Arquivos de Ciências do Mar

OCCURRENCE AND DOMINANCE OF AN INVASIVE TOXIN PRODUCING MARINE CYANOBACTERIA INTO MANGROVE ENVIRONMENT OF THE POTENGI RIVER ESTUARY, IN NATAL, RIO GRANDE DO NORTE STATE, BRAZIL

Ocorrência e dominância de uma cianobactéria marinha tóxica invasiva no ambiente de mangue do estuário Potengi em Natal, Rio Grande do Norte, Brasil

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RESUMO

Este trabalho visa registrar em uma análise geral da comunidade fitoplanctônica do estuário do rio Potengi em Natal/RN e a ocorrência e dominância das espécies invasivas do Mar (HAB) do grupo cianbacteérias, Nodularia *sp. O estuário do rio Potengi foi severamente impactado nos últimos anos, provocando uma queda acentuada na diversidade do fitoplâncton, aumento da clorofila e ocorrência e persistência de espécies* Nodularia *sp. Uma estação fixa foi escolhida durante todo o período do estudo, localizado próximo a Base Naval. O período entre 1990-1997 e outro entre 2000-2001, que representam o período antes e após a perturbação ambiental do ecossistema manguezal do rio Potengi. Os dados sobre temperatura, salinidade, nutrientes inorgânicos, grau de esgoto doméstico, desmatamento do mangue, índice de diversidade, dominância e concentrações da clorofila foram computados para análise estastística. Os resultados indicaram a redução significativa da diversidade do fitoplâncton e a extinção de espécies de diatomácea. A condição favorável do crescimento e o afloramento de espécies da cianobactéria tóxica* Nodularia *sp. e mortalidade dos peixes foram investigadas. Finalmente, o mecanismo do afloramento foi discutido.*

***Palavras-chaves**:* Nodularia *sp., espécie tóxica invasiva, Rio Potengi, Rio Grande do Norte.*

ABSTRACT

This paper describes a general account of phytoplankton and the occurrence and dominance of Harmful Algal Species (HAB) of a cyanobacterium, Nodularia *sp. to an environmentally impacted Potengi estuary of Natal, Rio Grande do Norte State of Brazil. It represents an analysis of decline of phytoplankton diversity, increased chlorophyll concentrations and the time and duration of the persistence of* Nodularia *sp. A fixed site was chosen near the Navy Base for the entire study period and the study was made in two different periods, one before (1990-1997) and one after (2000-2001) the period of environmental changes in the mangrove environment of the Potengi estuary to distinguish changes in phytoplankton diversity. The data on temperature, salinity, inorganic nutrients, sewage influx and the deforestration were computed for statistical analysis together with the data on phytoplankton species diversity and the levels of chlorophyll a concentrations. The results indicate the reduction in phytoplankton diversity with the extinction of an important diatom, Skeletonema costatum, the species highly required by the planktonic larvae for their growth. The growth condition of toxic bloom formation of* Nodularia *sp. and fish kill incidence hás been investigated. Finally, the triggering mechanism of bloom formation was discussed.*

***Key words**:* Nodularia *sp., toxic invasive species, Potengi River, Rio Grande do Norte State.*

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INTRODUCTION

Estuaries in general, represent areas of high plankton activity and high accumulation of trace metals. Besides, seasonal patterns in freshwater discharge are well known to influence both production and species composition in the marine environment (Ketchum, 1969). Potengi estuary is na ideal field laboratory for the study of phytoplankton dynamics in view of increasing environmental stress, which greatly altered the phytoplankton community structure and function and particularly between the years 1995-1999 (Costa, 1999).

Mangrove vegetation in Potengi estuary is situated on the northern margin of the river and had been studied intensively. Earlier planktonic studies were reported by Chellappa (1985) and Chellappa *et al*. (1996) and studies on the cultivation of *Mugil curema* by Araújo *et al*. (1980) show a species rich plankton environment and the high feasibility of *Mugil* cultivation in estuarine ponds. An intense urbanization starting in 1990 in the Potengi estuary resulted in the growth of tourism, increased the migrant population, sewage influx and consequently nutrients increase, heavy metal pollution and deforestation of mangrove vegetation. These anthropogenic impacts caused the irreversible changes in the phytoplankton community structure of Potengi estuary and were related to environmental impact (Costa, 1999; Macedo, 1996).

The second period of this decade (1995-1999) witnessed the large inputs of untreated sewage effluents, hospital refuse, and other biodegradable organic matter inputs, consequently increasing turbidity maximum (Macedo, 1996). Besides, the accentuated inputs of toxic heavy metal pollutants from the industrial zone and the accelerating pace of mangrove deforestation to favour shrimp farm culture (Figueiredo, 1997; Souza 1999) added another dimension to the pollution related problems of the Potengi River estuary.

The growth of *Nodularia* sp. has been reported in many parts of the world as an invasive toxin producing cyanobacterium (Bolch *et al*., 1999). The need of taxonomic revision of the genus *Nodularia* has been emphasised in view of their toxin producing ability (Komarek *et al*., 1993). These authors consider that various species of *Nodularia* are primarily of freshwater origin. Algal poisonings have long been associated with the ingestion of hepatotoxic *Nodularia spumigena* scums and blooms and nodularin is now assumed to be a primary causative factor for toxicity in the brackish water world over. The toxin has been identified from brackish waters of many parts of the Baltic Sea (Eriksson et al., 1988; Sivonen, 2002), coastal areas in New Zealand (Carmichael et. al., 1988), Australia (Jones *et al*., 1994), South Africa (Harding *et.al*., 1995), and the United Kingdom (Twist & Codd, 1997). The toxin is cyclic pentapeptide nodularin, a potent hepatotoxin and tumour-promoter, is commonly produced by environmental samples and laboratory strains of the filamentous cyanobacterium (blue–green alga), *Nodularia spumigena*.

A bloom of toxic cyanobacteria, *Nodularia* sp. and along with fish kill was observed in May 2000 during our routine monitoring of Potengi estuary. The local fish, *Mugil curema* is one of the stable diets of the population living on the riverside of the Natal city and therefore, caused much concern to riverine population. The *Nodularia* blooms of Potengi estuary bear many similarities to the *Nodularia baltica-spumigena* blooms reported during summer 1990 over an extensive area of a brackish lagoon located on the Southeastern coast of Uruguay as a consequence of eutrophication (Pérez *et al*., 1999). This brought many interesting points to make about the Potengi estuary in relation to cyanobacterial toxins and the piscicidal properties of the species of Cyanobacteria.

The aim of the present paper is intended to fulfil two main objectives. The first is to summarize the diversity pattern of phytoplankton during the unperturbed years (1990-97). The second is to provide the degree of changes in phytopalnkton diversity and chlorophyll biomass in relation to different environmental perturbations after perturbed period (2000-2001) and finally to understand the mechanism of bloom formation of *Nodularia* sp. and why they are episodic and unpredictable.

STUDY AREA

The Potengi River is a coastal plain estuary subjected to mixed semidiurnal tides and 70% of the water is exchanged with ocean water (Chellappa *et al*., 1996). It flows through the dry semi-arid region. The total catchment area is 3.180 Km^2 and formed from the fusion of three tributaries i.e. Rio Doce, Rio Jundiaí and Rio Potengi (Sérgio & Laporta, 1997). The principal factor regulating the hydrography of the Potengi estuary is the salinity gradient (vertically and horizontally) and linked to tidal inflow and large volumes of freshwater introduced during the rainy season (March to May). A fixed station at Naval Base (South margin) near Natal port was used for the collection site. The collection site was limited between 5°53'S and 35°05'W (Figure 1). The nature of Potengi Estuary, physico-chemical and biological details were extensively studied (Silva, 1990; Bezerra 1994; Chellappa *et al*., 1994; Macedo, 1996 & Costa, 1999) in relation to phytoplankton dynamics.

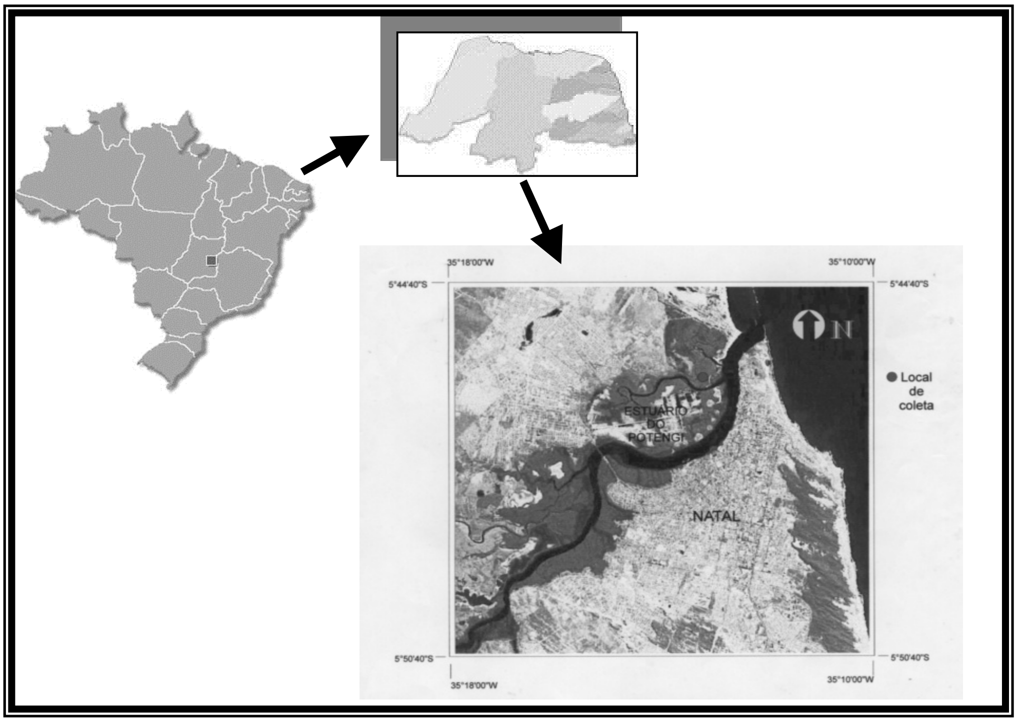

Figure 1- Location of the study site.

MATERIAL AND METHODS

Field samples were collected at monthly intervals during the years 1990-1997 and 2000-2001 (10 years data were computed) and only cumulative average data were used for the present study. All samples were collected from 600 meters off the river margin using fine net at a surface and from 4.0-meter depth. Samples were pooled and stored in a polyethylene tube to obtain an integrated sample. Diatom populations were found to be overwhelmingly dominant (almost 80-90%) throughout the study period excepting for a brief period in May 2000. Permanent mounting of diatom frustules was similar to previous studies (Chellappa *et al*., 1994).

Species diversity and other quantitative analysis were carried out by the methods of Ludwig & Reynolds (1988). Diversity of phytoplankton (H') was calculated by submitting the empirical data to the Shannon-Wiener index with a logarithm to the base 2. Equitability (E) was calculated from Pielou equation and the index of dominance from Simpson's index.

Phytoplankton species were identified some of them at species and others at genus level. Identification manuals for the respective taxa were used from Cupp (1943), Desikachary (1959), Hendey (1964), and Subrahmanian (1968). Estimations of chlorophyll *a*, corrected for degradation products, were made on ethanol extracts using the spectrophotometric readings.

For statistical analysis, all data were transformed logarithmically to ensure normal distributions. Minitab version 10 package was used for the statistical tests. The data were analysed statistically using ANOVA for environmental variables and phytoplankton abundance, diversity and dominance. Product-moment correlation was used to test and to relate various environmental characteristics to the abundance of cyanobacterial and diatom populations.

RESULTS

The mean surface water temperature ranged from 26.0 to 30.5°C for the study period. The low temperature occurred in august and high in May. Salinity ranged from 24.5% to 37.6% for the eleven years period. In general, annual low salinity occurred in months from April to June of every year and increased high during summer months (October to December). Table I presents the analysis of the ANOVA test results indicating the significant correlation between some of the environmental variables with biotic components.

One of the highly significant effects indicated from the ANOVA test is the positive correlation between low N:P ratio and the bloom formation of toxic cyanobacterium *Nodularia* sp. The occurrence of mass mortality of *Mugil curema* was recorded along the margins of Potengi estuary on the second week of bloom formation in May 2000.

Table I - Analysis of Variance (ANOVA) between salinity variation, Nitrate-nitrogen concentration and N: P ratio with biotic indices.

Independent variables	Dependent variables	F	P
Salinity	H –diversity of 1990-1997	73.62	0.0001
Salinity	H –diversity of 2000-2001	2.56	0.05
Salinity	Oxygen saturation	10.15	0.0049
Salinity	% Diatom population	16.94	0.0001
Salinity	TP	27.41	0.0001
Soluble reactive Silicate	%Diatom population	0.75	0.0162
Nitrate-nitrogen	% Population of Trichodesmium erythraeum	15.35	0.0013
NP ratio (low)	% of Nodularia	82.56	0.0001

Table II indicates the occurrence of common estuarine phytoplankton of Potengi River for the period of first period (1990-1997) and it is readily conceivable that the diatom population dominates the Potengi ecosystems of Rio Grande do Norte State. The number of phytoplankton taxa collected from Potengi estuary declined from 68 in 1990-97 to 30 during the second period of study (2000-2001). It is readily conceivable from Table II that the group Centrales represented by 22 species and the group Pennales with 23 species, a rich representation for a tropical water were reduced almost 50% indicating a sharp decline in phytoplankton diversity. Seasonal changes in phytoplankton from 1990 to 1995 were accompanied by shifts in community composition and finally sharp reduction in biodiversity and equitability in 2000-2001 and favouring the bloom formation of toxic cyanobacterium, *Nodularia* sp and the non-toxic *Trichodesmium erythraeum*. These two species of cyanobacteria are strictly marine and found to be invasive species in Potengi estuary even forming blooms in the meso-haline salinity gradient. Diatom population throughout the study period, excepting for the occasional presence of numerically reduced microflagellates, *Chroomonas minuta*, Cryptomonas and Rhodomonas spp., and persistent dinoflagellates, *Ceratium tripos, Peridinium* sp and *Gymnodinium* sp represented the majority of the phytoplankton. From 1990 till the end of 1997, we observed 45 Bacillariophyta (diatoms), 8 Cyanobacteria, 7 Dinoflagellates, 3 Chlorophytes, 2 Euglenophyteand 3 Phytoflagellates. The decline reached its maximum in the year 2001 representing 19 Bacillariophyta, 5 Cyanobacteria 3 Dinoflagellate, 2 each of Chlorophyta and Euglenophyta and 1 phytoflagellate. The total extinction of *Skletonema costatum* was perceptible.

Table II - Lists of phytoplankton flora of Potengi Estuary of Rio Grande do Norte, Brazil during 1990-97and 2000-2001. (Based on cumulative data of annual cycle)

List of species	1990-97	2000-01
BACILLARIOPHYTA		
A. CENTRALES		
Biddulphia mobiliensis Bailey	+	+
B. aurita (Lyngb.) Bréb.	+	+
Coscinodiscus centralis Ehr.	+	+
C. marginatus Ehr.	+	
C. radiatus Ehr.	+	
C. excentricus Ehr.	+	+
Chaetoceros boreale Bailey	+	
C. cerastoporum Ostenfeld	+	
C. debilis Cleve	+	
Cyclotella striata Kütz.	+	+
Ditylum brightwelli (Kütz.) Grun.	+	
Hemidiscus cuneformis Wallich	+	
Melosira moniliformis Muller	+	+
Planktoniella sol Wall	+	
Rhizosolenia delicatula Cleve	+	
R. fragilissima Bergen	+	
R. hebetata (Bailey) Grun.	+	
R. setigera Brightwell	+	+
R. stolterfothii Pergallo	+	+
Skeletonema costatum(Grev.)Cleve	+	
Thalassiosira gravida(Oster)Grun.	+	+
Triceratium favus Ehr.	+	
B: PENNALES		
Achnanthes longipes Ag.	+	
Amphiprora alata (Ehr.) Kütz.	+	
Amphora coffeaeformis Ehr.	+	+
Bacillaria paradoxa Cleve & Grun.	+	
Gyrosigma hipocampus (Ehr.) Hass.	+	+
Hantzschia marina (Roper) Grun. +		+
Mastogloia apiculata Smith	+	
Navicula acopularum Bréb.	+	
N. apta Hust.	+	
N. halophila (Grun.) Cleve	+	+
N. litoricola Hust.	+	
Nitzschia bilobata Wm Smith	+	+
N. closterium (Ehr.) Wm Smith	+	+
N. delicatissima Cleve	+	+
N. longissima (Bréb.) Ralfs	+	+
N. paradoxa (Gmelin) Grun.	+	+
Pleurosigma elongatum Wm Smith	+	
Surirella littoralis Hust.	+	+
S. ovalis Bréb.	+	+
Synedra gailloni (Bory.)Ehr.	+	
S. tabulata (Ag.) Kütz.	+	+
Thalassionema nitzschiodes Grun.	+	+
Thalassiothrix frauenfeldii Grun.	+	

CYANOPHYTA		
Agmenellum (*Merismopedia*)_sp.		+
Chroococcous sp.	+	
Anabaenopsis arnoldii Aptekarj	+	+
Nodularia sp. (*).	+	+
Sprirulina subsalsa	+	+
Lyngbya sp.	+	
Trichodesmium erythraeum Ehr.	+	+
Oscillatoria sp.	+	
DINOFLAGELLATES		
Ceratium tripos	+	+
C.furca	+	+
Peridinium sp.	+	+
Noctiluca sp.	+	
Gonyaulax sp.	+	
Polykeros sp.	+	
Dinophysis sp.	+	
CHLOROPHYTA		
Scenedesmus quadricauda Smith	+	
Chlamydomonas estuarina	+	+
Tetraselmis sp.	+	
EUGLENOPHYTA		
Euglena sp.	+	+
Lepocinalis sp	+	
PHYTOFLAGELLATES		
Chroomonas minuta	+	
Cryptomonas sp.	+	+
Rhodomonas sp.	+	
Quantitative data		
Number of Taxa	68	30
Species diversity	5.58	1.28
Equitability	3.35	0.22
Dominance	0.42	0.95

Quantitative analyses of phytoplankton of the Potengi estuary for the two periods were carried out on monthly samplings. The mean diversity, equitability and dominance indexes were computed from the results and presented in Table II. It reveals explicitly the dramatic reduction in the species diversity and the occurrence of bloom formation of *Nodularia* sp. and *Trichodesmium erythraeum* contributing significantly for the reduction of phytoplankton diversity.

The year 2000 witnessed a decline in the mean value of diversity index to 1.28, thereby demonstrating a tendency of developing signs of estuarine eutrophication essentially originated from the removal of mangrove vegetation and the loss of valuable sediment traps. As a consequence, inorganic nutrients accumulate and accentuate the eutrophication process. The diatom population dominated over other phytoplankton species during most of the study period, and was closely correlated to salinity variation and assimilation of soluble reactive silicate. The Cyanobacterial species such as *Anabaenopsis arnoldi, Trichodesmium erythraeum* and *Nodularia* sp. co-existed during the first period of study (1990-1997) suddenly altered the phytoplankton community structure in favour of them and were successful species in the second study period (2000-2001). This is basically because of increased nitrogen nutrient supply that enhanced invasive species like *Trichodesmium erythraeum* (P = 0.0001) initially and are outcompeted by *Nodularia* sp. through intraspecific compertion and its selective adaptation to low N:P ratio of the Potengi estuary (P = 0.0001). The estuarine ecosystem provides the advantage of being able to adapt physiologically under eutrophicated brackish water conditions and richly favouring dominance instead to that of diversity index.

Table III presents the product-moment correlation data between environmental variables and phytoplankton components. It can be readily conceivable from the analysis that nitrate-nitrogen concentration significantly correlated to the *Trichodesmium erythraeum* abundance and low N:P ratio to *Nodularia* sp. The high chlorophyll biomass observed during bloom formation readily served as dominance determinant of cyanobacteria than to diatom population.

Table III - Product-moment correlation (r) between environmental variables and percentage populations of Bacillariophyceae (Diatoms) and Cyanobacteria

(N = 108 Df =107; *= P<0.05 ** = P < 0.01; *** = P < 0.001)

Independent Variables	Populations of Cyanobacteria	Dependent Variables Population of Diatoms
pH	0.365	0.596*
Temperature	0.480	0.673**
Dissolved oxygen	0.501	0.522
Salinity	0.311	0.788***
Turbidity 0.045	0.580*	
Nitrate-Nitrogen	0.725** (% of Trichodesmium)	0.585*
Ammonia (Sewage source)	0.885***	0.853***
Species Diversity	0.219	0.820***
Species dominance	0.785** (% of Nodularia)	0,228
Chlorophyll biomass	0.802***	0.188
%Population of Diatoms	0.285	——

Figure 2 indicates the inverse correlation between the N:P ratio with species abundance of *Nodularia.* However, long-term monitoring indicates that total nitrogen content found to be linearly related to cyanobacterial abundance over time scale (Figure 3). The occurrence of common estuarine phytoplankton of Potengi River for the period of 1990-1997 and 2000-2001 showed an overall dominance of diatom population. The species abundance of diatoms found to be 82% in the first period (1990-1997), which was reduced to 64% during second period of study. A substantial increase in cyanobacterial population was observed between two periods indicating the eutrophication impact in Potengi estuary and favouring sporadic bloom formation of toxic cyanobacterium, *Nodularia* sp. and non-toxic cyanobacterium, *Trichodesmium erythraeum* (Figure 4).

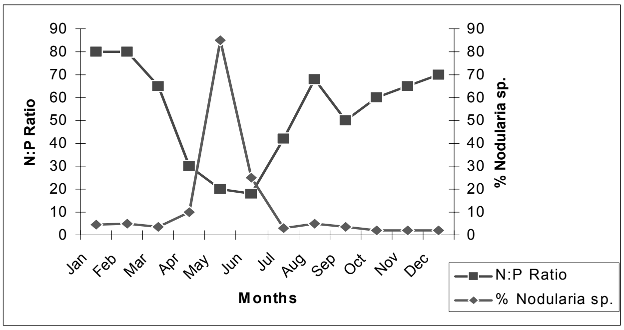

Figure 2 - Relationship between N:P and *Nodularia* sp. during May, 2000.

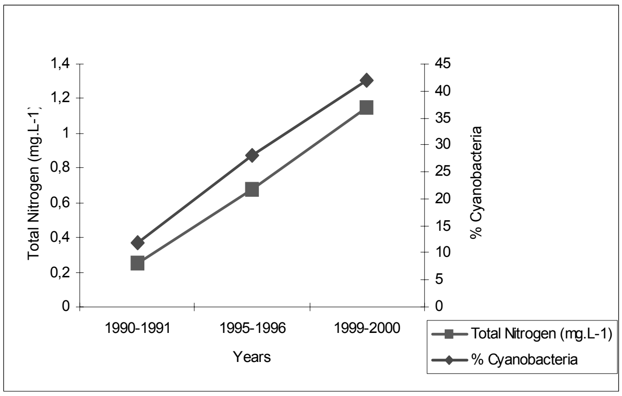

Figure 3 – Relationship between Total Nitrogen (TN) and Cyanobacteria abundance.

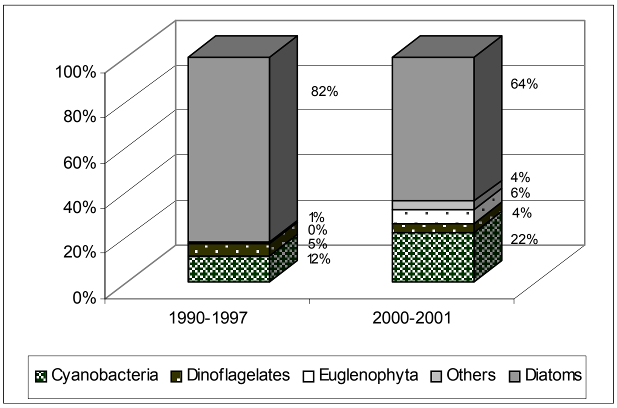

Figura 4 - Cumulative population representation of phytoplankton in Potengi estuary.

observed during study period showing the first period in which *Trichodesmium erythraeum* dominated, the second period by bloom formation *Nodularia* sp., the third period witnessed the dominance of *Odentella* (*Biddulphia* sp.) and finally by *Aulacoseira varians* (*Melosira varians*). The two species of cyanobacteria are strictly Marine in Rio Grande do Norte State invaded the Potengi estuary and produced occasional blooms in the meso-haline salinity gradients (Figure 5).

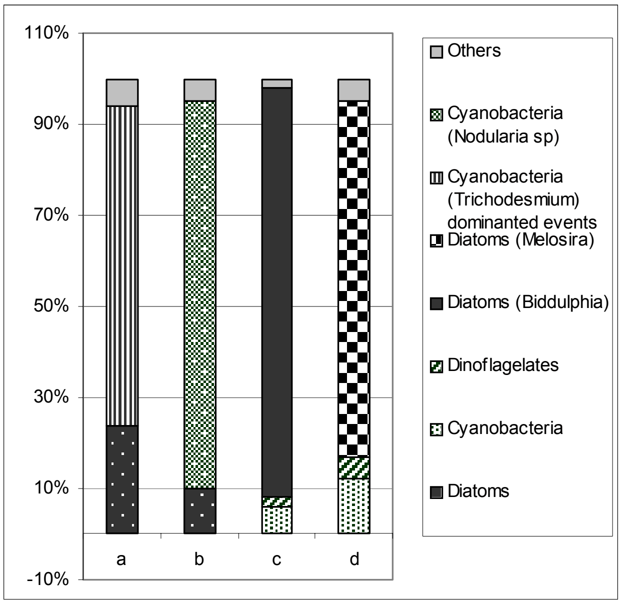

Figure 5 - Bloom dominated situation (a, b, c & d).

DISCUSSION

Mangroves are homogeneous open ecosystems that are extremely dynamic and therefore, the necessity of conservation is as important as their multiple use caused by population pressure. They support genetically diverse plant species in sheltered tropical coast lines and are important source of inorganic nutrients accumulation in the sediments. The fate of fine sediments in mangrove swamp is of primary importance for the growth, biomass production and primary productivity of phytoplankton (Wolanski *et al*., 1992). The ever-increasing environmental stresses are known to alter the structure and function of biotic communities and the impact eliminates valuable species in any given aquatic ecosystems (Harper, 1992). On the other hand, some of the aquatic organisms able to resist the constraints imposed by environmental impacts such as organic matter pollution, toxic metals accumulation and others (Clements, 1994). Some distinction has been made between these opposite effects in estuarine ecosystems to find out "sensitive" and "tolerant" organisms in relation to environmental impact.

The results of the phytoplankton community structure of Potengi estuary in the present study based on ten years of data were treated in relation to this established framework of mangrove ecosystems. The results of our study clearly indicate changes from phytoplankton diversity/dominance trend observed in the first part of the decade (1990-1997) to the dominance/diversity trend of the second part (2000-2001) of the study period, which corresponds to the natural and anthropogenic effects respectively. The species such as *Skeletonema costatum* and *Tetraselmis* sp. that once were dominant components of larval food in Potengi estuary is now absent and fail to reappear and are considered sensitive species. The bloom forming invasive species of Cyanobacteria such as *Trichodesmium erythraeum* and *Nodularia* sp. are registered as tolerant species for their selective utilization of excess of nitrogen and phosphorus nutrients emanated from the removal of mangrove vegetation.

Potengi estuary has been undergoing dramatic anthropogenic changes over the last ten years and more particularly at the stretch of 3 km around the naval base and port area of Natal from where the present study was undertaken. Environmental impacts were viewed from the three-dimensional stresses such as, influx of raw sewage of domestic and hospital origin (Chellappa, 1985); heavy metal contamination (Figueiredo, 1997) and the effect of deforestation of mangrove vegetation (Souza, 1999) and their impact on phytoplankton community structure and function (Chellappa *et al*., 2000). The results indicate reduced diversity of phytoplankton and increased chlorophyll biomass and are linked to disturbance theory in which deforestation provided more inorganic nutrients to the phytoplankton community of the Potengi estuary. The absence of the autotrophic competition from mangrove vegetation provides additional inorganic nutrients for phytoplankton growth and productivity, favouring specifically cyanobacterial species and our results are agree in part with the findings of diversity decline proposed for freshwater plankton (Vranosky, 1997).

The naturally occurring phytoplankton in lakes undergoes both qualitative and quantitative changes in response to anthropogenic impact (Anderson, 1993) The species diversity typically declines in response to increased nutrients (Schindler & Turner 1982; Chellappa 1990) and strongly selective environments (Reynolds *et al*., 1993). The findings of the present study based on one decade on species diversity and community similarity index showed a similar trend in the second phase (2000-2001) and were found to be consistent.

Trichodesmium erthraeum and *Nodularia* sp. represent non-nitrogen and nitrogen fixing cyanobacterial species of Potengi estuary and appeared inconsequential species during the first period of study (1990-1997). An intense bloom formation by *Nodularia* sp. and fish kill incidence appeared in May, 2000 as a consequence of environmental degradation, an episodic event occurred in the second period of study (2000-2001). The results of statistical analysis reveal that high nitrate-nitrogen availability in the euryhaline zone permitted the invasion of oceanic species, *Trichodesmium erythraeum* to the esturine region. The growth and bloom formation *Nodularia* sp. succeded subsequently and was positively correlated to low N:P ratio. It was reproted that *Nodularia spumigena* is one of the dominant organisms that perform nitrogen fixation and also produce a toxin, Nodularin in the open Baltic Sea. It is rarely found in the water mass in the winter-spring period, but is probably present most of the year in low quantities. *N. spumigena* is most abundant in July-August, and sometimes into September. It occurs predominantly in the open sea, where blooms can be found (Sivonen, 2000). The Baltic strains of *N. spumigena* are generally toxic and the blooms are patchy and episodic. There are some reports of human illness and fish, birds and mammal kills. The species produced a toxin called nodularin and easily enter the food chain. Typically 0.1-10 mg toxin per kg dry alga is produced during bloom formation and cause death of many organisms. We observed an extensive mortality of *Mugil curema* during the second week of bloom formation of *Nodularia* sp. in the Potengi esturay but toxic analyses have not been done.

Mangrove forests and their waterways have long been used as convenient sites for the disposal of sewage and waste water in tropical countries and the ability to trap allochthonous nutrients, transform and recycle the materials for the intense biological activities in estuaries (Robertson & Phillips, 1995). Mangrove vegetation in the Potengi estuary is composed by species of *Rhizophora* sp, *Avicennia* sp and *Laguncularia* sp and the early years estuarine ponds were constructed on the southern margins of Potengi estuary to rear mullet (*Mugil curema*) before the deforestation of mangrove vegetation (Araújo *et al*., 1980). The process of deforestation was accelerated in order to create more and more intensive Prawn farming on the northern margins of estuary and the removal of 37.73 ha observed in 1990-93 reached to 139.69 ha in 1996-97 (Souza, 1999). Consequent to this phytoplankton community structure altered creating more favourable environment for the blooms of Cyanobacterial species such as *Trichodesmium erythraeum* and *Nodularia* sp. Both species are potentially toxin-producing phytoplankton. We have based our arguments on phytoplankton diversity loss in the Potengi estuary to the considerable loss of mangroves over the last five years.

In conclusion, the present study based on the long-term observation on the structure and function of phytoplankton community of the Potengi estuary is distinguished those changes in the structure and composition of the phytoplankton which are direct, autogenic sequence of population growth to attain dynamic equilibrium of the Potengi estuary of 1990-1997. It is different from those that are driven by environmental impact such as eutrophication, deforestation and heavy metal pollution registered in the second study period (2000-2001). The high phytoplankton diversity was the result of an unperturbed environment and the higher species dominance of one or more species and to the high biomass are the results of perturbed situation found during 2000-2001 period.

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