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The amount of dissolved organic material which is present in a lake may be used as an index of the amount of food available for growth of micro-organisms, and is therefore of importance in studying the biological productivity of any given body of water.

The purpose of this investigation was to determine the amount and distribution of organic matter in the Okoboji Lakes. This was studied as a function of depth below the surface and also as a function of the particle size of the organic material, that is, whether the material could be considered as net plankton, nannoplankton, or as dissolved matter.

For this investigation two general methods were used: (1) Determination of the amount of readily oxidizable organic material by means of the potassium permanganate method. Data of this type are usually referred to as the oxygen consumption of the material. (2) Determination of the amount of organic nitrogen present by means of a modified Kjeldahl method. For convenience these will be considered separately.

The data presented for East and West Okoboji Lakes were obtained upon samples collected from two stations. The station on Lake West Okoboji was known as the "deep hole," a point located about 1000 yards to the south and about 500 yards east of the geographical center of the lake. The station on Lake East Okoboji was located near the center of the west end of the lake.

Samples for O_2 consumption were taken by means of a J. P. Foerst water bucket which was lowered to the desired depth, closed, and brought to the surface. Samples for organic nitrogen were obtained by means of a hose and pump.

Oxygen Consumed

In order to make separate determinations for the net plankton, nannoplankton, and dissolved organic matter, the sample was well shaken and two 50 cc. portions taken for determination without filtering. Another part was filtered through a standard No. 20 plankton net, and two 50 cc. portions of the filtrate taken for determination. The rest of the net filtrate was then passed through a

N. Berkefeld candle, and aliquot portions of this filtrate were taken for determination. After each filtration it was found necessary to clean the plankton net filter thoroughly with several washings of distilled water. It was also found necessary to pass a very dilute solution of sulphuric acid (1 per cent or 2 per cent solution) through the candle filter, and this was followed by several washings of distilled water. The washing of the filters prevented the accumulation of plankton which would have greatly affected the quality of succeeding samples.

The candle-filtrate gave directly the figure for the dissolved matter. This figure substracted from that of the net-filtrate gave the value for the nannoplankton (which passes the net but is held back by the candle). And finally the figure for the net-filtrate was subtracted from that for the natural water to obtain the value for the net plankton. The method employed here is commonly known as the permanganate method. It is described in Standard Methods of Water Analysis (1). The correction for oxidizable mineral substances was applied.

Determinations of the oxygen consumptive power of the net, nanno, dissolved, and total organic matter were made for various depths, about three times a week between the dates of July 9 and August 18, 1936 on Lake West Okoboji and between July 21 and August 18, 1936 for Lake East Okoboji. During the summer of 1937 two measurements were made on Lake West Okoboji (July 17, August 12). The data showed no significant changes in the porportions of O_2 consumed by the net plankton, nannoplankton, and dissolved materials throughout the summer, and neither was there a significant difference observed in material analyzed from different depths. Therefore, only the averages are given in table 1. The O_2 consumed was about the same for both nanno- and net plankton, and only the total is given in the table. This, of course, includes debris as well as living organisms.

Organic Nitrogen

In making separate determinations of the dissolved and undissolved organic matter, the sample was well shaken and one 500 cc. portion taken for determination without filtering. Another part was filtered through a Jena glass filter with an average pore size of 5-10 microns, and a 500 cc. portion of the filtrate taken for determination. The filter was cleaned after each filtration by 2 per cent sulphuric acid. The filtrate gave directly the figure for the dissolved matter. This figure subtracted from that of the unfiltered sample gave the value for the undissolved matter.

Determinations of the organic nitrogen content of the dissolved and undissolved organic matter were made for various depths about once a week between the dates of July 19 and August 7, 1937 on Lake West Okoboji, and between July 21, and August 14, 1937 for Lake East Okoboji. The results are shown in table 1.

Table I

	0_2 Consumed					Organic N				
	Particulate		Dissolved		Total	Particulate		Dissolved		Total
	cc.	Pctg. of Total	cc.	Pctg. of Total	cc.	ppm.	Pctg. of Total	ppm.	Pctg. of Total	ppm.
1936 W. Oko.	.914	17.9	4.2	82.1	5.11					
1936 E. Oko.	4.09	43.0	5.37	56.76	9.46					
1937 W. Oko.	.65	12.8	4.4	87.2	5.08	.097	12.0	.72	88.0	.817
1937 E. Oko.						.705	41.6	1.01	58.4	1.72

Discussion

The amounts of dissolved organic matter in East and West Okoboji Lakes, as indicated by the present data, are considerably different. East Okoboji has almost 25% more organic matter oxidizable with permanganate than West Okoboji (average values of 5.37 mg. O_2 for East Lake and 4.2 mg. O_2 for West Lake) and about 50 per cent more organic nitrogen (1.015 mgs./liter in East Lake and .72 mgs./liter in West Lake).

This brings up the question of how much mixing occurs between the two lakes. Neither has an appreciable outlet, and they are connected to each other by an offset channel. The nature of the channel is such as to prevent rapid mixing of the waters. However, in midsummer when East Lake is very green with algae and West Lake is comparatively clear, a decided increase in the algal content of West Lake can be noticed whenever there is a strong east breeze through the channel. One might not expect, therefore, such a large difference in dissolved organic matter unless pollution were much greater in one lake than in the other. In the present case, of course, that is true. East Lake, being shallow and warm, naturally might be expected to contain a large amount of organic matter. In addition to this natural factor, the sewage from local towns is dumped into this lake. The organic matter from East Lake seems to pass at an unknown rate into West Lake, thereby giving West Lake an organic content considerably above that for lakes of similar size and depth.

This organic matter tends to be broken down by microorganisms, but the exact cycle in the Okoboji Lakes is yet undetermined. Since

the amount of sewage dumped into East Lake is much greater in summer than in winter, it would be very interesting to compare the organic matter of the two lakes during early spring. It seems as if the organic matter of East Lake might be continually decreased during the fall and spring, both by mixing with West Lake water and by action of microorganisms. This is a problem which seems worthy of further investigation.

Studies of the organic nitrogen content of various lakes are reviewed by Welch (5). The most extensive studies have been those of Domogalla, Juday and Peterson (4) on the forms of organic nitrogen in Lake Mendota and of Birge and Juday (2, 3) on Lake Mendota and 83 other lakes. According to these workers the dissolved organic nitrogen in Lake Mendota varied from .559 to .304 mgs./liter with an average of .390. Little difference was found between surface and subsurface water except close to the bottom. There was a significant seasonal variation with a maximum in the winter and a minimum in the summer, but this variation was within the limits given above. Data on 83 other lakes showed a range from .186 to 1.540 mgs./liter with an average of .493. However, 50 per cent of these lakes had an average of .3 to .5 mgs. and only two contained more than 1 mg./liter. Of these two lakes one was very small (1.1 hectares) and received extractives from a large marsh (Mud Lake) and the other was small and shallow (Lake Mary, 3-4 meters deep, 49 hectares). Lakes which approximated the size of West Okoboji had an average organic nitrogen content of about .5 mgs./liter.

When these figures are compared with those for the Okoboji Lakes it is seen that the organic nitrogen content of West Okoboji is unusually high (.55 to 1.02 with an average of .72 mgs./liter) and that the organic nitrogen content of East Okoboji is still higher (.65 to 1.24 with an average of 1.015 mgs./liter). The available data indicate that East Okoboji is excelled in organic nitrogen content only by the two unusual lakes mentioned above.

The percentage of the total organic nitrogen which was dissolved was 88.0 per cent for West Lake and 58.4 per cent for East Lake. Of the lakes studied by Birge and Juday, about one third contained 90 to 98 per cent of the organic matter in solution, more than one half had 80-90 per cent in solution, and only 2 lakes had less than 70% in solution. The percentage for West Okoboji is within the normal variation and that for East Okoboji is rather low.

Summary

1. Indices of the amount of organic matter in the Okoboji Lakes were determined by the oxygen consumption method with permanganate and by the Kjeldahl nitrogen method. These determinations were made for natural water and for water passed through cloth, clay, and glass filters.

2. The organic nitrogen content of East Lake was found to be considerably greater than that of West Lake, and the organic nitrogen content of both of these lakes was much greater than that for lakes of comparable size and depth.

3. The percentage of the total nitrogen which was in solution, i.e., passed the finest filters, for west Okoboji was within the normal variation for such lakes, and for East Okoboji is below average.

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