AN ABSTRACT OF THE THESIS OF

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Samples of benthic and zooplankton fauna were taken, and physicochemical measurements were made on the Allen County Community Junior College Campus Pond once a month from September, 1975, through May, 1976, and twice a month from June, 1976, through August, 1976.

A total of 12,992 benthic individuals represented by 33 taxa was collected. Seventy % of the individuals were phantom midge larvae, *Chaoborus puntipennis*.

The Cladocerans and Copepods dominated the collections of zooplankters and a mean annual community diversity ($\bar{d}$) was 1.83, indicating the pond was moderately stressed. A significant difference was found to exist between community diversities at the one meter and two meter depths.

Temperature ranged from 5 C in January, 1976, to 27 C in July, 1976. The pond never stratified. The mean annual dissolved oxygen concentration was 6.5 ppm. A significant difference between the dissolved oxygen concentrations at the surface and the bottom was found.

The mean annual nitrate concentration was 13.69 and the mean annual phosphate concentration was .45 ppm. The pond was relatively transparent and low in turbidity. Nitrite and ammonia were found in low concentrations in the pond and the pond was slightly alkaline with a mean annual pH of 8.2.

THE LIMNOLOGY OF
A CAMPUS POND

A Thesis

Submitted to

the Division of Biological Sciences

Emporia State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Debra Gamache

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John D. Ransom

Approved for the Major Department

Approved for the Graduate Council

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INTRODUCTION

The science of limnology was established in 1869 by F. A. Forel when results were published on a study of the bottom fauna of Lake Geneva in Switzerland. E. A. Birge researched the microscopic, floating assemblage and plankton of Lake Mendota, Wisconsin in 1873. Later Birge and Chancey Juday made notable gains in American Limnology by conducting studies of Finger Lakes of New York and inland lakes of Wisconsin from 1914 to 1953. These studies were involved with physicochemical conditions, plankton and its quantity and chemical composition, dissolved oxygen and mineral content (Reid, 1961). Forbes studied certain high lakes of the Rocky Mountains, the results of which were published in 1893 (Welch, 1952). Several studies have been conducted on Western Lake Erie dealing with the phytoplankton, physicochemical composition and lake productivity (Chandler and Weeks, 1945).

The more recent studies were concerned with the environmental impact of various pollutants, both natural and artificial, on water quality. Various characteristics of benthic fauna communities have been used as criteria of measuring water quality (Gaufin and Tarzwell, 1952; Beck, 1955; Paine and Gaufin, 1956; Gaufin, 1958). Ransom and Dorris (1972) conducted a study on Keystone Reservoir in Oklahoma. In that study diversity indices based on data from benthic fauna collections were used as a tool to measure the influence of certain physicochemical factors on aquatic community structure.

In Kansas, many limnological studies on lakes and reservoirs, and one on roadside ditches (Ratzlaff, 1952), have been conducted. Andrews and Breukelman (1952) made a preliminary survey of nineteen state lakes, investigating physicochemical factors such as dissolved oxygen concentrations, temperature, pH, turbidity and biological populations of the phytoplankton and zooplankton. Studies of Lyon County State Lake near Emporia, Kansas, began in 1963 after the lake was drained in the summer and late fall of 1962. The purpose of draining the lake was to rehabilitate its fisheries (Prophet, 1964). This study continued through 1966 since it took thirty-two months to refill the impoundment. During this time physicochemical parameters such as dissolved oxygen concentrations, temperature, transparency, turbidity, nitrate and phosphate were monitored. Primary productivity and relative abundance and composition of zooplankton were recorded for determining changes during and immediately after reflooding (Prophet et al, 1966). As John Redmond Reservoir, located on the Neosho River near Burlington, was filled, research was conducted from 1964 to 1968 to find limnological features of a new impoundment (Prophet, 1966). In 1967 and 1968 a study was made on summer water quality of Marion, Council Grove, and John Redmond Reservoirs, all located on the Neosho River system in the eastern one-third of Kansas (Prophet et al, 1970). Then in 1971 and 1972 a study by F. L. Funk (1973) was conducted on species diversity, benthic fauna abundance and related physicochemical features of John Redmond Reservoir. These studies revealed John Redmond Reservoir to be a moderately polluted, shallow body of water influenced by organic wastes from feedlots, effluent from slaughter houses, runoff from fertilized cropland and the effluent from a waste treatment plant.

Kansas has many farm ponds but relatively little research has been conducted on them. Information relating to the variation of such features as water temperature, dissolved oxygen, alkalinity, turbidity, and its effects upon fish production, were published by Tiemeier and Moorman (1957) and Teimeier and Elder (1957). Five separate studies have been conducted on Gladfelter Pond on the Ross Natural History Reservation, Emporia State University. These studies were concerned with physicochemical conditions, zooplankton and benthic fauna with comparisons among studies (Griffith, 1961; Kingsbury, 1963; Osborne, 1968; Perez, 1970; Horner, 1977). Mahoney (1973) conducted a study from 1972 to 1973 to determine the affects of rotenone on the zooplankton, benthic macroinvertebrates and physicochemical features in a farm pond.

This study on the Allen County Kansas Community Junior College Campus Pond was undertaken to gain information concerning the physicochemical conditions, the benthic community structure and the zooplankton fauna.

DESCRIPTION OF THE STUDY AREA

The Allen County Kansas Community Junior College Campus Pond is located about one mile northeast of Iola, Kansas (Fig. 1). At the time of this study the pond was bounded by grassland on the south, southwest, and north and by a residential area on the west. The grass cover was mostly fesque. The dam was unusually long, bordering on the entire south and east edges and on half of the west side. A few willow trees were growing on the banks.

The maximum depth of the pond was two and one-half meters and the pond had a surface area of .33 ha. The bottom was soft ooze with a few small areas of sand mixed with decaying organic matter.

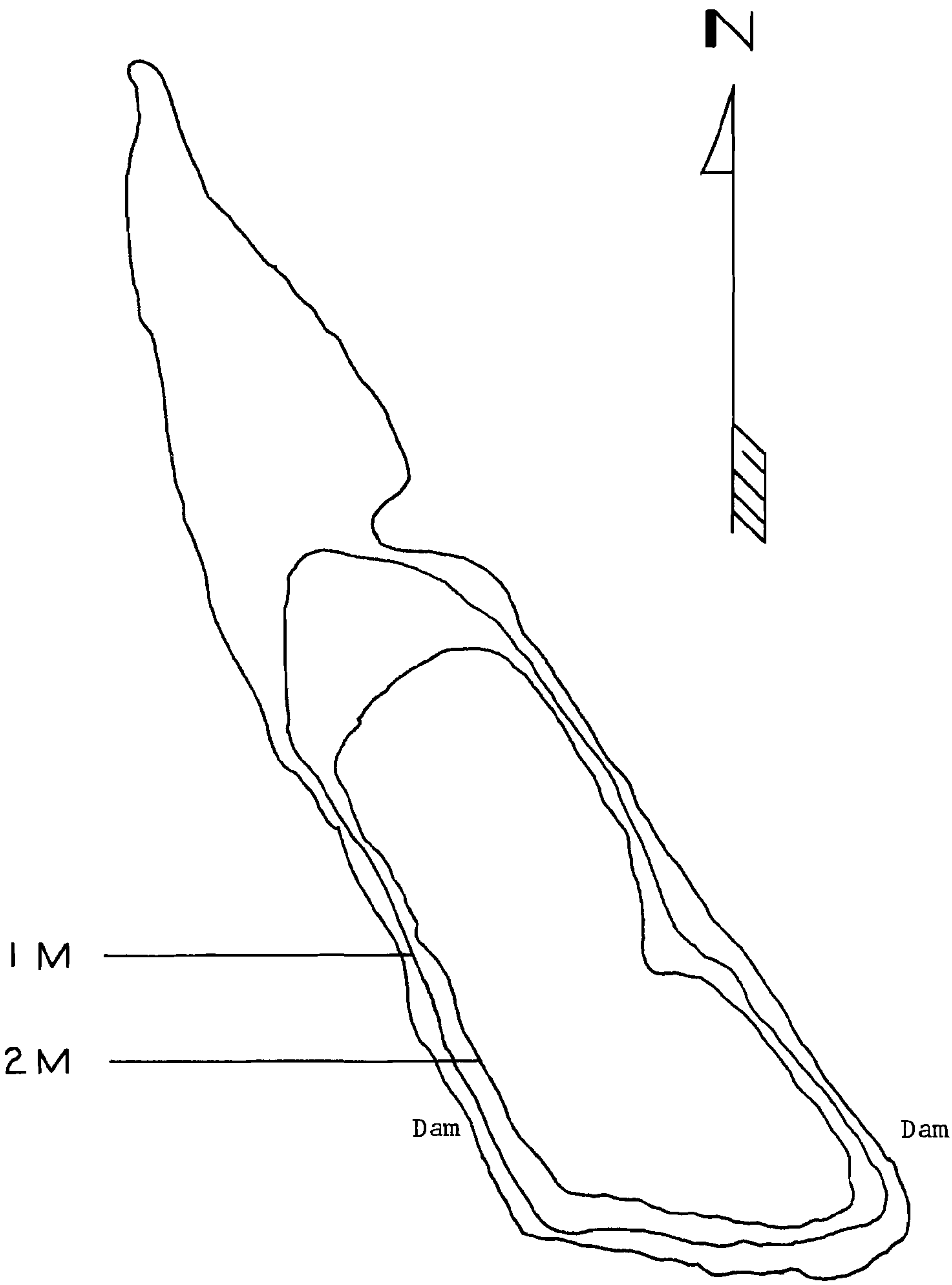

Figure 1. Allen County Community Junior College Campus Pond showing shoreline and basin morphometry

METHODS AND MATERIALS

Random samples of benthic fauna were taken from the pond once a month from August, 1975, through May, 1976, and twice a month in June, July and August, 1976. These samples were obtained at one and two meter depths by using an Ekman dredge. The benthic samples were washed in the field on a screen with .18 mm openings and the washed materials were preserved in formaldehyde for later sorting and identification in the laboratory. Identification was based on Pennak (1953) and Mason (1968).

Species diversity indices ($\bar{d}$) were determined on benthic fauna density data by using the Shannon and Weaver (1944) equation

$$d = - \sum_{i=1}^{s} \left[\frac{n_i}{N} \log_2 \frac{n_i}{N} \right]$$

where n_i is the number of individuals of any one species and N is the total number of individuals in all species.

Zooplankton samples were taken both vertically and horizontally. These samples were taken at random and preserved in isopropyl alcohol for later sorting and identification in the laboratory.

Water temperatures were taken at both the surface and the bottom with a telathermometer. A Secchi disc was used to determine light penetration.

Water samples for dissolved oxygen determinations were placed in a 300 ml glass-stoppered bottle. Bottom-water samples were collected with a Kemmerer water sampler. Dissolved oxygen concentration was determined by the Alsterberg (azide) modification of the Winkler Method

(APHA, 1961). Samples were fixed in the field and 200 ml samples were titrated in the laboratory with .0250 N phynlarsene oxide.

Water samples for other chemical tests were collected in glass jars and taken immediately to the laboratory for analyses. Turbidity, ammonia, sulfate, nitrite and nitrate concentrations were determined by the Spectronic 20 procedures of the Hach Chemical Company. Phosphate concentration and pH were determined on a Hach DR-EL laboratory kit. Statistical analyses were made using a Student t-test at P = .05 level of significance.

RESULTS AND DISCUSSION

Biological

Benthic Fauna Collected

A total of 12,992 individuals of benthic fauna representing 33 taxa was collected (Table 1). Nineteen percent of the total number of individuals were collected at the one meter depth and were represented by 30 taxa. The two meter depth yielded 81 % of the total number of individuals and were represented by 25 taxa.

The phylum Arthropoda comprised 93 % of the total number of individuals and 83 % of those individuals were in the Order Diptera. The Dipterans were represented by three families, Ceratopogonidae, Culicidae and Chironomidae. *Chaoborus punctipennis* Say larvae represented the largest total number of individuals, 9,081, which was 70 % of the total number of individuals collected. There was a significant difference between the number of *C. punctipennis* larvae collected at the one meter and two meter depths when compared statistically. The Family Chironomidae was represented by 14 taxa which was 12 % of the total number of individuals. Each of the remaining taxa represented less than one % of the total number of individuals.

Species Diversity Background

Species diversity indices ($\bar{d}$) calculated on benthic fauna density data summarize community structure and are expressed as dimentionless numbers. Those numbers are directly related to the quality of the aquatic environment from which the benthic organisms were collected. The numbers range between 0 and 4, where 0 to 1 indicates an

Table 1. Taxa list and total numbers of benthic invertebrates collected by depth

Organisms	One Meter	Two Meters
PLATYHELMINTHES		
TURBELLARIA		
Dugesia	1	7
ANNELIDA		
OLIGOCHAETA		
Dero Sp.	43	350
Tubiflex tubiflex	360	1081
ANTHROPODA		
CRUSTACEA		
Talitridae		
Hyalella azteca (Saussare)	172	123
INSECTA		
Coleoptera		
Macronychus alabratus (Say)	1	-
Diptera		
Ceratopogonidae		
Palpomyia sp.	71	26
Palpomyia tibialis (Meigen)	42	26
Culicidae		
Chaoborus punctipennis (Say)	757	8324
Chironomidae		
Chironomus sp.	-	1
C. (chironomus) sp.	39	194
C. (einfielda) sp.	71	9
C. (dicrotendipes) sp.	16	-
C. (cryptochironomus) sp.	63	31
C. (endochironomus) sp.	4	6
Ablabesmyia sp.	10	6
Coelotanypus sp.	57	1
C. concinnus	54	1
Glytotendipes sp.	2	1
Paralauterborniella sp.	137	136
Polypedilum sp.	4	-
Procladius sp.	97	114
Pseudochironomus sp.	243	3
Tanypus sp.	167	69
Ephemeroptera		
Baetidae		
Caenis sp.	75	3
Ephemerella sp.	1	-
Ephemeridae		
Hexagenia sp.	23	-

Table 1. (Continued)

Organisms	One Meter	Two Meters
Hemiptera		
Veliidae		
Microvelia sp.	-	1
Odonata		
Coenagrionidae		
Ischnura sp.	11	9
Gomphidae		
Gomphus sp.	1	-
Libelliidae		
Pachydiplax longipennis (Burm.)	-	1
Erythemis simplicollus (Say)	-	1
Erythemis sp.		
Perithemis tenura	2	2
MOLLUSCA		
GASTROPODA		
Physa sp.	2	-

environment undergoing heavy stress while 1 to 3 indicates an environment under moderate stress and numbers above 3 indicate clean water habitats (Wilhm and Dorris, 1966). Generally, if a large number of species with a few individuals per species is collected, a high $\bar{d}$ value results while a small number of species with a large number of individuals per species results in a low $\bar{d}$ value.

Pollution from any cause exerts stress on an aquatic environment. The less tolerant taxa of benthic and planktonic fauna may disappear or their numbers of individuals may be extremely reduced under stress. The number of tolerant species will increase, consequently lowering diversity and the resulting $\bar{d}$.

Species Diversity Analysis

A diversity index ($\bar{d}$) was calculated each month for both the one meter and two meter depths. These values are shown in Fig. 2. The mean annual $\bar{d}$ for both depths combined was 1.83, indicating the pond to be a moderately stressed environment. The mean $\bar{d}$ for the one meter depth was 2.60, also indicating a moderately stressed environment, but better than that of the two meter depth which was 1.07. Using a Student t-test at $p = .05$ level of significance, there was a significant difference between the $\bar{d}$'s for the one meter depth and those for the two meter depth.

Zooplankton

Approximately 13,434 zooplankton individuals were collected. Three orders of the Class Crustacea were represented by one class, Monogononta. The Cladocera dominated the numbers in both the vertical and horizontal samples.

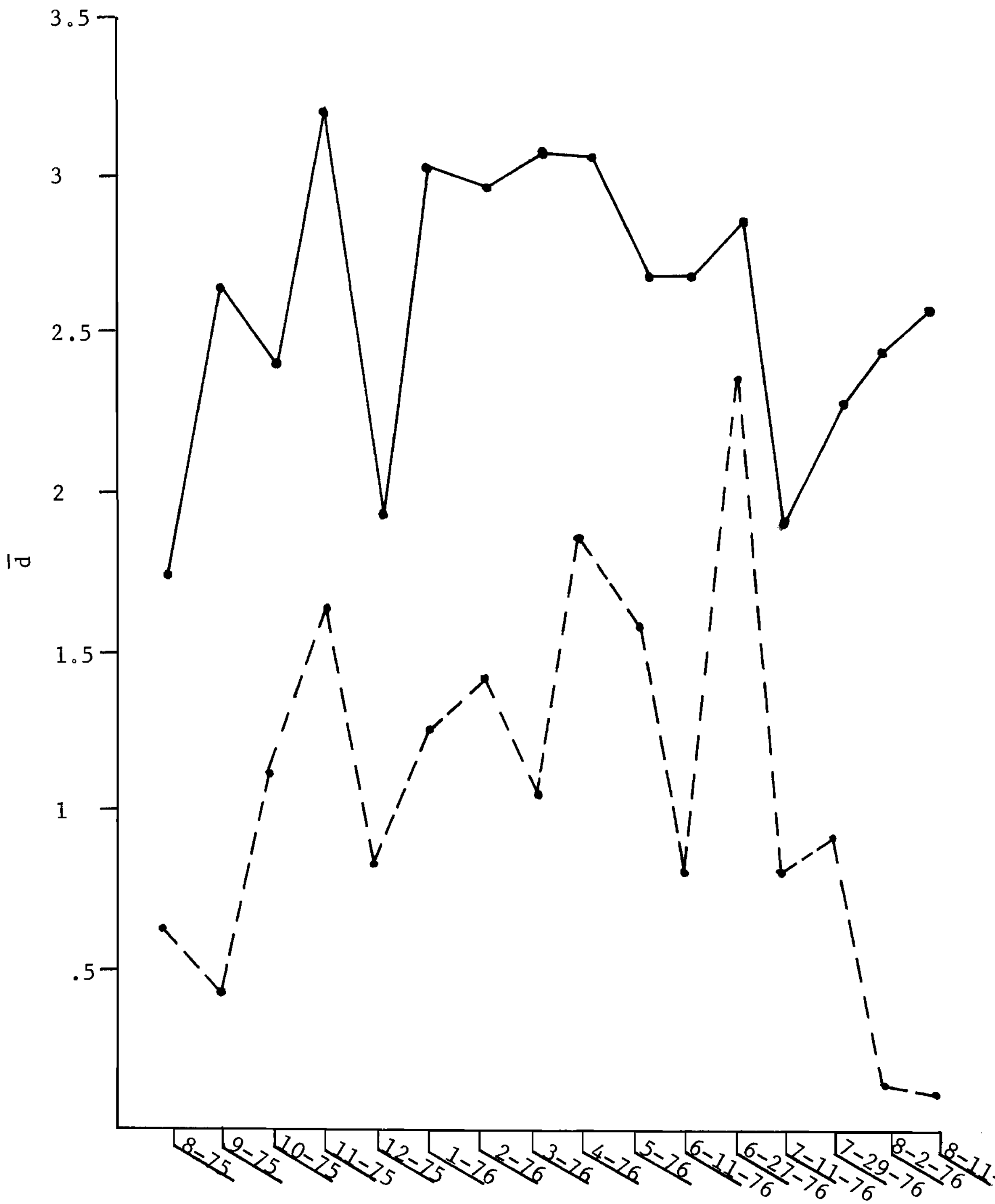

Figure 2. Diversity Indices by Depth and by Month
One meter = (___); Two meters = (- - -)

The total number of individuals collected from the horizontal samples was 4,975 while 8,459 individuals were collected in the vertical samples. Orders of the zooplankton were determined but no further classification was attempted.

Physicochemical

Temperature

Reid (1961) pointed out that thermal properties of water and attending relationships were doubtless the most important factors in maintaining the fitness of water as an environment.

The Allen County Community Junior College Campus Pond was holomictic. No stratification or tendencies toward stratification occurred during the study (Fig. 3). Using a Student t-test at $p = .05$ level of significance, no significant difference was found between the surface and bottom temperatures.

Dissolved Oxygen

Dissolved oxygen is one of the most significant chemical substances in aquatic environments. Its concentration is an indicator of lake conditions and it regulates metabolic processes of the entire community (Reid, 1961). Small amounts of dissolved oxygen may come from oxygen in the atmosphere, but in most aquatic environments oxygen is derived mainly as a by-product from rooted aquatic plants and phytoplankton during photosynthesis (Reid, 1961). The Allen County Community Junior College Campus Pond had an abundance of filamentous algae and *Chara* extending from the shoreline and entirely across the upper end of the pond. The minimum dissolved oxygen concentration of

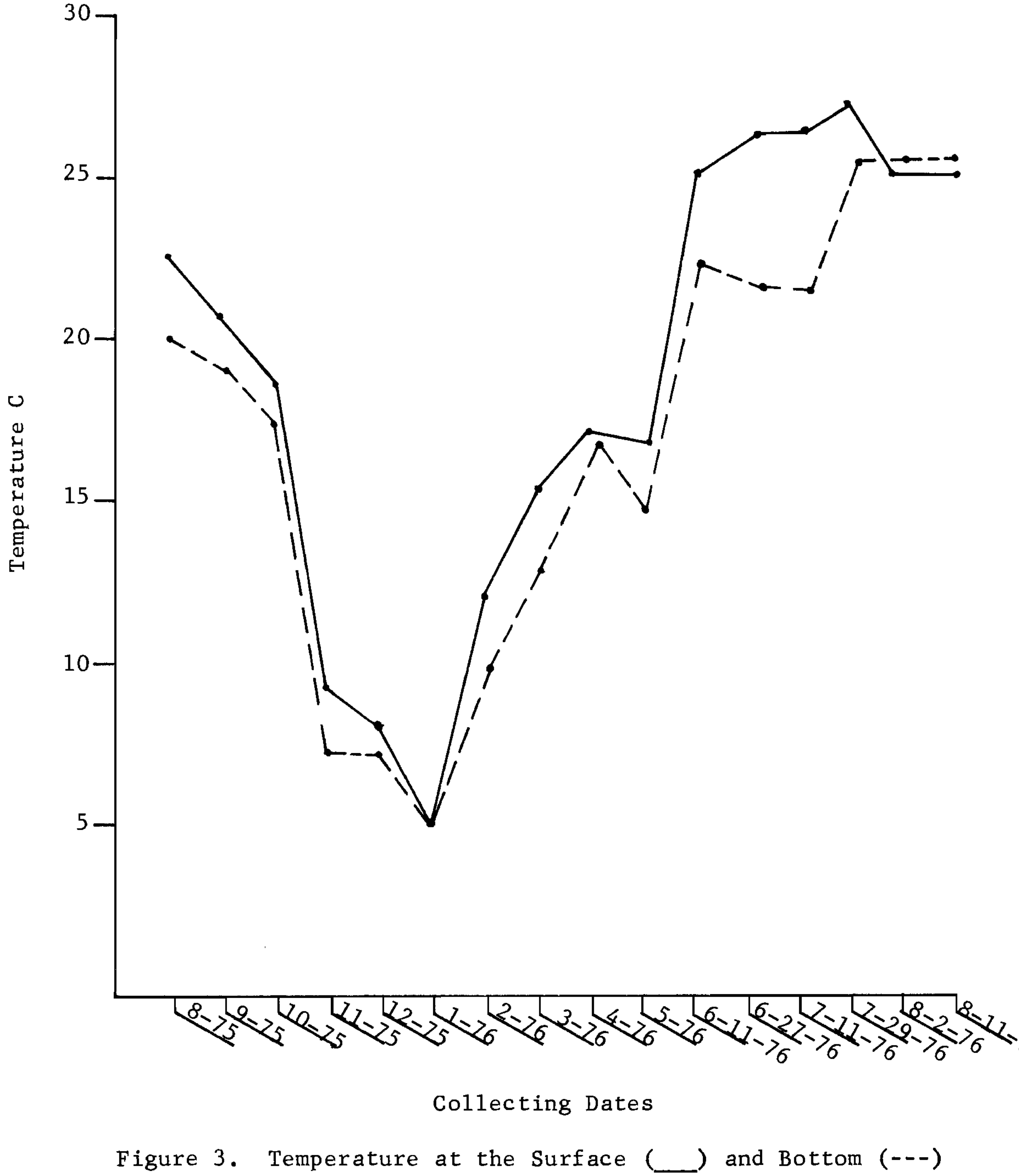

Figure 3. Temperature at the Surface (___) and Bottom (---)

2 ppm was found on July 29, 1976, and the maximum of 12.8 ppm in January, 1976, both at the bottom (Fig. 4). The mean annual dissolved oxygen at the surface was 6.5 ppm and 6.2 ppm at the bottom. Although there was only .3 ppm difference between the two means, using a Student t-test at $p = .05$ level of significance revealed there was a significant difference between the surface and bottom dissolved oxygen levels throughout the year.

The critical minimum concentration of dissolved oxygen for Kansas aquatic environments was set at 5 ppm by the Kansas Department of Health and Environment. However, many biologists consider the critical minimum for many aquatic organisms to be about 2 ppm. At these low levels of dissolved oxygen, considerable stress is exerted on the aquatic community. The concentration of dissolved oxygen in the Allen County Community Junior College Campus Pond was never below 2 ppm.

The fluctuations in dissolved oxygen concentration may be attributed to decomposition rate, plant and animal respiration, amount of cloudiness, which directly affects the rate of photosynthesis, and to the temperature. There is an inverse relationship between dissolved oxygen concentration and temperature. The solubility of oxygen in water is increased by lowering the temperature (Reid, 1961). This phenomena can be observed in Figure 5. The maximum dissolved oxygen concentration was observed at the same time of minimum temperature, occurring in January, 1976. The minimum dissolved oxygen concentration was observed at the time of the maximum temperature, which occurred on July 29, 1976.

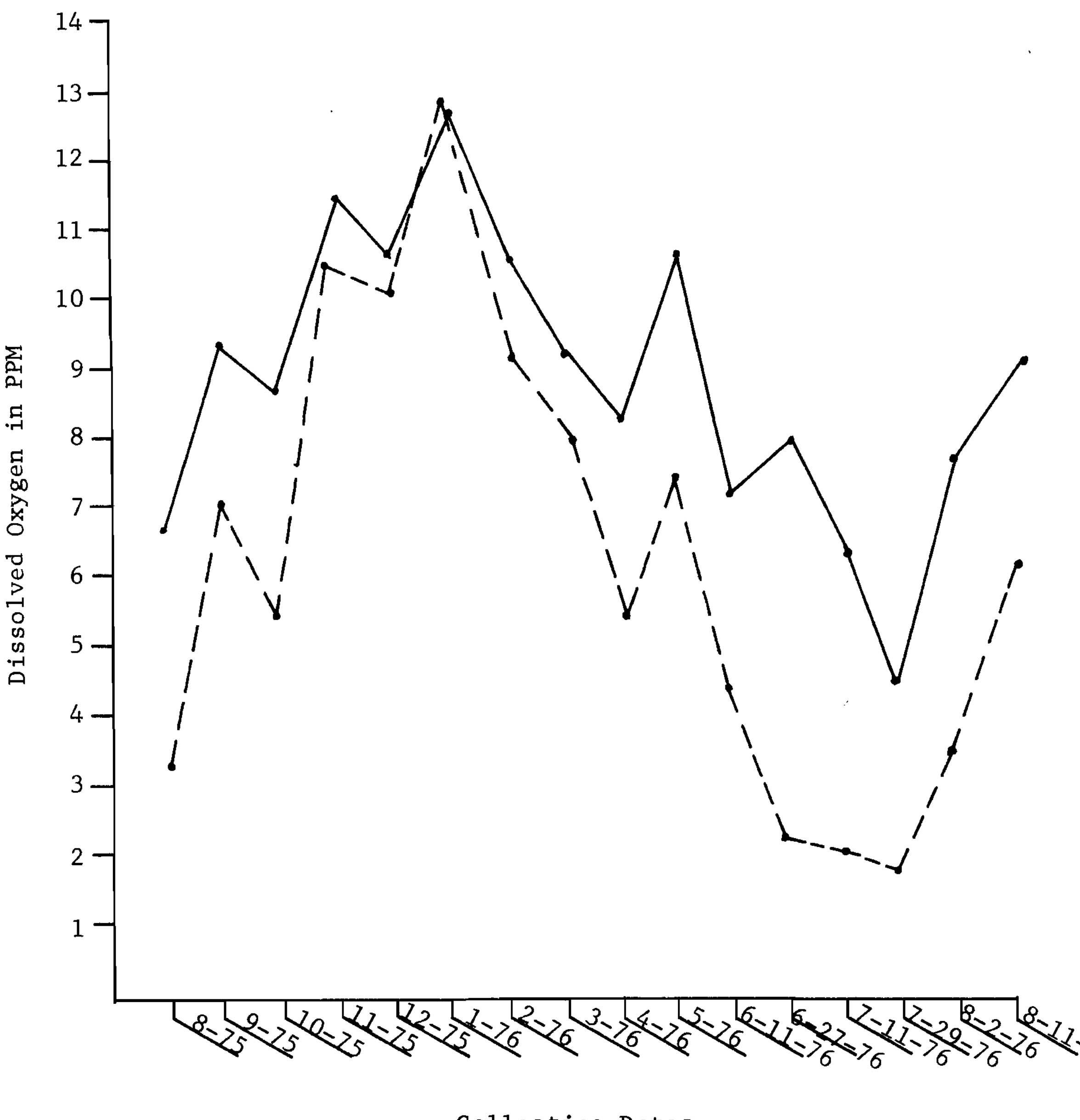

Figure 4. Dissolved Oxygen by Month at the Surface (___) and Bottom (---)

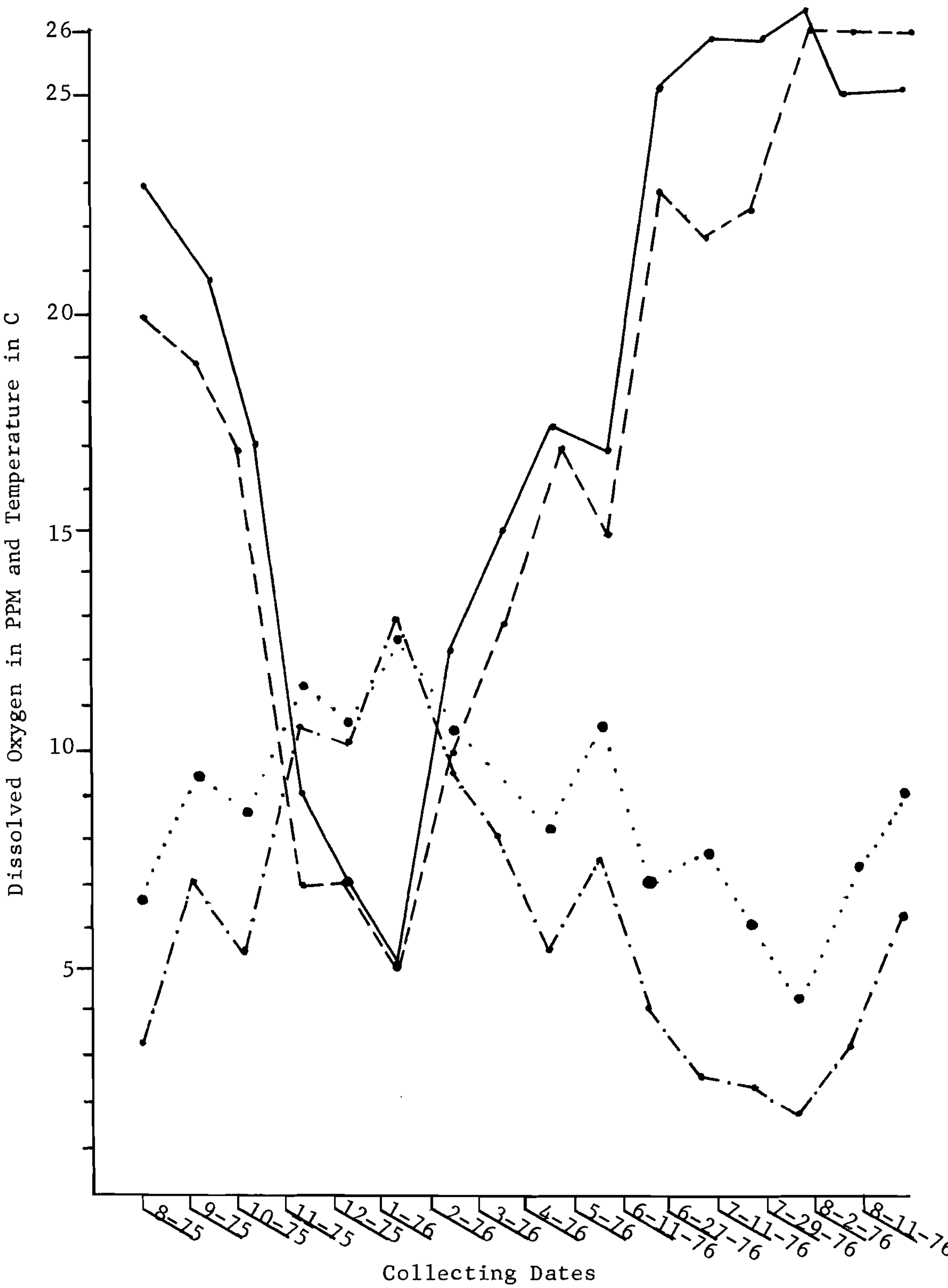

Figure 5. Dissolved Oxygen at the Surface (···) and Bottom (·–·) and Temperature at the Surface (___) and Bottom (---)

Nitrate

The average nitrate concentration in unpolluted fresh waters of the world is 0.30 ppm. Nitrate is important for metabolic processes involved with synthesis and maintenance of protein, carbohydrates and fats (Reid, 1961). Autochthonous sources of nitrates may be from decomposition of dead organisms, wastes from the metabolic process of living organisms, and from nitrogen fixation processes carried on by certain bacteria and algae. Allochthonous sources may be from surface runoff containing terrestrial compounds of nitrogen, including pollution by human agencies, precipitation, runoff carrying compounds of nitrates and ammonia, and from the inflow of ground water from springs and seepages.

In a study of John Redmond Reservoir from 1964 to 1968, nitrate concentrations reached .99 ppm for an annual mean and exceeded one ppm at various times of the year (Prophet et al, 1970). Studies on Gladfelter Pond by Perez (1970) revealed a minimum nitrate concentration of .18 ppm and a maximum of .8 ppm. Earlier, Osborne (1964) found the mean nitrate concentration in Gladfelter Pond to be .48 ppm. Nitrate concentrations of 60 ppm were found in Lake Superior and was attributed to organic pollution from flooding (Reid, 1961).

The mean nitrate concentration during this study was 13.69 ppm (Fig. 6). The minimum concentration was 3 ppm found in September, 1975, and August 1, 1976. A maximum concentration of 18 ppm was found on June 29, 1976. The pattern of nitrate concentrations is not similar to any other of the chemical concentrations found in this study and the nitrate concentrations do not correspond with seasonal variations.

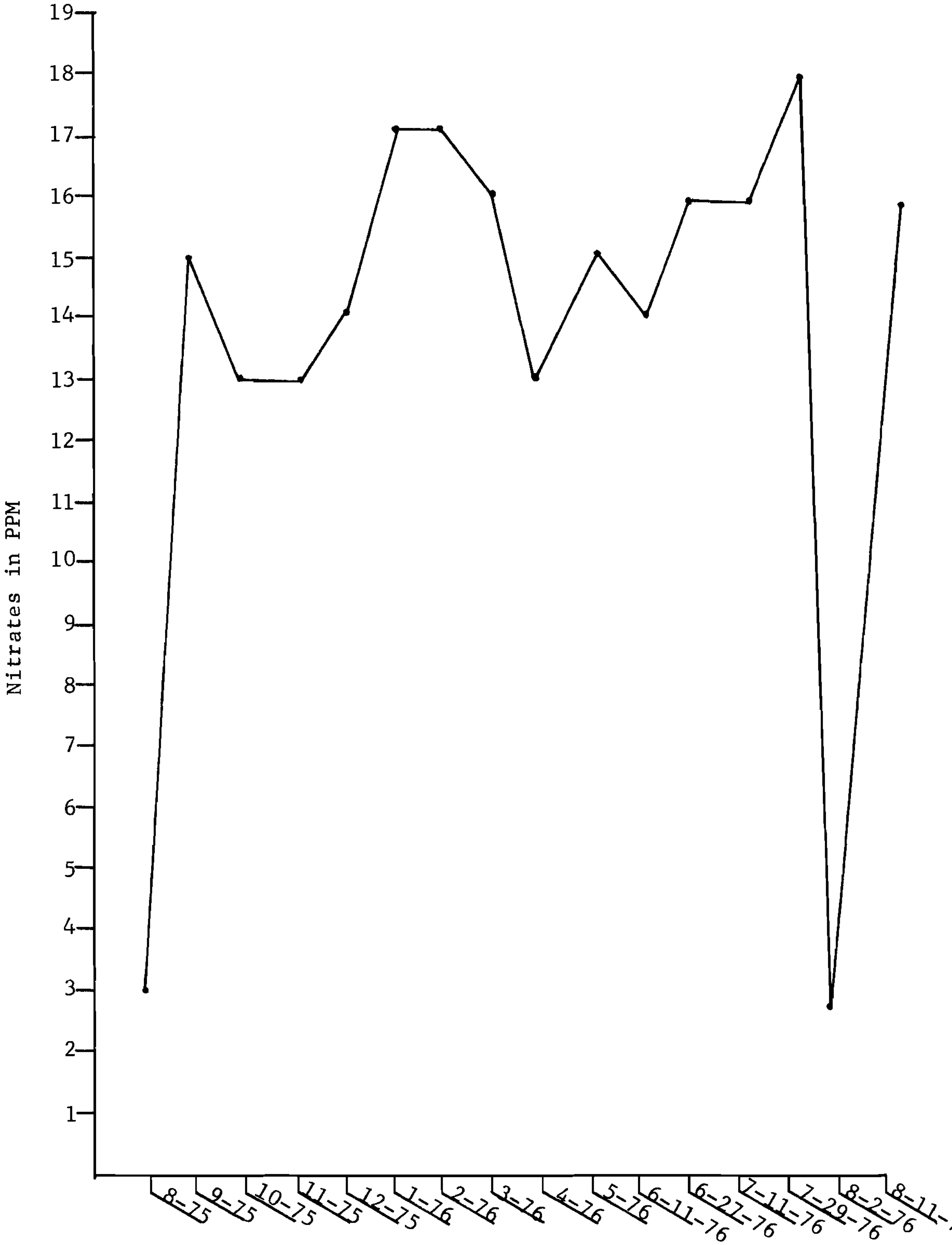

Figure 6. Monthly Nitrate Concentrations

Nitrate concentrations in the Allen County Community Junior College Campus Pond indicated there was some unusual source, or sources, of nitrogen compounds. Seepage of septic tanks from a nearby residential area may have contributed to a high nitrate level. There were about ten residences located in this area with drainage toward the pond. One house was located within 100 yards of the shoreline and the residents' pets (dogs, ducks, geese, and horses) were concentrated at the shore of the pond. The bottom of the pond was covered with dead organic matter which was probably another source of nitrate resulting from decomposition. Runoff water from the campus may have carried fertilizer containing nitrogen compounds into the pond. Farmland bordered the northeast and east side of the pond and drainage was toward the east and south. Therefore, little, if any, nitrate came from the farmland.

Nitrite

Nitrite sources are decomposition of nitrogenous substances, from nitrifying bacteria, and from oxidation-reduction of nitrates. It occurs in very minute amounts in unpolluted water (Reid, 1961).

The mean annual concentration of nitrite in the Allen County Community Junior College Campus Pond was 0.007 ppm with a maximum of 0.019 ppm in December, 1975, and a minimum of 0.001 ppm in September and October, 1975, and in January, February and June, 11, 1976. The nitrite concentrations in the pond were very low and could probably be considered at the same levels as the unpolluted waters of the world. There was no similarity of pattern of nitrite and nitrate concentrations.

Phosphate

Ecologically speaking, phosphorus is considered the most critical single factor in maintaining biochemical cycles (Reid, 1961). Phosphorus is essential to the energy transfer systems in living cells.

Concentrations of phosphates depend on several sources: the chemical composition of geological formations, drainage, stratification, and organic metabolism in the body of water, loss to sediment, and leaching in an agricultural area.

The mean total phosphate concentration in most lakes of the world ranges from about 0.010 ppm to 0.30 ppm (Reid, 1961). The mean annual phosphate concentration in the Allen County Community Junior College Campus Pond was 0.45 ppm. The maximum concentration was 0.9 ppm and the minimum concentration was 0.01 ppm (Fig. 7). These concentration levels would be considered high and may be attributed to leaching from the surrounding agricultural area and to seepage of the organic materials from the residential area which was discussed in the previous section on nitrates.

Secchi Disc Transparency

Secchi disc transparencies reveal the distance to which approximately five % of sunlight is transmitted down from the surface in water. The mean annual Secchi disc transparency in Allen County Community Junior College Campus Pond was 72.7 cm with a maximum of 106.4 cm in January, 1976, and a minimum of 37.4 cm in December, 1975 (Fig. 8). There was considerable fluctuation in water transparency during the study. The water was quite clear, except during periods of runoff and high winds when transparency was reduced.

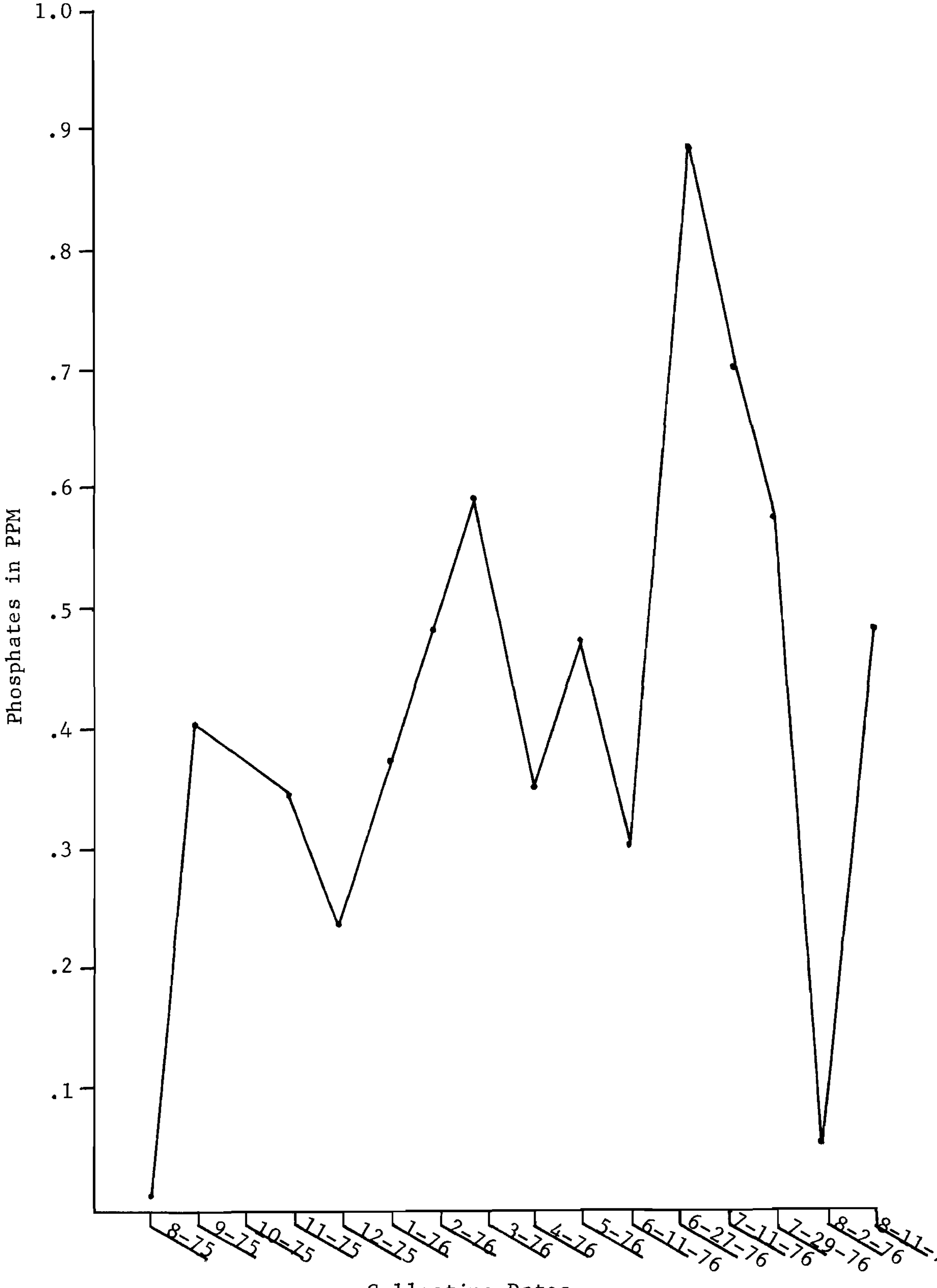

Figure 7. Monthly Phosphate Concentrations

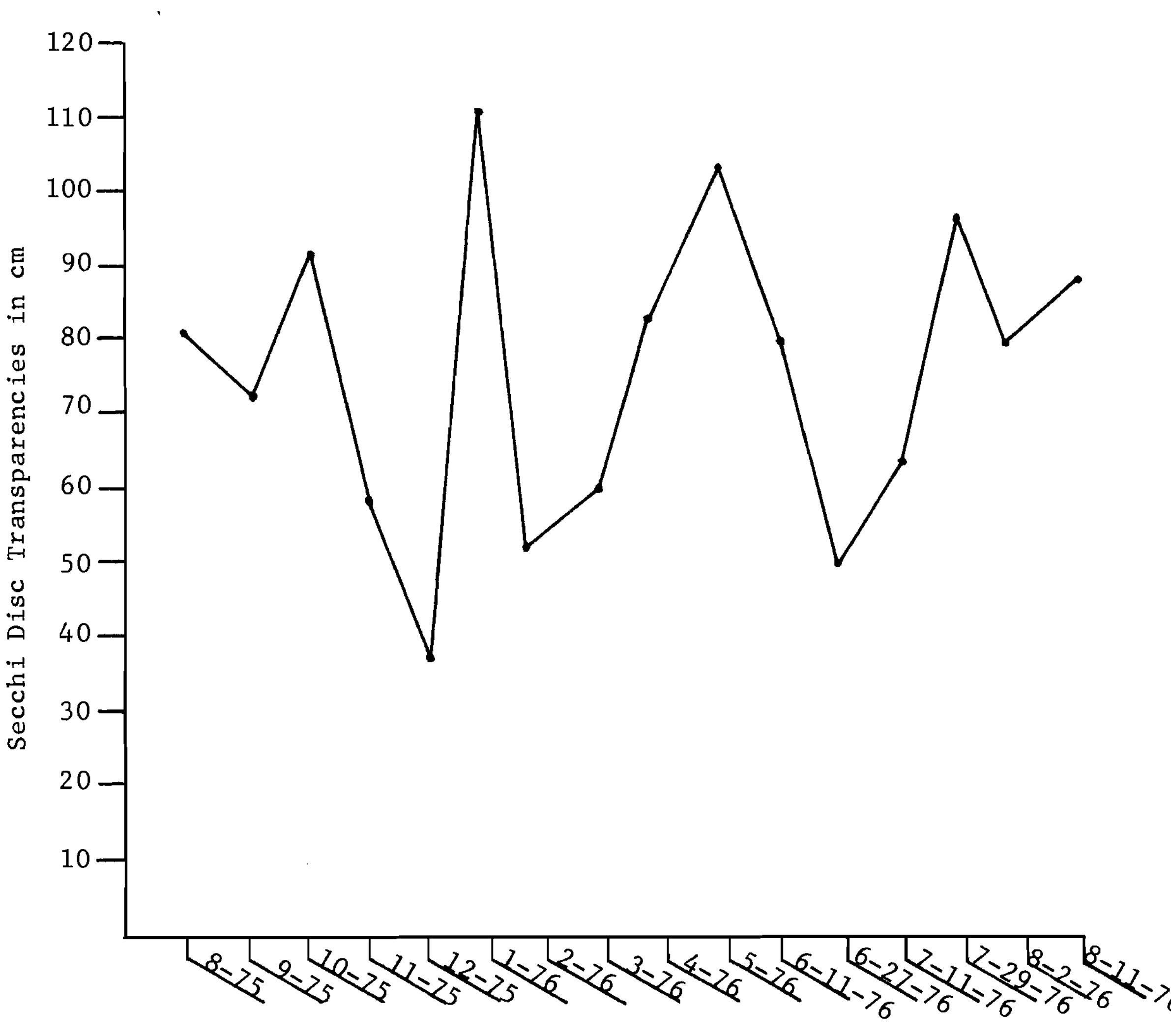

Figure 8. Monthly Secchi Disc Transparencies

Turbidity

Turbidity is used to describe the degree of opaqueness in water, which is affected mostly by suspended particulate matter. A large quantity of particulate matter would reduce light transmission, thus also reducing the productivity of the community. Kansas ponds tend to be quite turbid. Studies of Gladfelter Pond by Griffith (1961) revealed turbidity ranged from 10 JTU to 400 JTU. Perez (1970) found turbidity in Gladfelter Pond ranged between 30 to 123 JTU. Teimeier and Moorman (1957) found many ponds in Kansas to have a high turbidity, which was responsible for low production.

The mean annual turbidity of the Allen County Community Junior College Campus Pond was 27.77 JTU with a maximum of 47 JTU in February, 1976 and a minimum of 8 JTU in September, 1975 (Table 2). These readings indicated a pond low in suspended particulate matter and they corresponded well with the Secchi disc readings.

Ammonia

Ammonia in aquatic environments is derived from oxidative degradation of plant and animal proteins, mainly by the actions of bacteria and fungi. Nitrogenous wastes contribute some ammonia directly and results primarily in free ammonia with lesser amounts of ammonia hydroxide and ammonia carbonate. Ammonia usually occurs in very small amounts. One ppm or less is found in unpolluted waters of the world. High concentrations of ammonia in water are toxic to aquatic organisms.

The mean annual concentration of ammonia in the Allen County Community Junior College Campus Pond was 0.47 ppm with a maximum of 0.72 ppm on July 11, 1976 and a minimum of 0.21 ppm on August 1, 1976

Table 2. Monthly physicochemical conditions

Month	Turbidity JTU	Ammonia ppm	Sulfate ppm	pH
August '75	16	.48	14.0	8.0
September	8	.37	14.0	8.3
October	16	.48	14.5	9.0
November	39	.64	41.0	7.9
December	32	.56	23.5	8.6
January '76	36	.48	27.0	8.2
February	47	.50	31.0	8.2
March	44	.53	38.0	8.6
April	16	.37	39.0	8.6
May	30	.48	30.5	9.8
June #1	22	.40	25.0	9.0
June #2	30	.45	28.0	9.0
July #1	36	.72	17.5	6.6
July #2	22	.52	13.5	6.6
August #1	20	.21	11.0	8.9
August #2	30	.43	11.0	6.2

(Table 2). The level of ammonia was never high enough to cause stress on the pond community. The pattern of ammonia levels was not similar to that of the nitrate levels.

Sulfate

Sulfate is necessary for plant growth and protein metabolism. It may come from rain, from geologic formations and from organic breakdown. Decreases in sulfate concentrations may be due to reduction of sulfates to sulfides which is taken up in the bottom mud, but sulfate concentrations in aquatic environments are usually high and range between 20 to 40 ppm or higher.

The mean annual sulfate concentrations of the Allen County Community Junior College Campus Pond was 23.65 ppm with a maximum of 41 ppm in November, 1975, and a minimum of 11 ppm on August 1 and 10, 1976 (Table 2). Sulfate concentrations in this pond were at levels which would not cause stress to the aquatic community and were maintained by the normal sources.

pH

The mean annual pH value in Allen County Community Junior College Campus Pond was 8.2 with a maximum of 9.8 in May, 1976, and a minimum of 6.6 on July 11 and 29, 1976 (Table 2). There was nothing unusual about the pH values obtained from this pond.

Welch (1952) stated that most lakes and ponds have a pH reading from 6.5 to 8.5. The pond had a pH slightly above 8.5 in eight of the sixteen readings taken.

Physicochemical Effects on Species Diversity

The single most important physicochemical parameter that influenced directly the community diversity in the Allen County Community Junior College Campus Pond was dissolved oxygen. A correlation of .60 was found between the $\bar{d}$ and dissolved oxygen concentrations. As the dissolved oxygen increased so did the $\bar{d}$, probably indicating a greater survival of eggs and larvae with dissolved oxygen increases. The temperature influenced dissolved oxygen concentrations in this shallow, large-surface pond, and was indirectly influential on community diversity.

Two other chemical factors may have influenced community diversity somewhat, too. Phosphates and nitrates were found in unusually high concentrations, although there was no correlation between these chemical concentrations and $\bar{d}$. The effect was a long term one and could not be detected from month to month. Unusually high concentrations of phosphates and nitrates in aquatic environments result in an increase of the less desirable blue green algae and a reduction of the more efficient and desirable green algal forms. Thus, with the base of the food chains being the less desirable blue green algal forms, the entire community suffers. The high amounts of phosphates and nitrates in the Allen County Community Junior College Campus Pond were probably due to seepage from septic tanks and leaching from surrounding farmlands and did result in blue-green algal blooms.

SUMMARY

Samples of benthic and zooplankton fauna were taken, and physicochemical measurements were made on the Allen County Community Junior College Campus Pond once a month from September, 1975, through May, 1976, and twice a month from June, 1976, through August, 1976.

A total of 12,992 benthic individuals represented by 33 taxa was collected. Seventy % of the individuals were phantom midge larvae, Chaoborus punctipennis.

Approximately 13,434 individual zooplankters were collected. The Cladocerans and Copepods dominated the collections of zooplankters.

The mean annual community diversity ($\bar{d}$) was 1.83, indicating the pond was moderately stressed. A significant difference was found to exist between community diversities at the one meter and two meter depths.

Temperature ranged from 27 C in July, 1976, to 5 C in January, 1976. The pond never stratified. An inverse relationship was found between temperature and dissolved oxygen concentrations. The mean annual dissolved oxygen concentration was 6.5 ppm. A significant difference between the dissolved oxygen concentration at the surface and that at the bottom was found.

The mean annual nitrate concentration was 13.69 ppm and ranged from 3 ppm to 18 ppm. This was well above the world average for unpolluted fresh waters. Phosphate concentrations were also well above the world average of fresh waters. They ranged from 0.01 ppm to 0.9 ppm with a annual mean of 0.45 ppm.

The pond was relatively transparent, with a mean annual Secchi disc reading of 72.7 cm and a relatively low annual turbidity mean of 27.7 JTU.

Nitrite and ammonia were found in low concentrations in the pond and the pond was slightly alkaline with a mean annual pH of 8.2.

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