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Field Determination of the Critical Nutrient Concentrations for *Cladophora* in Streams

S. L. WONG AND B. CLARK

Ontario Ministry of the Environment, Limnology and Toxicity Section, Water Resources Branch, Rexdale, Ont. M9W 5L1

WONG, S. L., AND B. CLARK. 1976. Field determination of the critical nutrient concentrations for *Cladophora* in streams. J. Fish. Res. Board Can. 33: 85–92.

Many streams in southern Ontario experience excessive seasonal growth of aquatic plants such as *Cladophora* and *Potamogeton*. A direct relation, with a regression coefficient of 0.87, was observed between ambient P concentration in the water and P content of plant tissue in six rivers. Critical or growth controlling total P concentration of 60 μg/liter in stream water and 1.6 mg/gram dry weight in plant tissue were determined. Unlike P, no significant correlation was observed between N content of plant tissue and N concentration in water. The correlation of total P with plant growth can be used to estimate the waste load which would result in maximum growth rate of *Cladophora*.

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Plusieurs cours d'eau du sud de l'Ontario sont sujets à une croissance saisonnière excessive de plantes aquatiques telles que *Cladophora* et *Potamogeton*. Nous avons observé une relation directe, avec coefficient de régression de 0.87, entre la teneur du P ambiant dans l'eau et celle du tissu des plantes dans six rivières. La teneur en P total critique ou contrôlant la croissance a été établie à 60 μg/litre dans l'eau du cours d'eau et à 1.6 mg/gramme de poids sec dans le tissu de la plante. Contrairement au P, nous n'avons pas observé de corrélation significative entre la teneur en N de la plante et celle de l'eau. La corrélation entre le P total et la croissance de la plante peut être utilisée pour estimer la charge de déchets qui entraînerait une croissance maximale de *Cladophora*.

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ASSESSMENT of the trophic status of streams when based on specific aspects such as benthic fauna diversity or dissolved oxygen content provided only limited control devices for better watershed management. Even though these are good indices of water quality, they yield only descriptive data while serving to define problem areas. Deterioration of water quality resulting from increased nutrient supply, leading to nuisance plant growth, is a serious problem and makes evaluation of critical nutrient levels and the determination of the maximum waste load very important.

Since macrophytes and larger algae such as *Cladophora* and *Chara* have a great intracellular nutrient storage capacity, it is uncertain that lowering the available nutrients will reduce the plant growth. Gerloff and Krombholz (1966) observed a good correlation between plant yield and tissue content below the critical or growth controlling level. However, Wilson (1972) suspected that lowering the nutrient concentration in water would have no effect in controlling the spread of plant biomass since increased growth did not correspond to loss of nutrients in laboratory experiments.

Critical level determinations for aquatic plants from both intracellular and external supplies have been reported in many laboratory bioassay studies (Pitcairn and Hawkes 1973; Mackenthun 1968; Gerloff and Krombholz 1966), yet the range of phosphorus concentrations found to be the critical level by different workers has lead to much argument. Therefore, our objective is to evaluate the effect of phosphorus and nitrogen on *Cladophora*, our most troublesome plant species in streams, and attempt to determine critical nutrient concentrations by a direct approach at the field level.

Study Areas

Our field survey was initiated on a 20-km stretch of the North Thames River in Ontario during the summer of 1973. The reach had an average width of

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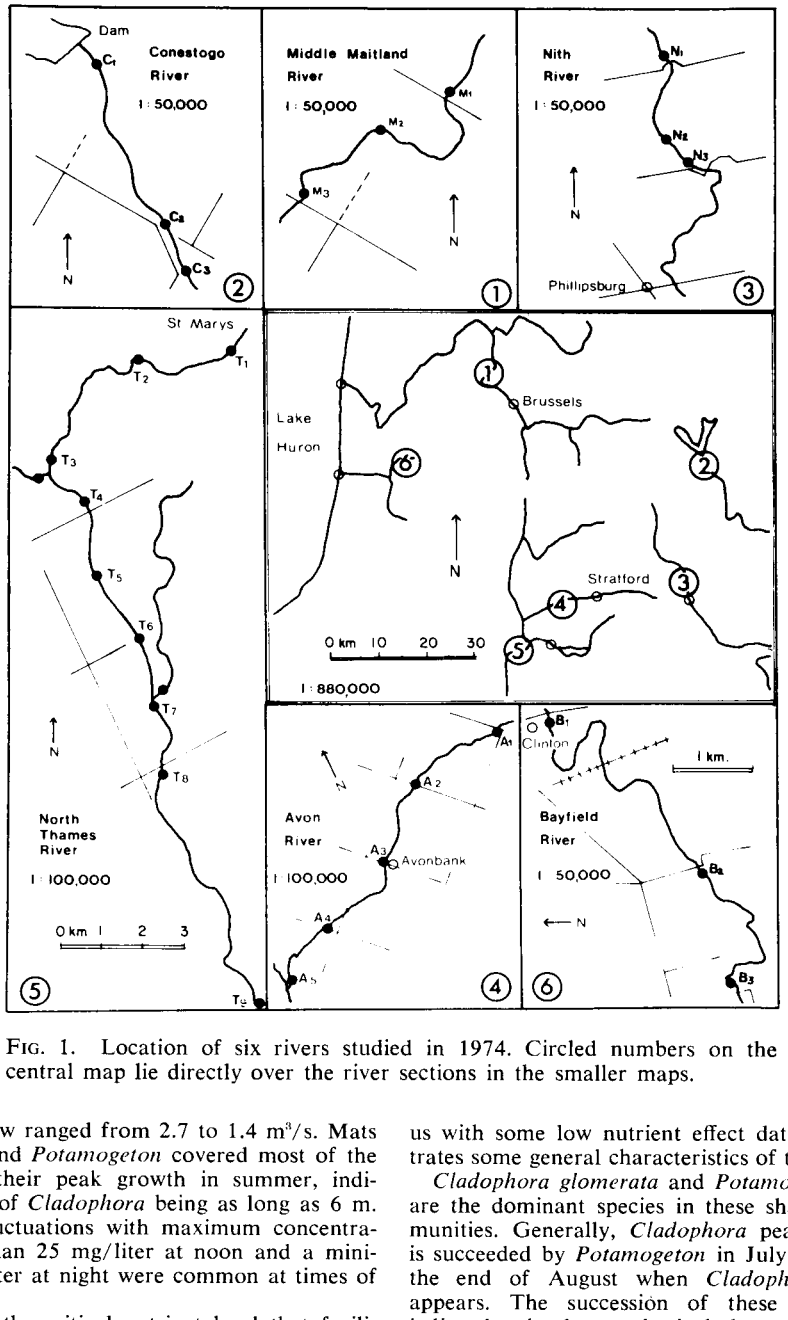

FIG. 1. Location of six rivers studied in 1974. Circled numbers on the central map lie directly over the river sections in the smaller maps.

40 m and the flow ranged from 2.7 to 1.4 m^3/s. Mats of *Cladophora* and *Potamogeton* covered most of the reaches during their peak growth in summer, individual filaments of *Cladophora* being as long as 6 m. Daily oxygen fluctuations with maximum concentrations of more than 25 mg/liter at noon and a minimum of 3 mg/liter at night were common at times of low flow.

To determine the critical nutrient level that facilitates maximum growth of plants, we studied six river systems during the summer of 1974. These were the Avon, Middle Maitland, Bayfield, Nith, Conestogo, and Thames, all within a 160-km *r* of Stratford, Ont. (Fig. 1). River sections were restricted to areas of similar substrate and were subject to varying municipal and industrial effluent discharges. The hope was that a broad range of nutrient loading would provide us with some low nutrient effect data. Table 1 illustrates some general characteristics of the six rivers.

Cladophora glomerata and *Potamogeton pectinatus* are the dominant species in these shallow lotic communities. Generally, *Cladophora* peaks in June and is succeeded by *Potamogeton* in July. This lasts until the end of August when *Cladophora* usually reappears. The succession of these two species is believed to be due to physical changes in the environment such as water temperature and photoperiod (Whitton 1971; Bellis and McLarty 1967).

Methods

Sampling stations were located at about 1.5-km intervals along the rivers. Each river was visited twice

TABLE 1. Some general characteristics of the six rivers studied in 1974.

River	Substrate	Max. mean daily temp.	Avg 1% light depth	Flow May–Sept. (*m/s*)	Alk. (*meg/liter*)	[P] mg/liter mean monthly min summer avg mean monthly max	[N] mg/liter mean monthly min summer avg mean monthly max
Thames	Rubble	24 C	2.8 m	max 9.2 min 2.2	3.6	.034 .155 .210	1.41 1.54 1.85
Avon	Rubble	24 C	4.0 m	max 0.83 min 0.26	4.5	.010 .064 .083	N.A.
Nith	Silt and rubble	24 C	1.8 m	max 9.8 min 0.7	3.6	.069 .082 .099	1.45 1.62 1.79
Conestogo	Rubble	21 C	1.2 m	max 4.5 min 0.8	2.9	.028 .082 .099	1.39 1.47 1.59
Maitland	Bedrock and rubble	24 C	3.5 m	max 5.0 min 0.3	4.2	.028 .045 .064	0.89 1.48 2.50
Bayfield	Rubble	26 C	3.9 m	dries up in July	4.0	.062 .069 .075	N.A.

a month and on each visit, 5 days of continuous water sampling and productivity studies were carried out.

The immediate effects of flow, runoff, and effluent discharges may cause local variations in nutrient concentrations over short periods of time. In addition, plant biomass acts as a good filtering mechanism thus diminishing the concentration to a greater extent between stations. Therefore, water samples for total phosphorus analysis were collected in duplicate, 2–3 times daily at all stations on the river throughout the 5 days. Uniform horizontal mixing of suspended particles at all stations was verified by determining the extinction coefficient. Exactly 50 ml of sample, collected from midstream, was immediately pipetted into 250-ml acid-washed Erlenmeyer flasks and later digested in the same flasks (Dillon 1974). Samples were collected in polyethylene bottles at the same time for total nitrogen analysis. All water samples were kept refrigerated and analyzed by the chemistry laboratory of the Ministry of the Environment in London, Ont.

Plant samples were collected twice within 20 days by removing all vegetation, including roots in the case of *Potamogeton*, with a Surber sampler. Four random quadrats were cropped along each of four transects between stations. Plant materials were washed thoroughly and blotted dry. After the addition of dry ice and steel balls the plant samples were ground for 5 min in a ball mill which was fastened in a paint shaker. Subsamples were taken for both dry weight determinations (105 C to constant weight) and tissue total phosphorus and total nitrogen content. Even though a small percentage of unhealthy plants may produce some error in the tissue analyses (Gerloff and Krombholz 1966), we feel that the entire quadrat sample will give a good representation of tissue content an eliminate the prejudice involved with choosing healthy plants. Random quadrats were individually analyzed to determine the concentration of P and N in plant tissue. An average monthly value was derived by averaging the results from two visits.

Community metabolism was measured using methods described by Odum (1956) and Armstrong et al. (1968). A continuous record of diurnal oxygen fluctuation at upstream and downstream stations was obtained by using EIL oxygen meters (Electronic Instruments Ltd., Richmond, Surrey, England) coupled with Rustrak recorders (Gulton Industries, Manchester, N.H.).

Solar energy was measured with a Weather Measure R401 pyranometer (Weather Measure Corp., Sacramento, Calif.) and underwater light energy was measured with a LI-COR quantum sensor model LI-185 (Lambda Instruments Ltd., Lincoln, Nebr.).

The total phosphorus concentrations in different watersheds on the Thames River were measured throughout the year by the water quality branch and the annual phosphorus export from the North Thames River headwater was calculated and used in the following discussion.

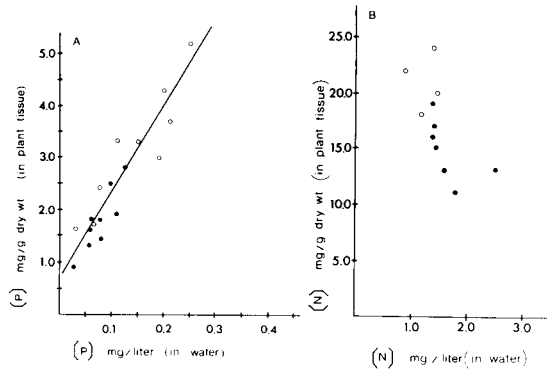

FIG. 2. Relation between A, phosphorus in the plant tissue and phosphorus in the water; and B, total nitrogen in the plant tissue and total nitrogen in the water. *Cladophora*, closed circles; *Potamogeton*, open circles. Nitrogen analyses were not conducted in three of the rivers. Similar results were obtained using inorganic nitrogen in place of total nitrogen.

Relation Between Nutrients in Plant Tissue and Nutrients in Water

Figure 2A illustrates the relations between total phosphorus concentrations in water and in plant tissue for the two dominant species, *Cladophora* and *Potamogeton*, in the six river systems. Individual regression lines for *Cladophora* and *Potamogeton* exhibit a similar slope with regression coefficients of 0.80 and 0.84, respectively. When the data were pooled as shown in Fig. 2, the regression coefficient (r^2) improved slightly to 0.87. The calculated regression line is

$$[P]\ \text{tissue} = 16\ [P]\ \text{water} + 0.67$$

Since the levels of stored P in the plant tissues are related to the concentrations of P in the external medium, this relation can be best explained by the theories of a high demand for phosphorus and the efficient use of phosphorus (Rigler 1964) in the plant community.

This relationship, however, differs from that found between P in plant tissue and P in water for 25 impoundments in southern Ontario (Wile and McCombie 1972) in that the slope of the calculated regression line found in the present study is less by a factor of 6 than that found in the pond study. This may have resulted because a) uptake of P through the root systems is probably much more important in the fertile ponds than in the rivers; b) only healthy plants were analyzed in the pond study and their P content would have been higher than that of dying or dead plant material (Caines 1965) included in the river study; and c) the plant species investigated in the pond study were different from those in the river study with one exception.

Unlike phosphorus, there was no relation between total kjeldahl nitrogen in plant biomass and total nitrogen ($NO_3 + NO_2 + TKN$) in water (Fig. 2B). Similar data have been reported by other authors (Gerloff and Skoog 1957; Golterman 1960; Krauss 1953). From the lack of any relation of total nitrogen between the two media, it is apparent that a change of total nitrogen content in solution may not have a direct effect on plant growth during times when excess nitrogen exists in the plant biomass. Accordingly, any interpretation of N:P ratios from water medium in relation with aquatic plant growth may be misleading.

Prediction of P Concentration in Water

Since growth response to nutrient supply is a long-term effect, addition of nutrient to flowing water does not give an instantaneous increase in plant biomass. Because of the unpredictable variations in nutrient concentrations a representative available nutrient value for a certain time interval requires many analyses. Another approach is to make a simple prediction based on the empirical relation of tissue content.

Nutrients in plant tissue are subject to less fluctuation and remain comparatively more stable. Quadrat samples along a given transect can be pooled and 5–10 random transects in a 1-mile stretch will give us a representative mean P in plant tissue value. The average nutrient concentration in the plant tissue from two separate croppings can be used to predict the average P concentration in water for the corresponding interval by using the following formula:

$$[P]_{\text{water predicted}} = 0.050\ [P]_{\text{tissue measured}} - 0.020$$

where [P] water is in milligrams per liter and [P] tissue is in milligrams per gram dry weight.

Although application of the above empirical relation requires further testing for other plant species, it would allow us to minimize the consideration of physical effects such as flow change and water depth on average nutrient concentration values.

Field Determinations of Critical Levels from Tissue Content

The critical level of an element in plant tissue is defined as the minimum concentration of this element required to promote maximum plant

growth. Determination of critical levels was confined exclusively to laboratory studies in the past. A tissue content of 1.3 mg P/gram dry weight proposed by Gerloff and Krombholz (1966) has been generally accepted as the critical concentration for aquatic plants. From our regression line in Fig. 2a this concentration in the plant tissue is equivalent to 0.042 mg/liter in water. On the other hand, if we consider Mackenthun's (1968) 0.10 mg/liter as the critical phosphorus concentration in water, the corresponding plant tissue concentration would be 2.3 mg/gram dry weight which is almost twice the concentration of Gerloff and Krombholz (1966). Other critical phosphorus level proposals such as that of Pittcairn and Hawkes (1973) (1.0 mg/liter in water) and Wilson (1972) (.6—.8 mg/gram dry weight in plant tissue) make us feel that an evaluation of this phosphorus level for our species under natural stream conditions is necessary.

Evaluation of aquatic plant growth is difficult due to the effects and interactions of physical factors such as available light energy, turbidity, shading, change in biomass due to loss and decay, and the uneven biomass distribution. Therefore, the detection of critical levels by using nutrient concentration growth–response relations has not been attempted under natural conditions.

Plant growth in most enrichment studies is often expressed as the change in biomass from plant harvesting. The inaccuracy of using dry weight to determine the productive development of aquatic plants has been pointed out by Wetzel (1964) in his study of higher plant productivity. Crop yield determination always underestimates net production of *Cladophora* due to the large amount of detached, drifting plant material which cannot be accounted for. We collected an average of 3.5 kg fresh weight of drifting *Cladophora* from the Thames River on a 1-m^2 screen over a period of 6 h during peak growth. In addition to these problems we know that the change in biomass is not the result of nutrient effects alone since light energy also plays a major role in plant production. To permit comparison of external effects on growth the direct measurement of productivity was employed and growth per unit population was expressed in the relative units pl/p_{max} as suggested by Ryther (1956) where pl is the daily photosynthesis for the corresponding light intensity at the plant depth and p_{max} is the maximum photosynthesis at or near light saturation.

Since daily production is governed by nutrient supply and the amount of light energy available, the nutrient effect on growth is apparent only when the influence of light energy has been considered.

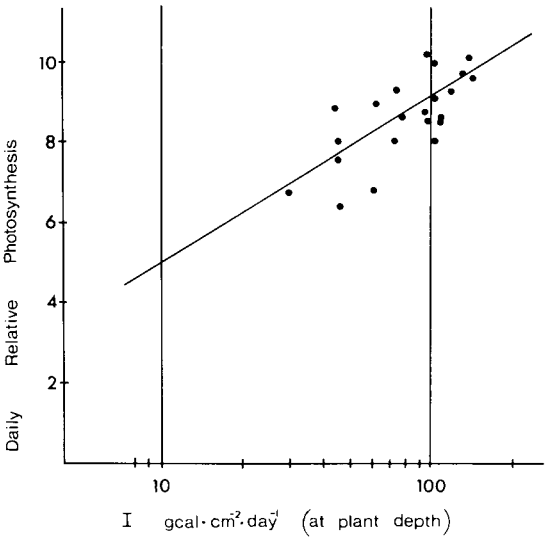

FIG. 3. Relation between photosynthetically available radiation (PAR) at the plant depth and the daily relative photosynthesis ($pl/p_{max} \times$ h daylight).

Figure 3 shows the relation between photosynthetically available radiation at plant depth (PAR) and the daily relative photosynthesis measured by the diurnal oxygen fluctuation technique. By using the empirical relation in Fig. 3 we can arrive at a correction factor which when applied, will allow us to observe the relative daily production independent of the effect of light. This correction factor will enable us to adjust our daily production figures such that they all appear to occur under maximum light conditions. Our data show the maximum light intensity (PAR) observed for a cloudless summer day to be 160 g $cal \cdot cm^{-2} \cdot day^{-1}$, allowing 80% surface light transmission to plant depth. Using this figure, the correction factor Rd on the daily pl/p_{max} can be computed from the equation

$$Rd = k \times \ln (I_{max}/I)$$

where Rd is in relative units, k is 1.85 (the empirical slope), I_{max} is 160 g $cal \cdot cm^{-2} \cdot day^{-1}$ and I is the measured PAR at plant depth. Rd is then added to the measured pl/p_{max} to give a result corrected to standard light regime.

Figure 4 shows the relation between P and N in the plant tissue and mean relative growth at a PAR level of 160 g $cal \cdot cm^{-2} \cdot day^{-1}$. From Fig. 4A we can observe that below approximately 1.6 mg P/gram dry weight the relative growth of *Cladophora* decreases. The low points on the curve represent healthy plants observed during

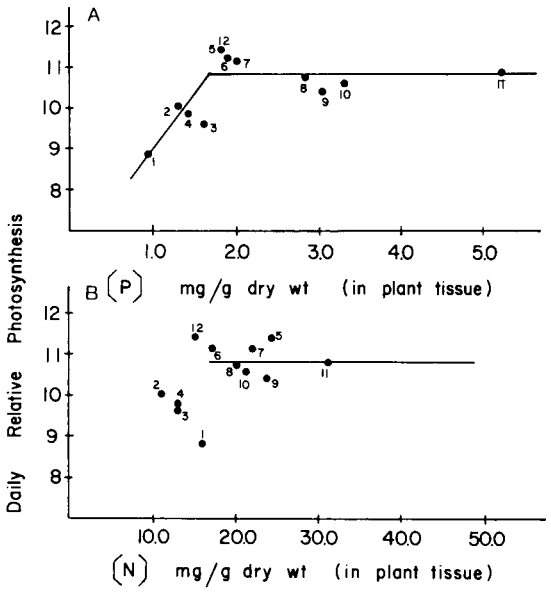

FIG. 4. Relation between A, phosphorus and B, nitrogen in *Cladophora* and the daily relative photosynthesis.

the growing season, May to June, when measured production was high; therefore, these low nutrient plant tissue results do not represent dying plants.

Figure 4B indicates that a critical nitrogen level lies between 12 and 15 mg N/gram dry weight. This agrees with Gerloff and Krombholz (1966) 13 mg N/gram dry weight as the critical level for nitrogen in plant tissue. The low daily relative photosynthesis values in Fig. 4A are a result of limiting phosphorus concentrations only, because tissue nitrogen concentrations were approximately 16 mg/gram dry weight during these observations. If 1.6 mg P/gram dry weight is taken as the critical level from field observations, then 0.06 mg P/liter becomes our critical level in water when referring to the regression line in Fig. 2A. If tissue analysis had not been conducted and the regression line in Fig. 2A were not available, we would have to rely on an average ambient phosphorus concentration determined from many samples. Such data are available and it appears that the critical phosphorus concentration determined by this technique is 0.07 mg/liter (Fig. 5).

ESTIMATION OF MAXIMUM P WASTE LOADING CAPACITY

To avoid excessive growth of *Cladophora*, phosphorus must be maintained well below the calculated critical level of 0.06 mg/liter. The maintenance of the ambient phosphorus concentration at 0.060 mg/liter will result in the maximum growth rate being realized. However, the total biomass and corresponding dissolved oxygen fluctuation caused by the plant biomass will depend not only on nutrient concentration but on available substrate area, light penetration, and temperature. With the existing data we cannot establish nutrient criteria necessary to maintain desirable total biomass and dissolved oxygen levels. The critical level of 0.06 mg/liter is valuable to determine the maximum waste load that a drainage area could assimilate which would result in maximum growth rate of *Cladophora*.

If the headwater land usage is comparable to similar polluted areas downstream, then we can use the export figures from the headwater region to estimate the background P loading from diffuse sources in the problem areas. The background P concentration can be derived by the equation

$$[P]_b = Es \times Ad/R \qquad (1)$$

where $[P]_b$ is the background concentration in milligrams per liter; Es is the export coefficient in milligrams$\cdot m^{-2}\cdot yr^{-1}$; Ad is the drainage area in m^2; and R is the total runoff in liters per year.

Having $[P]_b$ available, the maximum waste load capacity can be computed from the following expression:

$$L_w = ([P]_c - [P]_b) \times Q \qquad (2)$$

where L_w is the waste load capacity in kilograms; $[P]_c$ is the critical concentration, 60 μg/liter; and Q is measured, annual flow.

For example, the North Thames River above St. Marys with 90% agricultural land, has a drainage area of 1092 km^2 (Coulson 1967). The measured total P export coefficient was 18 mg$\cdot m^{-2}\cdot yr^{-1}$ (Thames River Report MOE unpublished data) and the mean runoff is 3.77×10^{11} liter/yr, derived by applying 1.0 cfs/$mile^2$ (from Coulson's [1967] long-term prediction in southern Ontario watersheds 1956) to the drainage area. By employing equation (1) a concentration of 0.050 mg P/liter of the background load is obtained. From a mean annual flow of 57 cfs (1.6 m^3/s) measured in the basin, the maximum waste load computed from equation (2) amounts to 500 kg/yr or 1100 lb/yr on top of the background load.

Seasonal phosphorus export coefficients are not available for the growing period of aquatic macrophytes (i.e. May–October), so an annual export coefficient was applied in the simple example above. However, the incorporation of seasonal export coefficients in the above equations will derive a more accurate background P concentration and should be used in practical applications.

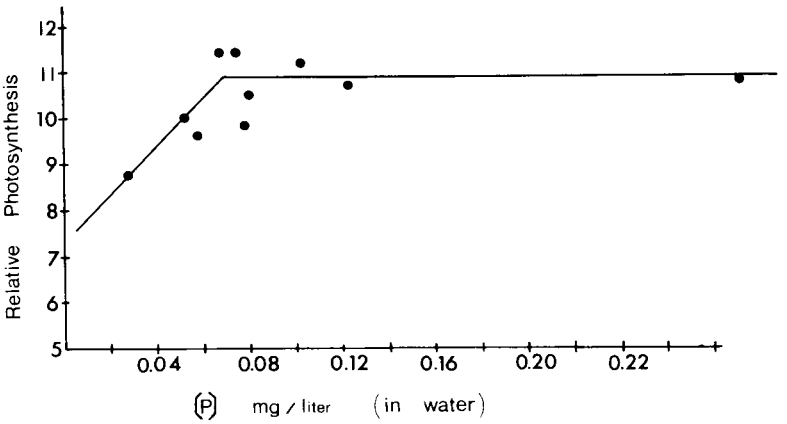

FIG. 5. Relation between P in the water and the daily relative photosynthesis of *Cladophora*.

Conclusions

The determination of the actual concentration of phosphorus below which the specific growth rate of *Cladophora* is reduced is difficult to determine, particularly under field conditions; nevertheless, it can be asserted from the existing data that the level is approximately 1.6 mg P/gram dry weight in tissue and 0.06 mg/liter in water. Unlike P, no significant correlation was observed between N content of plant tissue and N concentration in water. The correlation of total P with plant growth can be used to estimate the waste load which would result in maximum growth rate of *Cladophora*. However, this has no predictive value with respect to total biomass or dissolved oxygen fluctuations and further investigation is necessary to determine the ambient phosphorus concentration required to control these factors.

Since the phosphorus content in plant tissue is less affected by daily fluctuations in the ambient phosphorus concentration, it can be used to predict the average ambient nutrient concentration for a reach over a desired time period with less sampling required.

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ARMSTRONG, N. E., E. F. GLOYNA, AND B. J. COPELAND. 1968. Ecological aspects of stream pollution. Advances in water quality improvement. University of Texas Press, Austin, Tex. p. 83–95.

BELLIS, V. J., AND D. A. MCLARTY. 1967. Ecology of *Cladophora* glomerata (L) Kütz in Southern Ontario. J. Phycol. 3: 57–63.

CAINES, L. A. 1965. The phosphorus content of some aquatic macrophytes with special reference to seasonal fluctuations and applications of phosphate fertilizer. Hydrobiologia 25: 289–301.

COULSON, A. 1967. Estimating runoff in Southern Ontario. Dep. Energy, Mines Resour. Inland Waters Branch, Tech. Bull. 7.

DILLON, P. J. 1974. The prediction of phosphorus and chlorophyll concentrations in lakes. Ph.D. Thesis. Univ. Toronto, Toronto, Ont.

GERLOFF, G. C., AND P. H. KROMBHOLZ. 1966. Tissue analysis as a measure of nutrient availability for the growth of angiosperm aquatic plants. Kimnol. Oceanogr. 11: 529–537.

GERLOFF, G. C., AND F. SKOOG. 1957. Nitrogen as a limiting factor for the growth of *Microcystis aeruginoses* in Southern Wisconsin Lakes. Ecology 48: 556–561.

GOLTERMAN, H. L. 1960. Studies on the cycle of elements in freshwater. Acta Bot. Neerl. 9: 1–58.

KRAUSS, R. W. 1953. Inorganic nutrition of algae. Carnegie Inst. Washington Publ. 600: 000 p.

MACKENTHUN, K. M. 1968. The phosphorus problem. J. Water Works Assoc. 60: 1047–1053.

ODUM, H. T. 1956. Primary production in flowing waters. Limnol. Oceanogr. 1: 103–117.

PITCAIRN, C. E. R., AND H. A. HAWKES. 1973. The role of phosphorus in the growth of *Cladophora*. Water Res. 7: 159–171.

RIGLER, F. H. 1964. The phosphorus fractions and the turnover times of inorganic phosphorus in different types of lakes. Limnol. Oceanogr. 9: 511–518.

RYTHER, J. H. 1956. Photosynthesis in the ocean as a function of light intensity. Limnol. Oceanogr. 1: 61–70.

SCHWOERBEL, J., AND G. C. TILLMANNS. 1964c. Konsentrationsabhängige Hufnahme von wasscrlöslichom PO_4–P bei submersen Wassenpflanzen. Naturwissenschaften 13: 319–320.

WETZEL, R. G. 1964. A comparative study of the primary productivity of higher aquatic plants, periphyton and

phytoplankton in a large shallow lake. Int. Rev. Gesamten Hydrobiol. 49: 1–61.

WHITTON, B. A. 1971. Filamentous algae as weeds. Symposium on aquatic weeds. Eur. Weed Res. Counc. 3: 249–261.

WILE, I., AND A. M. MCCOMBIE. 1972. Growth of aquatic plants in southern Ontario impoundments in relation to phosphorus, nitrogen and other factors. Ont. Minist. Environ. Toronto, Ont.

WILSON, D. O. 1972. Phosphate nutrition of the aquatic angiosperm *Myriophyllum ixalbesceus* Fern. Limnol. Oceanogr. 17: 612–615.