The Effect of Cadmium on Population Growth of the Green Alga *Scenedesmus quadracauda*

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Increasing industrial utilization has led to increasing levels of bioavailable cadmium (Cd) in the environment (Kopp and Kroner, 1969; Lucas et al., 1970; Uthe and Bligh, 1971). The United States Department of Health, Education and Welfare has set the acceptable upper limit of Cd in drinking water at 10 ppb. This level is exceeded in many municipal water supplies (Flick et al., 1969, Kopp and Kroner, 1969; Durum and Hem, 1972; Cheremisinoff and Habib, 1972) and natural water bodies (Taylor, 1971; Kobayashi, 1972; Piley and Taylor, 1972; Abdullah et al., 1971; Ritchie, 1973). Moreover, Yamagata and Shigematsu (1970) state that even if Cd is undetectable in the water phase, large concentrations may be found in suspended particulate matter and sediment.

Little information is available regarding the effect of Cd^{2+} on aquatic plants, particularly at the primary producer level. Cadmium has been found to accumulate in the Southern Naiad Najas quadulepensis (Cearly and Coleman, 1973). At a concentration of 7 ppb, exposure for 21 days resulted in accumulation of 7.1 ppm (μg Cd/g ashed tissue). At concentrations of 90 and 830 ppb, tissue concentrations of 4357 and 5429 ppm were attained. Witkamp et. al. (1971) reported that ^{115}Cd was rapidly sorbed (5-15 min) by algae (species not specified) and that the concentration factor for ^{115}Cd was approximately 1000.

Herein, we report preliminary observations on the toxicity of cadmium to the freshwater alga Scenedesmus quadracauda.

Materials and Methods

The green alga Scenedesmus quadracauda was selected for study because of its sensitivity to toxic substances (Tiffany, 1962) and its ubiquitous distribution (Prescott, 1962). Stock cultures, from cells originally cultured in soil-water medium, were prepared in 500 ml Erlenmeyer flasks containing 250 ml of Bold's Basal Medium (BBM) prepared as follows: each 100 ml of stock medium contained 2.5 g $NaNO_3$,

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0.25 g $CaCl_2$ $2H_2O$, 0.75 g K_2HPO_4 1.75 g KH_2PO_4, 0.37 g $MgSO_4$ and 0.25 g NaCl. For each 100 ml of culture medium, 6 ml of stock BBM was added to 94 ml of distilled, dionized water. All cultures were kept in a greenhouse under 24 hour flourescent illumination. The temperature of the greenhouse, ranged from 21-30°C over the experimental period. The stock cultures were allowed to develop for approximately two weeks before experimentation. Concentrations of 0.061, 0.610, 6.10 and 6.0 ppb Cd^{2+} were obtained by addition of 6 ml of BBM to 93 ml of distilled deionized water plus 1.0 ml of serially diluted cadmium chloride (ACS, reagent grade) stock solution. One hundred ml each of the above concentrations and the control were innoculated with an equivalent number of algal cells harvested (by centrifugation) from 5 ml of stock culture. Cell populations were examined 2, 5, 6, 8, 9, 13, 14 and 16 days post-innoculation. The counting proceedure, essentially that of Rice (1956), consisted of shaking the culture vessels to randomize the cell suspension and pipetting sufficient volume to fill the chambers of an Improved Double Neubauer Hemocytometer. An average of the cell counts (cells/mm^3) in two chambers was used as an estimate of the cell population.

Results and Discussion

The time dependent population growth profile is illustrated in Table 1. The abrupt decrease in the cell counts on day 6 reflects a sudden drop in temperature from 28°C on day 5 to 21°C on day 6. Nonetheless, the general order of cell counts remained essentially the same (Table 1). Student's t-test was employed to establish the significance of the differences in mean population size at the different Cd levels and between a given Cd level and its control. There appears to be no significant effect of Cd on mean population size below the level of 6.10 ppb ($P = < .05$). However, statistically significant differences were observed between control media and progressive increases in Cd^{2+} concentrations. These data are illustrated in Figure 1. They indicate that concentrations of Cd^{2+} as low as 6.1 ppb have a significant inhibitory effect on the growth of the alga *Scenedesmus quadracauda* and that concentrations of 61 ppb and higher severely inhibit growth.

Although speculation about the mechanism(s) of growth retardation is premature, the possibility of essential enzyme inhibition must be considered since Vogels and van der Drift (1966) reported that Cd^{2+} (*in vitro*) inhibited allantoinases isolated from the bacteria *Pseudomonas flourescens* and *P. acidovoraus*

TABLE 1

The time dependent cell population growth of *Scenedesmus quadracauda* in increasing Cd^{2+} concentrations.

Cd^{2+} concentration (ppb)	Cells/mm^3 Days Post Administration 2	5	6	8	9	13	14	16
610	5	0	10	10	5	15	10	15
61	5	0	5	20	5	5	5	20
6.1	15	40	20	25	50	15	10	10
0.61	0	45	25	20	70	80	45	20
0.061	5	60	25	35	70	90	45	35
0.00	10	50	35	50	40	60	80	60

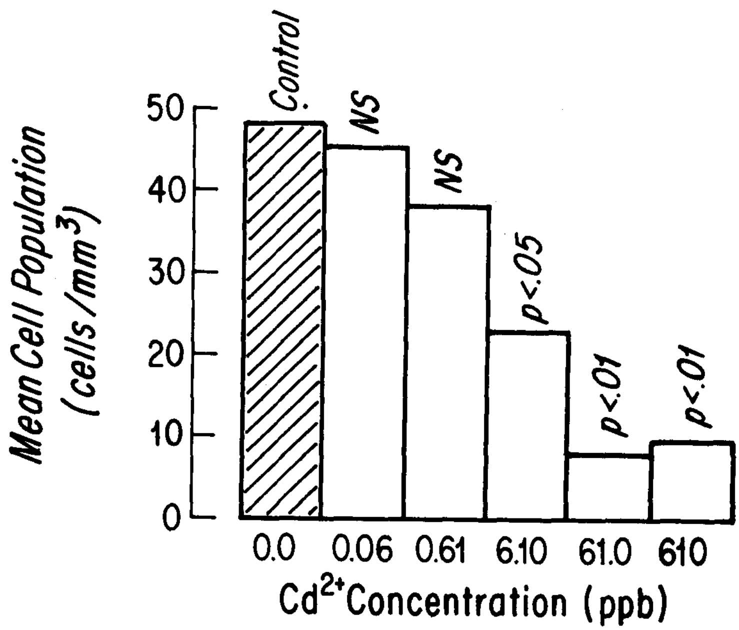

Figure 1 Statistical significance of increasing Cd^{2+} concentration on the time dependent mean population for the alga *Scenedesmus quadracauda*

and the yeasts Streptococcus allantoicus and Arthrobacter allantoicus.

In terms of the general health of the aquatic community, the 10 ppb guideline established as "safe" for human consumption appears to be in need of a downward revision if all members of the aquatic community are to prosper.

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