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Influence of Thermal Effluents on the Growth Characteristics of Phytoplankton in the Waters of Tuticorin Bay

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The paper reports the results of investigations conducted in 1990, on the physico-chemical aspects of Tuticorin Bay waters in relation to the abundance of phytoplankton. Selected species of phytoplankton were experimentally cultured to study the influence of thermal effluents. For this purpose cultures were raised in media collected from 4 stations, showing different extents of pollution. Four species of nannoplankton, namely, *Isochrysis galbana* (Haptophyceae), *Dicrateria inornata* (chrysophyceae), *Tetraselmis gracilis* (Chloro-phyceae) and *Chaetoceros calcitrans* (Bacillariophyceae) were grown in the water samples collected from selected stations. The experiments showed stimulatory trend of growth for the first 7-8 days and gradual inhibitory effect on the multiplication in subsequent days. Among them, the phytoflagellates (*Isochrysis, Dicrateria* and *Tetraselmis*)showed good growth in the samples of media collected from locations near to the pollution source. The rate of production of both *Tetraselmis* and *Dicrateria*, which are known to exist in the polluted waters, indicated enhanced growth in the Bay waters. The growth of the diatom, *Chaetoceros* has been found to be uniform except in the sample collected from the point nearest to the source of pollution. Though the long-term effects of these samples have not been studied, the experiments revealed the possible effects of thermal effluents on the phytoplankton population in the waters of Tuticorin Bay.

In recent years, many investigations have been carrried out in Europe and elsewhere on the composition and abundance of phytoplankton from nearshore, estuarine and enclosed marine ecosystems subjected to pollution. However, there have been very few reports dealing with pollution effects on phytoplankton from the coastal waters of India (Nair *et al.,* 1975; 1976; Pramila & Rao, 1977; Nair & Gopinathan, 1979; Ganapati & Raman, 1979; Raman & Phaniprakash, 1989 a). A lot of concern has been expressed in recent years about the deteriorating water quality in the coastal waters due to industrial pollution. In this context, it was decided to study the influence of thermal effluents on the natural population of phytoplankton in Tuticorin Bay waters during 1990. The field observations were corroborated with laboratory experiments on selected species of phytoplankton by raising the cultures in media collected from the vicinity of the Tuticorin Thermal Station.

Materials and Methods

Fortnightly collections of phytoplankton samples (1/2 m No.21 bolting nylon net, mesh size 0.069 mm) and surface water samples were made from 4 stations of the Bay waters of Tuticorin and inshore area (Fig. 1).

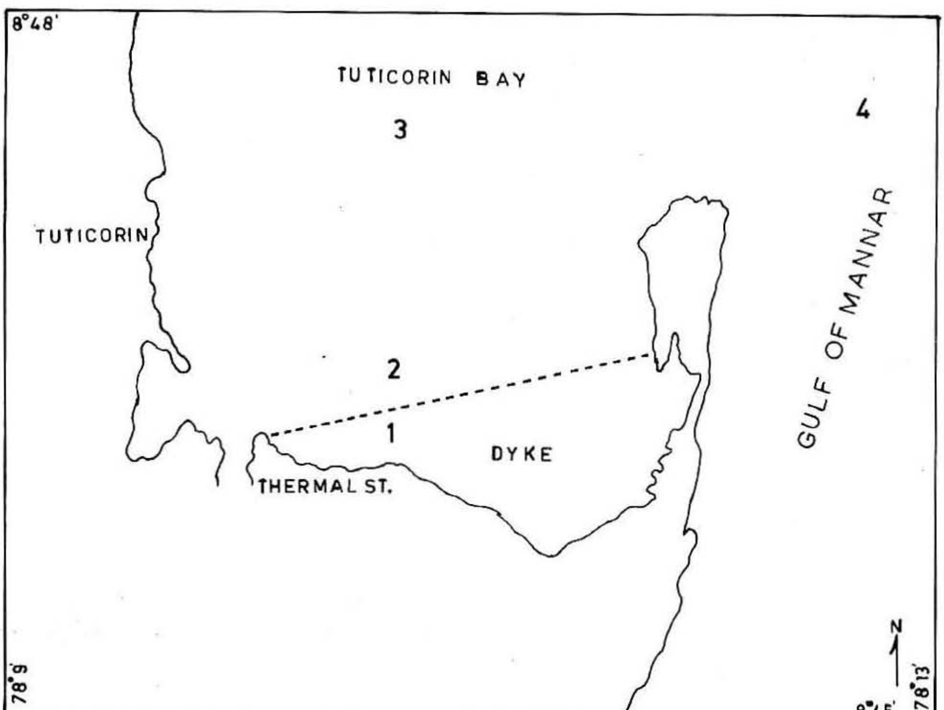

Fig. 1. Sampling stations in the Tuticorin Bay and inshore area

Atmospheric and surface water temperature, salinity, pH, dissolved oxygen and nutrients such as nitrite, nitrate, phosphate and silicate, in the samples were determined according to standard methods (Strickland & Parsons, 1968). The light and dark bottle oxygen technique (Gaarder & Gran, 1927) was employed for the estimation of primary production.

Five litres each of water samples were collected from 4 selected stations: off fly-ash storing dyke, outside the dyke, centre of the bay and inshore area. After sterilization by boiling, the culture medium was prepared by adding Conway medium (Walne, 1974). Four species of nannoplankton were used for the culture experiements, namely, *Isochrysis glabana* (Haptophyceae), *Dicrateria inornata* (Chrysophyceae),*Tetraselmis gracilis* (Chlorophyceae) and *Chaetoceros calcitrans* (Bacillariophyceae). Duplicate samples were used for the inoculation of these species in Haufkin culture flasks. Uniform light (1000 lux) and temperature (25°C) were provided. The experiments were continued for 15 days and the cell concentrations were measured by using a Haemocytomer.

Results and Discussion

For convenience, the hydrological data of the first 3 stations have been pooled together since they are located in the Tuticorin Bay and the 4th station in the inshore area (20 m depth) treated separately (Fig. 2).

Atmospheric temperatures in the Bay regions and in the inshore area are not showing much fluctuations. However, the water temperature, particularly at the discharging point of effluents into the Bay, showed higher values (35-42°C) throughout the year. Also in the middle of the Bay and in the inshore area, the surface water temperature indicated somewhat uniform values and the peak values were noted during the summer months of Feb-May in both the areas (Fig. 2A, B).

The data on dissolved oxygen content indicated (Fig. 2C) that values for the inshore waters were slightly higher than those for the Bay waters, revealing the cause of low primary production. Very low values of oxygen were noted in the Bay during March-May and August-October while comparatively high values were observed in the inshore area during these months. The relative reduction of oxygen content in the

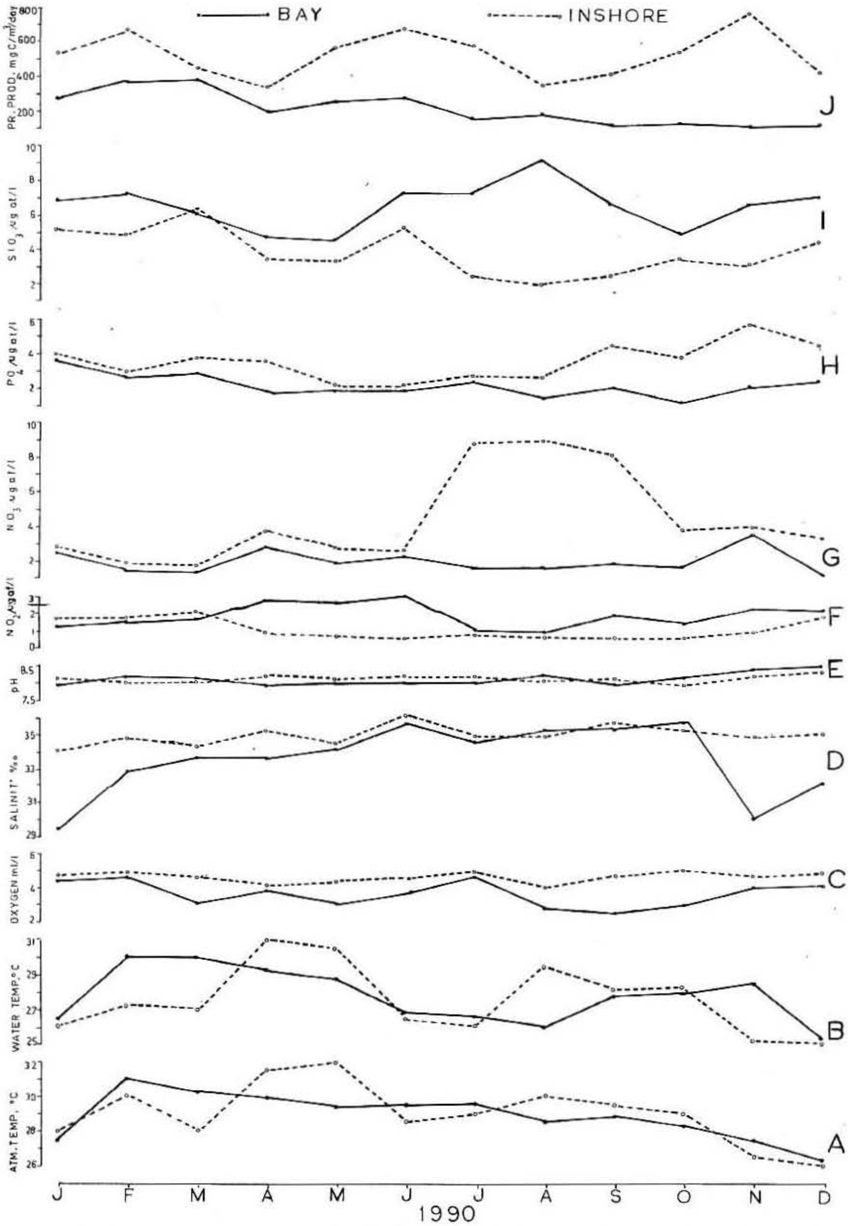

Fig. 2. Hydrological properties and primary production in the waters of the Bay and inshore area

Bay waters may be attributed to the high organic load of the effluents of the Thermal Station. The salinity values were also found to be slightly higher in the inshore waters when compared to the Bay waters (Fig. 2D). In the inshore area, salinity was generally uniform with slightly high values during June, whereas during the north-east monsoon months of Nov.-Jan., the Bay waters showed sudden fall in salinity which resulted in moderate production of phytoplankton.

pH values indicated less fluctuations in the waters of both inshore and Bay regions (Fig. 2E) and apparently this has no significant effect on the production of phytoplankton.

Among the nutrients, nitrite content in the Bay waters showed slightly higher values during April-June and October-November. (Fig. 2F) compared to the inshore waters. In the inshore waters, the levels of nitrite were negligible during the summer and winter months.

In contrast to the nitrite values, the values of nitrate were found to be higher in the inshore waters compared to the Bay (Fig. 2G). A distinct peak was observed in the inshore waters during July-September., while the Bay waters indicated low to moderate values throughout the period.

Phosphates also showed slightly higher levels in the inshore waters (Fig. 2H) compared to the Bay, especially during Sept.-December. Here also, the values of phosphate in the Bay waters were uniformly low throughout the period of study.

In contrast to the levels of nitrate and phosphate, the values of silicate showed slightly higher levels in the Bay waters in most of the months, particularly during July-December (Fig. 2I). The silicate content of the inshore waters were found to be low to moderate throughout the period of observation.

The rate of primary production was higher in the inshore waters when compared to the Bay waters throughout the period of study (Fig. 2J). In the inshore waters, three distinct peaks were observed, the first one during January-February, second one during May-July and the third, during October-December periods. However, the rate of primary production and thereby the abundance of phytoplankton was very low or in moderate levels in the Bay waters during the entire period of observation.

The effect of thermal effluents on the natural population of phytoplankton was studied by collecting the samples from the point of effluent discharge from the Thermal Station, Bay waters as well as from the inshore regions. The seasonal abundance of phytoplankton indicated distinct fluctuations from one station to another. During January-April and October-December periods, the Bay waters showed the dominance of Pennate diatoms represented by species of *Nitzschia, Thalassionema, Thalassiothrix* and Centric diatoms such as *Skeletonema costatum* and *Thalasiosira subtilis* and dinoflagellates, *Ceratium, Peridinium* and *Diplopsalis*. The plankton collected near to the Thermal Station revealed the abundance of eurythermal dinoflagellates such as species of *Prorocentrum, Dinophysis* and *Podolampas* and less abundance of both Pennate and Centric diatoms. Moreover, the samples collected from the dyke waters showed less number of phytoplankton and zooplankton, especially at the point of discharge of effluents. The samples collected during May to August showed the abundance of Centric diatoms both in the inshore and Bay waters, represented by the species of *Chaetoceros, Skeletonema, Biddulphia, Coscinodiscus* and *Thalassiosira*. Also the net samples indicated a gradual decrease in the quantity of suspended fly ash from the effluent discharge point to the interior of the Bay and almost nil in the inshore waters.

Four species of nannoplankters, namely, *Isochrysis galbana, Dicrateria inornata, Tetraselmis gracilis* and *Chaetoceros calcitrans* were used for the laboratory culture to study the effect of thermal effluents by raising the culture in seawater media collected from 4 stations. The growth and behaviour of the nannoplanktons in various samples showed the following results.

The growth and multiplication of *Isochrysis galbana* in the samples of dyke, outside the dyke as well as in the Bay waters showed similar pattern with slight fluctuations for 6 days, gradually enhanced growth upto 10 days and slowly entered the declining phase in subsequent days.

While the sample of inshore area showed steady and continuous growth even after 15 days, suggesting that this nannoplankton grows well in unpolluted waters (Fig. 3). In the samples from the dyke, decline of growth was noticed from the 9th day and gradual death phase was noticed in subsequent days.

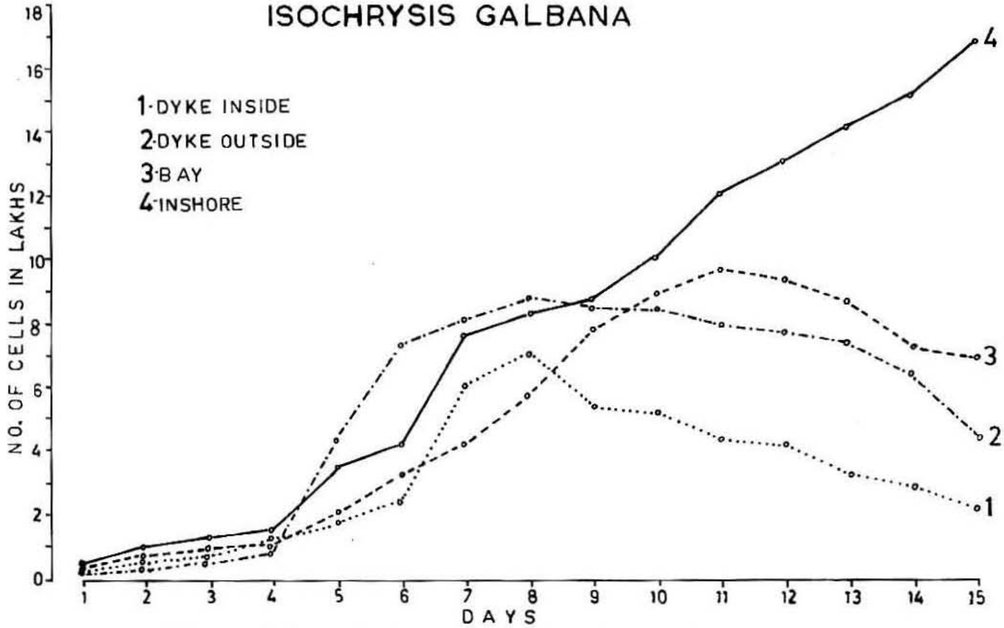

Fig. 3. Effect of thermal effluents on the culture of *Isochrysis galbana*

In contrast to *Isochrysis*, the green flagellate, *Tetraselmis gracilis* gave entirely different results. In all the samples, this flagellate showed steady and vigorous growth, especially in the samples of Bay upto 9 days. This flagellate indicated enhanced growth from the 10th day onwards in the dyke samples, reached the maximum on 13-14th day and then showed slight decline in the number of cells. The samples of inshore area showed steady and continuous growth as in the case of *Isochrysis* (Fig. 4).

Similar to *Tetraselmis*, *Dicrateria inornata* also showed somewhat same pattern of growth and multiplication in the samples of dyke and Bay waters (Fig. 5). An exceptional enhancement of growth and cell

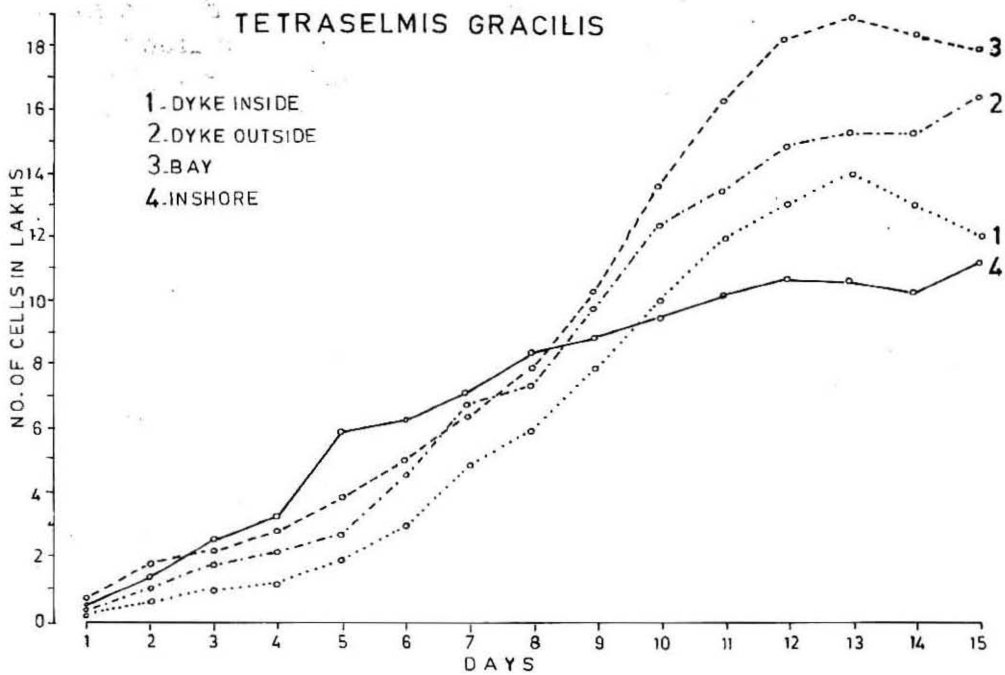

Fig. 4. Effect of thermal effluents on the culture of *Tetraselmis gracilis*

concentration were noticed in the samples form Bay waters and from outside the dyke after the 9th day. in both the samples, the flagellate was found to grow continuously even after 15 days. However in dyke samples, the growth and multiplication were found to be slow initially. In the samples of inshore area, *D. inornata* was observed to grow steadily as in the case of *Isochrysis*.

In contrast to the three flagellates, the growth of the diatom *Chaetoceros*, in the samples of dyke and Bay gave a different picture. In these samples, the multiplication of the cells was found to be very slow, while the sample of inshore area indicated steady and fast growth even after 15 days. However, in other samples, the number of this diatom decreased from the 12th day onwards (Fig. 6).

Present investigations showed that there is marked differences in the physico-chemical characteristics and phytoplankton compositions of the Bay waters subjected to effluent discharge from the thermal plant

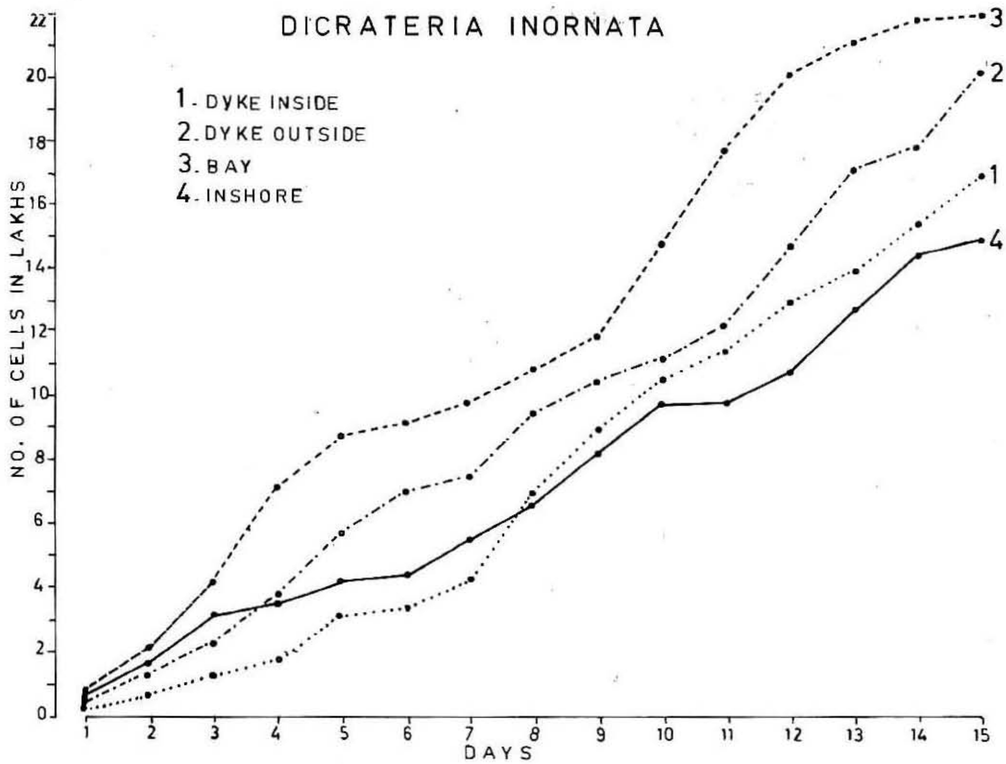

Fig. 5. Effect of thermal effluents on the culture of *Dicrateria inornata*

and the unaffected marine environment represented by the inshore waters. In the Tuticorin Bay the water circulation is poor and there is a high discharge of thermal effluents containing fly-ash at the effluent discharging point. The waters are characterised by a high temperature (35-42°C), high turbidity and low transparency (0.2 to 0.8 m), fluctuating salinity (29-35 ppt), low dissolved oxygen (2.5 - 3.8 ml/L), abnormally high rate of inorganic nitrogen (0.5 to 3.0 µg N/L) and high silicate (2.5 to 9 µg Si/L). This indicates that the waters are too polluted for the phytoplankton production. Since the dissolved oxygen content in the Bay waters was very low, the numerical species composition of the phytoplankton was also found to be less. Moreover, the overwhelming dominance of dinoflagellates and abundance of phyto-flagellates also revealed the polluted nature of the Bay waters. The discharge of sewage into the Bay also may be contributing to the pollution in this region.

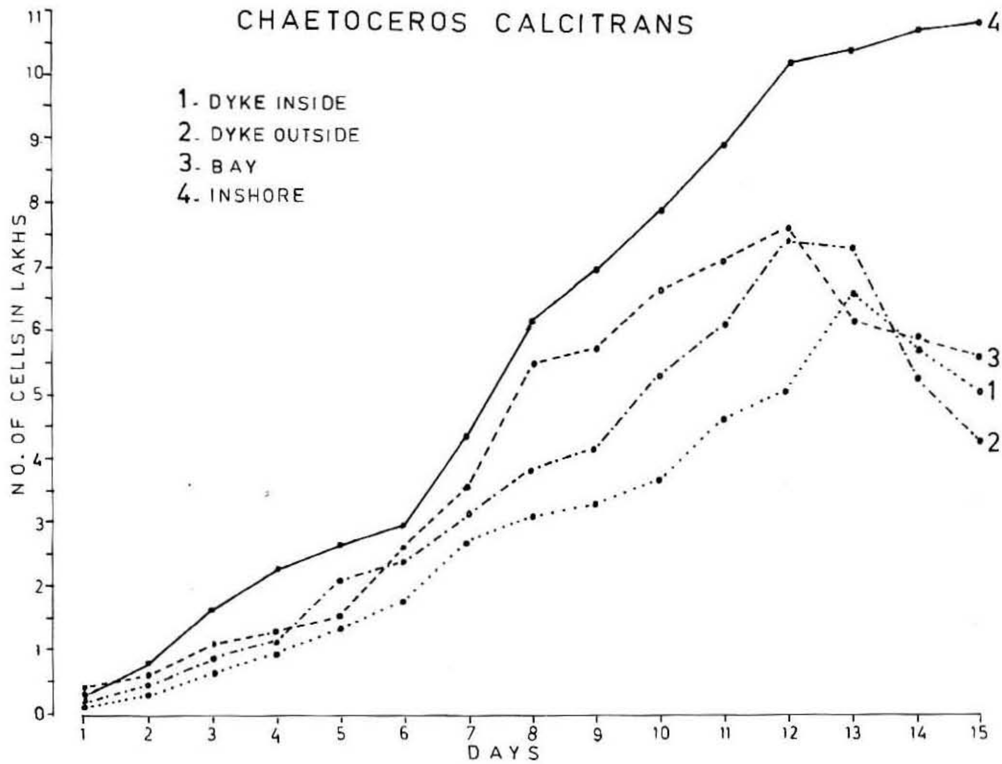

Fig. 6. Effect of thermal effluents on the culture of *Chaetoceros calcitrans*

Though the long term effects have not been studied, the culture experiments have revealed a close relation between water quality and composition and abundance of phytoplankton. For instance, the Bay waters outisde the dyke and the central region, where the effect of thermal effluents was maximum, the phytoflagellates represented by the species of *Dicrateria* and *Tetraselmis* were found to be the characterestic organisms, whereas in the inshore waters, where the water quality was good, the dominance of diatoms represented by the species of *Chaetoceros, Skeletonema, Thalassiosira* and *Nitzschia* could be observed.

Eppley and Weiler (1979) have reported about the possible use of nannoplankton dominance as an indication of marine pollution. Mahoney and McLaughlin (1979) observed that in New York harbour, the addition of sewage helped to produce intense blooms dominated by characterestic species of nannoplankters. In the coastal lagoons of Adriatic sea, unusal blooms of phytoflagellates caused by sewage pollution was of common occurrence, (Fanuko, 1984). According to North *et al.* (1972), the presence of high silicate in the water can stimulate the growth of micro-algae. While studying the phyto-plankton ecology in relation to pollution in Visakhapatnam harbour, Raman and Phaniprakash (1989b) indicated that high concentration of nutrients, low phytoplankton diversity and high chlorophyll content were the possible indicators of pollution in the harbour. Studies conducted elsewhere (Blanc *et al.*, 1972; Crowford *et al.*, 1979; Stockner & Cliff, 1979; Tsuruta & Yamada, 1980; Raman & Phaniprakash, 1989) revealed that nannoplankton in general, and species such as *Tetraselmis* and *Dicrateria* in particualr have been reported the world over as biological indicators of pullution in enclosed marine ecosystems.

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