SEASONAL ALGAL SUCCESSION AND CULTURAL EUTROPHICATION IN A NORTH TEMPERATE LAKE

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Abstract

A year-round study of the algal composition of a previously un-investigated north temperate, dimictic lake revealed the abundance of many pollution-tolerant forms, including such toxin-producing blue-greens as Anabaena and Aphanizomenon. A significant hypolimnetic oxygen deficit (0.4 ppm, 3.5% saturation) in late summer and the rate of oxygen depletion from 1 August to 19 September (0.13 mg/ml/day) further indicate eutrophic conditions. Of the three groups considered in this study (Chlorophyta, Bacillariophyta and Cyanophyta), the Cyanophyta were less diverse in terms of relative numbers of genera but produced the largest blooms. Chlorophyta had the greatest number of genera. Diatoms dominated in winter and spring, Chlorophyta in summer and fall and blue-greens in late summer, fall and winter. Spirogyra and Oscillatoria were the most ubiquitous members of the algal flora. Important perennials included Oscillatoria, Spirogyra, Closterium, Fragilaria, Meridion, Tabellaria and Cymbella. No unialgal blooms ever occurred. The accelerated rate of eutrophication in recent years is due primarily to excess nutrient loading resulting from input of raw domestic sewage. The completion of a sanitary sewer system is expected to alleviate the excessive nutrient loading and thereby slow the eutrophication process.

Introduction

Harveys Lake, located in Luzerne County, northeastern Pennsylvania (latitude: 41°22'30" N, longitude 76°2'30" W), is the largest natural lake in the state. The shoreline (14.5 m) drops off steeply in most places, reaching a maximum depth of 28.3 m. The lake is 375 m above sea level with a watershed area of 1866 ha, a surface area of 267 ha and a capacity of 29,272,484 m³. Underground springs and several small streams constitute the inflow, and Harveys Creek is the only outlet (Fig. 1). Oligotrophic until recent decades, the lake has supported a cold-water fish fauna and sport fishery. However, the input of raw domestic sewage from the growing lake-shore community has accelerated cultural eutrophication in recent years to the point that several swimming areas have been temporarily closed in the past. A sanitary survey in 1968 by the Wilkes-Barre Board of Health and
Kirby Health Center revealed high counts of coliform bacilli, an indicator of high organic pollution (James, 1975). A sanitary sewer system under construction is expected to alleviate the excessive nutrient input from domestic sewage, since the treated sewage will not flow into the lake. Recovery of aquatic ecosystems to a more oligotrophic state following reduction of nutrient loading has been demonstrated (Edmondson, 1970, 1972; Liepolt, 1967).

This study was undertaken to determine conditions in the lake prior to sewage diversion; future work will attempt to determine possible changes that may occur as a result of decreased nutrient input. The criteria which we have used as an indication of the trophic status of Harveys Lake include seasonal algal succession, blooms of blue-green algae (Hasler, 1947), hypolimnetic oxygen deficits and oxygen depletion rate in the hypolimnion (Dobson, 1967; Dobson & Gilbertson, 1971; Edmondson, Anderson & Peterson, 1956; Vollenweider, 1968). It is commonly accepted that some correlation exists between available nutrient supply and the qualitative nature of algal associations in freshwater lakes (Hutchinson, 1957, 1967). Palmer (1969) believes that nutrient levels influence algal composition more than any other factor in the aquatic environment. As a lake environment changes in response to accelerated eutrophication, a continually changing set of annual niches is made available to the algae (Moss & Karim, 1969). The use of certain pollution-tolerant genera and species as indicator organisms has become a useful evaluation scheme for assessing the degree of organic pollution in a lake and for indicating changes in trophic state (Cassie, 1974; Hooper, 1969; James, 1975; Palmer, 1969; Vollenweider, 1968). Studies using such biological eutrophication indices are well documented. Temperature and dissolved oxygen profiles were taken to determine the extent of oxygen depletion due to excess organic matter in the hypolimnion during summer stratification and beneath the ice cover in midwinter (Hutchinson, 1957). Oxygen content of the deeper water is particularly important for cold-water salmonids (Fry, 1971) and other fish species (Boyd, Prather & Parks, 1975).

Methods

We collected algae at approximately 2-week intervals from May 1974 through May 1975, at six stations located in the littoral areas of the lake, including an outlet stream, and at one station in the limnetic zone (Fig. 1). Vollenweider, Munawar & Stadelman (1974) stress the importance of year-round studies to cover seasonal variations. Three groups were considered in this study: Chlorophyta, Bacillariophyta and Cyanophyta. (Very few euglenoids, one dinoflagellate and no Rhodophyta were found.) Detailed station descriptions follow:

Station 1. Outlet spillway at Rt. 415 bridge.
- Substrate: rocks, pebbles, sand, mud, silt.
- Depth: 1 m above spillway, 0.5 m below spillway.

Station 2. Downstream from Stn. 1, at Ox Bridge on Harveys Creek.
- Substrate: rocks, mud, silt.
- Depth: to 0.6 m

Station 3. Spillway dam downstream from Stn. 2 on Harveys Creek.
- Substrate: rocks, mud, silt.
- Depth: 1.0 m

Station 4. Bridge over boat channel at Sunset Beach.
- Substrate: rocks, sand, mud.
- Depth: 1.5 m

Station 5. Dock at pole 40.
- Substrate: rocks, silt, mud.
- Depth: 1.0 m

Station 6. Dock at pole 107.
- Substrate: rocks, sand, mud
- Depth: 2.3 m

Station 7. Open water, adjacent to deepest part of the lake.
- Substrate: mud.
- Depth: 15-16 m

Different habitats within the same locality were sampled in order to procure a wide scope of the algal composition (Karim, 1968). Benthic algae were collected with a Peter-son-type dredge (19 x 11 cm) or by hand. Floating and attached filamentous algae were collected with a small hand net. Phytoplankton were collected with a fine-mesh nylon plankton net. All levels of the water column were sampled by vertical tows. In the outlet stream the net was held in the current for 10 min. Macrophytes and larger algae were examined microscopically for epiphytes, and all specimens were identified in the laboratory to at least the generic level while still alive (Needham & Needham, 1962; Prescott, 1951; Smith, 1950). The relative numbers of genera in the Chlorophyta, Bacillariophyta and Cyanophyta were determined for each sampling date and expressed as percentages (Fig. 2). No quantitative data were obtained, but in order to give some picture of bloom.