

THE OCCURRENCE OF RED TIDES IN THE COASTAL WATERS OF RIO GRANDE DO NORTE STATE OF BRAZIL

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RESUMO

O presente trabalho descreve a ocorrência do fenômeno de maré vermelha não tóxica, da espécie cianobactéria, *Trichodesmium erythraeum* Ehr nas águas costeiras do Estado do Rio Grande do Norte, nordeste do Brazil durante os meses verão de 1979-2002. A floração da alga *Trichodesmium erythraeum* Ehr foi encontrado como um evento periódico durante os meses de verão dos anos alternativos de 1979 a 2002 na praia de Ponte Negra. O organismo presente em todas as florações registradas é a cianobactéria *Trichodesmium erythraeum* A praia escolhida previamente foi Ponta Negra que localizada no município de Natal (05^o 40' 00" S Latitude e 35^o 09'00" W Longitude) A floração da alga, *Trichodesmium erythraeum* Ehr. provocou um aumento exponencial de números de filamentos e biomassa da clorofila no início e estabilizou na segunda semana e degenerou na fase final. A floração persistiu entre uma a três semanas e sempre na época de Verão e desapareceu o resto do ano. As conclusões foram: o aumento de temperatura na superfície da água, a taxa de descarga da água do rio Potengi, alteração de salinidade, e aporte dos nutrientes inorgânicos foram fatores limitantes de estimular a floração de cianobactéria, *Trichodesmium erythraeum* na baía de Ponte Negra da cidade Natal/RN.

Palavras chave: Maré Vermelha do RGN, Baía de Ponta Negra, Nutrientes inorgânicos

ABSTRACT

This paper describes the periodical events of the occurrence of non-toxic and nuisance algal blooms of red tide caused by the cyanobacterium, *Trichodesmium erythraeum* Ehr. in the coastal waters of Rio Grande do Norte, northeast Brazil during the summer months of alternate years from 1979 to 2002. The red tide phenomena was recorded in the Ponte Negra coastal waters of Natal and the sampling stations were located within the National grid lines of 05^o 40' 00" S Latitude and 35^o 09'00" W Longitude. The effects of environmental and nutritional factors on the species population of *Trichodesmium erythraeum* Ehrenberg were examined from long-term studies. The filament numbers and chlorophyll biomass increased steadily from the period of initiation of the bloom, then stabilized and finally a declined dramatically. The bloom formation persisted from 1 to 3 weeks and always during summer months

and the rest of the year the species waned totally. Conclusions were drawn that surface water temperature, the river discharge rate, alteration in salinity and allochthonous input of nutrients had triggered the bloom formation of *Trichodesmium erythraeum* in Ponte Negra Bay of Natal/RN.

Key words: Red tide of Rio Grande do Norte, Ponta Negra Bay, Inorganic nutrients

INTRODUCTION

The interest in 'Red tide' research attracted many research centres world over because of the detriment that the causative phytoplankton provoked during bloom formation. Red tide organisms have a competitive advantage over dominant coastal diatoms (HARRISON, 1976; BONEY, 1975). Routine monitoring of water samples and examination of phytoplankton samples allow some predicting of times of the year when the blooms of toxic algae arise. Researchers have long been questioned of what triggers red tide phenomena and various replies emerged time and again. Coastal upwelling, and the consequent sudden surge of nutrients, rivers in flood, and domestic sewage effluents to coastal waters are likely to cause red tides (SMAYDA, 1990). Recently, the Swiss researchers (SCHERTENLEB; GUJER, 2000) argued various points on new strategies in urban water management and recorded that the dramatic increase in population density and half of untreated municipal refuse were coupled to deteriorate in public hygiene adding to water ecological problems. The inputs arising from such anthropogenic sources set chains of environmental alterations and sequential changes in biotic components. One of the consequences in the input of pollutants into coastal waters is the reduction of phytoplankton species diversity and the dominance of selective species through their preferential nutrient assimilation in coastal waters (CHELLAPPA, et. al. 1995). The intense urbanization of costal areas of Natal city is coupled with the growth of luxury beach hotels and the spread of ecotourism created esthetic concerns and hygienic problems. The effluents of untreated urban sewage entering directly into the coastal waters of the ocean add three basic nutrients, ammonia, particulate organic matter and total phosphorus in excess and permits species dominance characteristic of phytoplankton community ecology (CHELLAPPA, et. al. 1995). The presence of cyanobacterial toxins has been confirmed with an outbreak bloom of *Oscillatoria erythraea* (= *Trichodesmium erythraeum*) Ehrenberg 1830) in northwest Pacific coast of Mexico (OCHOA, et al. 1996). The periodic events of bloom formation of red tides of *Trichodesmium erythraeum* during summer months near Ponte Negra bay is one of the repeated events observed along the growth of beach hotels in Natal city but toxicity had never been detected during 20 years of monitoring in the coastal waters.

The aims of the present report are three folds; first, to characterize the temporal and spatial distribution of a non-toxic *Trichodesmium* species population of Phytoplankton of Northeast coast of Brazil. Secondly, to find out the possible mechanisms that influence the periodic occurrence and finally to elucidate the manner in which physical and the nutrient environment influence the blooms of *Trichodesmium erythraeum*.

MATERIAL AND METHODS

Samplings were done on the alternate days during the bloom formation and based on triplicate analysis for both water analysis and chlorophyll content. The physical and chemical parameters analyzed in the present study include pH, temperature, salinity and dissolved oxygen through potable multiparameter kits. The inorganic nutrients such as nitrate, ammonia, soluble reactive silicate and soluble reactive phosphorus were analyzed spectrophotometrically in accordance with the recommendation of Strickland and Parson (1972). Identification and quantification of phytoplankton samples were based on standard taxonomic monographs. For determination of chlorophyll *a* the water sample were filtered onto Whatman GF/C glass fiber filters. After extraction period the chlorophyll was determined spectrophotometrically (Shimadru Double beam UV-Vis spectrophotometer) Berger-Parker index was used to determine species dominance index.

RESULTS AND DISCUSSION

1979-1983 - field study demonstrated the occurrence of Red tide not only triggered by *Trichodesmium erithraeum* Ehr. But also by two dinoflagellates species, *Gymnodinium breve* and *Dinophysis acuminatum*. The El nino year of 1983, we observed the increased surface water temperature and salinity factor along with humic substances from the decomposition of a marine alga, *Sargassum sp.* in the coastal waters of Ponte Negra Bay that triggered the red tide dinoflagellate bloom. In 1989-1998 - field survey indicated that during mid-January to early February was concurrent with the peak river discharge from the adjacent Potengi River of Natal. It was also concurrent with coastal upwelling of nutrients and surface winds and moderate down-coast currents. The near-surface salinity distribution indicated a narrow decline in its concentrations of 0.5 to 8,0km (Tab. 1). The highest *Trichodesmium erythraeum* concentrations (>180.000 filaments l^{-1}) were found along the Ponte Negra transect coincident with the comparatively lower saline waters of the river Potengi. However, concentration of reduced filaments (230 filaments l^{-1}) were found outside the coastal area, beyond 5.0 Km. These observations suggest that the Ponte Negra Bay area of Natal, just downstream of the Potengi River, may act as an initiation site for bloom formation during the summer populations of *Trichodesmium erythraeum*. It was also observed the local fish population adapted to avoid the bloom area and neither the shellfish toxicity or mortality of fish observed during 10 years of study period. The bloom formation persisted as little as 8 days to a high of 23 days and always during the months of January or February (Tab. 1).

Coastal upwelling occurred moderately due to the South east winds of the region that largely offered favorable conditions just prior to the bloom formation (First week of January) The distribution of salinity was also much more irregular and showed narrow range of variation than broad range variation observed under downwelling conditions. The last two years (1996-1998) though, the freshwater flow from Potengi River increased from its normal low discharge ($620 m^3/S$) and filaments of *Trichodesmium erythraeum* appeared under relatively calm conditions. With the ensuing calm conditions and lack of transport out of Ponte Negra Bay, the dominant

species population remained in the Bay for 2-3 weeks and gradually caused local fish to move away from Ponte Negra Bay and its adjacent areas but again no shellfish or general toxicity had been recorded. Furthermore, the diatom populations emerged as successful phytoplankton components in post bloom period. The increase and decrease in soluble reactive silicate coincided with the abundance of diatom population.

Another field approach sought to examine the short-term changes during bloom period by conducting repeated large-scale daily surveys. The most notable features of these observations were the slight changes in near-surface salinity structure and the exponential increase of filaments numbers during first 8 days followed by gradual decline and waned finally after 15 or 20 days. The change in color was also observed from initial brick red to brownish red and finally colorless condition. Similarly, the *Trichodesmium erythraeum* filaments were generally confined to small patches offshore of Ponte Negra Bay when the blooms showed pronounced decline and shortened the bloom period.

Meteorological records obtained from the Government station emphasize that the local winds were primarily responsible for the initiation of *Trichodesmium erythraeum* and intensified with the upwelling of water. Data analysis suggested that the major sources of nutrients to the surface derived from inputs of Potengi river, Coastal Current, wind-induced upwelling; tidally driven wave-sill interaction and sewage effluent from Via Costeria beach hotels of Natal. Analysis also indicated that the occurrence and persistence of red tide blooms of *Trichodesmium erythraeum* in Ponte Negra beach was a result of inorganic nutrient enrichment. Silicate levels are relatively high but not the diatom population, which is normally dominant strangely, remained non-competitive during intense bloom formation (Tab. 2).

Table 1 – The recorded data on the occurrence of Red tide in the Ponte Negra Bay of Natal/RN

YEARS	SPECIES	DURATION	MONTHS	DISTANCE FROM THE COAST (km)
1979	<i>Trichodesmium erythraeum</i>	12 days	February	0,5 – 12
1981	<i>Gymnodinium breve</i>	16 days	June	4,0 – 26
	<i>Trichodesmium erythraeum</i>	14 days	February	0,3 – 4,0
1982	<i>Gymnodinium breve</i>	14 days	Januar	3,2 – 18
	<i>Dinophysis</i>	11 days	February	2,0 – 12
1983	<i>Trichodesmium erythraeum</i>	21 days	January	0,3 – 6,0
1989	<i>Trichodesmium erythraeum</i>	10 days	February	0,5 – 8,0
1990	<i>Trichodesmium erythraeum</i>	20 days	Januar	0,5 – 12
1991	<i>Trichodesmium erythraeum</i>	23 days	February	0,2 – 24
1992	<i>Trichodesmium erythraeum</i>	15 days	January	0,3 – 10
1994	<i>Trichodesmium erythraeum</i>	22 days	January	0,5 – 8,0
1997	<i>Trichodesmium erythraeum</i>	08 days	February	0,2 – 6,0
1998	<i>Trichodesmium erythraeum</i>	14 days	January	0,5 – 12
2002	<i>Trichodesmium erythraeum*</i>	10 days	March	0,2 – 10
(*invaded deeply into Potengi estuary)				

Table 2 – Physico-chemical and Chlorophyll biomass data during the time bloom formation of *Trichodesmium erythraeum* in Ponte Negra Bay of Natal/RN

YEARS	pH	TEMP. (°C)	SAL. (Psu)	NO ₃ -N (ml L ⁻¹)	NH ₄ -N (ml L ⁻¹)	NO ₂ -N (ml L ⁻¹)	SRS (ml L ⁻¹)	SRP (ml L ⁻¹)	DISSOLVED OXYGEN (ml L ⁻¹)	CHLOR. a (mg/m ³)
1979	8,20	27,5	34,8	0,882	0,145	0,020	4,26	0,25	6,65	85,5
1981	8,30	27,0	33,6	0,480	0,220	0,015	4,55	0,10	7,80	32,8
1982	8,15	28,5	34,2	0,620	0,320	0,030	3,62	0,15	6,20	54,5
1983	8,20	29,5	35,5	1,065	0,180	0,010	5,65	0,34	7,20	128,0
1989	8,40	28,5	34,8	1,250	0,138	0,024	5,22	0,56	6,80	184,0
1990	8,20	27,0	33,8	0,770	0,205	0,012	4,80	0,43	5,90	142,0
1991	8,25	28,8	34,2	0,920	0,337	0,028	5,98	0,32	6,40	120,0
1992	8,40	27,7	32,0	0,855	0,222	0,010	4,15	0,29	7,40	105,0
1994	8,30	29,0	33,6	0,664	...	...	...	0,18	6,80	92,8
1997	8,25	27,8	33,0	0,976	...	...	...	0,23	5,50	112,0
1998	8,42	28,4	33,5	0,920	0,440	...	5,15	0,34	6,40	122,0
2002	8,50	28,2	34,4	0,075	0,325	...	4,45	0,45	7,15	88,0

Red tides dinoflagellates showed competitive superiority over coastal diatoms during the times of upwelling and nutrient input because of their ability to take up and assimilate nitrate in dark and other properties (ANDERSON, 1997; HARRISON, 1976). Ecologically, there are three aspects common to all toxic red tides: Increase in population size, called initiation phase; suitable salinity, conducive temperature, right type of nutrient availability as growth factors; maintenance and transport of blooms by hydrological and meteorologic forces (STEIDINGER, 1975). The present study based on 24 years of coastal water monitoring revealed the periodic events of *Trichodesmium* blooms and the capacity to outcompete the other populations of phytoplankton in the coastal waters of Natal city during summer months was evident. The low nitrate and ammonia levels during bloom formation indicate that the nitrogen was already "stripped" from the surface waters by the earlier *Trichodesmium* bloom. The higher silicate concentrations did-not trigger the usually dominant coastal water diatoms under bloom formation and its reduction in post-bloom period and the consequent increase in diatom population showed conventional distribution of phytoplankton community. The competitive superiority is based on their capacity to assimilate selectively the nitrogenous nutrients and increase the chlorophyll biomass during bloom formation. The statistical analysis using Product-moment correlation showed significant positive correlation (Nitrate: N=60, df=59, P < 0.001; ammonia: N =60, df=59 P < 0.05), between nitrate, ammonia and *Trichodesmium* blooms.

CONCLUSION

This study registers the periodic events of non-toxic cyanobacterial bloom of *Trichodesmium erythraeum* in Ponte Negra Bay and its adjacent areas during summer months of alternate years. It enable us to document the distribution and abundance of non-toxic species its formation, break in rhythm and reappearance. Some basic factors such as, low wind speed of different amplitudes, moderate discharge rate from Potengi River, slight lowering of salinity, increased surface water temperature, coastal currents and upwelling and consequent nutrient outputs contribute the bloom formation. Furthermore, the importance of the anthropogenic nitrogenous nutrients emanating from beach hotels also emphasized why the bloom formation was sustained over two weeks period.

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