Micron and Microscopica Acta, Vol.14, No.3, pp.257-258, 1983.
Printed in Great Britain

0739-6260/83 $3.00 + 0.00

ULTRASTRUCTURAL MODIFICATION OF THREE BLUE-GREEN ALGAE FOLLOWING HEAVY METAL EXPOSURE

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Algal responses to heavy metal exposure may vary with the species and similarly, various metals may cause a differing response within a species. In blue-green algae metals can be accumulated, and reduction in growth rates and inhibition of phosphate uptake are common effects that have been attributed to heavy metal treatment. More specifically, heavy metals can induce drastic effects at the ultrastructural level such as changes in the volume and number of cell-sustaining inclusions. The present study was conducted to determine the effects of various heavy metals on the ultrastructure of three blue-green algae and thus to evaluate their susceptibility to a particular heavy metal.

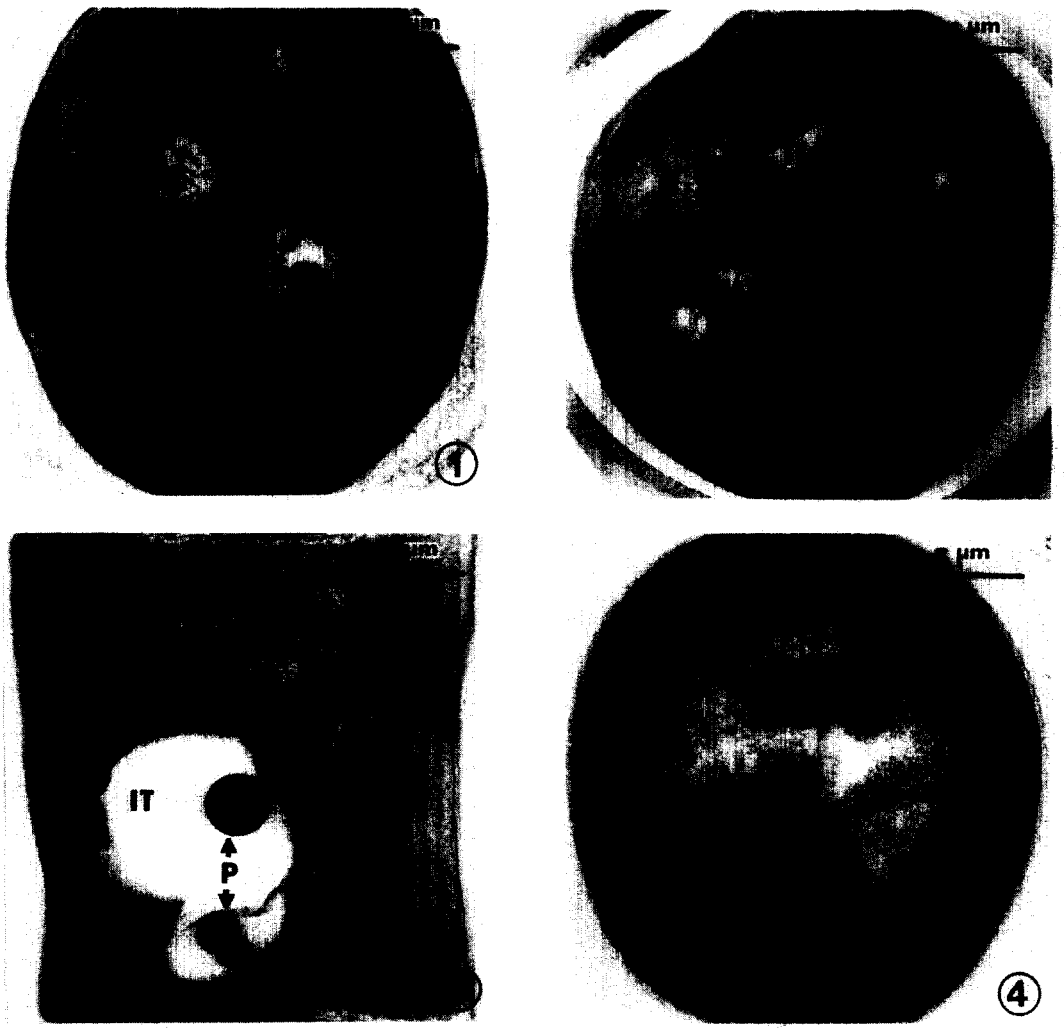
Plectonema boryanum, *Microcoleus vaginatus*, and *Schizothrix* sp. (Cyanophyceae) were selected for the study. *Plectonema* originated from a culture collection, while *Microcoleus* and *Schizothrix* were isolated from an algal mat collected from Grand Haven Harbor of Lake Michigan. All cells were grown at 25°C in modified Fitzgerald's medium and aliquots of each were incubated separately with the metals Cu, Pb, Cd and Zn at concentrations of 0.1 µg-at/l. The inoculum with no metal exposure served as a control, and samples were taken from each metal treatment after 3 days exposure. The samples were fixed in a solution of 1% paraformaldehyde-glutaraldehyde in sodium cacodylate buffer and post-fixed in OsO_4. After dehydration in an ethanol-propylene oxide series, they were embedded in Epon for transmission electron microscopy.

Preliminary results of detailed ultrastructural examination of the control and the metal treatments showed some indication of common responses among the algae. The most noteworthy of these was a decrease in polyhedral body volume in practically all species and all treatments. The only exception to this was the copper-treated *Microcoleus* in which there was a slight increase. The number of polyhedral bodies also decreased in most treatments. Additionally, *Plectonema* and *Schizothrix* were effected similarly in that there was a greater relative volume of polyphosphate bodies in each of the metal treatments. However, the polyphosphate body volume decreased in all metal-treated *Microcoleus*. In general, it appeared that more cellular changes were present in *Microcoleus* suggesting that it was more sensitive to heavy metal exposure than the other species. Although *Plectonema* and *Schizothrix* reacted somewhat differently to the metals, the overall degree of change in the cells was comparable.

Consideration of the effects of the individual metals indicated a similar response in that all cells treated with zinc showed increased vacuolization. No other common effect could be attributed to a particular metal. Overall, it appeared that zinc induced the highest degree of cellular changes, while copper seemed to cause the least amount of change. When the different species and different metal treatments were evaluated, *Microcoleus* and *Plectonema* appeared to be more sensitive to the metals zinc and cadmium, whereas lead and copper had a greater effect on *Schizothrix*.

Whole cell mounts of *Microcoleus* and *Plectonema* were examined by x-ray energy dispersive analysis, and zinc and cadmium were accumulated by *Microcoleus*, while lead was present in *Plectonema*. Copper could not be detected in either species.

Supported by grant R807516010 from the Office of Exploratory Research, U.S. Environmental Protection Agency.



Figs. 1-4. *Microcoleus vaginatus* and *Schizothrix* sp. Intrathylakoidal space (IT), polyhedral bodies (PH), polyphosphate bodies (P), thylakoids (T).

Fig. 1. Control cell of *M. vaginatus* with no metal exposure. Polyhedral bodies, thylakoids, and large polyphosphate bodies are present.

Fig. 2. Zinc treated *Microcoleus*. An increase in intrathylakoidal space was evident with this treatment. Note the presence of small polyphosphate bodies.

Fig. 3. *Schizothrix* sp. exposed to copper. Polyphosphate bodies and a large area of intrathylakoidal space are present.

Fig. 4. Zinc treated *Schizothrix*. Polyphosphate volume is greatest for this species with zinc exposure.