United States
Environmental Protection
Agency

Environmental Research
Laboratory
Duluth MN 55804

Research and Development

EPA-600/S3-84-016 Mar 1984

EPA

Project Summary

The Nutritional Ecology of Great Lakes *Cladophora glomerata*

Gerald C. Gerloff and J. Vic Muth

Various bioassays, primarily plant analyses, were utilized to evaluate relative nutrient supplies and primary growth limiting nutrients for *Cladophora glomerata* growth in parts of Green Bay, Lake Michigan, known to differ markedly in degree of pollution. Preliminary studies indicated that emphasis should be placed on evaluations of five nutrients: phosphorus, nitrogen, boron, sulfur, and vitamin B_1. The bioassays indicated that phosphorus very likely is the critical nutrient in nuisance *C. glomerata* growths and that at times phosphorus supply actually is reduced to growth-limiting concentrations. However, the possibility that vitamin B_1 may at times be critical for *C. glomerata* cannot as yet be eliminated.

The bioassays employed (total P, hot-water-extractable P, and alkaline phosphatase activity) were in agreement and consistent in indicating that phosphorus availability limited *C. glomerata* growth.

In further development of plant analysis as a bioassay, nitrogen and phosphorus critical concentrations were demonstrated to be relatively constant in *C. glomerata* of different ages and grown under various environmental conditions which would affect the rate and amount of growth.

A requirement for vitamin B_{12} and very high requirements for sulfur and boron were confirmed as unusual nutritional features of *C. glomerata*. Comparisons with the requirements for other green and blue-green algae established the uniqueness of the high sulfur requirement for *C. glomerata*. There was no indication of sulfur deficiency in *Cladophora* sp. from the Great Lakes.

Data obtained from solution replacement cultures indicated that, even when adequate total phosphorus is available, the growth of *C. glomerata* becomes less than optimum at phosphorus solution concentrations of 0.014 ppm and less, and at potassium and calcium concentrations below 0.18 and 0.24 ppm, respectively. This supports the concept of critical concentrations in the water for optimum *C. glomerata* growth.

Trace element studies indicated that *C. glomerata* requires an inorganic nutrient not generally recognized as essential for plant growth. The alga responded positively and significantly to a mixture of elements suspected to be essential. However, systematic elimination of elements from the mixture failed to identify one element as responsible for the yield increases. The situation is more complex than anticipated.

The culture and nutrition of *Nitzschia palea*, a very common diatom in the Great Lakes, was investigated. Silicon concentrations well above those in available media were essential for successful laboratory growth of *N. palea*.

Various algae, primarily from Lake Michigan, failed to produce inhibitors of *C. glomerata* growth to a degree that would suggest they are important in the ecology of *C. glomerata* in the Great Lakes.

Laboratory studies were initiated on the toxicity of heavy metals to *C. glomerata*.

This report covers the period May 1, 1976 to September 30, 1978.

This Project Summary was developed by EPA's Environmental Research Laboratory, Duluth, MN, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The pollution of the Great Lakes with municipal and industrial wastes has resulted in increased growths of nuisance algae. Filamentous green algae in the genus *Cladophora* are among the most troublesome of the nuisance organisms. The development of measures for the reduction of the *Cladophora* growths, based on nutrient limitation, will be facilitated by an understanding of the importance of specific nutrients in the growth of *Cladophora,* i.e., the nutritional ecology of *Cladophora.* A primary goal of this project has been to identify the nutrients, both inorganic and organic, most likely to limit and control the growth of *C. glomerata* in Lake Michigan. A second goal was to continue experiments on the nutrition of *C. glomerata.* Plant analysis was the diagnostic technique used in the study.

For the bioassays, samples of *C. glomerata* and of lake water were obtained primarily at five Lake Michigan sites, four of the sites on the Green Bay side of Door County, and a fifth on the Lake Michigan side. The sites were selected to represent a range of pollution and fertility resulting from the entry of the Fox River into lower Green Bay.

C. glomerata samples were obtained by clipping filaments, indicated as healthy by their green color, from heavy growths close to rocks, the shore, or from rock-breakwaters which extended out from the shore. The algae samples were rinsed in distilled water to remove contaminating debris. Samples were hand-squeezed and transported to the laboratory under refrigeration. They were oven-dried and ground in a Wiley mill. Analyses for N, P, S and B were by generally accepted quantitative techniques.

In the plant analysis bioassay, reduction in the supply of an element to a growth controlling level for a particular species at a particular site is indicated by a concentration of the element in a sample of the species at or below the critical concentration, the minimum plant concentration which permits optimum growth. A concentration above the critical level indicates that the algae from the site sampled were adequately supplied with the element.

In the differential nutrient enrichment experiments aliquots of lake water from specific sites were enriched with the various nutrients. Concentrations of added nutrients were those in the synthetic culture medium of *Cladophora.* One or several nutrients were omitted in each treatment. After innoculation with the *C. glomerata,* cultures were incubated for 21 days under continuous fluorescent light at a temperature of 23 ± 1°C. Any element present in the lake water in an amount adequate to support 50% of the yield in the complete medium in lake water was considered unlikely to limit algae growth under field conditions. Of the nutrients tested, this eliminated calcium, magnesium, manganese, molybdenum, zinc, copper, boron, sulfur and vitamin B_{12} as critical in *C. glomerata* growth. Every enrichment test indicated that four nutrients (N, P, Fe and vitamin B_1) were most likely to limit growth of *C. glomerata.*

Yields of *C. glomerata* in the enrichment cultures were slightly better when nutrients were added to lake water rather than distilled water. This suggested that lake water contains some unrecognized essential trace nutrient, or that the ratios of nutrients in the synthetic medium are not optimal.

Overall results indicated that phosphorus is the key nutrient in nuisance growths of *C. glomerata* in Green Bay of Lake Michigan.

Conclusions

1. *C. glomerata* becomes phosphorus deficient in parts of Green Bay during late summer. Phosphorus seems to be the key nutrient in the development of nuisance *C. glomerata* growths.
2. There is a close correlation between nutrient inputs to Green Bay and the development of phosphorus deficie in *C. glomerata.*
3. *C. glomerata* has extremely high unique requirements for sulfur boron, but these elements are critical in the nutritional ecology of organism.
4. While phosphorus very likely is the factor in nuisance *C. glomer* growths, the possibility that vitamin is a critical nutrient cannot be elimina at this time.
5. Relatively simple bioassays are availa for evaluating nutrient supplies for *glomerata.*
6 Critical nitrogen and phosphorus cc centrations, which are the basis nutrient assays through plant analys are relatively constant for *C. glomer* under a variety of environmental cc ditions and at various stages of grow This is a critical point of support plant analysis as a reliable nutrie bioassay.
7. *C. glomerata* growth seems to be le than optimal when the phosphor solution concentration decreases 0.014 ppm and below.
8. Inhibitor production by common alg probably is not a major factor in tl ecology of *C. glomerata.*
9. An adequate supply of soluble silicon a critical factor in the successf laboratory culture of the diatom *Nit schia palea.* Media commonly used f culturing blue-green and green alg contain inadequate silicon for optimu growth of the diatom.

☆ U S GOVERNMENT PRINTING OFFICE, 1984 — 759-015/76

Gerald Gerloff and J. Vic Muth are with the University of Wisconsin, Madison, WI 53706.
***Nelson A. Thomas** is the EPA Project Officer (see below).*
The complete report, entitled "The Nutritional Ecology of Great Lakes Cladophora glomerata," (Order No. PB 84-136 571; Cost: $16.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Environmental Research Laboratory
U.S. Environmental Protection Agency
6201 Congdon Blvd.
Duluth, MN 55804

United States
Environmental Protection
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Center for Environmental Research
Information
Cincinnati OH 45268
