) depend on the difference of sediments of the beaches and a wide range of grain size may indicate a significant relationship with the heterotrophic flora. Hence no relationship could be expected in the three beaches where the range of grain size was very small.

The presence of high concentration of dissolved and particulate organic matter is an important factor in the distribution of heterotrophic bacterial population. The particulate organic matter in the sand of the 3 beaches ranged from 0.02–1.08% (Fig. 3). In general, the carbon content of the Colva beach was higher where the total bacterial load was also more than the other two beaches. The maximum value was noted in January (1.08%) and minimum in July (0.24%). The maximum value at Arambol was 0.24% in September and minimum of 0.02% in February. In Bawal, the maximum organic content was recorded in May and February (0.36%) and minimum in April, June, September and November (0.12%). It was found that the organic carbon showed significant positive correlation with both halotolerant and limnotolerant forms ($r=0.8$ and 0.84 respectively). Similar correlation was also seen in the nearby Baina beach (Achuthankutty, Stirling, Nair, Bharathi and Menezes, 1978).

It was of interest to note that during the monsoon period no relationship existed between organic matter and bacterial population. During the premonsoon

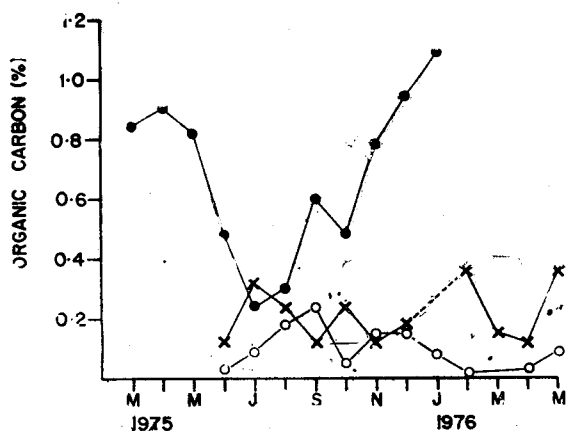


Fig. 3. Particulate organic carbon in sand during different months in the sandy beaches. (closed circles indicate Colva; open circles indicate Arambol; crosses indicate Bawal).

period good relationship was seen with the Limnotolerant forms ($r=0.78$) and during the postmonsoon period both the forms showed significant correlation ($r=0.73$ and 0.80). A significant positive correlation between particulate carbon and bacterial flora has been established in sandy beaches of temperate and tropical environments (Dale, 1974; Meyer-Reil, Dawson, Liebezeit and Tiedge, 1978; Achuthankutty, Stirling, Nair, Bharathi and Menezes, 1978). The bacterial load is proportional to organic input when sand aggregation is not a limiting factor (Boucher and Chamroux, 1976). However, this cannot be significantly expressed until the nature of sedimentary organic matter and dynamics of its utilization by the microbes are studied (Dale, 1974).

It could be inferred from the present study that the quantitative distribution of the heterotrophic flora in a tropical beach is characteristic of its own which is influenced by the complex processes to which the beach in question is exposed. Nevertheless, the bacterial content of the sandy beach is, to a large extent, governed by the various sediment properties and appears more to be a function of the content of utilizable organic matter (Rheinheimer, 1977).

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