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Differential Response of Marine Diatoms to Trace Metals

Mahasin G. Tadros, Peter Mbuthia, and Woodrow Smith

Department of Biology, Alabama A&M University, P.O. Box 13, Normal, Alabama 35762, USA

Phytoplankton constitutes the base of aquatic food chains and is thus important to aquatic communities. Trace metal micro-nutrients play a significant role in the ecology of phytoplankton (Ryther and Guillard 1959). Trace metals are waste products of many industrial processes and in many places are released into the ocean. Therefore, they are important causes of environmental pollution. A number of studies indicate that trace metals are toxic to phytoplankton (Genter et al. 1987; Rachlin et al. 1983; Rao and Subramanian 1982; Whitton 1979.)

Phytoplankton species vary in their tolerance to trace metals (Brand et al. 1986; Stratton 1987). Diatoms in particular are able to detoxify trace metals by the excretion of organic compounds (Butler et al. 1980). In a previous study, Tadros (1987) reported that diatoms collected from different sites in the Gulf of Mexico varied in their physiological characteristics.

We examined the effect of copper, nickel and zinc on ten marine diatoms to determine whether they differed in their responses to these metals.

MATERIALS AND METHODS

The ten species of diatoms were collected and isolated from the intertidal region of the Gulf of Mexico (Tadros 1987). The strains were: Amphora coffeiformis, Cylindrotheca sp., Amphiprora hyalina, Chaetoceros muelleri, Cyclotella cryptica, Navicula acceptata, Navicula saprophila, Nitzschia dissipata, Nitzschia inconspicua and Nitzschia pusilla. All species were maintained and tested in Guillard's f/2 medium (McLachlan 1973) enriched with artificial sea-salt mix (Instant Ocean) and with trace elements. Salinity of the medium was 20 parts per thousand and the pH ranged between 8 and 8.2. All diatom species were axenic. For each experiment the concentration of each metal was varied. The metals tested were copper (as $CuCl_2 .2H_2O$), nickel (as $NiCl_2 . 6H_2O$) and zinc (as $ZnCl_2$).

Send reprint requests to M.G. Tadros at the above address.

A coarse screening experiment was conducted to obtain approximate concentrations for metal toxicity thresholds. All glassware was cleaned with acid and sterilized. Test cultures were treated with metals to be assayed in concentrations of 0.0 (control), 1, 5, 10 and 15 M^{-8}. The assay was carried out in tubes containing 25ml medium. All assays were conducted in triplicate test tubes. Each test tube was inoculated from exponential growing cells at an initial density of approximately 4 X 10^3 cells per millilitre. All cultures were incubated for 96h at a temperature of 30±2°C under cool-white light producing 100 uE m^{-2} s^{-1} irradiation in continuous cycle. During the incubation period, the cultures were shaken once daily. The growth was measured after 96h spectrophotometrically at 525 nm on a Fisher electrophotometer. All tests were run in three replicates. The results were averaged.

RESULTS AND DISCUSSION

Results of the assays are presented in Figures 1, 2 and 3. All data are expressed as percentages of the control levels.

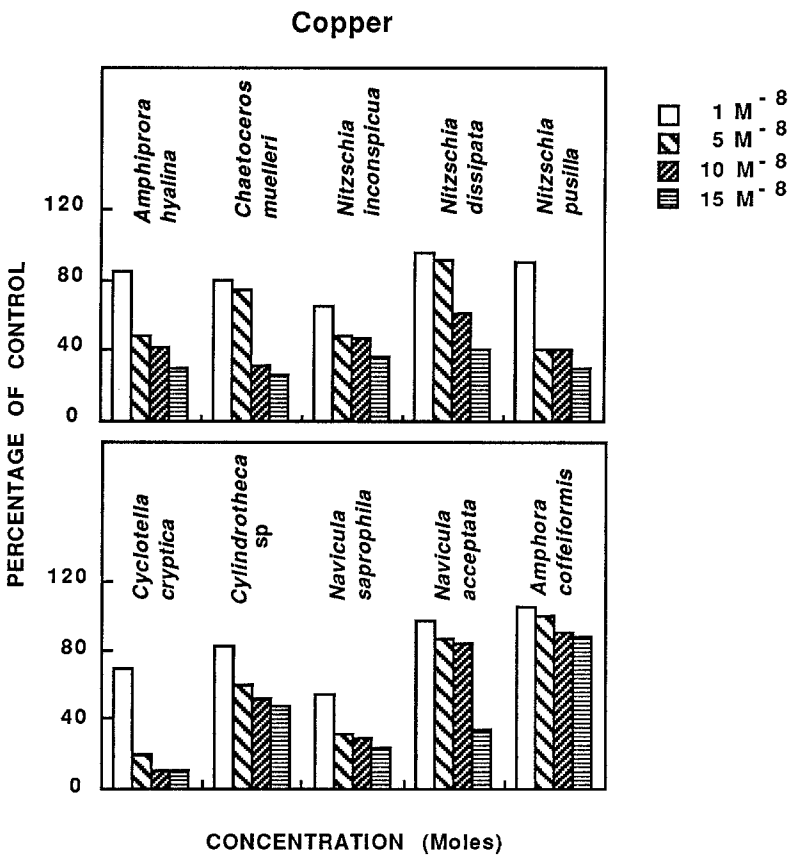

Figure 1: Effect of copper on growth of marine diatoms, expressed as a percentage of the control. Standard deviation did not exceed 2%.

Copper: in medium treated with 1 M^{-8} (Figure 1) copper, Nitzschia dissipata, Nitzschia pusilla, Navicula acceptata and Amphora coffeiformis were not inhibited, but all other species were. Increasing the concentration of copper led to varying degrees of inhibition in all species. Cyclotella cryptica was the most sensitive species to copper, whereas Amphora coffeiformis was the most tolerant.

Nickel: at a concentration of 1 M^{-8} (Figure 2) Navicula acceptata and Amphora coffeiformis were not inhibited, but all other species were. Cyclotella cryptica, Cylindrotheca sp. and Navicula saprophila were the most sensitive species to nickel. Increasing nickel concentrations inhibited Navicula acceptata, while Amphora coffeiformis tolerated the higher concentrations.

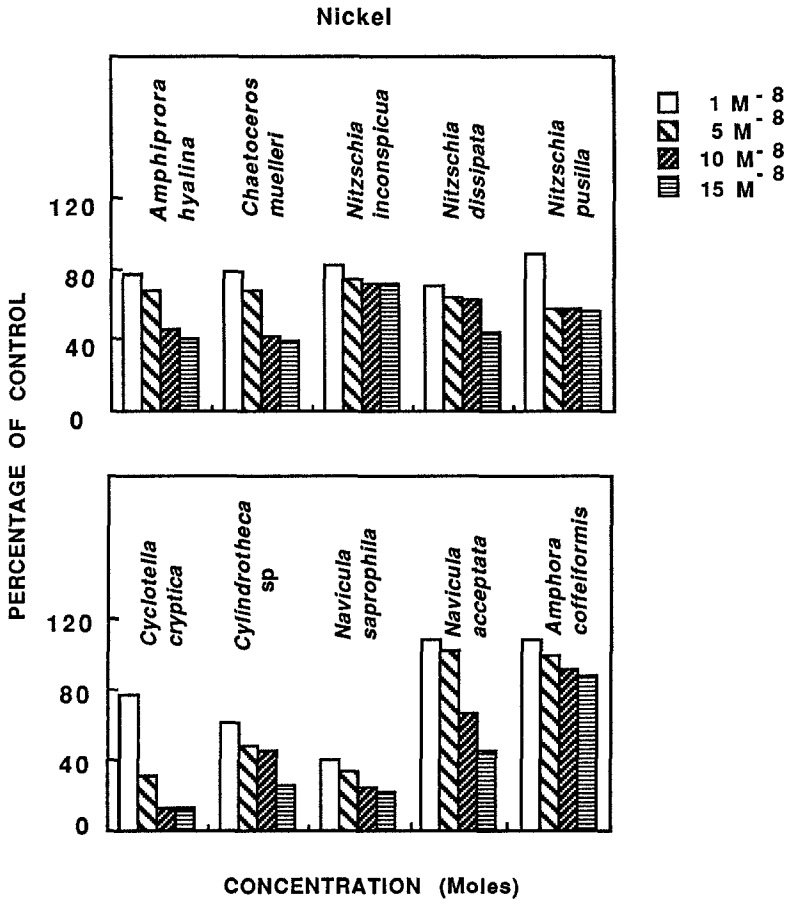

Figure 2: Effect of nickel on growth of marine diatoms, expressed as a percentage of the control. Standard deviation did not exceed 2%.

Zinc: all species responded positively to 1 M^{-8} (Figure 3)

concentrations. Increasing concentrations of zinc, however, led to some inhibition of some species. Cyclotella cryptica was very sensitive to increasing zinc concentration, when compared to the rest of the species. Amphora coffeiformis tolerated all concentrations of zinc more than the other species.

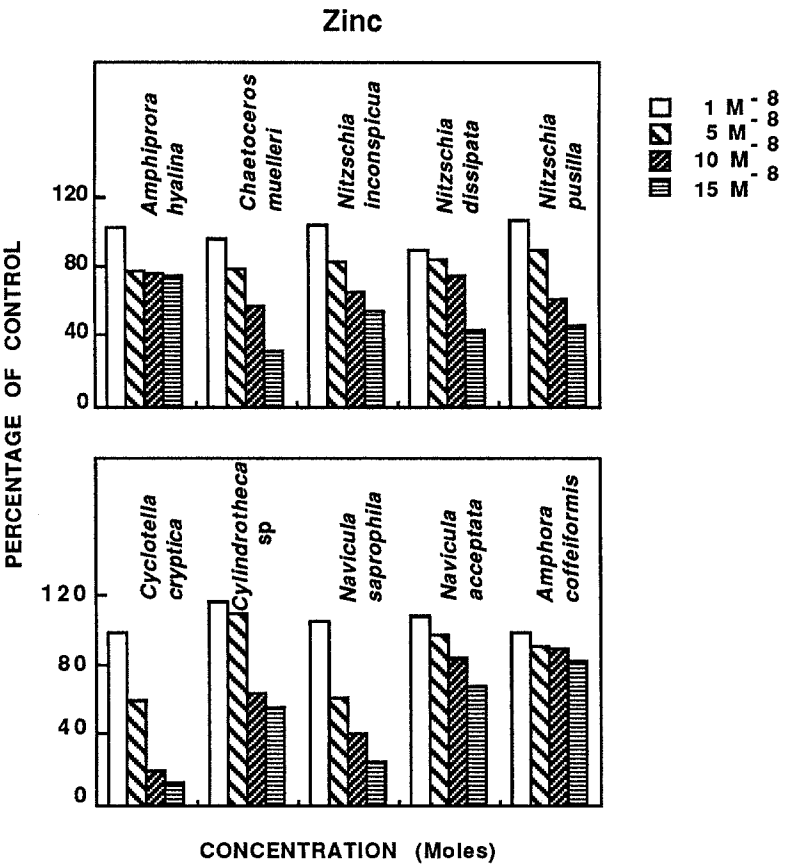

Figure 3: Effect of zinc on growth of marine diatoms, expressed as a percentage of the control. Standard deviation did not exceed 2%.

The data indicated that the addition of copper, nickel or zinc to algal culture media can promote or inhibit the growth of the species. Variations existed between species in their response to the different trace metals. Zinc was the least toxic metal to Navicula incerta when compared to other metals (Rachlin et al. 1983). Copper was more toxic than zinc to planktonic ciliates (Stoecker et al. 1986). In another study (Rao and Subramanian 1982), Cyclotella meneghiniana was reported to be more sensitive to copper than zinc, while Nitzschia palea and Navicula confervacea were sensitive only to copper rather than to zinc. This is in agreement with our data as far as Nitzschia and Navicula varieties are concerned.

Our results showed that some species were tolerant to high concentrations of the three metals tested, as in the case of Navicula acceptata and Amphora coffeiformis. Tolerance of diatoms to trace metals has been reported (Thomas and Robinson 1987; Brand et al. 1986; Rao et al. 1980; Steeman-Nielsen and Wiem-Anderson 1971). In most cases such tolerance has been attributed to detoxification of metals which most likely involved the production of a metal binding agent. (Butler et al. 1980; Fogg and Westlake 1955). Differential sensitivity of the diatom species to the elements could induce species shifts within communities (Brand et al. 1986; Genter et al. 1987).

The data presented suggest that when bioassays are conducted to determine the effect of trace metals on diatom species, one should consider several species to obtain realistic data (Holister and Walsh 1973).

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