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Illinois River Studies, 1929-30[1]

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A sanitary chemical and bacteriological study has been made of the middle reaches of the Illinois River during a normal summer season (1929) as compared with a low-water summer season (1930).

From these data, as well as earlier data (I), it is evident that the dissolved oxygen, biochemical oxygen demand, and bacteriological data collected from a polluted stream vary geographically in such a way as to indicate that they are chiefly dependent upon the amount and type of pollution introduced, dilution, time, rate of flow (as it affects re-aeration, scour, and sedimentation), available oxygen, temperature, and microflora.

As noted in 1923 and in 1930, low-water seasons bring about lower dissolved-oxygen values in the polluted reaches of the river and in general higher bacteriological counts. The biochemical oxygen demand of a stream depends on so many variables that it is hard to predict its numerical value.

THE Illinois River is the most important river in the state of Illinois. Steamships and barges ply their course as far upstream as LaSalle, which is located 223 miles from the confluence of the Illinois and Mississippi Rivers. Smaller boats may reach Chicago and Lake Michigan by the use of canals. The Illinois River basin drains 28,344 square miles, or 50 per cent of the area of the state. Under these circumstances one might expect to find this river polluted. And so it is.

The Illinois River carries a higher pollution load than any

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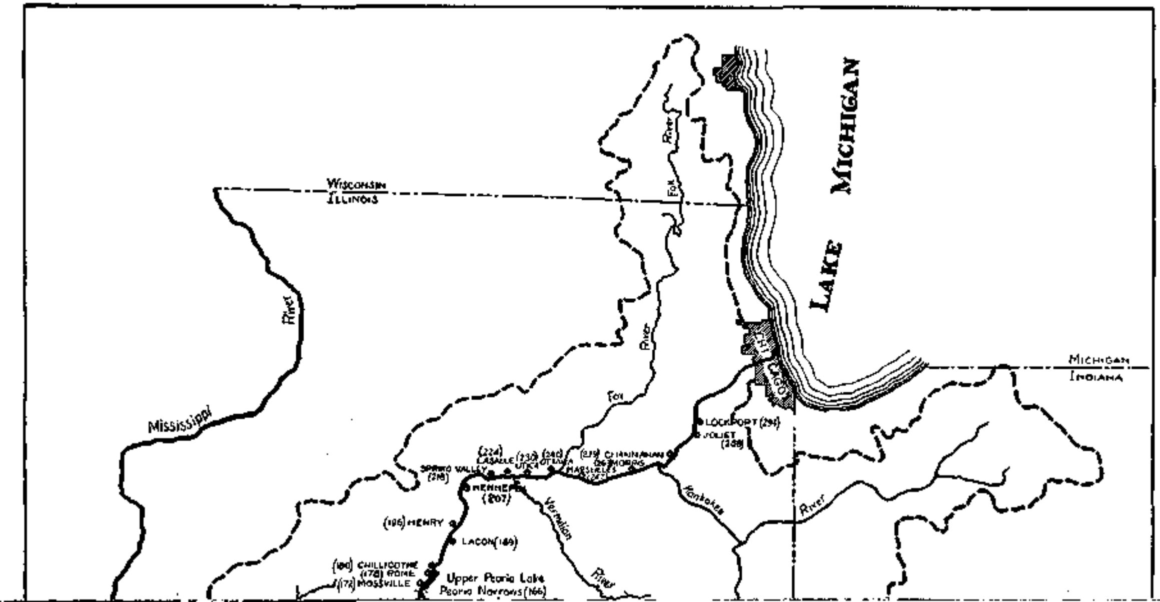
other river in the state. The Illinois-Desplaines River at Lockport (Figure 1), which has an average flow of only about 600 cubic feet per second, receives all the sewage and dilution water from the Chicago Sanitary District Canal. The pollution load of the city of Chicago is usually considered as being equivalent to a population of about 5 million. With the building of treatment plants and the recovery of by-product wastes by the industries, this load has been materially reduced. The only other cities along the Illinois River that add appreciable volumes of wastes are Peoria and Pekin, located 130 and 143 miles, respectively, downstream from Lockport. Peoria furnishes 17 per cent of the total pollution load thrown upon the river, while Pekin furnishes only 2.2 per cent. Chicago contributes 75 per cent of the total. A more detailed analysis of the pollution load will be found in the State Water Survey Bulletin *(1)*. As noted by the writer in earlier studies *(1, 2)*, the river may be divided into the following six sections or zones, which, although not definite in their limits, aid in classification of the data:

(1) Recent pollution, Lockport to Ottawa.
(2) Septic, Ottawa to Hennepin.
(3) Polluted, Hennepin to Chillicothe.
(4) Marked recovery, Chillicothe to Peoria (Peoria Lakes).
(5) Repollution, Peoria to Kingston Mines.
(6) Slow recovery, Kingston Mines to Grafton.

Sections 3, 4, and 5 have been considered the most interesting and have been given the major portion of the time allotted for study. Section 4, or that part of the river from Chillicothe to Peoria, is made up of three lakes known as the Upper, Middle, and Lower Peoria Lakes. These bodies of water have an average width of about half a mile and a total length of 16 miles. These lakes have been shown to have a very marked effect on the natural purification of the Chicago wastes *(1,4)*.

The State of Illinois has been conducting scientific studies on the Illinois River since 1874, or 26 years prior to the time Chicago started to divert her wastes into its waters. The State Water Survey, since its foundation, has been furnishing chemists and bacteriologists for these studies and has been in full charge of the sanitary chemical and bacteriological studies since 1923. From 1923 to 1928 permanent head quarters were established each summer at Peoria, from which city daily surveys were made of the river. These studies have been published in State Water Survey Bulletins 20 and 28. During the summer season of 1929 and 1930 the continuous survey policy was exchanged for a more conservative plan—namely, that of conducting occasional inspection trips from the main laboratories at Urbana.

During the summer season of 1929 three such trips were made, with an additional trip in early October. During the summer of 1930 five such surveys were conducted. The data collected during these investigations constitute the subject matter of this paper.


LAKE MICHIGAN
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
Mississippi
River
Fox River
Fox
River
CHICAGO
LOCKPORT (291)
JOLIET
(288)
CHANNAHAN
MORRIS
MARSEILLES
OTTAWA
UTICA
(224)
LASALLE
SPRING VALLEY
(218)
HENNEPIN
(207)
(196) HENRY
LACON (189)
(180) CHILLICOTHE
(178) ROME
(172) MOSSVILLE
Upper Peoria Lake
Peoria Narrows (166)
Vermilion
River
Kankakee
River

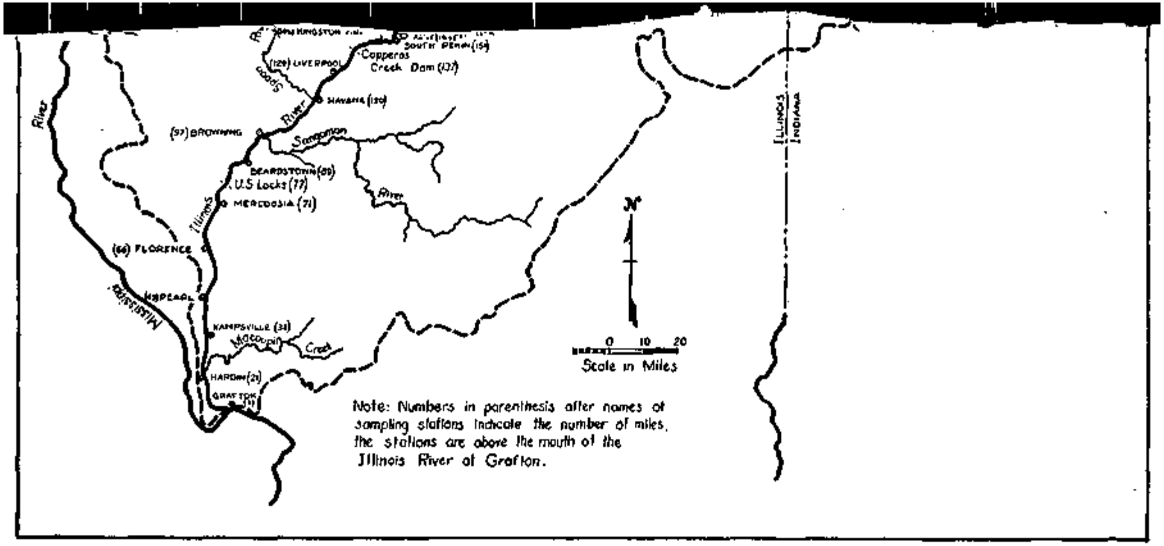


Figure 1—Sampling Stations along Illinois River

Experimental Procedure

Of the many parameters that are available for river studies probably the best chemical ones are the dissolved-oxygen and biochemical oxygen demand determinations. These two, with bacteriological counts, total at 37 degrees and *B. coli*, give a valuable index as to the condition and progress of self-purification of a stream.

The six dissolved oxygen samples drawn at each station were collected during the forenoon, such samples having been noted in previous studies *(1)* to be more representative than afternoon samples. All were drawn by the use of an appropriate sampler and were run in the field using the Rideal-Stewart modification of the Winkler method *(5)*. The biochemical oxygen demand sample collected at each station was drawn from channel waters at a point which cross-section studies have shown to be representative of the river at this station, and was composed of equal portions of water collected 1 foot below the surface of the water and 1 foot above the bed of the channel. The B. 0. D. determinations were made by the dilution method *(1)* using stored and aerated distilled water containing 300 p. p. m. of sodium bicarbonate as the dilution water. Duplicate incubations were made on all samples. As a rule the final titration of these duplicates checked within 0.1 to 0.2 p. p. m. The bacteriological samples were collected from channel waters, iced, and shipped to Urbana for analysis.

The average stage of water at Peoria during the three surveys of 1929 was 14.9 feet. This corresponds to a flow of 20,000 cubic feet per second. The average summer stage since 1900 has been about 12.0, or a flow of 13,300 cubic feet per second. In this connection it is interesting to note that the average river stage at Peoria for the months of June, July, and August from 1867 to 1900 or, in other words, prior to the time Chicago started to divert her diluted wastes down the Illinois River, was only 5.8 feet *(6)*. This means since 1900 that the Illinois River has been, on an average, 6.2 feet higher than it was prior to the time Chicago started to divert her wastes down its course.

The summer season of 1930 was a very dry one. As shown in Figure 2, the stage at Peoria was lower than the average and much lower than that of 1929. The average stage of water found at Peoria during the five summer surveys was 10.2 feet. This corresponds to a flow of 10,300 cubic feet per second. This is a lower stage of water than noted during the dry summer season of 1923. The average stage during the three summer months of this season was 10.9 feet, or a flow of 11,400 cubic feet per second. Data collected during this low-water season have been reported for the Water Survey by Greenfield (S). On July 1, 1930, the Chicago Sanitary District, in accordance with a predetermined program, cut the dilution water being diverted from Lake Michigan from an average of 8500 cubic feet per second to 6500 cubic feet per second. This cut undoubtedly had its effect on the river, although the rate of fall still continued about the same. On August 3 the stage at Peoria got as low as 9.2 feet, which corresponds to a flow of only 9000 cubic feet per second. On this basis the sanitary canal was furnishing 72 per cent of the water found in the river at Peoria. Owing to the low stage of water and continued drought conditions, the War Department on August 15 granted a temporary permit to the Chicago Sanitary District to increase their diversion up to 12,000 cubic feet per second. This, with the welcomed arrival of general

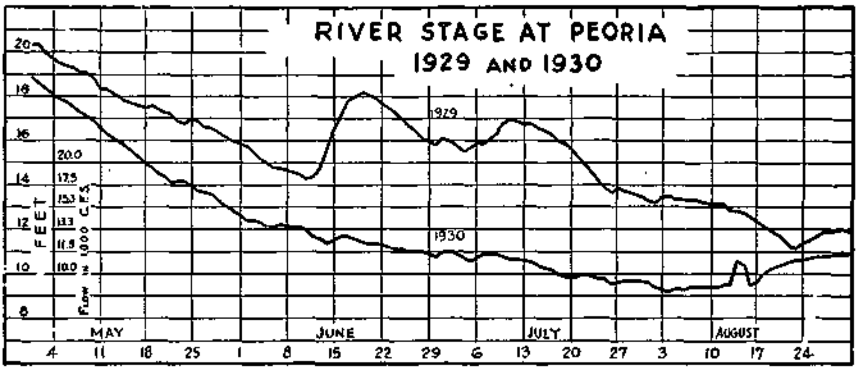
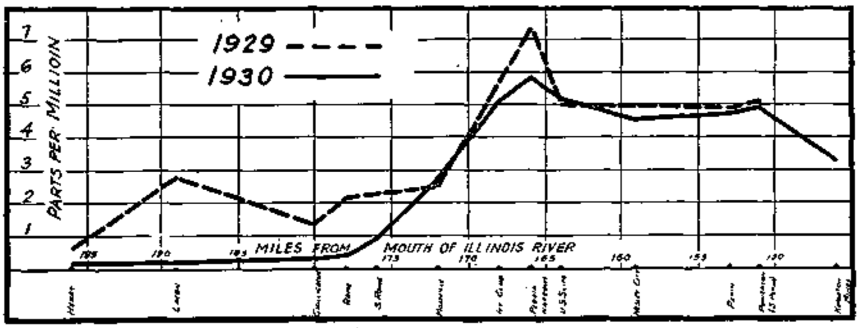


Figure 2



AVERAGE DISSOLVED OXYGEN, ILLINOIS RIVER, SUMMER SEASONS OF 1929 AND 1930.

Figure 3

showers along the river, brought about a gradual increase in the river stage. The last survey trip of the summer of 1930 (August 18 and 19) was made during this period. Prom these data it is apparent that the Illinois River during the summer season of 1929 was characterized by a flow somewhat above normal, while during the summer of 1930 the flow was considerably below normal.

The averages of the summer dissolved oxygen, biochemical oxygen demand, and bacteriological data for all stations between Henry and Kingston Mines are shown in Figures 3, 4, and 5. As stated earlier in this paper, this reach of the river contains those sections—namely, 3, 4, and 5—which are most interesting from a scientific viewpoint. . Additional data collected in the upper and lower reaches of the river are not shown.

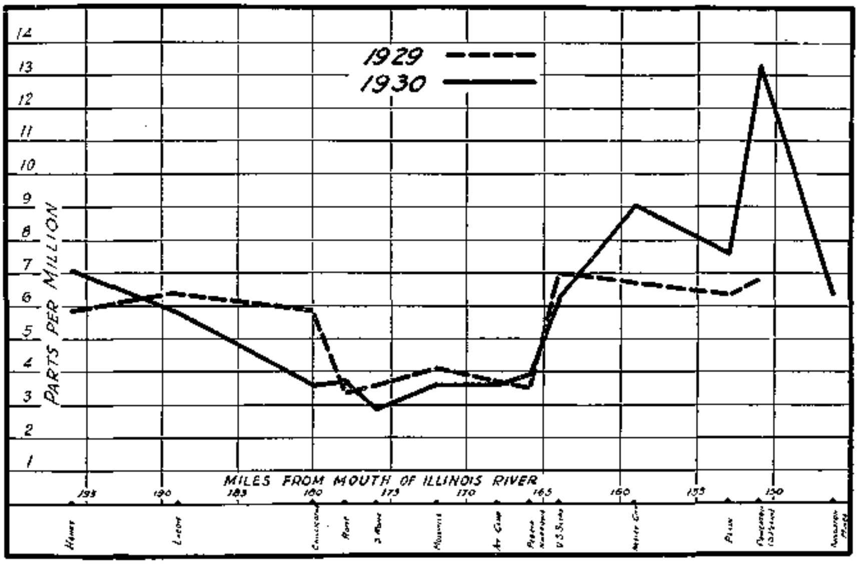
Dissolved-Oxygen Data

The dissolved-oxygen data for 1929 are noted to be of a little greater magnitude in the section of the river between Henry and the Peoria Lakes, than noted during the low-water season of 1930. In fact, low dissolved-oxygen contents were noted in the channel waters of Upper Peoria Lake. On August 19, 1930, the dissolved oxygen of the channel waters at. South Rome, located 4 miles from the head waters of this lake, was only 0.2 p. p. m. Never before, with the exception of the low-water summer season of 1923, has the pollution penetrated the lake to this distance. Very low dissolved-oxygen values have often been obtained at Chillicothe, which is located just at the upper end of the lake, but these low values are usually raised very rapidly as the water enters and is mixed with the slow moving waters of the lake.

As noted in Figure 3, the dissolved oxygen values increase quite rapidly in the lake region between Rome and Peoria. This rapid increase is caused by the greater amount of reaeration which is due to the greater width of the river, and to the greater aeration brought about by the waves found in these larger bodies of water. The slow rate of flow found in these lakes permits a great deal of sedimentation to take place which leads to clearer water and to the development of large amounts of algae and plankton. As a result of all these factors the river water upon arrival at Peoria, following its 2-day trip through the Peoria Lakes, is in good condition. It is practically always over 70 per cent saturated with dissolved oxygen, it has a biochemical oxygen demand not uncommon to unpolluted streams, and a total bacteriological count of only about 1000 per cc. and a *B. coli* count of less than 50 per cc. Many times the bacteriological results are even more favorable. As noted in Figure 3, the dissolved-oxygen content of the river falls below Peoria. This is due to the oxygen demand of the wastes added by Peoria and Pekin. The population equivalent of the city of Peoria is about 1,100,000 and that of Pekin about 150,000 *(1).* One industrial fermentation plant in Peoria empties about 4 million gallons of slops to the river each day. These wastes, during the summer of 1930, had a 5-day biochemical oxygen demand of from 8500 to 12,000 p. p. m. The dissolved-oxygen content of the river below Peoria and Pekin never returns to even a moderate figure.

Biochemical Oxygen Demand

The biochemical oxygen demand data plotted in Figure 4 does not show so heavy a pollution load in the river immediately below Henry in 1930 as in the higher water season of 1929. It is quite probable that the lower flow of 1930 permitted more sedimentation in the uppermost reaches of the river. The 5-day biochemical oxygen demand values for the lake regions are very similar and compare well with those obtained during the more extensive surveys of 1925 to 1928. The effect of the low stage of water on the biochemical oxygen demand of the river below the Peoria and Pekin sewer outfalls is very evident. The values for 1928, which was more of a normal season, fall nearer those of 1929 than those of 1930. The occasional high values (5 to 6 p. p. m.) obtained in lake samples have been attributed to biological life caught in the samples, and not to domestic or industrial wastes present in



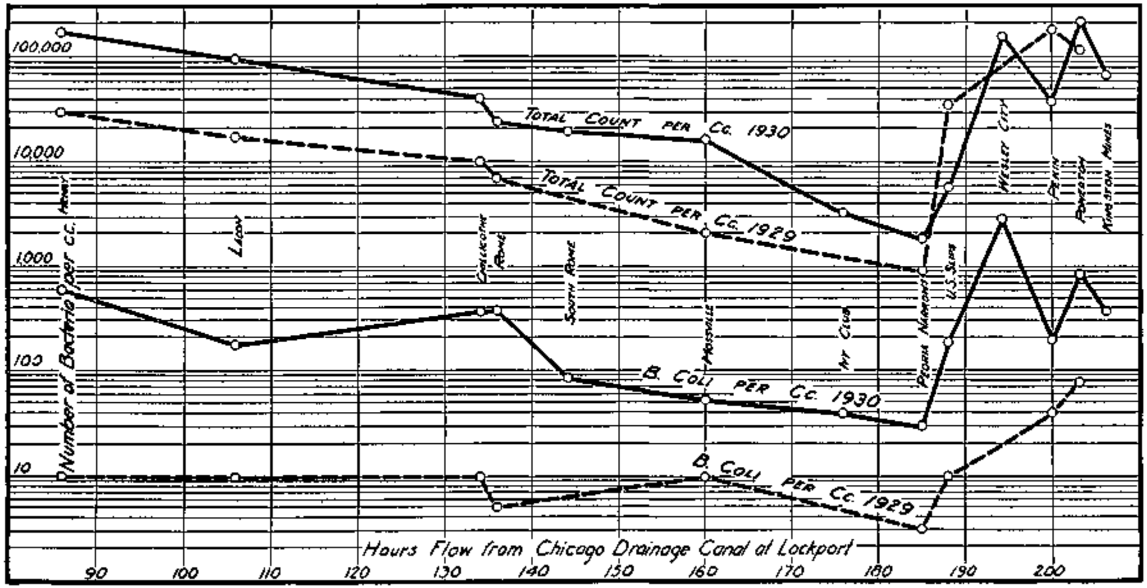
AVERAGE BIOCHEMICAL OXYGEN DEMAND, ILLINOIS RIVER, SUMMER SEASONS OF 1929 AND 1930.

Figure 4

the water. At times the lake waters were very green with algae. Examination showed these growths to be mainly Hydrodictyon with some Ulothrix and Rotifera and a few Spirogyra.

Bacteriological Data

The bacteriological data plotted in Figure 5 show plainly the effect of the drought on the data for 1930. The average total counts and the *B. coli* counts are all higher for the low-water season. Here again one notes the gradual self-purification of the river in the section from Henry to Chillicothe and in the lake region from Chillicothe to Peoria. The reader's attention is called to the fact that the counts are plotted logarithmically against time rather than distance. This



AVERAGE BACTERIOLOGICAL COUNTS, ILLINOIS RIVER, SUMMER SEASONS 1929 AND 1930

Figure 5

takes care of the slow flow found in the Peoria Lakes. The counts are seen to rise quite rapidly upon the addition of the Peoria and Pekin wastes.

The Super-Power Company of Pekin has found the river immediately below Pekin so polluted that they have had to resort to chlorination to keep down sphaerotilus growths so that they could use the river water in their condensers.

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