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Seasonal dynamics in the occurrence and abundance of *Pseudo-nitzschia* species in the Maheshkhali channel of the Bay of Bengal, Bangladesh

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Abstract

Occurrence and abundance of *Pseudo-nitzschia* spp. at the mouth of the Maheshkhali channel of the Bay of Bengal, Bangladesh were studied. Plankton and water samples were collected monthly from the sub-surface water during high tide at daytime from June 2000 to May 2001. Four species of *Pseudo-nitzschia*, namely *P. pungens*, *P. pseudodelicatissima*, *P. delicatissima* and *P. australis* were identified and among them the first three were most commonly encountered and they varied seasonally. *Pseudo-nitzschia delicatissima* was the dominant species during the autumn and winter months, whereas *P. pungens* was dominant during the summer and spring months. *Pseudo-nitzschia pseudodelicatissima* exhibited its highest abundance level during the summer. Surface water temperature, salinity, nitrate-nitrogen (NO_3-N) and phosphate-phosphorus (PO_4-P) were recorded and their relationship with the occurrence and abundance of *Pseudo-nitzschia* species were studied. At the mouth of the Maheshkhali channel, *Pseudo-nitzschia* cell density was highest in late autumn (November) when highest salinity (35‰) and PO_4-P (3.2 mg/l) concentrations and low temperature (23 °C) were recorded.

Key words : *Pseudo-nitzschia*, Maheshkhali channel, Bay of Bengal

Introduction

Toxic phytoplankton blooms are raising serious problems for aquaculture throughout the world and it is believed that these blooms have recently become more prevalent, posing a great threat to human health and marine life (Anderson 1989, Smayda 1992, Brusle 1995). There has been an increasing number of reports of domoic acid in various shellfish during the last few years, caused either by *Pseudo-nitzschia multiseries*, eg., in Japan (Kotaki *et al.* 1996) or *P. australis*, eg., in New Zealand (Rhodes *et al.* 1996).

The Maheshkhali channel of the Bay of Bengal, Bangladesh is rich in fish fauna and different traditional fisheries have developed around the channel. Mariculture operations in this area have received greater attention as they are considered to be very important for the national economy and export earnings. Nutrients from industrial wastes, agricultural lands, rural and urban sewages and from the adjacent shrimp farms have been carried directly to this channel, converting the area eutrophic, which induces the growth of many harmful algal species.

Several species of the diatom genus *Pseudo-nitzschia* have the ability to produce domoic acid, a potent neurotoxin that causes amnesic shellfish poisoning (ASP) (Subba Rao *et al.* 1988a). The threat of ASP has been taken seriously in areas of finfish and shellfish production, resulting into an intensified study of and search for toxic *Pseudo-nitzschia* species. Amnesic shellfish poisoning was reported for the first time at Prince Edward Island (Canada) in 1987, where consumption of contaminated mussels resulted in illness of over hundred people and death of a several (Wright *et al.* 1989) and temporarily devastated the molluscan shellfish aquaculture industry (Addison and Stewart 1989, Wessells *et al.* 1995). However, these recent events and the subsequent concern for seafood safety have led many researchers to assess this potential new threat of a toxin-producing diatom group in many coastal and estuarine regions around the world.

The monitoring programs of plankton are important because they may serve as early warning systems to detect the onset of potentially hazardous blooms, may suggest predictive factors for blooms and may provide information on possible new introductions. While very high abundances (10.55×10^6 cells/l in some cases) of *Pseudo-nitzschia* have been shown to occur in the coastal waters of the Bay of Bengal, but this species were not studied in our coastal waters previously. The aim of this work was to identify *Pseudo-nitzschia* species composition and to determine the effects of environmental factors on the occurrence and abundance of *Pseudo-nitzschia* spp. in a restricted area of the Maheshkhali channel of the Bay of Bengal.

Materials and methods

Monthly plankton samples were collected for 12 months from June 2000 to May 2001 during daytime at high tide using a 15 μm mesh plankton net at a fixed station near the mouth of the Maheshkhali channel of the Bay of Bengal, Cox's Bazar, Bangladesh. For qualitative plankton study, the plankton net was towed just under the water surface for one minute at a speed of approximately 1 m/s. From the net, the collected samples were drained in a polyethylene bottle and were preserved with 5% buffered formalin in sea water. For quantitative study, a known volume (100 litres) of sub-surface water was passed through a plankton net (mesh 15 μm) and the concentrate was collected from the bucket and preserved in 5% buffered formalin in sea water. The quantitative estimation of phytoplankton was done by Sedgewick-Rafter counting chamber (S-R cell) using an Olympus phase-contrast microscope.

Surface water temperature and salinity were determined on the spot using a Celsius thermometer and a hand refractometer, respectively. Nitrate-nitrogen (NO_3-N) and phosphate-phosphorus (PO_4-P) concentrations were measured in the laboratory by HACH kit (DR/2010, a direct reading spectrophotometer) using high range chemicals (NO_3-N by NitraVer 5 nitrate reagent powder pillows for 25 ml sample and PO_4-P by PhosVer 3 phosphate reagent powder pillows for 25 ml sample).

For species identification, a sample was gently shaken to resuspend all the materials and it was allowed to settle for one minute. Then three drops were removed from the middle of the sample and placed on a glass slide. A cover slip was placed on the slide and the entire slide was scanned for the species present. Observations were made using an Olympus phase-contrast microscope at 100 to 400 X with brightfield illumination. Taxonomic identification was based on Hasle and Fryxell (1995), and Hasle and Syvertsen (1996). Seasons were divided as follows: summer (June through August), autumn (September through November), winter (December through February) and spring (March through May).

Results

In the Maheshkhali channel, *Pseudo-nitzschia* spp. were found round the year. *Pseudo-nitzschia* cell density was lowest (1.5×10^5 cells/l) in July. The cell density began to increase in mid October, when PO_4-P concentration began to increase and temperature began to decrease, and reached to its highest level (105.5×10^5 cells/l) in November (late autumn). After that *Pseudo-nitzschia* cell density decreased gradually with the increase in temperature and decrease in PO_4-P concentration (Figs. 1 and 2).

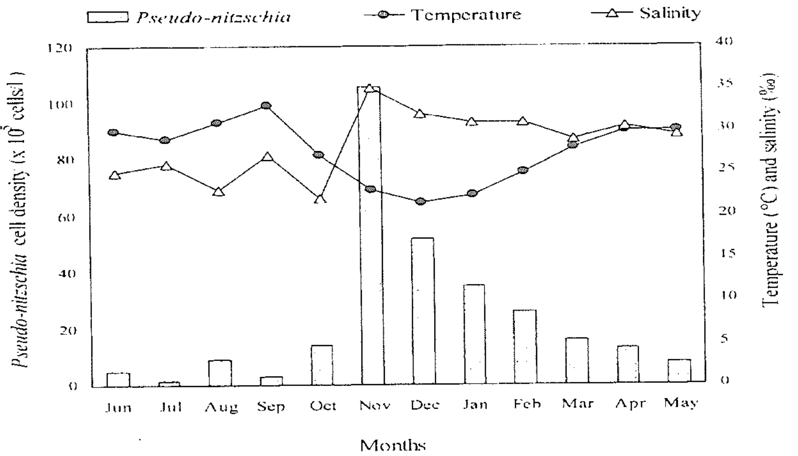

Fig. 1. Effects of temperature and salinity on the seasonal abundance of *Pseudo-nitzschia* species in the Maheshkhali channel.

During the study period, salinity fluctuated from 22 to 35‰ with the maximum recorded in November when the bloom of *Pseudo-nitzschia* was found to be at peak. The water temperature varied from 22 to 33 °C, the highest in September and the lowest in December (Fig. 1). pH values was in a narrow range of 7.4 to 8.5; and NO_3-N concentration in water ranged from 0.8 to 3.0 mg/l, the highest value in September and the lowest in July. During the study period, PO_4-P concentration fluctuated widely from 0.06 to 3.2 mg/l with the maximum (3.2 mg/l) in November when the cell density of *Pseudo-nitzschia* was highest (Fig. 2).

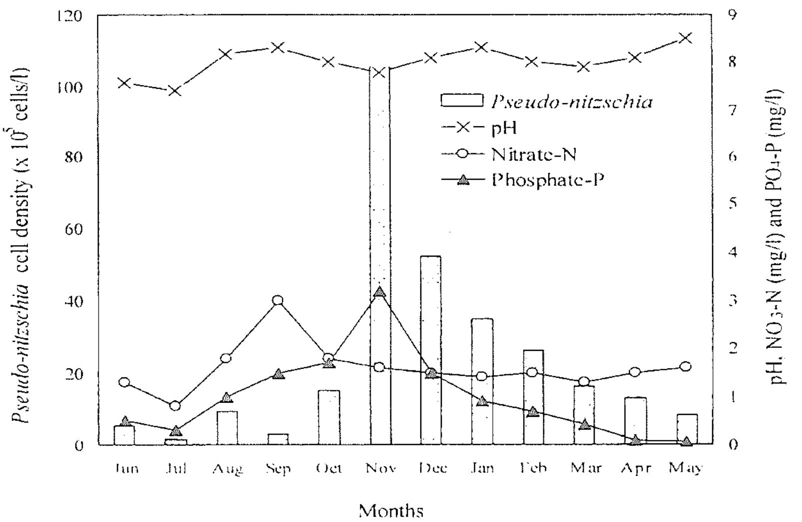

Fig. 2. Effects of pH, nitrate-nitrogen and phosphate-phosphorus concentration on the seasonal abundance of *Pseudo-nitzschia* species in the Maheshkhali channel.

The three most common *Pseudo-nitzschia* species were *P. delicatissima, P. pseudodelicatissima* and *P. pungens*, and all the species were found to vary seasonally. The remaining species, *P. australis* was less common, and it did not exhibit any apparent seasonal fluctuation. *Pseudo-nitzschia delicatissima* was the dominant species during the autumn and winter months, whereas *P. pungens* was dominant during the summer and spring. *Pseudo-nitzschia pseudodelicatissima* exhibited its highest abundance level during the summer (Fig. 3).

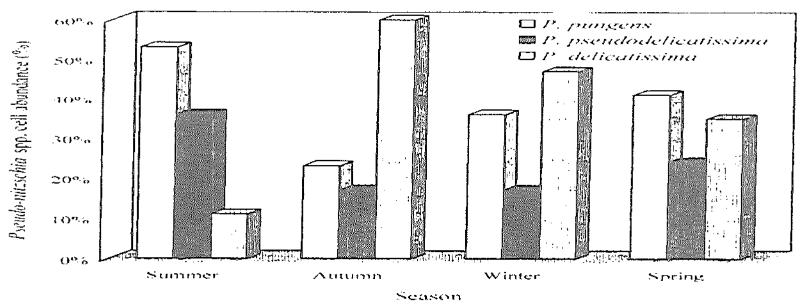

Fig. 3. Seasonal abundance values of the three most common *Pseudo-nitzschia* spp. at the mouth of the Maheshkhali channel during the study period.

Discussion

Pseudo-nitzschia spp. cell density was highest in the channel waters during the late autumn, with a secondary maximum in the winter months. The autumn maximum in *Pseudo-nitzschia* abundance may be associated with the low temperature (23 °C), higher salinity (35‰) and nutrient enrichment, particularly PO_4-P concentration (3.2 mg/l).

Lewis *et al.* (1993) reported that higher cell density at lower temperature might be an important factor affecting the dominance of *Nitzschia pungens* during late autumn in field sample. At the Maheshkhali channel, *Pseudo-nitzschia* cell density was highest when salinity reached 35‰, agreeing with the findings of Sayce and Horner (1996), who reported that *Pseudo-nitzschia* cell abundance increased in Willapa Bay when salinity reached 29 psu.

During the present study, a heavy rainfall occurred in mid October which carried nutrients from agricultural lands, street washings, rural and urban sewages, domestic organic wastes and discharged directly to the channel. Furthermore, there are many shrimp farms established adjacent to the channel. Due to heavy rainfall most of the shrimp farms were overflowed or out flowed the excess water through outlet which carried nutrient-rich water of the shrimp farms directly to the channel and converted the estuarine water to eutrophic conditions i.e. increased phosphate-phosphorus concentrations into the channel in November. These increased nutrients might have created favourable conditions for the outbreak of the *Pseudo-nitzschia* blooms in November. Similar results was found by Smith (1993), who reported that *Pseudo-nitzschia* bloom developed in unusually rainy autumn because rain water carried nutrients, via river run-off which driven the blooms. Similar increases in *Pseudo-nitzschia* abundance have been observed in Cardigan river, Prince Edward Island when nutrient inputs increased due to run-off from a rainfall events (Smith *et al.* 1990a). Dortch *et al.* (1997) observed spring blooms of *Pseudo-nitzschia* spp. in Cardigan Bay, Prince Edward Island, as well as in northern Gulf of Mexico, which was associated with peaks in out flow from the Mississippi river.

In the Maheshkhali channel, an inverse relationship was observed between temperature and *Pseudo-nitzschia* cell abundance. During the summer and spring months when temperature was relatively high, *Pseudo-nitzschia* cell density was found to be low and relatively high cell density was observed in late autumn and winter months when temperature was found to be low. So, it can be assumed that temperature may be an important factor for the onset of *Pseudo-nitzschia* cell abundance at the Maheshkhali channel. Subba Rao *et al.* (1988b) observed a bloom of *Pseudo-nitzschia pungens* f. *multiseries* in late autumn and early winter in eastern Prince Edward Island.

Four species of *Pseudo-nitzschia* have been confirmed to be present in the coastal waters of the Maheshkhali channel: *P. pseudodelicatissima, P. delicatissima, P. australis* and *P. pungens.* These four species have been reported to have the ability of producing domoic acid in varying degrees and frequencies elsewhere (Martin *et al.* 1990, Smith *et al.* 1990b, Buck *et al.* 1992, Rhodes *et al.* 1996). However, no species from the coastal waters of Bangladesh have yet been tested for domoic acid production and there is no report of fish and other animal mortality due to ASP or DAP production to date.

The number of stations occupied and frequency of sampling during the study were limited and these were due to lack of facilities. If the frequency of sampling (preferably weekly) and number of stations are more, then we can get better information about the occurrence and abundance of *Pseudo-nitzschia* species, as well as other noxious algae and their relationship with the environmental factors. More comprehensive field studies, however, are urgently needed for better understanding of different noxious algal population in coastal waters of Bangladesh.

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