

140  
2/26  
2012

THE DETERMINATION OF DISSOLVED  
OXYGEN IN POLLUTED SURFACE  
WATER

BY

CHARLES HERBERT SPAULDING

---

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN CHEMICAL ENGINEERING

IN THE

COLLEGE OF SCIENCE

OF THE

UNIVERSITY OF ILLINOIS

1912

1912  
Sp 2

UNIVERSITY OF ILLINOIS

JUNE 1 1912

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

CHARLES HERBERT SPAULDING

ENTITLED THE DETERMINATION OF DISSOLVED OXYGEN

IN POLLUTED SURFACE WATER

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN CHEMICAL ENGINEERING

*Edward Barlow*

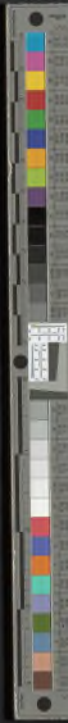
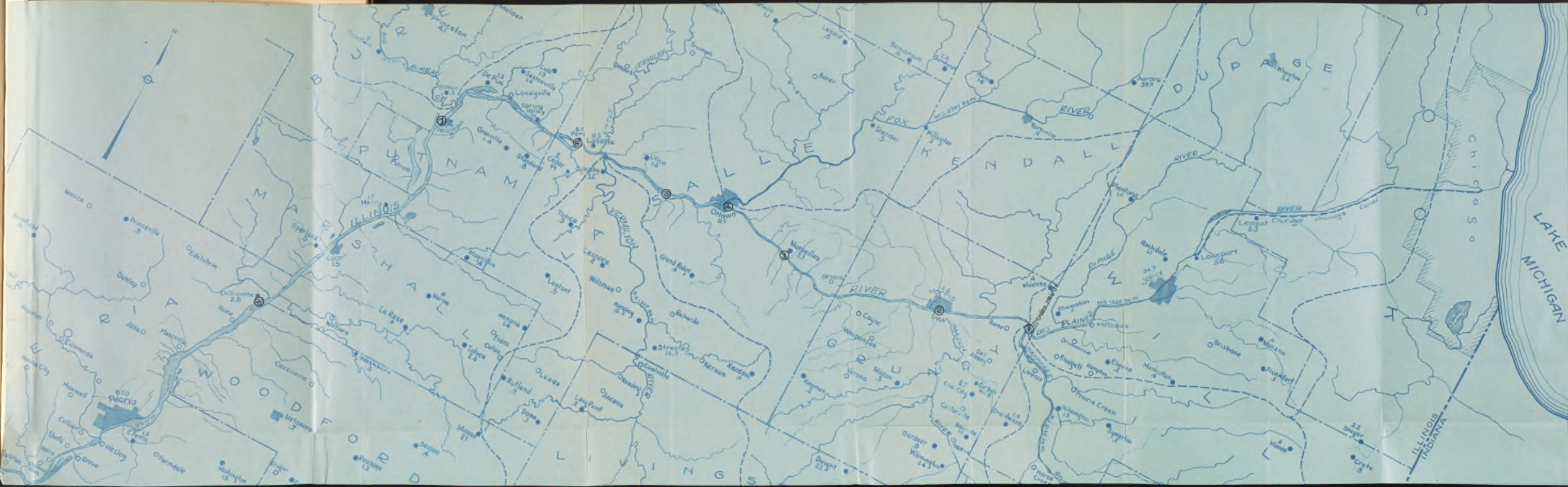
Instructor in Charge

APPROVED:

*Sw Parr*

*Acting* HEAD OF DEPARTMENT OF

*Chemistry*



## INTRODUCTION.

The object of this work was to determine the effect of Chicago sewage on the Illinois River and to find out how far down the river the effect was evident. At the same time, biological investigations were carried on to determine the nature and condition of fish and lower forms of life which are influenced by sewage. Measurements were made of dissolved oxygen and carbon dioxide and also, frequently, of alkalinity, chlorides and nitrites.

The work was carried on from July 21 to September 11, 1911. At this time the weather was dry and the river low, consequently the amount of dilution of the water from the Chicago Drainage Canal may be considered to have been at a minimum. During July and August the gage at LaSalle showed a mean of 12.7 and 12.6 feet respectively and continued there until the 10th of September after which it rose with heavy rains as high as 18.2 feet and varied between 15 and 17 feet for the balance of the month.

The general appearance of the Illinois for twenty six miles from the junction of the Kankakee with the Desplaines was very bad. The river had a distinctly bad odor and a sloppy appearance; the water was roily with grey, mossy strings of slime. In hot weather lumps of scum composed of some sewage growth floated down stream; these lumps varied in size from a diameter of a few inches to two or three feet; if struck with an oar, they disintegrated and sunk, giving off bubbles of gas.

In the shallow water along the banks in many places, bubbles of gas, identical in composition with gases from septic tanks, were rising from the bottom sediment. The microscopic plants and animals were mostly sewage forms. No fish were known to be present.

The determination of dissolved oxygen in natural waters has not been used to any large extent until very recent years. The general facts of its occurrence have, however, been investigated for some time. In 1871, Dr. Reinhold Heinrich published investigations on the "Influence of Temperature and Light on the Evolution of Oxygen by Water Plants". (Landw. Versuchsst 13, 136). He showed that not only sunlight but also artificial light, especially burning magnesium has the power to cause the reduction of CO<sub>2</sub> by water plants. Temperature affected the rate of evolution of oxygen in any case.

In 1877, König und Matschler published results of dissolved oxygen tests on well water. (Berichte 10, p. 2017). They made determinations on waters from numerous wells and found that in October - November the dissolved oxygen averaged 8 - 10 c.c. per liter, in July - August it averaged 3 - 3.5 c.c. per liter; while in April - May it was 6 - 6.5 c.c. per liter.

During 1899 and 1900 a large number of dissolved oxygen determinations were made on Illinois River water from various points along the stream. (Report of Streams Examination, The Sanitary District of Chicago). In 1899 supersatura-

tion was often found due to chlorophyl-bearing micro-organisms which are very abundant in the Illinois. The green plants growing in the lagoons along the river are very abundant and are the source of large quantities of oxygen which at times may be seen coming off in streams of bubbles. In 1900, after the opening of the drainage canal, the determinations showed lower values for dissolved oxygen. Above the Beartrap dam at Lockport in June, 10.9% of saturation was found; below the dam it was 55.5%; at Joliet there was 27.8% above Dam No. 1 and 81.3% below the dam. At Averyville, about the same time, 74 - 77% of saturation was found.

W. J. Dibdin, in "The Purification of Sewage and Water" (1903) describes a series of experiments in which the rate of absorption of oxygen by oxygen-free water was determined. He allowed the water to stand for various lengths of time in open pans and from a number of determinations he plotted a curve showing the increase of the aeration with the time. The rate of absorption decreased with the time for, while 20% of saturation was absorbed in two hours, it took 10 hours for the percent of saturation to reach 50%, and so on. He made determinations of dissolved oxygen in the Thames from Kew down to The Nore. It decreased from 70% of saturation to a minimum, at Woolwich, of 22.2% at high water and then rose again to 90% by the time the water reached The Nore. Dibdin considered that these figures represented the

equilibrium between the rate of absorption of oxygen from the air and the rate of consumption of the dissolved oxygen by the organic matter in the river. He evidently neglected the oxygen given off by plants and micro-organisms.

Weigelt ("Beitrage zur Lehre von den Abwasser" Die Chem. Ind. Vol. 27, 1904, p. 514) investigated a lake, discharging into the Rhine, in which fish could not live. He found a total absence of dissolved oxygen due to the reducing action of ferrous salts from industrial wastes discharged into the lake. Where this water entered the Rhine the dissolved oxygen in the river water was reduced below that required to sustain fishes, for a distance of 100 meters down stream.

"A Remarkable Experience with Pond Waters" is reported by Baldwin and Whipple. (Eng. Rec. Dec. 8, 1906). In Weequahic Lake at Newark, N. J. about 120,000 fish, 15 tons, died in two days during the summer. The lake is an artificial pond with an area of 30 acres and average depth of 5 - 6 feet. The condition of the fish indicated suffocation and it was found that oxygen was practically exhausted throughout the pond except at the very surface where the maximum of 79% of saturation was found. The exhaustion was attributed to the sudden death of a heavy growth of algae which settled through the pond and decomposed. The decomposition consumed oxygen which could not be replaced because no other chlorophyll-bearing organisms or plants were present. Very hot weather and lack of

any breeze to stir the surface had prevented absorption of atmospheric oxygen.

Dr. A. Lederer (Eng. News, Vol. 64, p. 289, Sept. 15, 1910) discusses the "Relation of Dissolved Oxygen in Water to the Quality of the Water". He states that quantity of oxygen is a valuable index but cannot always be taken at its face value. Thus two waters may show the same oxygen content though one is pure lake water, while the other is the effluent from a sprinkling filter. If kept in anaerobic condition for 24 hours, however, the first will show a loss of about 10% oxygen while the other has lost 80%. Likewise, a fairly good water is sometimes low in oxygen. Cold has a retarding effect on the consumption of oxygen.

Birge and Juday have made a study of the dissolved gases in the lakes of Wisconsin (Bull. No. XXII, Wis. Geol. and Nat. Hist. Survey). Aeration cannot go on as rapidly in these waters as in rivers, because they are not being mixed except during wind storms and then only to a small depth. The effect of microorganisms on the gases is thus more pronounced. At the bottom of these lakes the oxygen is largely depleted, due to respiration of animals and to decomposition of organic matter. Near the surface supersaturation is often found. Even in winter, when a lake is covered with ice, oxygen sometimes increases in the upper stratum, especially on bright days and in places where the ice is transparent and free from snow.



In the study of the effect of sea-water on sewage, Letts and Richards have used dissolved oxygen tests (Municipal Journal and Engineer, 30, 887-8, 1911). It has been claimed that sea-water inhibited the decompositions of organic matter, which consume oxygen, and so the authors compared the stability of dissolved oxygen in mixtures of sewage with tap water and with sea water. They found that the decrease was the same in either of such mixtures after four or five days; in tests of five or six weeks, however, the oxygen did decrease to a greater extent in tap water. They therefore conclude that sea-water has an inhibitive action in the later stages of oxidation only.

Dissolved oxygen has been considered the most satisfactory criterion of purity of the waters of New York Harbor by Black and Phelps (Munic. Jour. and Eng., August 16, 1911). The rate of absorption of oxygen from the air by these waters has been computed as 1.9% of saturation every 24 hours under most favorable conditions. 70% of saturation is given as the lower limit which should be allowed. The quantities actually found have varied from 0 - 100% of saturation.

(Report of Metropolitan Sewerage Commission of New York).

The lower quantities were found near shore where pollution was more concentrated. Surface and bottom samples in the Hudson River showed little difference in the amount of dissolved oxygen.

At the time that the work described in this paper was carried out, similar determinations were made for the Sanitary District of Chicago (Report on Sewage Disposal, October 12, 1911). It is stated in the report of this work that summer conditions on the Illinois are the worst. The dilution of Chicago sewage with lake water is then least effective, since 1000 cu. ft. per minute in summer is equivalent to only 585 cu. ft. in winter. In 1911 conditions were worse than before, for several reasons. The Western Avenue sewer was opened April 15; the Wilmette pumps (draining Bubbly Creek) were in operation after May; and furthermore, the annual spring freshet, which washes out the river channel, was lacking. The report advises against the accumulation of sediment in the upper channel as it lowers the efficiency of the oxidation processes. Two trips were made beginning at the mouth of the Chicago river, passing through the Drainage Canal, the Desplaines River, and the Illinois to its mouth. The first trip was made between August 31st and September 5th. In the canal, no oxygen was found, at Morris, about 1.3 parts per million, and the same above the dam at Marseilles. Below the dam it rose suddenly to 4.3 parts per million and continued almost 4.0, until below the dam at Henry it fell to 2.5 and then rose to about 3.0 at Chillicothe. In Peoria Lake, the content of oxygen rose rapidly to a maximum of 6.3, but after passing Pekin it fell again, until, at Havana, it was only 3 parts per million.

From here on it rose gradually to 6.5 at Kampsville and continued at this point to the mouth of the river. On the second trip, which lasted from October 24 - 30, the dissolved oxygen from Marseilles to Grafton varied from 7.0 to 9.5 parts per million, the higher values being near the mouth of the river. At Morris about 5.0 parts was found and minimum was 1.0 in the canal at Lockport. It may be mentioned that, for a month before this trip, the river had been swollen with heavy floods.

Samples were taken at Dresden Heights, Morris, Marseilles, Ottawa, Starved Rock, Peru, Hennepin, and Chillicothe, as indicated on the map. The stations were closer along the upper portion of the river because this part was of most importance in our investigation. The samples were collected from a boat in midstream unless for the comparison of different points in the cross-section of the river. Samples were taken from different depths on the first trip down the river in order to see if the oxygen content showed any variation with depth. No difference was found except at Chillicothe, where, in a current of about one mile per hour, samples from a depth of 10 1/2 feet showed an average of 0.4 parts per million less oxygen than samples from a depth of 18 inches. At the stations above Chillicothe, where the current was swifter and the river more shallow, no

difference could be detected between surface and bottom samples. Consequently samples were taken from a depth of 18 inches, thereafter, wherever depth of the water was sufficient.

The summary of the quantities of oxygen, and also carbon dioxide, found at the different stations is shown in Table I. Usually two or more determinations were made on each day and in most cases the figures given are the means of several determinations. Three trips were made down the river and the variation in the quantities of oxygen on the three trips is represented in the graph plotted from Table I.

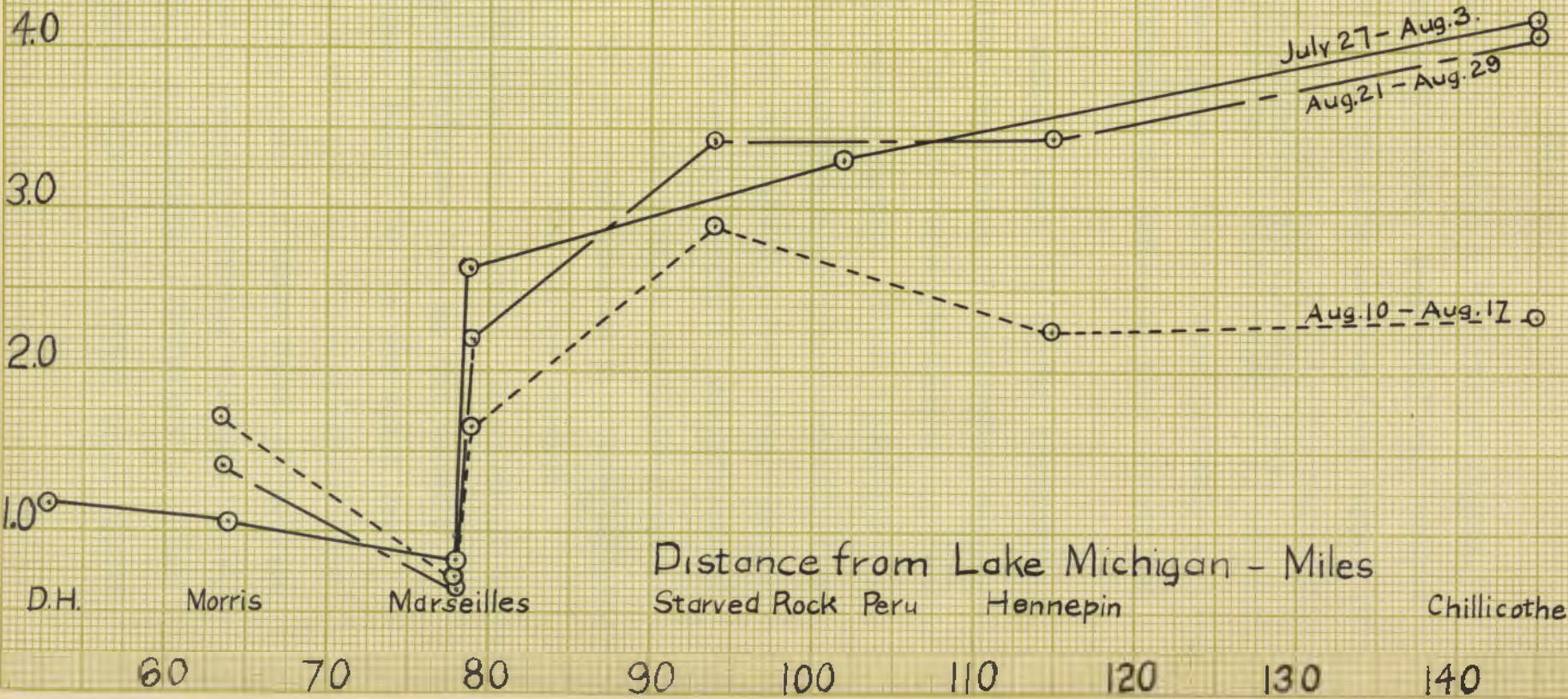
The first samples on each trip were taken from the Kankakee which was usually supersaturated with oxygen and alkaline in reaction to phenolphthalein. At Morris the mixture of the Desplaines and Kankakee seemed to be complete for samples taken from midstream and near the south bank on July 22 showed less than 0.2 parts variation. The minimum on the three trips was found above the dam at Marseilles where the oxygen consuming processes were evidently most active. A fall of 12 - 14 feet over the dam at Marseilles afforded considerable aeration which showed in the water  $3/4$  mile down stream where the average quantity found was 2.2 parts per million. It is probable that the water, just after passing over the dam, contained a much larger quantity of free oxygen which was immediately exhausted by the unstable compounds present. In fact two determinations made about 200 yards

TABLE I. Carbon  
Oxygen Dioxide  
Pts. per Mil. P.P.M.

Location	Date	Oxygen Pts. per Mil.	Carbon Dioxide P.P.M.	Temp. C.
Desplaines River at Dresden Heights	July 27	1.19	13.1	20.0°
Kankakee River at mouth	July 24	10.57	2.2	20.0°
	Aug. 10	9.66	absent	27.0°
	Aug. 21	9.31	"	23.6°
Illinois River Morris	July 21	.12	---	24.0°
	July 22	.25	---	25.0°
	July 28	1.07	11.2	20.0°
	Aug. 11	1.72	7.7	22.0°
	Aug. 22	1.37	6.8	22.5°
	Aug. 23	1.47	6.4	22.6°
	Aug. 31	1.10	7.4	21.0°
	Sept 13	.87	---	---
Marseilles above dam	July 30	.83	5.9	21.0°
	Aug. 12	.98	11.2	22.0°
	Aug. 14	.48	11.1	22.5°
	Aug. 24	.55	8.0	21.7°
	Aug. 25	.78	8.6	21.0°
	Sept 1	.58	7.4	21.0°
	200 yds. below dam	Sept 1	5.90	5.8
Marseilles 3/4 mi. below dam	July 31	2.63	5.8	21.6°
	Aug. 14	1.65	8.7	22.5°
	Aug. 24	1.72	5.9	21.5°
	Aug. 25	2.80	6.2	21.2°
Starved Rock South Side	Aug. 15	2.57	7.3	25.0°
	Aug. 26	3.07	5.6	21.0°
Starved Rock North Side	Aug. 15	3.25	7.3	25.0°
	Aug. 26	3.80	5.5	21.8°
Peru	Aug. 2	3.32	6.7	22.0°
DePue	Sept 11	2.65	7.16	24.8°
Hennepin	Aug. 16	2.25	7.5	26.0°
	Aug. 28	3.45	6.3	22.7°
Chillicothe	Aug. 3	4.44	5.9	24.4°
	Aug. 4	3.97	5.7	24.4°
	Aug. 17	2.35	6.8	26.0°
	Aug. 29	4.11	6.3	22.6°

Variation in Quantity of Dissolved Oxygen  
in Illinois River from Dresden Heights to Chillicothe

50 Dissolved Oxygen - Pts. per Million



below the dam on September 1st showed 5.9 parts of oxygen. After this thorough aeration the water apparently had reached a fairly stable condition. On the trip lasting from August 10 - 17, the quantities found at Hennepin and Chillicothe were quite low and at Marseilles on September 14 heavy rains fell, causing a rise of 18 inches at that place. These rains probably stirred up the sediment in the channel. By August 21 this effect had disappeared again.

It was often noticed that the oxygen increased in the river during bright days even where the pollution was still bad. A series of six tests made at Ottawa, September 2, is shown in Table IIa and the accompanying curves. These results were not included in Table I because they were taken directly from the shore where the water was only about a foot deep, though the current was good. Thus they can hardly be considered to represent the main stream, but, since other conditions were constant so far as known, it has been assumed that the variation represents the effect of sunlight. The carbon dioxide decreased as oxygen increased and vice versa. In water of better quality the increase in oxygen during the day was usually larger; thus in the Kankakee, August 10, it increased from 8.67 at 11:30 A.M. to 10.54 at 3:30 P.M. with an accompanying rise of 2.0°C. in temperature. On the other hand, at Morris, in very foul water, it never increased during the day, in mid-stream. There was, however, a consistent variation in gases during the day in some shallow shore water where green plants

TABLE Iia.

DISSOLVED OXYGEN AND CARBON DIOXIDE IN ILLINOIS  
RIVER AT OTTAWA.

Samples collected September 2, 1911 from south bank just  
above mouth of Fox River.

Time	Oxygen Pts. per Mil.	CO <sub>2</sub> Pts. per Mil.	Temp.
11:30 A.M.	4.75	---	23.0*
1:45 P.M.	5.50	4.6	23.7*
2:45 "	5.82	4.2	23.7*
3:40 "	5.70	4.3	23.7*
4:30 "	5.42	4.7	23.7*
5:30 "	4.87	5.5	23.7*

TABLE Iib.

DISSOLVED OXYGEN AND CARBON DIOXIDE IN SHALLOW  
WATER AT MORRIS.

Samples collected August 31, 1911 in water 4 in. deep,  
over stigeclonium.

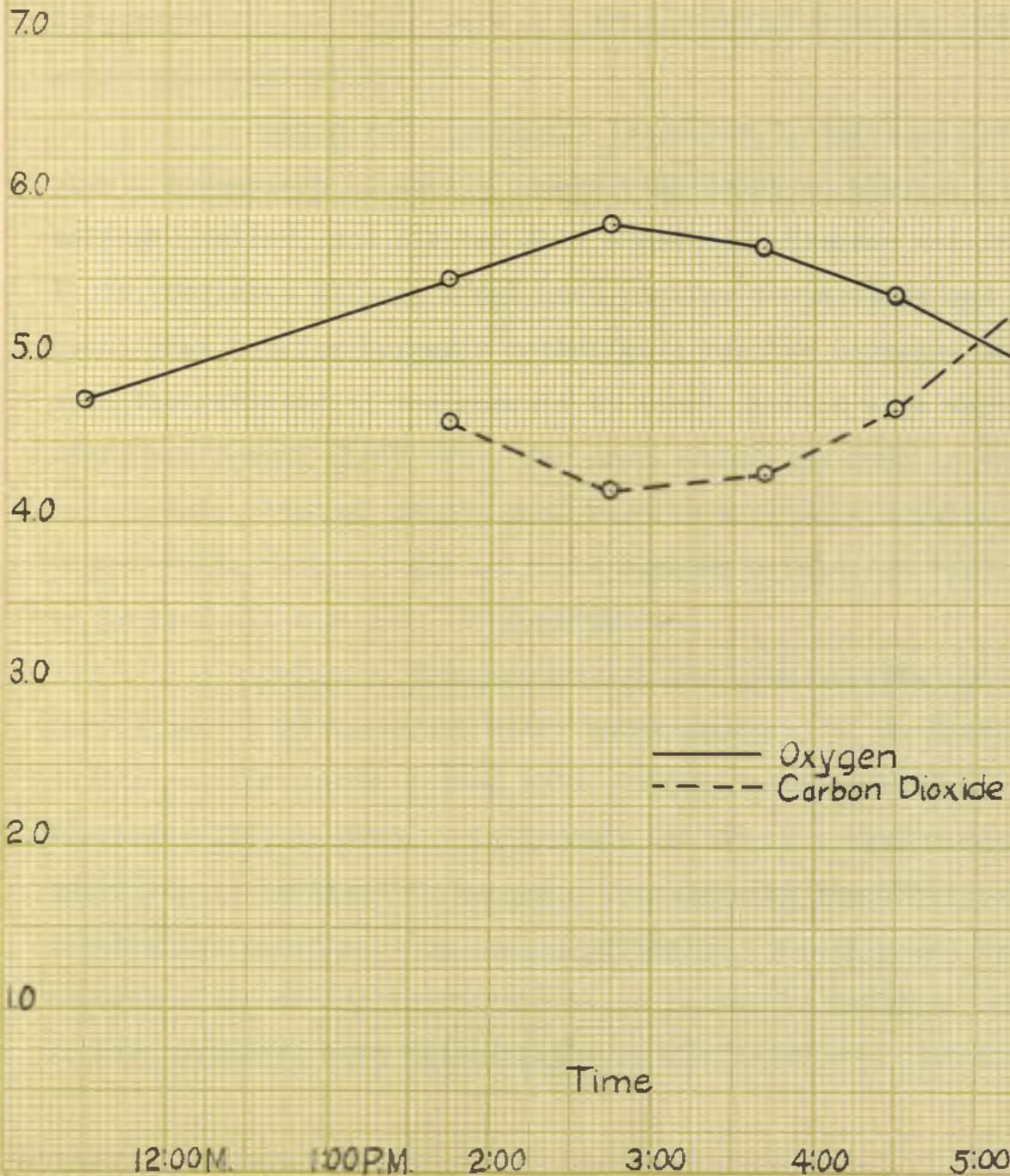
Time	Oxygen	Carbon Dioxide	Temp.
8:30	3.50	7.18	20.8*
1:30	6.05	4.15	22.3*



# Illinois River at Ottawa

## Variation in Quantities of Dissolved Gases on a Clear Day

8.0 Dissolved Gases — Pts. per Mil.



were growing. (Table I Ib).

## PART II. COMPARISON OF WINKLER AND LEVY METHODS.

The basis of comparison of various methods for determining oxygen in waters has been the gasometric. This was perhaps the original method, but is not suited for rapid determinations or field work and consequently titration methods have been resorted to.

König and Mutschler, (Berichte V. 2017) in 1877, made a comparison of Mohr's method with Schützenberger's thio-sulphate method, and adopted Mohr's method. Tiemann and Preusse (1879, Berichte XII, p. 1768) made similar comparisons and found that Schützenberger's method gave results agreeing better with the gasometric; the results by Mohr's method were very low. König and Krauch (1880 Zeit. für Anal. Chem. XIX 268) in further experiments obtained fairly good results with Mohr's method, though these results were a little high as a rule due to failure to exclude all air from the apparatus.

Owing to disagreement in the results obtained with Mohr's method by these and other investigators, L. W. Winkler devised an iodimetric method which he published in 1888. (Berichte XXI, p. 2843). It depends on the fact that manganous hydroxide is oxidized to manganic hydroxide by dissolved oxygen in alkaline solution. By adding potassium hydroxide and hydrochloric acid, an equivalent amount of iodine is set free, which is then titrated with thiosulphate in the usual way. Winkler

found that the presence of carbonates necessitates the use of larger quantities of manganous salt, because manganous carbonate is unaffected by oxygen in solution. He also altered the method slightly for waters containing nitrites. It is well known that iodimetry cannot be carried out in the presence of nitrites owing to the reaction of hydriodic acid with nitrous acid, giving free iodine and nitrous oxide which rapidly absorbs oxygen from the air with formation of nitrous acid again. Winkler added the potassium iodide to the solution after acidifying, for by this procedure the nitrites were oxidized to nitrates by the manganic chloride present, before the potassium iodide was introduced. It might be pointed out here, that if the oxygen were low and the nitrites high, enough manganic chloride might not be formed to oxidize all the nitrites and consequently this method would fail. (This is not an impossible condition in view of the fact that as much as 0.50 parts per million of nitrogen as nitrites were found several times in Illinois river water during the summer of 1911.) If the nitrites amounted to more than 0.10 parts per million of nitrogen, Winkler made a correction for the amount of oxygen used to oxidize the nitrites to nitrates, by treating a separate sample with an exact quantity of a manganic chloride solution and after this had stood for three minutes, he added potassium iodide and titrated the iodine set free. A blank with the same quantity of manganic chloride solution in distilled water showed by difference the amount of nitrites in the sample.

In the tests conducted by Prof. Palmer and others on Illinois River water in 1899 and 1900 (Report of Streams Examination, The Sanitary District of Chicago) the Levy method (Mohr's method with special apparatus) was compared with the Winkler method and the Levy method adopted because of the ease with which a blank could be determined. A blank was considered necessary with polluted surface water.

In the Analyst (1901. p. 141) Rideal and Stewart proposed a new correction for the Winkler method. They titrated a 50 c.c. acidified sample of the water with permanganate until a pink color was permanent for 10 minutes. They then added the calculated amount of permanganate to a regular sample and allowed this to stand for 10 minutes. If any pink color then remained, it was removed by addition of 1 c.c. of 2% potassium oxalate solution, after which the regular procedure was followed. The method gave good results but is evidently not very practical.

Dr. Herman Noll (Zeit. für Ang. Chem. XVIII, p. 1767, 1905) found that Winkler's correction for nitrites gave erroneous results due to the vigorous oxidation of organic matter by chlorine set free from manganic chloride in acid solution. He therefore introduced potassium iodide before adding the manganic chloride, with the purpose of protecting organic matter by this means.

Dr. Cronheim (Zeit. Ang. Chem. XX. 1939) in further experiments found that free iodine itself attacks a

certain amount of organic matter in water.

Birge and Jaeday, experimenting with Wisconsin lake waters, used Winkler's method for no blank was required with those waters. Both the Winkler and Levy methods had been tried and found equally reliable.

The Metropolitan Sewerage Commission used the Levy method which was endorsed by Prof. Gill of the Massachusetts Institute of Technology. (1910 Report)

The Mohr-Levy method was chosen by us for the determination of Oxygen in the Illinois River. It is carried out as follows:

Collect the sample in a pipette of 107 c.c. capacity provided with a stop-cock at each end, and at one end a small cup by which reagents are admitted. Place 2 c.c. of potassium hydroxide in the cup and draw this into the pipette by opening both stop-cocks enough to allow 2 c.c. of the sample to escape into a flask containing 2 c.c. of dilute sulphuric acid (1:2). Add next exactly 5 c.c. of ferrous ammonium sulphate by the same means allowing 5 c.c. of the sample to escape into the same flask as before. Then mix the reagents with the sample by shaking and turning the pipette. Now allow the mixture to stand while running a blank with another sample. After this, put 5 c.c. of sulphuric acid in the cup and open the upper stop-cock. The sulphuric acid will diffuse down into the pipette and dissolve the precipitate of ferrous and ferric hydroxides. Then allow the whole solution to run into the

flask and titrate with permanganate. The 7 c.c. of reagents added above displace an equal volume of water, leaving a 100 c.c. sample treated. The permanganate used is of such strength that 1 c.c. = .0001 mg. of oxygen, so that in a 100 c.c. sample of water 1 c.c. of this solution is equivalent to 1 part per million of dissolved oxygen. To run the blank, place a 107 c.c. sample in a flask containing 7 c.c. of sulphuric acid; add 2 c.c. of potassium hydroxide and then 5 c.c. of ferrous ammonium sulphate; titrate with permanganate. The difference in the number of c.c. of permanganate required for the blank and for the test represents oxygen in parts per million. The solutions required above are:

Potassium hydroxide, 150 g. per liter,  
Sulphuric acid, 50%,  
Ferrous ammonium sulphate, 16.5 g. per liter,  
Potassium permanganate N/80

To collect a sample, lower the pipette described above into the water by means of a light metal case attached to a marked chain. Have both stop-cocks open and have the upper end of the pipette connected by means of a rubber tube to a trap in the boat. The trap consists of a Wolfe bottle from which the air can be partially exhausted by means of a bicycle pump in which the plunger is reversed. The trap should hold three or four times as much as the pipette and thus, when it is full, this quantity of water has passed through the pipette, leaving a sample which has not been in contact with the air. Pump the trap full

of water, close the rubber tube with a pinch-cock and raise the pipette to the surface of the water. Close both stop-cocks at once, disconnect the rubber tube and remove the metal case.

The determinations made with the Winkler method were carried out as follows:

Collect the sample in the 107 c.c. pipette as before. Add first 2 c.c. of manganous sulphate, then 2 c.c. of NaOH-KI solution, mix thoroughly and allow to stand several minutes. Then add 5 c.c. of sulphuric acid and mix again. Finally let the contents of the pipette run into the flask and titrate the free iodine with thiosulphate. The solutions used are.

Manganous sulphate, 480 g. per liter,  
(Sodium hydroxide, 360 g. per liter,  
(Potassium iodide, 150 g. per liter,  
Sulphuric acid, 50%,  
Thiosulphate, N/80,  
Starch indicator.

The results of determinations of dissolved oxygen by both Levy and Winkler methods on samples of the same water are shown in Table III. In every case the Levy method gave higher results than the Winkler method, the average difference being 0.50 parts per million. On the samples from the Illinois-Michigan Canal the difference was less than this amount, while

TABLE III.

DISSOLVED OXYGEN BY WINKLER AND LEVY METHODS.

Samples Collected From	Winkler	Levy
Illinois River at Morris	.35 .10 .35 .30	.70
" " "	.04 .00	.85 (error) .50 .48
" " "	.15 .60 (exposed .03 to air)	.65 .70
Illinois-Michigan Canal At Morris	6.36 6.51	6.80
Illinois Michigan Canal At Morris (kept 18 hrs)	5.94 6.00	
Illinois River at Morris	1.33 1.34	2.00 2.05
" " "	.35 .39 .40 .55	.85 .90

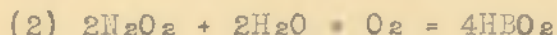
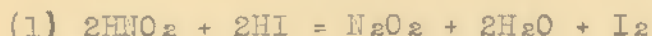
on Illinois River samples it averaged higher.

Attempts were made to use the Winkler method, unmodified, on river water kept for twenty four hours or more. When the samples had been kept that long, however, iodine was continually liberated in the solution after it had been acidified, for titration with thiosulphate. This was no doubt due to the continuous reaction of nitrous acid with hydriodic



acid which has been mentioned by Winkler and others.

R. W. Clarke (Analyst, August 1911) writes the reaction as follows:



The oxygen in (2) is supplied by the air from which it is readily absorbed by nitric oxide.

From these results it is evident that the Winkler method, without corrections, was not suitable for the water under examination. On the other hand the blanks and other corrections proposed by various investigators cannot compare in simplicity with that of the Levy method. If, therefore, the Levy method can be shown to give results which check with the gasometric as has been stated by several authorities recently, it is the better method for such a polluted water.