

## Some Notes on Stream Limnology in Oklahoma<sup>1,2</sup>

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Although lakes in the United States have a shorter life span than streams, the latter have been subject to much less investigation. Data are available with regard to most of the larger lakes, but have been rarely collected from even the major streams. In Oklahoma, little attention has been paid to the productivity potentials of any stream.

Stream management in Oklahoma has often become involved in the problem of adequate flow. It is generally true in the central and western parts of the state that fluctuations of flow are a major factor in management. Gaging stations of many agencies have revealed the transient nature of the streams and even those with some regularity of flow do not maintain sufficient volume of water to be useful for a long period of the year. The rainfall is sometimes of such volume that floods are a major concern.

As industry is encouraged to enter the state, more attention must be paid to water management and to what constitutes good water management. The basic problem of conservation of a limited resource enters the picture. Good water is required for most industrial processes. The processes often leave the water polluted. It is becoming increasingly important to determine an accurate definition of what constitutes dangerous pollution, and basic to this problem is a study of normal Oklahoma stream conditions.

During the summers of 1950 and 1951, data were collected from several streams in eastern Oklahoma and since 1949, scattered data have been taken in central Oklahoma. Some of the thermal conditions of these streams have been published (12), however, the bulk of the data collected has been analyzed only recently. Ten data collections were recorded from the Arkansas River and nine each from the Illinois and Grand Rivers. Twenty-seven separate data analyses were made from several small creeks. Although these data are incomplete, they indicate certain things of interest to the advancement of stream management in the state.

### METHODS

All limnological data were secured with the techniques described by Welch (13). The Rideal-Steward modification of the Winkler method served for oxygen analysis of the waters. A Whitney direct-reading thermometer of the resistance type was used for temperature data. Hydrogen-ion concentration was measured with a Hellige colorimeter. A Jackson turbidimeter was used to measure turbidity. The alkalinity data are expressed in cubic centimeters of N/50 sulfuric acid used to reach the end point for methyl orange and phenolphthalein in order to establish the longer term stability of the pH of the water.

### STREAM DATA

*Arkansas River.* The Arkansas River was sampled at the U. S. Highway 64 bridge at Webbers Falls, Oklahoma. The water was declared unfit for swimming by the State Health Department because of the high bacterial population due to sewage pollution from upstream points.

Turbidity and light penetration were quite variable. Upstream rains resulted in high water level and increased current velocity. Under such conditions, readings as high as 2700 ppm. of erosion soil turbidity were obtained. On one occasion, after 6 weeks of low water, the turbidity was less than 25 ppm. The average of 10 readings was 960 ppm. Visibility of Secchi's disk on one occasion was 2 feet but was usually much lower (as

<sup>1</sup> Contribution Number 241 from the Zoology Department and the Research Foundation, Oklahoma A. and M. College, Stillwater, Oklahoma.

<sup>2</sup> Received for publication December 17, 1954.

low as 1 inch in the most turbid waters). Photosynthesis would be greatly curtailed by the lack of adequate light penetration.

The chemical features of this stream are subject to fluctuation. Variation in pH (7.4 to 8.4, avg. 8.0) was correlated with vibration in stream volume. A lower water level coincided with a higher pH reading. Free CO<sub>2</sub> varied somewhat with the water level. However, the readings varied only from 0.0 to a maximum of 5 ppm. The dissolved oxygen content of the water was 9.8 ppm. at one visit but more often was nearer to the minimum reading of 4.1. The average dissolved oxygen content was 6.1 ppm.

The phenolphthalein and methyl orange alkalinities of the water are useful as indicators of the soluble electrolytes. Their direct relationships to bicarbonates, carbonates, and hydroxides give an estimate of the long-term productivity potential for organisms. Phenolphthalein alkalinity was present only once when 1.2 cc. of acid was used. Methyl orange alkalinity was also comparatively low the readings varying from 6.2 to 16.0 (avg. 9.6).

The total plankton counts from six samples during the summer of 1950 show an average of 1400 organisms per liter of water.

*Illinois River.* The sampling station for the Illinois River was located just below the site of Tenkiller Dam. In the past, this river has been quite productive of fishes. However, the heavy rains of recent years have flooded and scoured the bottom to modify most of the original habitat.

The pH of the Illinois River varied from 7.5 to 8.3 with an average of 7.8. The free CO<sub>2</sub> varied from 0.0 to 4.0 with an average of 1.4 ppm. Dissolved oxygen varied from 6.9 to 11.5 with an average reading of 7.7 ppm. Phenolphthalein alkalinity was registered only twice at 0.2 and 0.8 ppm., being completely absent at the other visits to the stream. Methyl orange alkalinity was recorded at 6.1 to 7.6 with an average of 6.8.

Turbidity of the water was always low with readings of more than 25 ppm. on only three occasions. These three averaged 98 ppm. of soil turbidity when the water was at near flood stage. Secchi disk readings varied from slightly less than 1 foot up to 6 feet.

The average total plankton count of six samples taken during the summer of 1950 was 1100 organisms per liter of water.

*Grand River.* The Grand River station was located at the bridge on State Highway 10 east of Fort Gibson, Oklahoma, above the confluence of the Grand and Arkansas rivers and below the Fort Gibson Dam.

The chemical features of this river were not as variable as those of the Arkansas. The pH of Grand River varied from 7.4 to 8.0 with an average reading of 7.8. Free CO<sub>2</sub> varied from 0.0 to 3.5 ppm. with an average of 1.5 ppm. Dissolved oxygen averaged 8.1 ppm. with a range of 7.2 to 9.8 ppm. Phenolphthalein alkalinity was absent at all visits. M. O. alkalinity averaged 8.1 while ranging between 6.7 and 10.3.

The physical features were less variable in the Grand River than in either of the other two rivers. The turbidity was less than 25 ppm. except for two occasions when it was 50 and 57 ppm. respectively. Visibility of Secchi's disk varied from 1 to 2½ feet, averaging 2 feet .

The average total plankton count of six samples was 3300 organisms per liter.

*Other Streams.* Scattered data have been collected from creeks in eastern and central Oklahoma including determinations from 27 different stations. These data are averaged in Table I to give a composite picture.

TABLE I.

*Average data from 27 creek determinations.*

Turbidity	pH	Free CO <sub>2</sub>	Diss. O <sub>2</sub>	phth. alk.	M. O. alk.
25	7.8	4.8	8.4	0.2	16.5

The "average creek" shows one or two discrepancies due to special situations. Three of the carbon dioxide readings were especially high, being 30.0, 12.0, and 11.0, respectively. These readings were taken in a sewage-polluted creek and interfere with the "average." The low turbidity is due to the fact that data were collected during periods of low water. Practically all Oklahoma streams are turbid during periods of rainfall with turbidities reaching at least 18,000 ppm. (9).

Six plankton samples were taken from Manard Bayou, a tributary of the Arkansas River in the summer of 1950, and the total counts averaged 500 organisms per liter. No other samples were counted.

#### DISCUSSION.

Temperature of Oklahoma streams varied within approximately the same range as found in other parts of the United States. Temperature is related to water depth, exposure to direct sunlight, and rate of flow of the water (14). As mentioned in a previous paper (12) the temperature of streams would not seem to be a problem of great significance in the state.

Turbidity must be recognized as one of the most important factors in stream management (1). The tillage of Oklahoma soil and the extremely fine particle size of the soil itself have combined to produce conditions ideal for gully erosion. It is a rare stream in any area of the state, the waters of which do not become turbid with topsoil when a normally heavy rain occurs. This turbidity is not all bad. It eliminates organisms that might cause difficulty in water supplies. It causes the precipitation of organic materials to reduce effects of pollution and is itself settled by the reaction. Silt-clay turbidity is easily precipitated to produce potable water supplies. Certain of the soluble minerals add to water fertility. Undesirable water weeds are mostly absent in turbid waters.

However, it can hardly be suggested that the loss of topsoil is desirable. Grover (7) found that a small stream (Stillwater Creek) with 165 square miles of drainage carried a total of 118,376 tons of suspended matter past a gaging station of the U. S. Geological Survey in 273 days; that 61,600 tons (more than half of it) was carried in one day (June 21, 1935); and that 98,960 tons were transported in six days. The recreational value is almost completely removed by turbidity. The water is less desirable for stock water and fish production. The lower stretches of the stream fill and floods become prevalent in the delta areas. Any method of reducing soil erosion would be desirable in the state.

The pH, phenolphthalein alkalinity, methyl orange alkalinity, free carbon dioxide, and oxygen contents of the water must be considered together as they are interrelated and affect one another. In comparison to other more productive areas, Oklahoma waters are low in pH, alkalinity, and oxygen and are high in carbon dioxide. These factors indicate three things: (1) a relatively poor soil in the watershed area (2) inconstant flow (3) pollution. If the soluble elements in the soil were high, the alkalinity of the water would be higher. During constant flow the water produces its own organisms that synthesize useful compounds and maintain clarity of the water. Pollution products may add active chemicals that neutralize the more permanent productive components of water to leave the water temporarily unstable. The result is usually a temporarily high production of a few organisms, or an elimination of all living things from the stream.

Wickliff (15) advocated: (1) erosion control; (2) stabilized stream flow; (3) control of bank erosion and (4) pollution control as the most important measures for stream improvement. The flood control impoundment program in Oklahoma is operated for the first three of these purposes. Impounding stream waters during times of excessive flow and release of these waters during periods of low flow have undoubtedly been beneficial to the life in the stream.

Several authors (10, 5, 4) have shown that dams on TVA streams have drastically changed the bottom conditions and fish habitats. There is some evidence that many stream organisms do not persist in lakes (3) and that production of bottom fauna will be lowered (8). However, the bottom forms are often replaced by other organisms that allow ample fish production (2). Impounded lakes produce a larger plankton crop (6, 11) than streams.

The problem of pollution control remains to be solved.

Some suggested stream improvement devices include deflectors, cover crops on the watershed, barrier dams, terracing, and related practices. The dividends of stream improvement include more fishes, more game animals, a sound permanent agriculture, and industrial development of an area.

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