THE DIURNAL OXYGEN PULSE IN EAGLE (WINONA) LAKE.

Will Scott, Indiana University.

This paper presents data which demonstrates an observable oxygen pulse in the surface water of Eagle (Winona) Lake when the weather is clear and relatively calm.

When a lake stratifies after the vernal overturn, the hypolimnion is sealed from the air and the respiration of the organisms and the decay of the organic matter gradually reduce the amount of oxygen present in this stratum. In the epilimnion the water may be circulated by the wind and consequently any part of it may be exposed to the air and may take up oxygen or give it up depending on the amount it contains. The upper levels of this region receive most of the light absorbed, so that photosynthesis is more pronounced at these levels than deeper.

In the epilimnion the amount of dissolved oxygen may be increased by absorption from the surface and by photosynthesis. It may be decreased by discharge at the surface, by respiration of organisms, and by the decay of organic matter. All of these factors that influence the amount of dissolved oxygen are continuous except photosynthesis. It occurs only in sunlight and consequently is diurnal on clear days.

So long as the amount of oxygen remains below the saturation point, it is difficult to establish the combination of factors which is responsible for the amount observed. However, when the water becomes saturated, as it often does in calm weather, it can be accounted for only by photosynthesis, modified slightly by temperature changes.

In building up high supersaturation, the increase must occur all in one day, or there must be a series of daily rises, or there must be a diurnal rise and fall in the amount of dissolved oxygen. This would be more marked near the surface on calm days. On windy days the water in Eagle Lake is mixed to such a depth (five meters in Eagle Lake) that the effect of photosynthesis is obscured.

Observations were made at two stations, a littoral and a pelagic. The littoral station was in an embayment just offshore from the Biological Station. This bay was filled with aquatic phanerogams, chiefly Potamogetons and the accompanying biota. The pelagic station was about 100 meters beyond this in the open water. The oxygen was determined by the Winkler method. The water was collected by means of a 100 cc. pipette and discharged into rubber stoppered bottles until an amount equal to the capacity of the bottle was flushed. The water was treated and titrated at once. The water was always collected within a few centimeters of the surface.

Two types of observations were made. One consisted of collections made at 9:30 a. m. and 4:15 p. m. The second type consisted of serial collections running as near 24 hours as the lake remained calm. These were very difficult to get complete. The lake might be perfectly calm in the morning and after a few samples had been taken the wind would disturb conditions so that the series would have to be discontinued.

"Proc. Ind. Acad. Sci., vol. 33, 1923 (1924)."

Table 1 shows a series of the first type that was taken in 1922 at the littoral station. The data columns give: (1) the water temperature, (2) the amount of oxygen necessary to saturate water at that temperature, (3) the amount of oxygen present in cubic centimeters per liter, and (4) the per cent of saturation. On July 20 it was slightly cloudy and in consequence slight changes occurred. The temperature increased 1.5° C., the oxygen decreased slightly (.08 cc. per liter) the per cent of saturation increased 2 per cent. On the other four days the amount of oxygen, the temperature, and the per cent of saturation increased. The average increase in temperature was 4.3° C., the increase in oxygen was 3.33 cc. per l. and saturation increased 72 per cent. While the 9:30 observations were not the minimum for the 24 hours yet the amount present at 9:30 on July 25 and 26 was greater in each case than it was on the preceding evening at 4:15.

TABLE I.

Data Obtained from Semi-Daily Observations at Winona Lake, Indiana

DATE 1922	A. M. Readings				P. M. Readings				Weather
	Water temperature °C.	Oxygen for saturation	Oxygen present cc. per l.	Per Cent of saturation	Water temperature °C.	Oxygen for saturation	Oxygen present cc. per l.	Per Cent of saturation	
July 20	22	6 04	7 55	121	23 5	5 89	7 27	123	Cloudy
July 21	22	6 04	8 37	138	29 4	5 45	10 74	196	Clear
July 24	21 7	6 07	5 88	96	28	5 54	9 95	179	Clear
July 25	27 5	5 57	5 73	135	29 5	5 45	11 27	206	Clear
July 26	27	5 60	6 53	117	30 5	5 40	10 47	193	Clear
Average last four days	24 5		7 07	121	29 3		10 40	193	.....

We have secured three sets of serial observations taken as follows: 9 a. m. to the folowing 8 p. m.; 6:30 a. m. to 11:30 p. m.; and from 6:30 to 8:30 p. m. The first is for the littoral station alone. The other two are for both stations in parallel.

The pulse in Series 1 (fig. 1) reached its maximum at 6:30 p. m. The notch in the oxygen curve at 3:00 was due to clouds between 12 noon and 3 p. m. At 3 p. m. it was again clear and remained so. At 6 p. m. the temperature had fallen 2° C., and the oxygen had increased slightly more than 2 cc., both of which facts tended to increase the per cent of saturation. Sometime between 9 p. m. and 12 p. m. the per cent of saturation became less than 100 per cent and remained so until 8 a. m. the next day when it was exactly 100 per cent.

The lowest temperature was at 3 a. m. although it probably became slightly lower between that hour and sunrise.

In Series 2 (fig. 2) the maximum occurred at 3:30 p. m. at the pelagic station and at 5:30 at the littoral. The amount of oxygen at the pelagic station at 6:30 p. m. exceeded the amount at the littoral station. This condition was again reached at 9:30 p. m. and 11:30 p. m. Between 6:30 a. m. and 9:30 p. m. there was more oxygen at the lit-

toral station than at the pelagic station. In other words the maximum is greater and the minimum less at the littoral station than at the pelagic. This means that there was more photosynthesis on the one hand and more respiration and decay on the other in the dense population of the littoral station.

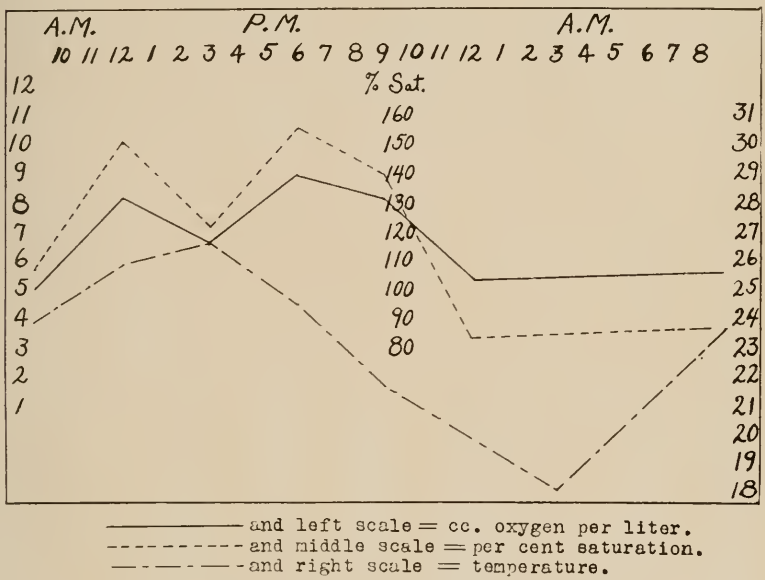

Fig. 1. Graph of records taken at Eagle Lake Littoral Station, August 9, 1922.

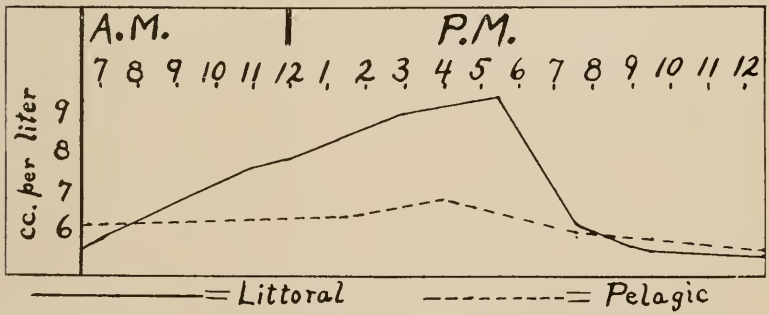

Fig. 2. Graph comparing the records taken at littoral and pelagic stations, respectively, August 9, 1922.

Series 3 is essentially like Curve 2 except that the maxima at both stations occurred at 3:30 p. m. At 6 p. m. a wind arose and from that time until 9 p. m. the curves approached each other.

It is evident from the data that an oxygen pulse occurs in the surface water of Eagle Lake on calm, clear days and that this pulse is

greater among the plants of the littoral than in the pelagic region of the lake.

Birge and Juday[1] report a diurnal oxygen pulse in Lake Mendota. They determined the amount of oxygen in the upper three meters of water just after 6 a. m. and a little before 5 p. m. They found a slight variation (.2 cc. per l.) at the surface, but a very decided pulse (1.8 cc. per l.) at the 1.5 m. level. Their observations were made September 20, 21, and 22.

[1] Birge, E. A., and Juday, C. 1911. The Inland Lakes of Wisconsin. The dissolved gases of the water. Bul. No. XXII, Wis. Geol. and Nat. Hist. Survey, p. 43.