Butler University Botanical Studies

Volume 6 Article 4

Plankton and its relationship to chemical factors and environment in White River canal, Indianapolis, Indiana

Eugene R. Hupp
Butler University

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Recommended Citation
Hupp, Eugene R. (1943) "Plankton and its relationship to chemical factors and environment in White River canal, Indianapolis, Indiana," *Butler University Botanical Studies*: Vol. 6, Article 4.
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Butler University Botanical Studies

(1929-1964)

Edited by

Ray C. Friesner

The *Butler University Botanical Studies* journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana's vegetation in past decades. Authors were Butler faculty, current and former master's degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler's first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner , included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

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PLANKTON AND ITS RELATIONSHIP TO CHEMICAL FACTORS AND ENVIRONMENT IN WHITE RIVER CANAL, INDIANAPOLIS, INDIANA[1]

By EUGENE R. HUPP

PURPOSE OF THE INVESTIGATION

A stream or body of water displaying a large population of algae presents a major problem to the water purification department of many inland cities which depend upon surface supplies as their source of water. Such water when used in the purification process of public supplies, has obnoxious tastes and odors which cannot be completely removed by known treatments. The heavy population of algae will also cause filter matting and clogging which is another problem of equal importance.

The water industry would receive a useful tool if it knew when to expect these plankton pulsations, and what their effect would be upon purification treatments. From this point of view, it would be beneficial to know a prerequisite factor for algal growth and changes occurring in the stream during a plankton pulse.

REVIEW OF LITERATURE

Most of the work published to date on algal growth, its requirements and effects, has been with lake waters and not rivers. Forbes and Richardson (4) in their work on the Illinois River show that the plankton increased 69% after the opening of the drainage canal of the Sanitary District of Chicago, January 17, 1900. This increase in plankton was due mainly to the increase of food supply furnished by the Chicago sewage.

Kofoid (7) in his work on the Illinois River, 1894 to 1899, sought a factor to which he might attribute the diatom pulses. Changes in nitrate content yielded no marked correlation either in amount or direction. This was explained by suggesting that the nitrates are far

[1]A portion of a thesis submitted to the Faculty of the Division of Graduate Instruction in partial fulfillment of the requirements for the degree Master of Science, in the Department of Botany, Butler University.

in excess of the demands of diatoms, due to sewage contamination. Diatom pulses occurring throughout the year seemed to preclude the factor of temperature as the immediate cause of the pulse except as it might affect the growth in individual species. The vernal pulse was obtained each year about May 1, at which time the water passed the temperature of 16° C. The average of the recorded surface temperature of 1898 in the river was 14° C. Kofoid found ten pulses in 1898 from March to January. Seven were found on declining floods and but three on rising water, and two of these three appeared during the slow rise of October-November. He concluded that there was a failure to exhibit any periodic rhythm in food matters in solution and suspension in the river water with which these pulses of chlorophyll-bearing organisms might be correlated.

Atkins (1) states that a deficiency of phosphates apparently limits production of fresh water plants, while Juday (6) claims that there is no definite evidence that the soluble phosphorus was a limiting factor in the production of phytoplankton of lake waters of northwestern Wisconsin. An investigation of limestone quarry pools by Wimmer (16) revealed that there was a general correlation between organic nitrogen and the plankton crop, although no correlation was found between soluble phosphorous and plankton.

Working on the Mississippi River, Weibe (15) concluded that the inorganic nitrogen is apparently not a limiting factor for phytoplankton, but soluble phosphorous may be at times. A study of the Hocking River by Roach (14) included light, acidity, current, chemical condition of the water and water temperature. Only the chemical composition and temperature showed variations that corresponded with changes in plankton. Plankton abundance varied directly with temperature. At three stations, the river was polluted with domestic sewage, and the total plankton decreased, while Myxophyceae and Protozoa increased.

Purdy (13) found on the Ohio River that holophytic organisms are certainly dependent upon sunlight for miximum growth. "The presence of large amounts of organic matter such as sewage resulted in numerous animal forms rather than plants, while dissolved inorganic matter resulting from advanced decomposition, favors the presence of plants as the dominating organisms. If the conditions of the stream were stable and the water was clear enough to admit sunlight, a heavy plankton, principally of diatoms, was the usual result, even if the temperature was low."

In a study of the phytoplankton in English lakes, Pearsall (12) found that diatoms follow the maxima of nitrates, phosphates and silica. Asterionella tended to have higher requirements than Tabellaria. Diatoms did not develop in abundance when the silica was below 0.5 and calcium below 3.0 mgm per liter. Green algae occurred when nitrates and phosphates were low. Myxophyceae showed a general correlation with high organic matter.

Work conducted in California by Goudey (5) indicated that there is a direct relationship of plankton multiplication to the ultra-violet radiations in sunshine. The radiations were measured by a constant recording instrument utilizing a photo-electric cell. Maximum algal growth coincided with the period of maximum ultra-violet ray activity.

Much of the literature stresses importance of an abundance of organic matter in the water as a means of producing a rich plankton. The fact is so well known that growers of pond fishes in Europe deliberately manure their ponds to increase the algae as food supply for their fish. The plankton of the Elbe is largely increased by the sewage of Hamburg and Altona poured directly into that stream. While the indications are that sewage pollution will ultimately increase the plankton, there seems to be, however, a general disagreement among the various workers as to definite chemical and physical requirements essential for plankton growth.

LOCATION AND CONDITIONS OF INVESTIGATION

The present study is one covering a period of four years in which algae from the White River canal were studied at one station and several chemical and physical factors of the water were determined in order to detect correlation between algal pulse and chemical and physical deviations.

The work done in this investigation was on water from the west fork of White River at Indianapolis, Indiana. This river receives sewage from the towns and cities upstream. Until recently, cities such as Anderson and Muncie discharged untreated sewage into this river. It is a flashy stream, that is, it fluctuates easily with normal rainfall. During the late summer and periods of low rainfall the stream is low and very sluggish, having many pools. Two of the major pools are formed by dams at Riverwood and Broad Ripple. The Riverwood dam facilitates local power production, while the Board Ripple dam serves the purpose of feeding water to the canal which is owned and maintained by the Indianapolis Water Company for its supply of water. The pooled water back of the Broad Ripple dam flows through the canal headgates and travels about six miles through the canal to the intake of the Indianapolis Water Company. The rate of flow through this canal is governed by means of gates, making it quite variable. Under normal conditions the rate of flow is approximately 1 mile per hour.

The samples for plankton enumeration were collected daily at 1:00 P. M. in the canal at the intake of the Indianapolis Water Company. All samples were worked as soon as they were collected except those collected during the week-end and these were preserved cither by 5% formalin, or by cold storage at 6° C. until Monday morning. The cold storage preservation was soon adopted in preference to formalin because many of the motile organisms were distorted by its action.

METHOD OF PLANKTON ENUMERATION

The organisms of an aliquot portion of the collected sample were concentrated by filtering through fine sand in a Sedgwick-Rafter funnel. The sand and the final 10 ml of the sample were then caught in a small beaker which was swirled gently to dislodge adhering organisms. One ml of this concentrated sample was then poured into a Sedgwick-Rafter plankton counting chamber. It was allowed to stand for about 10 minutes before examination, thus permitting most of the organisms to settle to the floor of the chamber.

The counting chamber was then placed on the mechanical stage of the microscope and examined by using a 20X objective and 10X eyepiece. The eyepiece was fitted with a ruled ocular micrometer, the outer boundaries forming a square field which was divided into 100 smaller squares by the rulings. For a representative count of a sample being examined all of the algae in 10 fields were counted. Each field was that area defined by the large square of the ocular micrometer. The 10 fields selected for counting were evenly spaced along the linear axis of the counting chamber from one end to the other. Each organism or coenobe was counted as one unless it was filamentous or elongated and then it was counted once for each of the small squares it spanned. The organisms thus counted were grouped into, Diatomaceae, Chlorophyceae, Cocci, Myxophyceae, Zooplankton, Euglenophyceae, Heterokontae, Chrysophyceae, and any other group which was found to be represented. The predominating genera occuring in each sample were noted but not given a numerical value individually.

The area outlined by the large square of the ocular micrometer was determined. The number of algae per ml of sample was calculated by multiplying the total number of algae counted in the 10 fields, by the factor that is required to bring the area of one field up to 1 cu mm. This was then multiplied by 100 to bring the volume up to 1 cc,, and was then divided by the concentration of the sample.

$$\frac{\text{Count in 10 fields X factor X 100}}{\text{Concentration of sample}} = \text{Algae per ml}$$

The necessity of working as rapidly as possible led to the adoption of the above method in preference to a more exact but longer one.

CHEMICAL ANALYSIS

Chemical analyses of water taken from the same sampling point as that used for plankton enumeration, were taken from the daily record of the Indianapolis Water Company's laboratory. The chemical analyses used in this study were: alkalinity, free carbon dioxide, dissolved oxygen, pH, ammonia, nitrites, nitrates, phosphates and silicates. Bacterial counts made on agar plates incubated at 37° C. for 24 hours, water temperature and rate of river flow were also obtained from the laboratory records. The ammonia, nitrite and nitrate results were in terms of nitrogen.

RELATIONSHIP OF PLANKTON TO CHEMICAL FACTORS

During the years of 1938, '39, '40 and '41, a daily plankton count was made during the algal season which usually extended from April to December, and a weekly count was made during the winter months of 1940 and '41. Graphs were prepared using the daily results and semi-monthly averages of each of the above-mentioned chemical analyses and the plankton count. By preparing graphs such as these for the four years of work, correlation of the chemical results to the total plankton count were noted. Particular attention was given any factor which seemed to deviate from normal immediately preceding a plankton rise.

In the examination and interpretation of these fluctuations the very important factor, rainfall, must be considered. This affects the chemical results and the algal count by dilution, and may affect plankton multiplication by substituting soft water for hard water, as is usually found in their natural environment. It was noted that when a large amount of rainfall occurred, the algae count made a sharp decline which was a simple dilution factor. During the summer and fall when smaller amount of rainfall occurred, there was a marked increase in the algal count which was probably due to flushing of heavily populated algal pools in the stream and on the watershed. In order to determine the amount of flushing that occurred each year, graphs were prepared using the data obtained from the river gauges located on White River at Broad Ripple and east of Nora, Indiana. The data obtained were rates of flow in terms of cubic feet per second.

RESULTS

1938

The daily results of total algae, diatoms, dissolved oxygen, pH, alkalinity, carbon dioxide, hours of sunshine per day, water temperature, and rate of river flow were used for this year. During this year there were four distinct plankton peaks (plate I). The first occurred during the last of April and the first of May, the second during the last of June, the third during the last of August and the fourth during the first part of October. The first and second pulses were composed of approximately 50% diatoms while the remaining organisms were chiefly Chlorophyceae. The third and fourth pulses were mostly diatomaceous, the third being more so than the fourth, which contained many Chlorophyceae and Cocci, which included spheroid cells occurring singly.

During the summer months there were six different periods of fairly heavy rainfall which increased the rate of river flow and affected all chemical analyses. The rate-of-flow curve continued in a straight line between the middle of September and November 20, thus eliminating rainfall as a factor affecting the other curves. During this period the major plankton peak of the season occurred accompanied by an increase of dissolved oxygen and an initial decrease in alkalinity and pH, with both rising during the middle of the pulse. The carbon dioxide remained fairly constant around 3.0 ppm (parts per million), which is not as might be expected. The number of hours of sunshine occurring during each day was also graphed but no definite correlation with plankton was noted.

The graphs representing daily results had many irregularities which were overcome by graphing semi-monthly averages (table I). Thus obtaining a more general curve. These curves lack detail and in many cases they are not in exact correlation with those of the daily

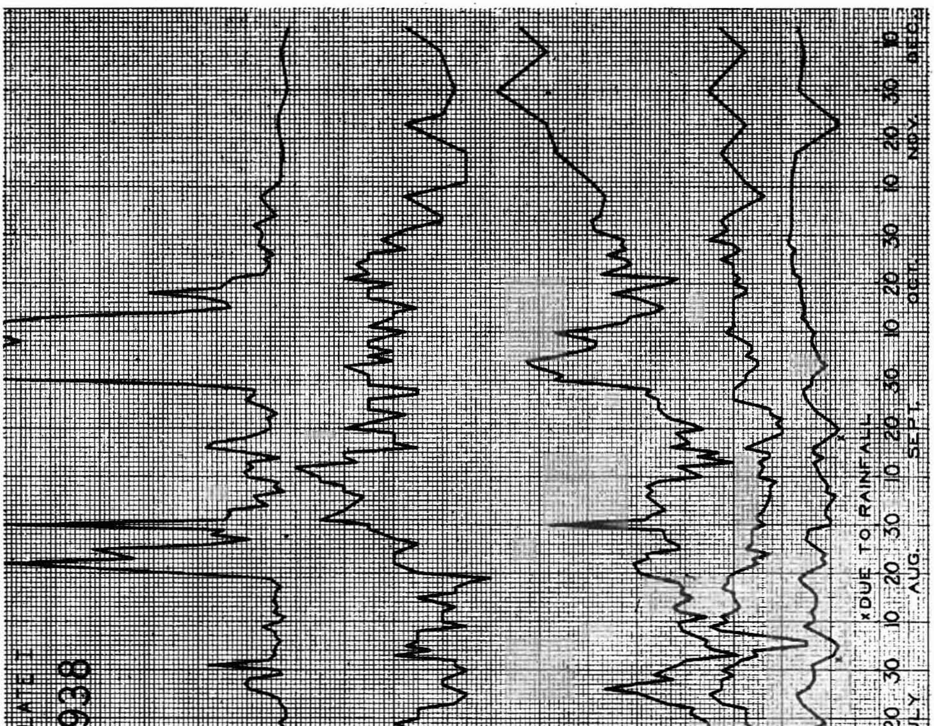
PLATE I
1938
TOTAL ALGAE
ORGANISMS PER
CO2
DISS. O2
ALKALINITY
x DUE TO RAINFALL
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.

results, but in order to present seasonal fluctuations a graph of this sort is necessary. The semi-monthly averages show that during the August and October plankton pulses there was a corresponding increase of dissolved oxygen while the pH and carbon dioxide did not correlate as well as by using the daily results.

The water temperature had increased to 18° C. before the first vernal plankton pulse occurred. There was no correlation of temperature to plankton population during the warm season. The last plankton peak of the season took place in cooling water that had fallen to 18° C.

1939

During this year the daily results of total algae, diatoms, Chlorophyceae, dissolved oxygen, pH, alkalinity, carbon dioxide, ammonia, water temperature and rate of river flow were used.

The total plankton count (plate II) reached at least three peaks during the season. The first occurred during the first half of June, the second during the last of August and the first of September and the third during the first part of October. Diatoms seemed to be the predominating organisms during the spring and fall peak periods, but during the mid-summer months, Chlorophyceae were generally the predominating organisms.

By following the graphs representing daily results (plate II), the dissolved oxygen increased with plankton peaks, showing very close correlation. The pH fell as the plankton reached its peak but in many cases it rose as the peak was approached and then fell. The alkalinity curve was affected on five different occasions during the season by rainfall which contributed soft water to the small flashy stream. In general the correlation between alkalinity and plankton was very vague during this year. The carbon dioxide did correlate with plankton in most cases in that it decreased as the plankton increased.

The ammonia seemed to fall during a plankton peak and rise after it, but due to limited results it is difficult to conclude that this is the true picture. As previously mentioned, upstream there are cities such as Anderson and Muncie, which during this time contributed untreated sewage to the stream and any ammonia fluctuations may be due to these sources. On the other hand, if the ammonia fluctuates because of plankton population, the high content following a plankton peak may be due to decaying algal cells while the low content during

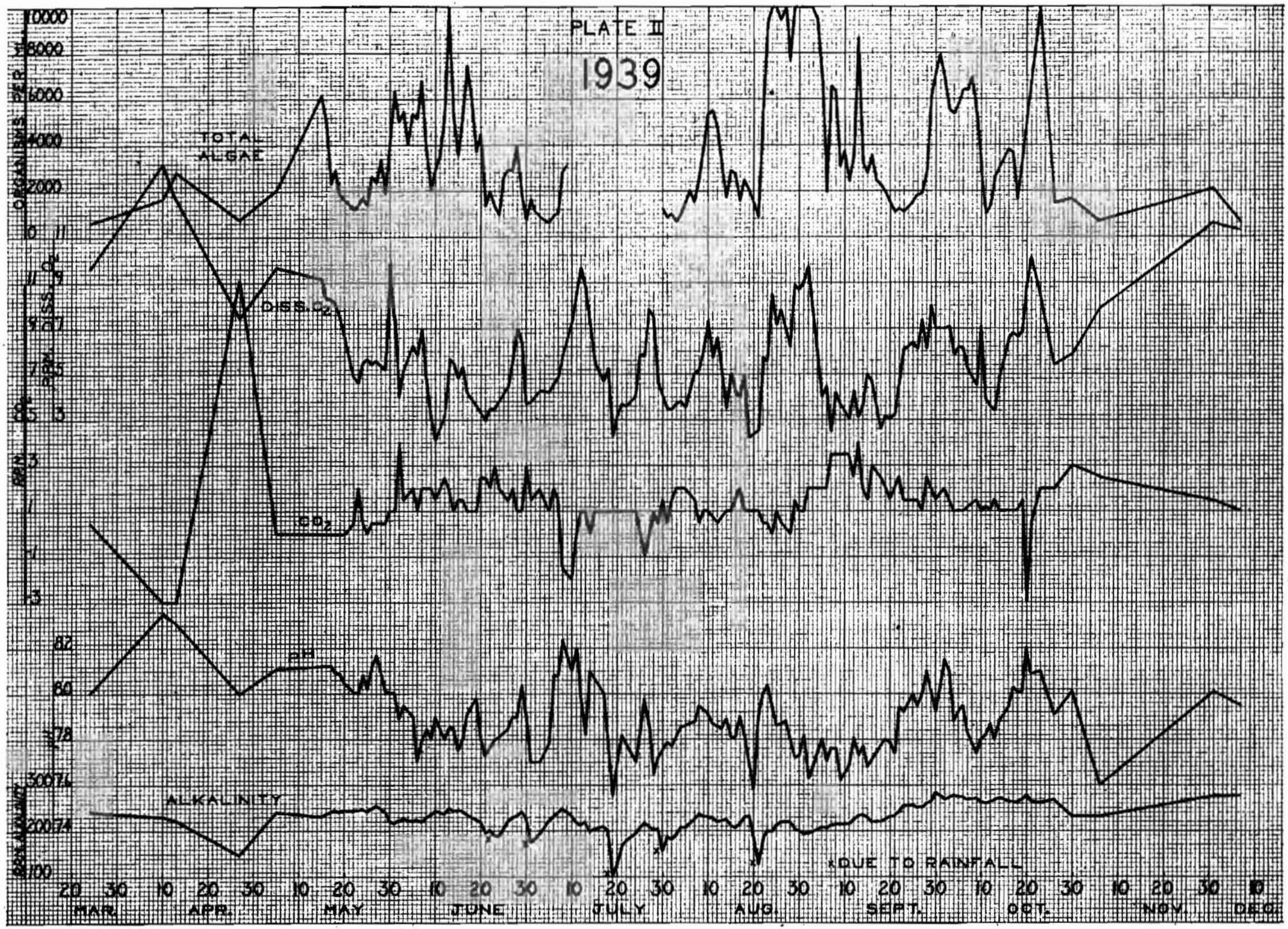
PLATE II
1939
TOTAL ALGAE
ORGANISMS PER
DISS. O2
CO2
PH
ALKALINITY
x DUE TO RAINFALL
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.

a plankton peak may be caused by its consumption by the algal cells during this period of intense activity.

The temperature had reached 10° C. before the first vernal peak which consisted almost entirely of diatoms. By the middle of May the temperature had reached 16° C. and a second diatom peak occurred with only a few Chlorophyceae. The preponderance of Chlorophyceae first appeared on June 1, at which time the water temperature had reached 24° C. The Chlorophyceae then remained as a major class throughout the summer until October 1, when the diatoms were the predominating organisms, and the water temperature had fallen to 18° C.

The graphs composed of the semi-monthly averages (table I) lack detail and magnitude. In order to get a clear picture of the season's results, the graphs of the daily results are necessary (plate II).

1940

The data obtained during this season represented the daily results of total algae, diatoms, dissolved oxygen, pH, alkalinity, carbon dioxide, ammonia, nitrites, phosphates as PO_4, silicates as SiO_2, 37° bacteria per ml, temperature and rate of river flow.

The total algae (plate III) reached four peaks during this season, two of which were major while the other two were of short duration. The first peak, which was a major one, occurred during the middle of May at which time the diatoms also reached their first peak. The second and third pulsations were of short duration and were considered as minor peaks, occurring on June 9 and August 26, respectively. The fourth and last major peak occurred during the last half of October. The organisms composing this flora were practically all Melosira.

At this time attention should be called to a few observations which are irrelevant to the main text of this paper. During the Melosira pulse, numerous upstream and canal surveys were made and each time the Melosira population was greatest in the head waters of the canal. During the flow through the canal from the head waters to the Indianapolis Water Company's intake (approximately 6 miles), 90% of the organisms were lost. The diminishing plankton was directly related to a decrease of dissolved oxygen and an increase of ammonia both of which were probably due to decaying algal cells producing an oxygen demand and liberating ammonia from the algal cells during bacterial assimilation.

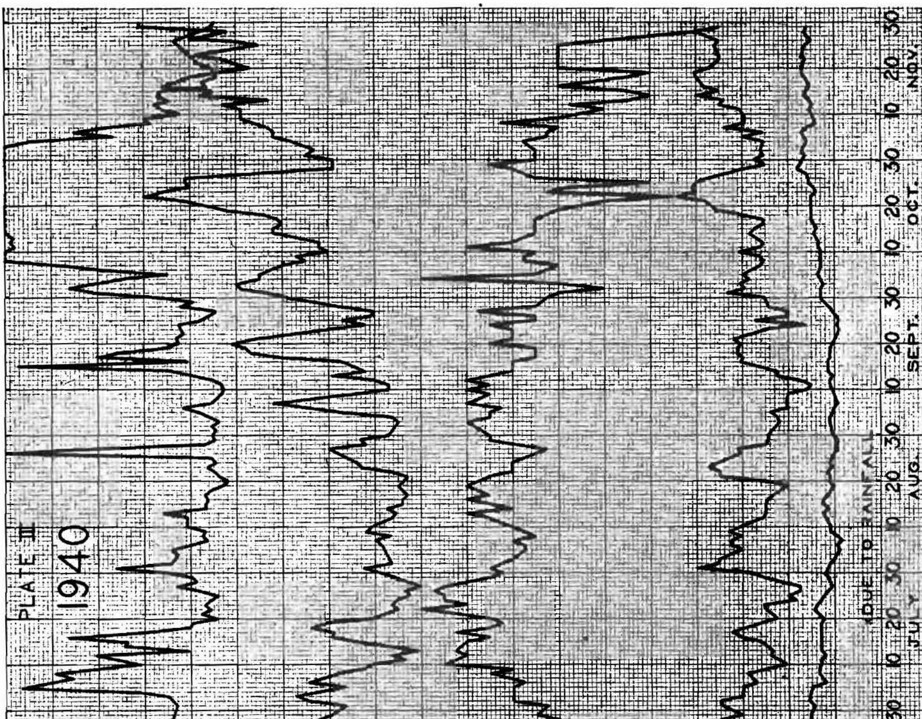
PLATE II
1940
TOTAL ALGAE
DISS. O2
CO2
PH
ALKALINITY
DUE TO RAINFALL
ORGANISMS PER ML.
PPM DISS. O2
PPM CO2
PPM ALKALINITY
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.

By plotting the daily results (plate III) there is a very close correlation between total algae, dissolved oxygen, carbon dioxide and pH. As previously shown each plankton rise was accompanied with a rise in dissolved oxygen and pH while the carbon dioxide decreased.

The silicate and phosphate determinations were limited in number and were made only in the latter part of the season. During this time there were two diatom peaks and each seemed to correlate with the soluble silicates in that there was a very rapid decrease in silicates as the diatom population increased. There was no correlation between phosphates and plankton, but this may have been due to technical difficulties experienced in the determination of phosphates.

The ammonia and nitrite nitrogen did not correlate with plankton changes although the semi-monthly averages of nitrate nitrogen rose to 4.3 ppm and immediately began to fall as the plankton approached its spring peak. As the plankton declined, the nitrate nitrogen again increased to 3.08 ppm on June 15, and immediately decreased until July 15, at which time the plankton had reached another peak. This seems to indicate that nitrates were utilized by the increasing plankton and may have been essential in its multiplication. If the source of nitrates remains constant and their concentration is not lowered by dilution, then possibly a sharp reduction of them might be used as an indication of a subsequent plankton pulse.

The alkalinity was affected on three different occasions during the spring rainfall, but during the remainder of the year when rainfall was negligible, there was no indication that it or bacterial counts were functions of plankton pulsations.

During early spring the temperature of the water increased quite rapidly from 11° C. to 18° C., accompanied by a high plankton peak, 50% of which were diatoms. There was no definite relationship of temperature to plankton during the warm summer weather and the water temperature had fallen to approximately 16° C. before the autumn pulse began. This pulse, which consisted almost entirely of diatoms, remained high for about one month, the end of which occurred as the water temperature fell rapidly from 12° C. to 1° C.

The semi-monthly averages were tabulated (table I) and those factors which correlated with total algae were graphed (plate VI). The total algae did not correlate with dissolved oxygen, carbon dioxide and pH during the last of June, but by using the graphs representing daily results these factors correlated very well during this time.

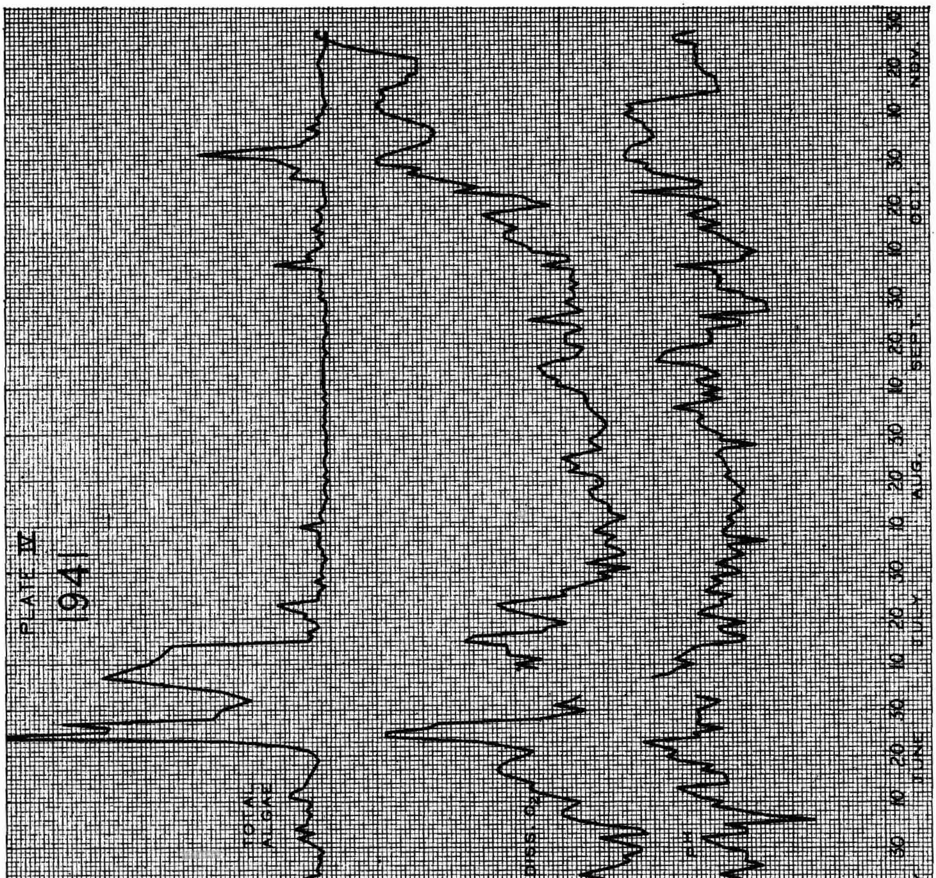
PLATE IV
1941
TOTAL ALGAE
DISS. O2
PH
ORGANISMS PER ML
PPM
MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV.

1941

This season's work included total algae, Chlorophyceae, diatoms and the same physical and chemical data as in 1940 with the exception of phosphates and 37° bacteria.

The total algae (plate IV) reached its vernal peak during the last of April and the first of May. The flora of this pulse consisted of about equal proportions of diatoms and Chlorophyceae, although the diatoms preceded the Chlorophyceae both in initial preponderance and in reduction by 3 to 4 days. The second pulse consisted of a split peak, the first section occurring in the last of June and the second during the first part of July. The first section of this pulse contained twice the number of diatoms as Chlorophyceae while the second section contained a few more Chlorophyceae than diatoms. The third and last pulse of the season occurred on the first of November and consisted almost entirely of diatoms, tentatively identified as Cyclotella and Synedra. The autumn peak of this season occurred later than in any of the three previous years probably due to the low rate of flow through the canal which is explained later.

Graphs representing daily results show that total algae, dissolved oxygen and pH curves (plate IV) parallel each other during their fluctuations while the carbon dioxide curve (plate V) is inversely related. These three chemical curves are more closely related to the diatom curve (plate V) than to either the Chlorophyceae or total algae. The alkalinity and ammonia curves had no correlation with algae, but nitrites, nitrates, and silicates were usually high preceding a plankton pulse and decreased rapidly just before the peak was reached. The nitrites and nitrates correlated fairly well with total plankton while silicates correlated with diatom pulses (plate V).

Water temperature increased rapidly during early spring. It rose 18° C. from March 20, to April 19. On April 9, there was an Euglena bloom as the water temperature reached 12° C. Immediately following the Euglena bloom was the vernal plankton pulse at which time the water temperature was 16° C. During the warm season there was no relationship of temperature with plankton. The autumn peak of diatoms occurred in a cooling water that had fallen to 12° C.

There was very little rainfall during the year, and most of that occurred in the first half of June. The rainfall of this time apparently had little or no effect on plankton; although, there was a mid-summer peak as the river declined to normal summer flow.

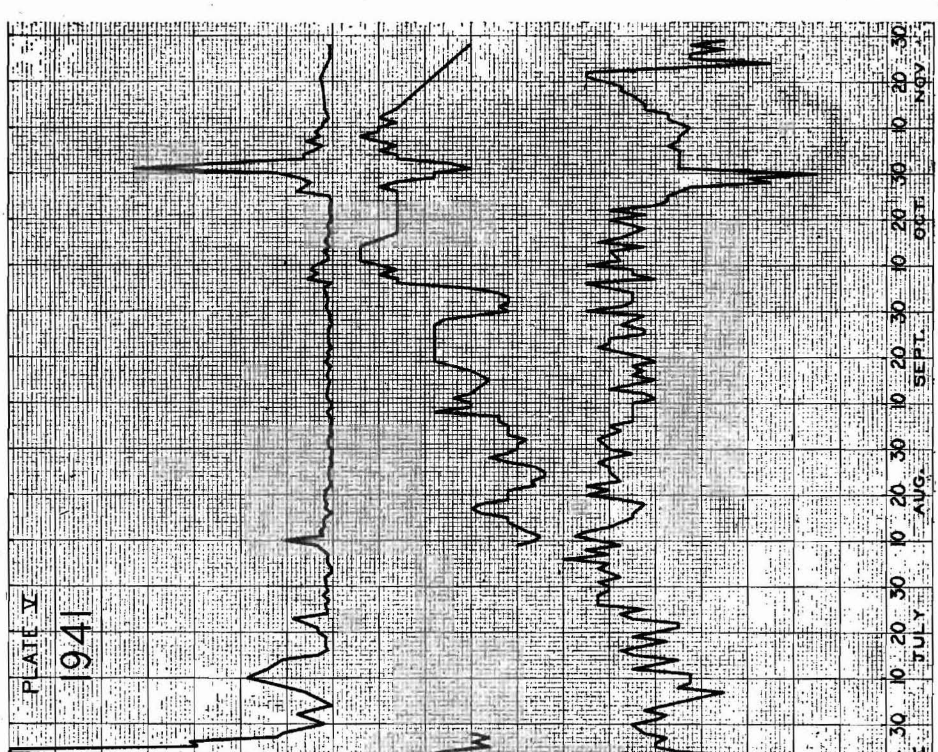

PLATE V
1941
DIATOMS
SiO_2
CO_2
ORGANISMS PER ML.
35000
30000
25000
20000
15000
10000
5000
0
PPM SiO_2
20
15
10
5
0
PPM CO_2
6
4
2
0
2
4
6
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.

DISCUSSION

During the four years of study the rhythm of plankton pulsations seemed to be fairly constant, but the magnitude was different from year to year (plate VI). The vernal pulses occurred in April or May, followed by summer pulses occurring in June or July, and in August during 1938 and 1939, and the autumnal pulses occurred in October during 1938, 1939 and 1940 and in November during 1941. Previous work by Calvert (2) in 1920 on water in the White River canal showed a peak occurring in September. In 1934, a similar study by Coffing (3) on water in the White River canal showed two peaks, one during June and the other during October.

Fluctuations of total algae were closely correlated with dissolved oxygen, pH and carbon dioxide, i. e. with plankton rises there was an increase in dissolved oxygen, a higher pH and a decrease in carbon dioxide. These conditions do not exist during the winter months because of the low water temperature, thus permitting greater solubility of gases. There seemed to be a general tendency for the nitrites, nitrates and silicates to diminish preceding a plankton rise which was especially true of the latter when compared with diatom pulses.

The diatom pulses were usually limited to spring and fall while Chlorophyceae were more abundant after the spring diatom peak and during the warmer months. The vernal peak never occurred in a water having a temperature of less than 10° C., while the autumn peak always occurred before the water had cooled to 10° C. These two extremes usually supported diatom pulses. As the water temperature increased during late spring and summer, there was apparently no correlation with plankton. During the early spring previous to any plankton pulse, there were quite often minor plankton fluctuations which ran parallel with changes in water temperature.

The plankton population of many streams is affected by factors usually not found in lake waters isolated from metropolitan areas. Sewage and industrial wastes affect plankton both quantitatively and qualitatively. Since the year 1940, sewage has been effectively treated by disposal plants of two cities upstream from Indianapolis, but previous to that time, White River received the bulk of these discharges as raw untreated sewage. The stream was always rich in nutrient material thus establishing optimum conditions for plankton multiplication.

The quality of the plankton is affected by sewage in that the type

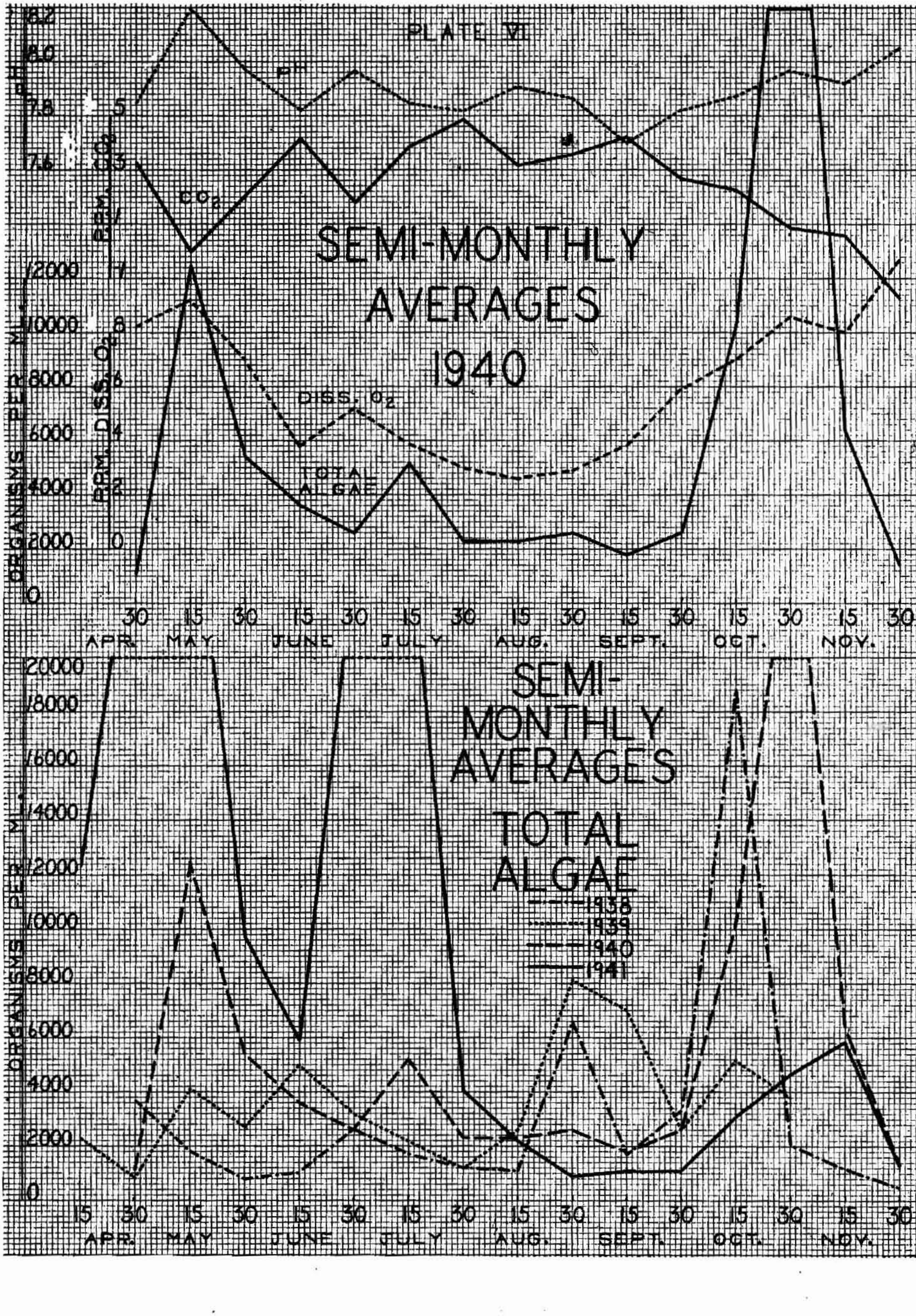
PLATE VI
SEMI-MONTHLY AVERAGES 1940
pH
CO_2
DISS. O_2
TOTAL ALGAE
P.P.M. CO_2
P.P.M. DISS. O_2
ORGANISMS PER ML.
APR. MAY JUNE JULY AUG. SEPT. OCT. NOV.
SEMI-MONTHLY AVERAGES
TOTAL ALGAE
1938
1939
1940
1941
ORGANISMS PER ML.
APR. MAY JUNE JULY AUG. SEPT. OCT. NOV.

of flora changes from an area of pollution to one of relatively clean water. These pollutional and clean water types were demonstrated by Lackey (8) in his work on the Scioto River and by Palmer (11) in his work on White River below Indianapolis. Industrial wastes are also a major factor in determining the type of organisms found in streams receiving such discharges. Some organisms are especially tolerant to extreme conditions while many others are completely inhibited as is shown by Lackey in his work on streams receiving acid mine waste (9) and distillery wastes (10).

Rate of stream flow is also a factor in determining the number and kind of organisms found at any sampling station on the stream. Plankton numbers usually decrease immediately below a point of heavy sewage pollution and then gradually increase downstream as bacterial action on organic material proceeds and finally begin to decrease again as the nutrient material is utilized and the cycle is completed. The location of highest plankton population may be constant or it may move either upstream or downstream. A low sluggish stream will keep the heavy plankton relatively close to the point of sewage pollution while a swift stream will move the plankton peak farther downstream.

During the summer months of 1940 and '41, several river surveys were made upstream from Indianapolis. On September 30, 1940, a survey of this sort was made, which included sixteen sampling points. The farthest upstream sampling point included Chesterfield, Indiana, which is approximately seven miles above Anderson and 57.5 miles from Indianapolis. The remaining stations were consecutively located downstream, the last two being canal stations at Indianapolis. The sampling of these stations was done by working downstream from Chesterfield, taking the first sample at 10:45 A. M. and the last (Indianapolis Water Company intake) at 2:50 P. M. The samples were immediately taken to the laboratory and worked as soon as possible. Plankton samples were usually stored in the refrigerator until the next day.

The results (table II) showed that the plankton was relatively low above Anderson with a gradual increase until the stream received the Anderson sewage and then remained fairly constant until the stream began its natural purification at which time the plankton rapidly increased to large numbers. The plankton peak was reached at Northern Beach, 16 miles from Indianapolis, and then began its sharp decline as the water progressed downstream.

The dissolved oxygen parallels the plankton except just below Anderson which is due to the oxygen demand of sewage contributed by Anderson at a point just above Moss Island. The earbon dioxide is inversely related to plankton except when affected by the Anderson sewage.

The ammonia, nitrites and chlorides were good indicators of sewage pollution while the silicates and phosphates were as high above the Anderson sewage outfall as they were below and continued to decrease as the water continued downstream. The water entered the White River canal containing only a trace of ammonia and increased as the water traveled through the canal, which received no outside pollution. This increase in ammonia is thought to be due to the decaying algal cells of a diminishing plankton.

The decreasing amounts of phosphates and corresponding increase in plankton as the water progressed downstream, indicated that the plankton may have utilized the soluble phosphates in their metabolism. There was also a decrease in silicates downstream from Northern Beach as the diatoms increased, reaching their peak at the canal head gates, thus indicating that soluble silicates may have been utilized by the diatoms. The results of other river surveys by previous workers reveal that the same conditions as outlined above were true during the time they were studied.

If the plankton peak can be held upstream by decreasing the rate of water flow a low plankton can then be expected at the intake of the Indianapolis Water Company, where its presence is certainly not desirable. Establishment of these conditions was realized during the summer of 1941 when the river level was low, and the lower canal gates were closed, permitting only the amount of water being actually used by the water company to flow through the canal. During this time the plankton was excessively heavy upstream but had greatly reduced by the time the water reached the intake. The high plankton peak during November at the intake occurred after the canal gates had been opened and the rate of flow greatly increased. The autumnal peaks during the three previous years occurred periodically within two weeks of each other during October. The reduction in rate of flow during that period of 1941 is considered as responsible for the delayed peak.

CONCLUSION

1. The vernal and autumnal plankton peaks were fairly constant from year to year in their periodicity and were usually the major

peaks of the season. The diatoms reached their maxima during these two peaks. Those peaks which occurred during the summer were quite often represented by excessive numbers of organisms but were of short duration; therefore, they were considered as minor peaks.

2. The high plankton peaks were accompanied by an increase in dissolved oxygen and pH and by a decrease in carbon dioxide, nitrites, nitrates and silicates. Obviously, the fluctuations of dissolved oxygen and carbon dioxide were merely the results of photosynthesis, while pH seemed to be governed by the amount of free carbon dioxide, i. e., the greater the carbon dioxide content of the water the lower the pH.

3. The nitrite and nitrate content of the water decreased previous to plankton pulses represented by a mixed flora, thus indicating that these compounds were essential for multiplication of most planktonic organisms.

4. The soluble silicates decreased prior to increases in diatom populations but did not correlate very well with other types of organisms.

5. A decrease in nitrites, nitrates and silicates might be used as an indication of an impending plankton pulse represented by diatoms or a mixed flora and a decrease in only nitrites and nitrates with silicates remaining fairly constant would indicate that the flora would be deficient in diatoms.

6. River surveys above the sampling point showed that the heaviest plankton population was always downstream from the point of sewage pollution, and the location of the plankton peak seemed to be governed by the rate of river flow. This is due, probably to the fact that bacteria must change the character of the organic matter of the sewage before it can be utilized by most algae. With water temperature remaining constant, bacterial decomposition of the organic matter takes place at a given rate; therefore, an increase in rate of flow extends the decomposition process and the plankton peak farther downstream.

ACKNOWLEDGMENT

The writer wishes to acknowledge with appreciation the cooperation of the Indianapolis Water Company in its permission to use laboratory data and especially to C. K. Calvert, superintendent of purification, and the instructional aid and suggestion of this paper as was contributed by Dr. C. M. Palmer. He is also indebted to Mrs.

Jeannette Freyn Lloyd for the typing of the original paper and to his wife, Mrs. Gladys Lloyd Hupp, for her help in preparing the final graphs.

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TABLE I

Showing semi-monthly averages, 1938-1941

	Total Algae per ml	Diatoms per ml	Dissolved O_2 ppm	CO_2 ppm	pH	Alkalinity ppm	NO_2 ppm	NO_3 ppm	SiO_2 ppm	Rate of River Flow cu. ft. per. sec.
1938										
Apr.			9.4	3.5	7.60	137				9,300
	3,700		9.2	.04	8.07	237				1,165
May	1,820		8.9	.8	8.05	247				568
	780		7.5	1.7	7.91	225				1,382
June	1,030		6.8	2.2	7.98	221				1,510
	2,560		6.5	3.4	7.90	203				2,761
July	1,660		6.1	2.8	7.98	232				1,703
	1,204		5.7	1.2	8.00	240				530
Aug	1,070		4.6	1.4	7.90	222				663
	6,600		6.4	2.4	7.90	232				261
Sept.	1,685		5.4	5.3	7.74	214				248
	3,270		6.1	3.1	7.80	226				311
Oct.	18,830		8.9	3.5	7.92	238				159
	2,090		7.3	3.7	8.00	269				175
Nov.	1,180		8.7	1.0	7.96	278				189
	535		10.6	.8	8.00	242				392
1939										
Apr.	2,252		11.8	—2.1	8.26	232				875
	763		8.7	3.7	7.75	139				6,110
May	4,103		9.3	.1	8.15	228				810
	2,690		6.6	.4	8.05	244				461
June	4,990		5.0	1.9	7.85	233				374
	3,160		4.4	1.9	7.85	219				651
July	2,325		6.2	.6	7.97	217				357
	1,235		4.6	.6	7.73	182				794
Aug.	2,555		4.8	1.2	7.89	214				332
	8,100		6.2	.9	7.83	204				329
Sept.	6,975		4.7	2.6	7.73	216				128
	2,590		5.3	1.9	7.93	244				100
Oct.	5,200		5.4	1.3	7.90	266				122
	3,770		6.8	1.5	8.00	263				185
Nov.			8.4	2.4	7.85	250				173
			9.8	1.2	7.97	276				178

TABLE I—(Continued)

Showing semi-monthly averages, 1938-1941

	Total Algae per ml	Diatoms per ml	Dissolved O_2 ppm	CO_2 ppm	pH	Alkalinity ppm	NO_2 ppm	NO_3 ppm	SiO_2 ppm	Rate of River Flow cu. ft. per. sec.
1940										
Apr.	1,137		8.2	3.3	7.85	169	.086	4.30		3,456
May	12,473		9.2	—.04	8.20	226	.119	2.59		729
	5,380		7.0	2.1	7.97	249	.082	1.09		449
June	3,580		3.8	4.2	7.82	211	.192	3.08		720
	2,635		5.2	1.8	7.97	257	.110	1.72		287
July	5,150		3.9	3.9	7.85	236	.035	.33		181
	2,270		3.0	4.9	7.82	225	.041	.29		134
Aug.	2,310		2.6	3.2	7.91	207	.010	.16		104
	2,620		2.9	3.6	7.87	207	.028	.58		89
Sept.	1,840		3.8	4.2	7.70	205	.024	.40		75
	2,560		5.9	2.7	7.82	205	.016	.30		72
Oct.	10,160		7.0	2.3	7.87	233	.018	.42		88
	45,600		8.6	.9	7.97	275	.046	.50		128
Nov.	6,430		8.0	.6	7.92	259	.117	1.80		132
	1,440		10.7	—1.7	8.05	263	.203	2.24		126
Dec.	742		12.3	—1.7	7.99	267	.250	1.67		141
	2,330		10.6	—3.3	8.09	234	.210	2.78		267
1941										
Apr.	12,329	8,287	12.4	—3.9	8.22	207	.145	1.19	4.6	319
	55,348	24,125	10.9	—1.8	8.06	209	.109	.70	.4	241
May	37,949	12,338	8.0	.8	7.88	222	.078	.30	1.3	158
	9,660	4,322	4.0	3.0	7.75	224	.079	.45	6.6	125
June	5,872	2,470	3.3	3.8	7.68	168	.135	5.24	15.0	1,278
	25,182	9,086	7.1	2.6	7.83	198	.075	4.73	12.7	612
July	29,141	4,323	5.3	1.3	7.83	196	.034	.62		248
	3,951	1,192	4.4	3.1	7.70	186	.038	.70		151
Aug.	2,234	1,153	1.8	4.3	7.65	184	.027	.25	4.1	85
	905	405	2.8	3.8	7.67	194	.020	.27	5.6	80
Sept.	1,147	416	3.3	3.2	7.82	204	.028	.40	8.1	91
	1,081	458	3.7	3.2	7.75	196	.019	.24	12.4	55
Oct.	3,064	1,060	4.5	3.5	7.69	175	.131	1.14	15.5	
	4,656	2,250	8.5	1.1	7.90	200	.090	2.27	18.0	
Nov.	5,939	4,093	10.8	1.3	8.01	219	.153	2.27	18.0	
	1,254	830	12.3	1.5	7.82	226	.197	2.60	12.0	

TABLE II

Showing the White river survey, September 30, 1940.

Sampling Point	Approx. Dist. in Miles	Time	Temp. °C.	Diss. O_2	Alk.	Chlorides	CO_2	NO_2	NH_3	SiO_2	PO_4	Total Algae per ml.
				Parts per Million								
Chesterfield	0	10:45a	16.	5.0	289	37	0	.16	2.64	16.	.36	1,952
4 mi. above Anderson	3	11:00	16.5	5.4	280	32	—0.5	.20	2.28	16.	.40	2,523
Anderson (bridge)	7	11:10	21.5	8.6	294	34	—7.0	.20	2.32	17.	.35	3,442
Moss Island	10	11:40	19.	5.0	313	34	—3.0	.08	4.20	18.	.25	6,014
Hamilton Bridge	14.3	11:55	18.	5.0	305	32	—2.0	.40	2.00	16.	.10	5,757
Perkinsville	18.8	12:10p	17.25	9.8	280	32	—8.0	.18	.34	14.	.06	6,786
Strawtown	23.5	12:25	18.5	11.4	269	28	—9.0	.06	.21	8.	.01	10,280
Riverwood	28.0	12:35	17.75	12.8	261	29	—11.0	.05	.16	8.	.01	44,760
Potters Bridge	30.4	12:45	17.75	15.4	247	27	—13.0	.02	.06	9.	.01	46,940
Noblesville (Iron bridge)	32.7	1:00	16.75	14.6	238	26	—14.0	.02	.02	8.	0	49,543
State Road No. 234	36.7	1:35	17.75	12.4	255	27	—12.0	.03	.06	10.	0	101,893
Northern Beach	41.7	1:50	17.5	14.2	248	24	—13.0	.015	.04	11.	0	107,493
86th St. Bridge	46.9	2:10	17.5	10.0	258	22	—10.0	.04	tr.	7.	0	28,087
Above Canal Head Gates	51.5	2:25	17.	15.0	236	21	—12.0	.01	tr.	2.	0	40,151
Northwestern Ave.	54.5	2:40	16.75	6.4	231	20	—1.0	.015	.17	1.5	0	9,565
Indianapolis Water Co. Intake	57.5	2:50	17.	8.8	228	20	—2.0	.01	.22	1.6	tr.	4,863