THE EFFECT OF LAKE BLOOM ON THE TOTAL HARDNESS CONTENT OF WASCO LAKE[1]

RICHARD L. TABOR[2]

Northern Illinois University, DeKalb, Illinois

ABSTRACT

The effect of aquatic bloom on the total hardness content of a small lake was investigated in this study. It was found that total hardness decreased rapidly and, in general, quite uniformly from the date of the first lake bloom. The lowest hardness content was reached at all sites about one month from the onset of bloom. After that date total hardness increased steadily at all sites. A drop in the magnesium content, which was particularly sharp during the initial bloom, was noted. This was attributed to the incorporation of magnesium into the chlorophyll molecules of the bloom.

INTRODUCTION

The study of the many aspects of the chemical composition of fresh water lakes has received a great deal of attention in the last few years. Those investigations have resulted in the gaining of much new knowledge in the subject, but many problems remain unsolved.

Anderson (1958) has presented a thorough study of the seasonal characteristics of two saline lakes in the state of Washington in which he reports on a large variety of elements. Mann (1958) has published a very detailed investigation of the annual fluctuation of sulphate and bicarbonate in ponds, which suggests that the fall in calcium concentration in the spring is correlated with the sulfide ions associated with bottom deposits. Eyster's (1958) results indicate that calcium carbonate concentration in marl lakes is strongly associated with phosphate deficiency. An investigation of the water and sediments of 16 Canadian east coast lakes, which describes a method for the indirect estimation of the total amounts of Na and K, has been reported by Hayes and Anthony (1958). Gorham (1955a, b; 1956a, b; 1957) has published several investigations of the chemical composition of bogs and fens of the English Lake District while simultaneously studying the relationship of rainfall to the chemistry of these bogs.

This investigation was undertaken to determine the effect of plant bloom on the total hardness content of a shallow lake. The author wished to ascertain not only the amount of total hardness decline but also the time span over which this decline occurred.

DESCRIPTION OF THE AREA

Wasco Lake in Campton Township, Kane County, Illinois.

The topography of the area has been shaped by glacial ice and running water. The area is relatively level and undissected except for minor stream valleys and a few relatively low areas, many of them created by glacial outwash plains. The annual rainfall in the area ranges from 25 to 35 inches.

Wasco Lake, which has a watershed of 6,800 acres, occupies an area of about 35 acres. The lake ranges in depth from 3 to about 15 feet and averages approximately 5 feet. The lake bottom is covered with recent silt, clay, and organic sediments.

The lake has a shallow inlet about 80 yards across at its western extremity. During the reported observation period only half of this width was under water and even this was in many places "choked" with vegetation. During the spring months the water level in the inlet is much higher. The lake also is fed by several small springs in the bottom near the center. The current moves from the inlet at the west end to an outlet at a small dam on the east end of the lake. The current is not readily apparent because of the small volume of water passing over the dam.

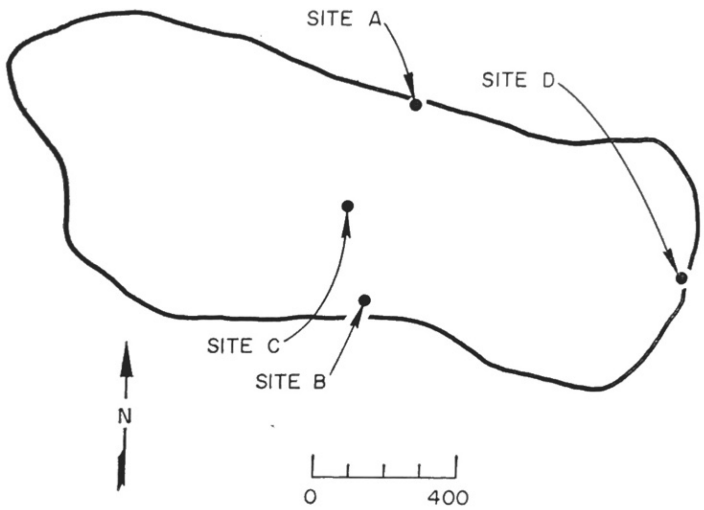

Figure 1. Wasco Lake

METHODS AND MATERIALS

This investigation was conducted during the months of June, July, and August, 1964. Figure 1 illustrates the configuration of Wasco Lake and also indicates the testing sites used during the investigation.

During the collection process, the sampling vessel was lowered to the desired depth, opened, allowed to fill, closed, and brought rapidly to the surface. Samples were taken at the surface, middle, and bottom of the water column at the two deep sites C and D, but only surface and bottom samples were collected from the shallow sites A and B. Bottom sampling was done at a distance of approximately 8 inches above the actual lake floor to avoid contamination from the bottom muds.

A standard EDTA method of water analysis for the determination of total hardness was used (Elgin Softener Corporation 1964). Total hardness was analyzed and defined as the sum total of Ca and Mg. The pH of each sample was determined by the potentiometeric

[1] Part of the work reported in this paper was submitted in a thesis to the Graduate School of Northern Illinois University for the M.S. degree in earth science.

[2] Present address: 106 Newton Lane, Oak Ridge, Tennessee 37830.

method using the calomel electrode apparatus. Water temperatures were determined by substituting a thermos bottle containing a thermometer in place of the sampling vessel.

Results and Discussion

The first week of testing revealed an average surface reading of 276 p.p.m. of total hardness. Before July 1, 1964, the designated time for the second analysis, the lake bloomed with a growth of *Cetatophyllum demersum* L. and *Heteranthera dubia* (Jacq.) MacM. During this sampling period, the total hardness concentration decreased. This effect probably was brought about, as suggested by Clarke (1965), by the increased photosynthetic activity of the aquatic plants and the subsequent removal of CO_2 from solution, which caused the precipitation of $CaCO_3$ according to the following reaction:

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3 \rightleftharpoons H^+ + CO_3 =$$

$$CO_3 = + Ca^{++} \rightleftharpoons CaCO_3 \text{ (ppt)}$$

A sharp drop in the magnesium content was noted at the time of initial lake bloom. This effect probably was caused by the incorporation of the magnesium ion into the chlorophyll molecule. This process required more magnesium at the onset of lake bloom (Meyer 1960).

The decline in the total hardness within the first week (June 24-July 1) was analyzed statistically and the results indicated a significant difference ($P \angle 0.01$). This would suggest that the total hardness content of a small lake could be modified significantly for short periods of time by an increae in photosynthetic aquatic vegetation since the PH remained close to neutral, and the small variations in water temperature which occurred during the investigation could not affect the solubility product of $CaCO_3$ to any degree (Hutchinson 1957). However, as shown by this study, these variations occur within a short time span, are seasonal, and therefore are of little consequence in the over-all total hardness content of the lake.

A steady decrease in the total hardness was observed with few exceptions through July 28 (see Figure 2). On that date a low point in the total hardness (197.5 p.p.m. average in the surface layer and a 205.5 p.p.m. average in the bottom layer) was reached at all test sites, with the exception of the bottom waters of Site C. A statistical analysis of total hardness in all water columns at all sites on June 24, compared to equal volumes on July 28, indicated a highly significant difference.

After July 28 the total hardness content began to increase steadily. On this date, presumably, the maximum effect of the vegetation on the total hardness of the water took place. The percentage of increase or decrease in the total varied greatly from one collection date to the next, and a thorough study by the author failed to reveal any particular pattern. The total hardness values for both surface and bottom waters at all sites are plotted together at weekly intervals in Figure 2.

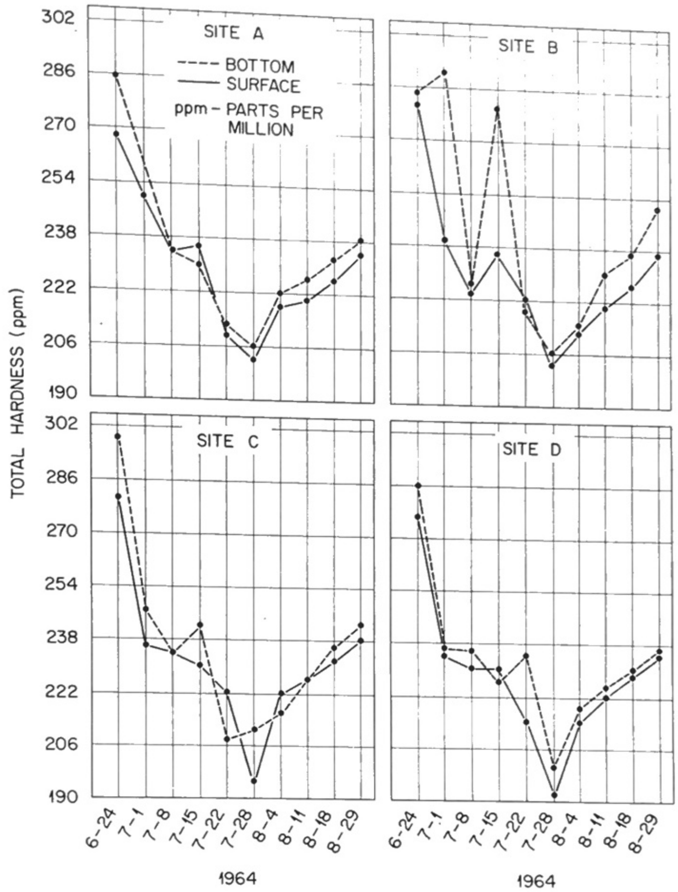

Figure. 2. Total Hardness of Bottom and Surface Waters Compared

The data for the total hardness concentrations of the surface readings compared to the bottom readings for the entire period of the investigation resulted in a statistical T value of 1.75 in which 1.65 was at the 10-percent confidence level and 1.96 at the 5-percent confidence level. Similar analysis performed with surface waters compared with the intermediate depth of the water column indicated no significant difference whatever. If a small difference does actually exist, it occurs in the lower half of the water column.

The total hardness content of the various sites showed a high degree of homogeneity over the entire investigation period. As can be seen in Figure 2, the process of total hardness decrease, with the exception of the surface layer of site B, was rather uniform at all sites on the lake. The higher hardness content of site B was expected because of the decreased plant density on the surface.

According to Hutchinson (1957) fresh water generally should be tending to a composition of Ca $\searrow$ Mg $\searrow$ Na $\searrow$ K. This is not true of many lakes in southeastern Wisconsin and northeastern Illinois. In many lakes of this area, Mg content exceeds Ca content. This is the condition in Wasco Lake. This peculiar situation is explained by the large amount of ancient magnesian limestone outcroppings in the drainage basin or incorporated into the drift in which the lakes lie (Hutchinson 1957).

Water temperatures followed a definite pattern. The first readings at all sites on the surface on June 24, 1964, averaged 21.25°C. The bottom readings for the same date averaged 18.75°C. Bottom temperatures averaged about two degrees cooler than the surface in the shallow sites and about three degrees cooler in the deep sites.

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