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SYNERGISTIC EFFECTS OF PHOSPHORUS NUTRIENT STATUS AND LEAD EXPOSURE IN THREE ALGAE

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There is some indication in the literature that nutrient status may mitigate toxicity effects of heavy metals in algae. Monahan (1973) demonstrated that cells of the green alga *Hormotila* which were phosphate sufficient were less susceptible to lead toxicity than cells which had no phosphate. Similarly, our laboratory (Sicko-Goad and Stoermer, 1979) reported that lead may be incorporated into polyphosphate bodies thereby reducing the amount of lead available to intracellular sites. We designed a series of experiments to determine (1) the effects of lead exposure on certain algae and (2) the effects of phosphorus nutrient status on lead toxicity.

Three algae were selected for study: *Cyclotella* aff. *meneghiniana* (Bacillariophyceae), *Scenedesmus quadricauda* (Chlorophyceae), and *Plectonema boryanum* (Cyanophyceae). The algae were grown to logarithmic phase at 20°C on a 12/12 light-dark cycle in either WC or modified Fitzgerald's medium. Both *Scenedesmus* and *Cyclotella* were initially grown separately in WC medium in Corning tissue culture flasks. However, for the experiment, beginning with transfer to PO_4-free medium before luxury uptake, the two were combined and treated as one culture for ease of handling. *Plectonema* was maintained separately throughout. Samples were treated as previously described (Sicko-Goad and Lazinsky, 1982).

Data for *Plectonema* (Table 1) suggest that metal exposure of P sufficient cells for 3 days results in more morphological changes than brief exposure to the metal under P sufficient or uptake conditions with withdrawal of the metal. Polyphosphate bodies are larger and occupy a much larger volume. Constant exposure to the metal also results in a significant decrease in polyhedral (carboxysome) relative volume (V_V) and number per volume (N_V).

Exposure of *Scenedesmus* to lead during phosphate uptake also resulted in a number of significant morphological changes during polyphosphate degradation. In uptake treatments, both with and without added lead, there were significant reductions in polyphosphate V_V and N_V. Autophagic vacuole V_V increased to approximately 4% in lead treated cells after 4 days. This increase to 2% in control cells was not as dramatic. The increase in autophagic vacuoles is negatively correlated to the reduction in lysosomes.

No significant morphological changes were observed in *Cyclotella* in the quantitative data except for a transient (2 day) decrease in storage in this diatom.

The data suggest that in terms of Pb sensitivity, the three algae tested may be rated as follows: *Plectonema* > *Scenedesmus* > *Cyclotella*. Phosphate sufficient cells are less susceptible to lead exposure.

Monahan, T. J. 1973. Lead inhibition of *Hormotila blennista* (Chlorophyceae, Chlorococcales). *Phycologia*, 12, 247.

Sicko-Goad, L. and D. Lazinsky. 1982. Polyphosphate body formation and degradation in *Plectonema boryanum* (Cyanophyceae). *Micron*, 13, 459-460.

Sicko-Goad, L. and E. F. Stoermer. 1979. A morphometric study of lead and copper effects on *Diatoma tenue* var. *elongatum* (Bacillariophyta). *J. Phycol.*, 15, 316-321.

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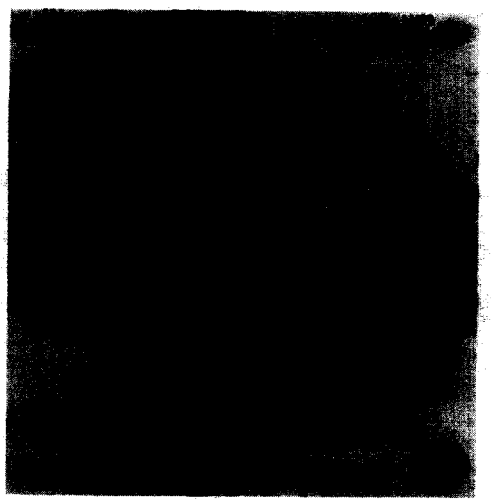
TABLE 1 Quantitative Changes in *Plectonema* with Phosphate and Lead Treatments. V_V = Relative Volume, N_V = Number/Volume. Results are the Mean + 1 S.E.

Treatment	Poly P V_V	Poly P N_V	Polyhed. V_V	Polyhed. N_V	I.T. Space† N_V	Other V_V
P sufficient	0.45 (0.11)	157 (34)	2.30 (0.44)	2.83 (0.49)	4.91 (0.70)	92.34 (0.73)
P sufficient + Pb**	1.97 (0.30)	39 (6)	1.37 (0.24)	0.78 (0.17)	2.00 (0.50)	94.65 (0.70)
P uptake*	0.51 (0.11)	80 (15)	2.44 (0.45)	2.18 (0.39)	9.37 (1.07)	87.68 (1.13)
P uptake + Pb*	0.37 (0.09)	63 (13)	1.91 (0.38)	3.81 (0.87)	7.02 (0.84)	90.70 (0.88)

*2 days post transfer to P-free medium.
**3 days continuous metal exposure.
†Intrathylakoidal space.



Figs. 1-2. *Scenedesmus quadricauda*. Autophagic-like vacuole areas (A), lysosome-like organelles (L), polyphosphate (P), starch (S).

Fig. 1. P uptake cell three hours. Note polyphosphate in vacuoles and lysosome-like organelles. Starch is also apparent.

Fig. 2. P + Pb uptake treatment. Cell sampled 4 days after transfer to P deficient medium. Note large autophagic-like vacuole areas. Starch grains are numerous and scattered throughout the cell.