A comparison of diatoms on horizontal and vertical substrates in Georgetown Lake, Montana

by William Joseph Foris

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Botany
Montana State University

Abstract:
Georgetown Lake is a relatively small reservoir located in southwestern Montana. Its main uses are power production, industrial purposes, irrigation and recreation. The present study was part of a larger limnological project to evaluate the limnology of the reservoir. This particular study was undertaken to determine the seasonal periodicity and differences between the attached diatoms on horizontal and vertical plexiglass plates.

Isotherms and conductivity isoclines showed that thermal and chemical stratification was non-existent during the ice free months. During ice cover there was a slight thermal stratification and a strong chemical stratification. Oxygen concentrations and pH values were found to be similar with the highest measurements occurring during the ice free months and the lowest values during the ice covered months.

The water of Georgetown can be characterized as bicarbonate with calcium as its most abundant cation. Silica concentrations were found to be above the minimum requirement of most diatoms.

A total of 31 genera, 159 species and 168 varieties of diatoms was identified. Pseudoperiphyton accounted for 26% of the average yearly percent cell volume on the horizontal plates and 11% on the vertical plates. Epithemia turgida, Fragilaria erotonensis and Rhopoladia gibba were the three most important species, respectively, according to average annual percent cell volume on both the horizontal and vertical substrates. In terms of average yearly percent relative abundance, pseudoperiphyton accounted for 29% on the horizontal plates and 15.4% on the vertical plates. The three most important taxa, according to average annual percent relative abundance, on both the horizontal and vertical substrates were, respectively, Aohnanthes Jninutissima, Fragilccria erotonensis and Stepthandiscus astrea.

Estimates of seasonal production were based on organic weight accumulation numbers of diatoms, volume of diatoms and chlorophyll a measurements. The organic weight estimate of seasonal production illustrated a bimodal trend with an average accumulation rate of 47.83 mg.m^-2.day^-1 on the horizontal plates and 17.7 mg.m^-2.day^-1 on the vertical plates. Number and volume estimates both illustrated a unimodal trend. The average number of diatoms was 4548.cm-2.day-1 on horizontal plates and 1444.cm^-2.day^-1 on vertical plates. The average volume estimates was 4365 ú^3.cm^-2.day^-1 on horizontal plates and 1033 µ^3.cm^-2.day^-1 on vertical plates. Chlorophyll a production estimates illustrated a trimodal trend with an average accumulation rate of 16.83 µg.m^-2.day^-1 for the horizontal plates and 8.36 µg.m^-2. day^-1 for the vertical plates.

The chlorophyll a to cell volume ratio versus cell volume curve suggests a density dependent relationship between chlorophyll a and cell volume.

The chlorophyll a to organic weight ratio was used as an estimate of shading differences between horizontal and vertical substrates. At low organic weights vertical plates had a higher chlorophyll a to

organic weight ratio than the horizontal plates. At moderate to high organic weights, vertical plates had a lower ratio than did the horizontal. Thus there is relatively more dead and non-active material on vertical plates than horizontal plates at moderate to high organic weights.

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Date September 20 1976

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by

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A thesis submitted in partial fulfillment
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of

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in

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ABSTRACT

Georgetown Lake is a relatively small reservoir located in southwestern Montana. Its main uses are power production, industrial purposes, irrigation and recreation. The present study was part of a larger limnological project to evaluate the limnology of the reservoir. This particular study was undertaken to determine the seasonal periodicity and differences between the attached diatoms on horizontal and vertical plexiglass plates.

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Estimates of seasonal production were based on organic weight accumulation numbers of diatoms, volume of diatoms and chlorophyll *a* measurements. The organic weight estimate of seasonal production illustrated a bimodal trend with an average accumulation rate of 47.83 $mg.m^{-2}.day^{-1}$ on the horizontal plates and 17.7 $mg.m^{-2}.day^{-1}$ on the vertical plates. Number and volume estimates both illustrated a unimodal trend. The average number of diatoms was $4548.cm^{-2}.day^{-1}$ on horizontal plates and $1444.cm^{-2}.day^{-1}$ on vertical plates. The average volume estimates was 4365 $\mu^3.cm^{-2}.day^{-1}$ on horizontal plates and 1033 $\mu^3.cm^{-2}.day^{-1}$ on vertical plates. Chlorophyll *a* production estimates illustrated a trimodal trend with an average accumulation rate of 16.83 $\mu g.m^{-2}.day^{-1}$ for the horizontal plates and 8.36 $\mu g.m^{-2}.day^{-1}$ for the vertical plates.

The chlorophyll *a* to cell volume ratio versus cell volume curve suggests a density dependent relationship between chlorophyll *a* and cell volume.

The chlorophyll *a* to organic weight ratio was used as an estimate of shading differences between horizontal and vertical substrates. At low organic weights vertical plates had a higher chlorophyll *a* to organic weight ratio than the horizontal plates. At moderate to high organic weights, vertical plates had a lower ratio than did the horizontal. Thus there is relatively more dead and non-active material on vertical plates than horizontal plates at moderate to high organic weights.

INTRODUCTION

Attached algal communities are known contributors to the overall primary production of aquatic ecosystems. Odum (1956) states that lotic environments have been shown to be some of the most productive of the aquatic systems. Of the organisms which contribute to this productivity the periphyton seem to be the most important. Attached algae also play an important role in the overall primary production of lentic environments, especially in the littoral zone of shallow lakes. Schlinder (1973), Hutchinson (1975) and Wetzel (1975) review the importance of these attached communities in the overall production of lentic environments.

The present investigation has attempted to develop a satisfactory quantitative method for measuring the changes in the attached algae (Aufwuchs). The great heterogeneity in the terms Aufwuchs and periphyton has been reviewed by Sladeckova (1962) and Wetzel (1964, 1975). The terms in this paper will be considered synonymous and refer to that assemblage of organisms that are firmly attached to the substrate but do not penetrate into it (Ruttner 1953). For the period from July 1974 to September 1975 submerged plexiglass plates were used as a removable substrate for measuring attachment and growth of epiphytic, epipelic, epilithic and any other algae which may contribute to the overall net primary production. This study was part of an extensive limnological investigation dealing with water chemistry, phytoplankton production, sediment chemistry, zooplankton dynamics and macrophyte production of a reservoir in southwestern Montana.

The periphytic algae of Montana have been rarely investigated. Previous studies have dealt primarily with lotic environments; Jacobs (1950), Gumtow (1955), Roeder (1965), Jones (1967), Bahls (1971), and Stadnyk (1971). To my knowledge no study has been conducted on any lentic habitat in Montana either as a general floristic study and/or production study of periphytic algae.

Differences resulting from the positioning of artificial substrates for the study of attached organisms is of prime interest. Newcombe (1949) found that the amount of attached matter per unit area was appreciably greater on horizontal substrates. He also noted that loss during removal of vertical slides may exceed the amount that remained while horizontal slides could be removed with a minimum of disturbance. Castenholtz (1960) also found that there was a minimum of loss upon removal of horizontal plates and, therefore, this position was satisfactory. Conversely, Sladeckova (1962, 1965) stated that horizontal substrates besides collecting true periphyton also accumulate large amounts of settling seston, i.e. detritus and decaying plankton. She suggested that vertical positioned slides are much better because the periphyton on them corresponds with the water quality in different depths more precisely. King and Ball (1966), working on a large stream in Michigan, found organic weight ratios of 1 to 1.15 and that loss of organic matter was greater on the horizontal than vertical substrates when they were removed from the water. They also found that phytopigment-organic weight ratios (corrected for organic sedimentation) for the vertical and horizontal substrates were in the order of 1 to 1.06. They, therefore, concluded that Aufwuch production proceeded at about the same rate on the two types of substrates. No study, however, has compared the species compositional differences between vertical and horizontal substrates in terms of percent relative abundance and percent cell volume nor has anyone compared the chlorophyll *a*-organic weight ratios for both positioned substrates.

The objectives of this investigation were, accordingly, (1) to describe the attached diatom community of Georgetown Lake, (2) to describe the seasonal periodicity of the attached diatom community and determine possible causes, and (3) to determine what differences exist between horizontal and vertical positioned substrates in terms of species composition and chlorophyll *a*-organic weight relationships.

HISTORY AND DESCRIPTION OF THE STUDY AREA

Georgetown Lake, a reservoir formed from the impoundment of Flint Creek, is located at latitude 46° 10' 16" longitude 113° 10' 42" in Sec. 16, T. 5N, R. 13W, in Deer Lodge County approximately 17 miles west of Anaconda, Montana. Three creeks empty into the reservoir; Stewart Mill Creek, the North Fork of Flint Creek and Hardtla Creek. Contents of the reservoir are used for power production (Montana Power Co. [MPC]), industrial purposes (Anaconda Mining Co. [AMC]), irrigation and recreation.

In 1885 a small earthen dam was built across Flint Creek by the Montana Water, Electric and Power Company to produce power for the Bimetallic Mining Company. AMC purchased the dam in 1901 and built a masonry dam. In the same year MPC put in a power house to supplement its power demand. In 1925 the entire project was deeded to the MPC. They strengthened the dam and built a two-lane highway across it in 1966 (Beal 1953 and Georgetown Lake Pre-Study 1973). Currently rights to the water in Georgetown are shared by the AMC, MPC and irrigation concerns in Phillipsburg valley.

The masonry core structure has a crest length of 94.5 m, top width of 2.2 m and a maximum base width of 10 m.

At maximum pool elevation the lake is 7.05 km (4.38 mi.) long with a maximum and mean breadth of 3.64 km (2.26 mi.) and 1.72 km (1.07 mi.), respectively. The mean depth is 4.89 m (16.03 ft.) with a maximum

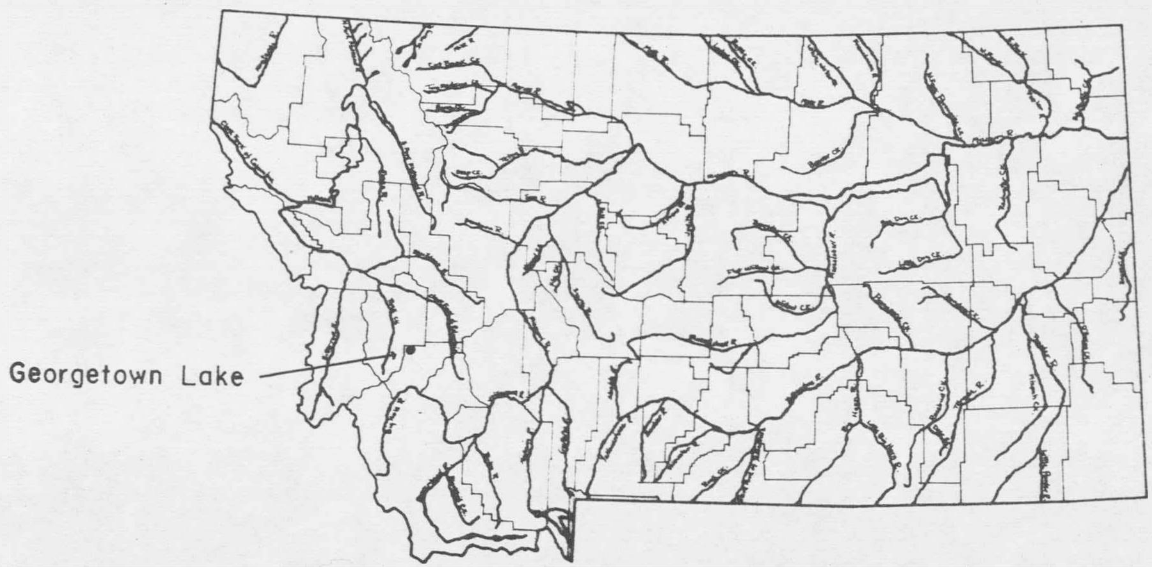

Figure 1. A map of the state of Montana and its major river systems showing the location of Georgetown Lake.

depth 10.67 m (35 ft.). Table 1 presents the ranges of morphometric data observed during the study.

TABLE 1. MORPHOMETRIC DATA DURING THE STUDY.

	Full Capacity	Range[1]
Maximum Depth	10.67 m (35.0 ft.)	9.27-10.27 (30.4-33.7 ft.)
Mean Depth[2]	4.89 m (16.03 ft.)	3.9-4.6 m (13.80-15.09)
Maximum Length	7.05 km (4.38 mi.)	7.00-7.03 km (4.33-4.37 mi.)
Maximum Breadth	3.64 km (2.26 mi.)	3.60-3.56 km (2.24-2.21 mi.)
Mean Breadth[2]	1.72 km (1.07 mi.)	1.56-1.67 km (0.97-1.04 mi.)
Length of Shoreline	26.87 km (16.7 mi.)	24.6-26.2 (15.3-16.3 mi.)
Shoreline Development[2]	2.18	2.11-2.16
Mean Retention Time	Summer 804 days Winter 493 days	337-6112 days

[1]Range was maximum and minimum during 10 July 73-16 June 75.

[2]Definition of these parameters in Reid (1961).

The North Fork of Flint Creek drains an area of approximately 4895 ha (12,096 acres). Flint Creek originates in the area of Fred Burr Pass and flows past old mines and the most developed section of the lake watershed.

Stewart Mill Creek originates from a spring approximately 200-300 m from the lake. The spring receives its flow from a drainage area of approximately 4222 ha (10,432 acres).

Hardtla Creek, a return flume from Silver Lake, has a capacity of 1.13 $m^3.sec^{-1}$ (40 cfs) (AMC data).

Since the entire drainage area of Georgetown Lake is 13,728 ha (33,920 acres), the remaining area (excluding Flint Creek and Stewart Mill) presumably discharges ground water to the lake.

A general geological description of the study can be found in Alt and Hyndman (1972). Morphometric and hydrologic data associated with the structures on Georgetown Lake is summarized by Knight *et al.* (1976).

METHODS

Light

Chemical and physical data were collected at biweekly intervals during the summer months, June 74-August 74 and at monthly intervals during the period September 74-June 75. Figure 2 shows the sampling station location.

Total daily solar radiation incident upon the reservoir surface was measured with either a Kipp and Zonen Model CM-3 or a Kahl pyranometer and recorded with an Esterline Angus Model 80-M recorder; these were installed at the Montana Fish and Game Department cabins located on the North Fork of Flint Creek. Daily radiation was converted to Langley.day^{-1} as described by the Kipp and Zonen instrument manual.

A vertical profile of light penetration at one meter intervals through the water column was obtained by a Kahl submarine photometer containing a selenium photocell. The extinction coefficients were calculated by the method of Hutchinson (1957).

Temperature and Conductivity

Temperature was recorded at one meter intervals using a Yellow Springs oxygen meter equipped with an electronic thermistor.

Conductivity measurements corrected to μmhos.cm^{-2} at 25° C were measured in the laboratory at a frequency of 1 kH with a Yellow Springs AC Conductivity Bridge, Model 31.