

Short Communication

Diatom colonization on stainless steel panels in estuarine waters of Goa, west coast of India

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Temporal variations in diatom fouling was investigated at the Dona Paula Bay located at the mouth of the Zuari estuary, Goa. Stainless steel panels measuring 15 x 10 cm were exposed to the environment every month for four consecutive days, over a period of one year (March '96 to February '97). Qualitative and quantitative enumeration of the diatoms from the fouling film as well as that from the water column was carried out. The surrounding waters were dominated by the centric diatoms whereas the pennates were abundant in the fouling film. The pennate diatom *Navicula* was the most dominant genera both in the water column and the fouling film. The population of the diatoms in the environment did not change much during the course of four days of exposure in a given month, except during the bloom of *Skeletonema* which was observed in September. The accumulation rate of diatom cells with respect to period of exposure was not linear on most of the occasions. The centric diatom blooms in the ambient waters did not have significant influence on the diatom composition of the fouling film.

Materials exposed to the marine environment get colonized by a variety of aquatic organisms. This growth, a natural process, assumes economic importance when the biological debris thus formed affects the functioning of the marine facility. The diatoms are amongst the first autotrophic colonizers and are a major source of energy in the form of reduced carbon available on the immersed surface. Among microalgae, diatoms (Bacillariophyceae) are the first eukaryotic algae which colonize and dominate microcommunities in marine, brackish and freshwaters. According to Marzaiek *et al.*¹ and Carlton & Sieburth² much of the biomass accumulated on illuminated surface in the sea is derived from diatoms. The studies show that diatoms form a significant component of the biofilm, which is an important stage in marine fouling. The quantitative and qualitative aspects of diatom colonization on different substrata have not received adequate attention. Earlier observations on the diatom settlement on fibreglass and cupronickel substrata have been reported. Stainless steel, which is a commonly used material in the marine environment was used in the present investigation to study the aspects of diatom colonization.

This study was carried out at the mouth of the Zuari estuary (15° 27.5' N, 73° 48' E) at Dona Paula

Bay, Goa, west coast of India, over a period of one year (March '96 to February '97). During this period, observations on microfouling were made once every month for four consecutive days. Physico-chemical characteristics such as temperature, salinity, dissolved oxygen and nutrients (NO₂-N, NO₃-N, PO₄-P and Si) were analyzed following standard procedures⁴. The water samples for quantification of diatoms were preserved in Lugol's Iodine and analyzed later by sedimentation method⁵.

Stainless steel was chosen as the substrata to assess the diatom colonization. The steel test panels (15 x 10 cm) were cleaned thoroughly in dilute hydrochloric acid, washed, rinsed in distilled water and finally dried in an oven at 40°C. These panels were fixed with PVC nuts and bolts to a fibreglass frame and immersed at the sub-surface level (approx. 1m below lowest tide level). Exposure was carried out for 4 consecutive days, once every month, in order to obtain one, two, three and four days old biofilms for a period of one year (March '96 to February '97). The panels were brought to the laboratory in seawater, scraped with a soft nylon brush into known quantities (approx. 100 ml) of 0.45 µm membrane filtered seawater and preserved in Lugol's iodine. Quantitative and qualitative analyses of diatoms from these samples were done with the help of a binocular

stereoscopic microscope and the results are presented in terms of diatom cells per dm^2 area of the panels. Diversity and evenness of the diatom populations were evaluated with the help of Shannon-Wiener's diversity index (H')⁶.

Environment—At the study site, surface water temperature varied from 26°C to 32°C. The salinity values fluctuated between 13‰ and 37‰. The concentration of silicate (Si) ranged from 5 to 57 $\mu\text{g at/l}$, phosphate ($\text{PO}_4\text{-P}$) ranged from 0.5 to 4.8 $\mu\text{g at/l}$ whereas nitrate ($\text{NO}_3\text{-N}$) and nitrite ($\text{NO}_2\text{-N}$) ranged from 0.5 to 15 $\mu\text{g at/l}$ and 0.1 to 1.4 $\mu\text{g at/l}$ respectively. Highest salinity was recorded in June (37‰) since there was a delay in the onset of monsoons. Silicate concentration was highest in August (57 $\mu\text{g at/l}$) and September (50 $\mu\text{g at/l}$). The maximum values during August and September period may be attributed to the influx of the river waters. The influx of fresh water is also indicated by the considerable lowering of salinity during this period (August-13‰ and September- 21.5‰).

Diatoms from the water column—The highest number of diatom cells was observed in September (400 $\times 10^3$ cells/l) which was due to a bloom of *Skeletonema* in the ambient waters (Fig. 1A). This bloom coincided with a prevalence of low salinity. Reduction of salinity is linked with nutrient enrichment in the coastal regions. In the present study, nutrient enrichment and low salinity conditions were observed in August and September. Earlier studies⁷ on phytoplankton of the west coast of India carried out over a period of five years showed that almost all the peaks coincided with the period of low salinity. The high silicate concentration also coincided with the bloom of *Skeletonema*. Abundance of *Rhizosolenia*, *Chaetoceros*, *Nitzschia* and *Navicula* was observed during the postmonsoon months (January, February, March, April and May). Of the 34 genera of diatoms recorded, 19 were centric diatoms (*Biddulphia*, *Coscinodiscus*, *Hyalodiscus*, *Rhizosolenia*, *Chaetoceros*, *Ditylum*, *Lauderia*, *Planktoniella*, *Melosira*, *Skeletonema*, *Guinardia*, *Corethron*, *Cerataulina*, *Eucampia*, *Closteridium*, *Climacodium*, *Leptocylindrus*, *Striatella* and *Hemianthus*) and 15 were pennate diatoms (*Navicula*, *Nitzschia*, *Thalassiothrix*, *Pleurosigma*, *Grammatophora*, *Amphora*, *Achnanthes*, *Fragilaria*, *Asterionella*, *Licmophora*, *Cocconeis*, *Bacillaria*, *Coscosira*, *Cymbella* and *Epithemia*). Centrales dominated over the pennales in terms of abundance

and this is shown as a ratio in Fig. 1B. *Navicula* was the dominant genus and was found during all the three seasons (premonsoon i.e., February to May; monsoon i.e., June to September; and postmonsoon i.e., October to January). Generic diversity of the diatom fauna in the water column was maximum during June (diversity index 3.27; evenness 0.97) while during September and February, diversity indices were 0.3 and 0.8 respectively with the corresponding evenness values being 0.3 and 0.1 respectively (Fig. 1C). Dominance of *Skeletonema* in September resulted in a very low diversity and unevenly distributed population.

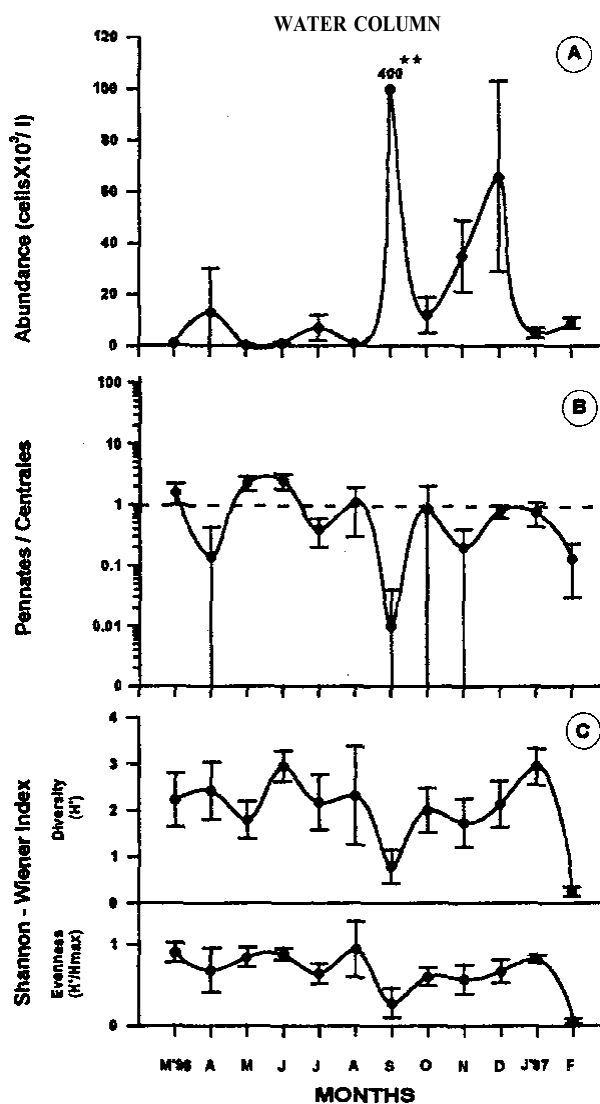


Fig. 1—Monthly variation in A) diatom cell abundance B) ratio of pennate/centric diatoms and C) diatom diversity (H') and evenness (H'/H_{max}) in the surrounding water column (Mar '96 to Feb '97).

[**: standard deviation large (diatom bloom observed on day 3 & 4) (** = ± 818)].

Diatoms from the fouling film—Diatoms which fouled the stainless steel panels belonged to 25 genera. Out of these, 13 genera belonged to pennates (*Navicula*, *Nitzschia*, *Thalassiothrix*, *Pleurosigma*, *Grammatophora*, *Amphora*, *Achnanthes*, *Fragilaria*, *Asterionella*, *Licmophora*, *Cocconeis*, *Cymbella* and *Epithemia*) whereas 12 genera belonged to centrales (*Biddulphia*, *Coscinodiscus*, *Rhizosolenia*, *Chaetoceros*, *Ditylum*, *Lauderia*, *Melosira*, *Skeletonema*, *Cerataulina*, *Closteridium*, *Climacodium* and *Hemianthus*). The pennate diatoms were dominant in the fouling film (13 pennates and 12 centrales) whereas in the water column, centrales were abundant (19 centrales and 15 pennates). The temporal variation in the fouling diatom cell abundance on stainless steel for different exposure periods is shown in Fig. 2. Among the pennates, *Navicula* was found to be the most dominant diatom, both in the water column and the steel panels. Its preponderance in the fouling film can be traced to both its high density in the ambient waters as well as its attachment capabilities owing to the presence of raphe⁸. Earlier observations have revealed that pennate forms dominated even on fibreglass and cupronickel substrata³.

Observations with glass slides in the Florida Bay⁹ indicated that the relation between exposure duration and the diatom cell number was logarithmic and opined that the increase in number was by surface associated organisms rather than by the process of continuous recruitment. However, in this investigation the rate of accumulation was not logarithmic in most of the cases, indicating that there were other factors which controlled the development of a microfilm community. These may include the

interactions amongst different components of the microfilm as well as the substratum characteristics.

During February and September, the diversity in diatom population in the water column was minimal. This trend, however, was not observed so far as the diatom population in the biofilm is concerned. The centric diatom blooms in the ambient waters did not have significant influence on the diatom composition of the fouling film formed on stainless steel surface. However, earlier observations carried out at the same site and during the same period with fibreglass coupons revealed that the influence of the bloom of *Skeletonema* did alter the community structure. It was also observed that in the case of cupronickel (toxic surface) the community was influenced, though to a lesser extent, as compared to fibreglass. Such varying substratum differentiation clearly shows that the surface characteristics do influence the community structure of the diatom population. It is therefore necessary that to study both temporal and spatial variations in the microfilm diatom community structure and growth, similar exposure procedures as well as analytical methods are adopted to arrive at dependable results. Work in this direction is being pursued.

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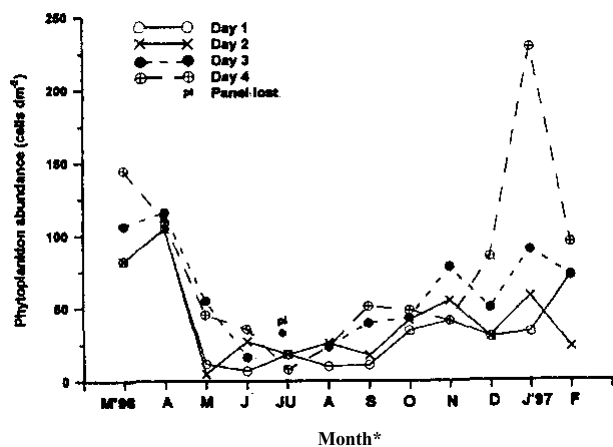


Fig. 2—Temporal variation in the fouling diatom cell abundance on stainless steel for different exposure periods (1 to 4 days).

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