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PLANKTON COMMUNITY RESPONSE TO DECHLORINATION OF A
OF A MUNICIPAL EFFLUENT DISCHARGED
INTO THE TRINITY RIVER

THESIS

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

By

Brynne L. Bryan, B.S.

Denton, Texas

December, 1994

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Chlorine is used by the Village Creek Waste Water
Treatment Plant to kill pathogenic microorganisms prior to
discharge of the effluent into the Trinity River. The
residual chlorine in the river impacted aquatic life
prompting the U.S. Environmental Protection Agency in
December 1990 to require dechlorination using sulfur
dioxide.

One pre-dechlorination and four post-dechlorination
assessments of phytoplankton, periphyton, and zooplankton
communities were conducted by the Institute of Applied
Sciences at the University of North Texas.

Dechlorination had no effect on the phytoplankton
community. The periphyton community exhibited a shift in
species abundance with a more even distribution of organisms
among taxa. No change occurred in zooplankton species
abundance, however, there was a decrease in zooplankton
density following dechlorination.

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CHAPTER I

INTRODUCTION

Human beings began to recognize at least 6000 years ago that human and animal waste in the vicinity of water was related to the occurrence of disease, but not until this century have measures been taken to remediate the consequences of this association (Wolman, 1986). Earlier in this century municipal wastes were disposed of directly into waterways that were often the primary source for drinking water. In 1918, the State of Texas Health Department Annual Report indicated that the majority of citizens in the city of Fort Worth relied on a Trinity River reservoir, Lake Worth, for drinking water. Household and industrial sewage was treated by settling, and the effluent was discharged into the Trinity. The main industry in Fort Worth was the processing of cattle, and the effluent from the abattoirs resulted in extreme changes in the color, odor, and viscosity of the river (Texas State Department of Health Annual Review 1925).

The seriousness of the problem of waste disposal as it relates to human health was recognized, and it was not long before pathogen-killing treatment systems were in place in all urban and then all rural areas. Chlorine has been used as a sewage disinfectant since the early days of municipal

sewage treatment. It was used in the Dallas and Fort Worth sewage treatment operations as early as 1922 (Texas State Dept of Health Annual Review). Chlorine is very effective in killing pathogens, but at elevated levels it is toxic to organisms in effluent-receiving systems.

The effects of chemicals and wastes on non-human organisms were not of widespread interest or study until the 1940s and 50s (Buikema et al 1982). The Clean Water Act of 1977 was created to address growing popular concern for the health of the environment as well as human health. As methodologies have been developed to assess environmental quality, it has become apparent that in order for information about a system to be complete, the chemical and physical status of the system must be accompanied by biological response data (Cairns 1982 and James 1979). The response of lotic communities to changes in the environment are more rapid than in lentic communities, so the evaluation of biological indicators are particularly valuable in river studies (James, 1979). Toxicity testing of EPA-approved surrogate species in the laboratory has been the favored tool for assessing biological response, but there is a growing awareness of the need for information about complex in situ communities as a necessary compliment to laboratory bioassays (Cairns 1981). The U.S. Environmental Protection Agency recognizes the need for biological criteria in its water-quality standards as well as the need for states to

adopt biological criteria in their water quality programs in order to attempt to meet the goals of the Clean Water Act, (EPA [1988 and 1990] in Karr, 1991). This represents the EPA's recognition that regulation of effluent toxicity and laboratory bioassays have not been sufficient to restore biological integrity of ecosystems, and inclusion of criteria for assessing ecological conditions in receiving waters should be a part of the process (Karr, 1991).

Chlorine is effective as a disinfectant in concentrations of several tenths of a milligram of chlorine per liter, which exceeds the concentration toxic to fish (Newbry, unpublished). This is well in excess of EPA's water quality criteria for chlorine, which attempt to meet the goals of the Clean Water Act.

The major regional wastewater treatment plants of the Dallas/Ft. Worth metroplex have been required by the Texas Water Commission and Region 6 of the Environmental Protection Agency to dechlorinate their effluent before it is discharged into the Trinity River. The Village Creek Wastewater Treatment Plant began dechlorinating its effluent in December of 1990. Prior to this, in August of 1990, the Institute of Applied Sciences at the University of North Texas conducted a survey of the biological, chemical, and physical status of the water quality of the river upstream and downstream from the treatment plant's discharge. This baseline study involved a three-tiered approach which

included: 1) water chemistry analysis and traditional laboratory toxicity analysis of ambient water and sediments using EPA approved test organisms; 2) in situ toxicity to caged fathead minnows, Pimephales promelas and caged Asiatic clams, Corbicula fluminea; and 3) sampling of four biotic communities: a) fish; b) benthic organisms via Ponar grabs; c) phytoplankton and zooplankton from water samples; d) macroinvertebrate and periphyton colonization onto artificial substrates. The Institute of Applied Sciences proposed to the EPA that potential ecosystem recovery trends be monitored for a 2-year period after dechlorination was implemented.

The choice of indicator species may be based on personal biases according to the criticisms of Whitton (1979). He points out that most biological surveys of rivers have focused on animals. Whitton advocates the use of algae as indicator species because they have narrower growth and tolerance limits compared to other organisms and are thus more suited for indicating conditions in an ecosystem. Microbial communities have certain advantages over macrofauna, such as fish and insects, for field monitoring of ecosystems integrity in that, relative to macroinvertebrate communities, they are easy to collect and transport, are in such abundant numbers as to be essentially unaffected by sampling, are cosmopolitan in distribution, and have complex species assemblages within communities such

that their responses may closely resemble the entire natural community (Cairns 1979). Organisms that can be colonized onto artificial substrates add the advantage to river studies because there is more flexibility in choosing sampling locations than if several identical natural substrates had to be located (Hawkes 1979). Numerous studies have shown that the communities colonized onto glass slides closely resemble the communities on natural substrata in the sampling vicinity (Whitton 1979). The selection of planktonic and periphytic communities as a component of the broader biological assessment was based on the advantages mentioned above.

Objectives

Dechlorination of the sewage treatment plant's effluent had the potential of affecting biotic communities in the river. The purpose of this study was to test the hypothesis that dechlorination had no effect on the integrity of three select communities: periphyton, phytoplankton, and zooplankton. These communities have constituents from different trophic levels, and each level had the potential of being affected in different ways, either directly from the removal of chlorine or indirectly from shifts in the composition of adjacent trophic levels.

Within each community there were different aspects, or parameters, evaluated to test the hypothesis that there was

no effect on that community from removal of chlorine. Zooplankton were analyzed for total densities, taxa richness, and distribution. Phytoplankton were analyzed for chlorophyll-a concentrations as well as for total densities, taxa richness, and distribution. Periphyton were analyzed for ash-free dry weight and chlorophyll-a concentrations as well as for densities, taxa richness, and distribution. These evaluations were conducted before as well as after dechlorination went into effect. Examination of changes in the zooplankton, phytoplankton, and periphyton communities may give insight into the response of the entire ecosystem to dechlorination.

CHAPTER II

METHODS

Study Area

Seven sampling sites, designated TR1 through TR7, were selected along a segment of the Trinity River that crosses the limits of three cities (Figure 1). The effluent from Village Creek Wastewater Treatment Plant is discharged into the Trinity River within the city limits of Ft. Worth. The reference sites, TR1 and TR2, were located upstream from the sewage treatment plant's discharge, also in Fort Worth. TR3 was located immediately downstream from the discharge. The length of the study area extended 20.5 miles from TR1 to TR7.

Sampling was conducted on a quarterly basis in an attempt to include seasonal variation. The data gathered before dechlorination went into effect were included in this study. Henceforth, the sample periods will be referred to as pre-dechlorination and post-dechlorination (Table 1).

The methods used for obtaining and processing samples for each parameter are found in Standard Methods (1974, 1992).

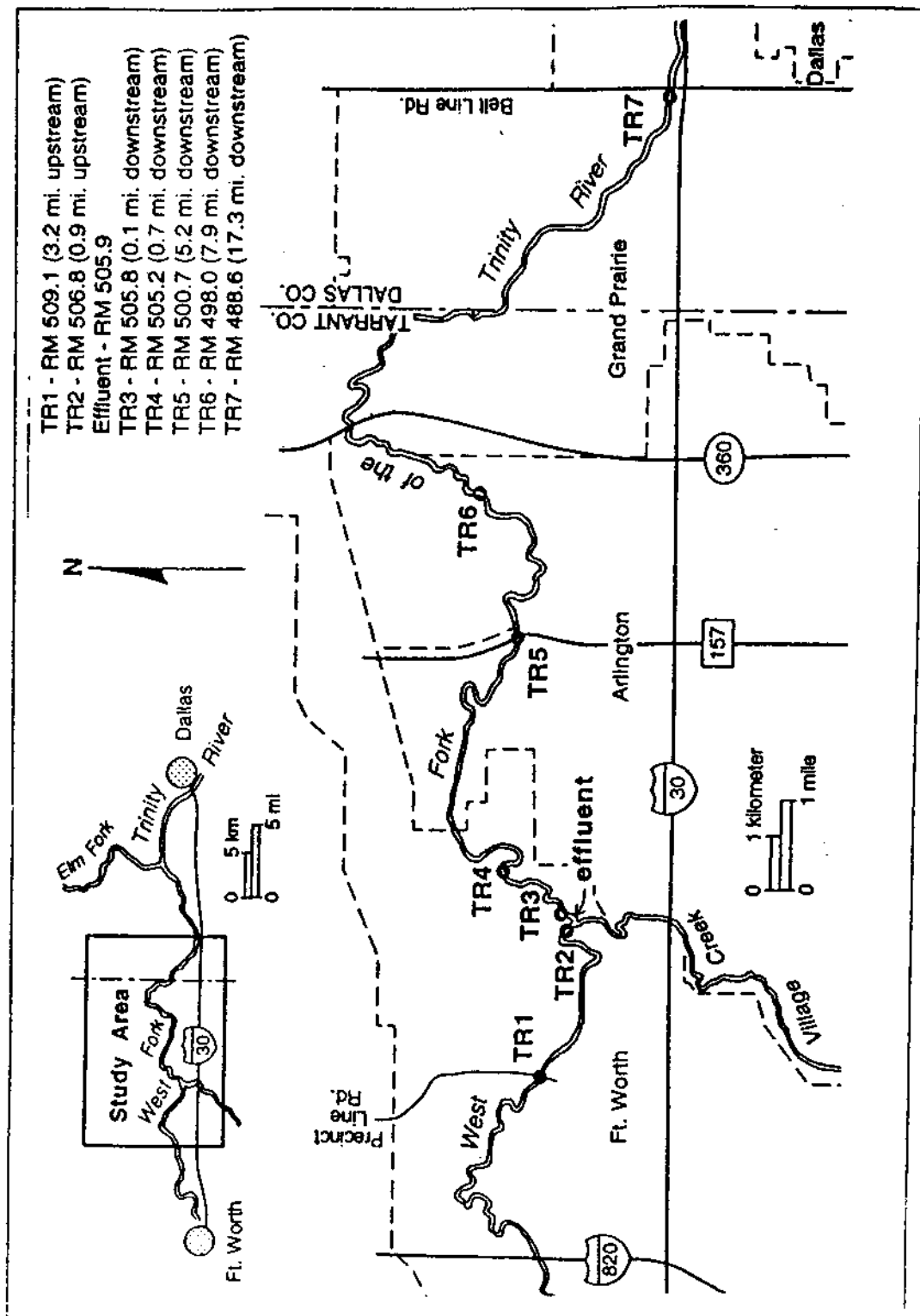


Figure 1. Map of the study area with river mile locations of each site (upper left corner).

Table 1. Actual dates when zooplankton, phytoplankton, and periphyton samples were retrieved from the Trinity River.

	<u>Pre-dechlorination</u>	<u>Post-dechlorination</u>
Phytoplankton and Zooplankton	8/30/90	5/22/91 8/21/91 5/13/92 8/14/92
Periphyton	9/14/90	6/11/91 9/16/91 4/30/92 8/18/92

Nutrients

On each of the sample dates three samples were collected from each site for water chemistry analysis. Data obtained from nitrate and phosphate analysis were studied to determine their influence on the plankton communities.

Chlorine

The water samples collected on each sample date were analyzed for chlorine concentrations. These data were included in this study in order to evaluate the potential effects chlorine had on the plankton communities.

Phytoplankton

Chlorophyll-a Analysis

On each sample date and for each site, triplicate two-liter samples of water were collected for laboratory water chemistry analysis. Water was also collected directly from the effluent on all dates except August 1990 and August 1991. A 200 ml subsample was taken from each sample and filtered in the lab through a glass-fiber filter having a pore size of 0.45 micron. Filtration was accomplished with a vacuum pump at a maximum pressure of 25 pounds/inch². The filter with the impinged algae was put in a scintillation vial with a saturated solution of magnesium carbonate (MgCO_3), acetone, and deionized (DI) water. These extracted samples were kept at a maximum of 0 degrees Celsius for a minimum of 24 hours in the dark to facilitate cell rupture (Standard Methods 1974 and 1992).

A Beckman spectrophotometer was used to measure chlorophyll-a and pheophytin concentrations. The spectrophotometer was calibrated using a deionized water blank at 664, 665, and 750 nanometer wavelengths. A 3 ml aliquot of each sample was filtered through a syringe equipped with a filtering apparatus into a cuvette with a 1 cm pass length. This was placed in the spectrophotometer, and the optical density of the light absorbed by the sample was read and recorded at 664 nm. Each sample was acidified with 0.1 ml of hydrochloric acid for 90 seconds, then read

and recorded at 665 nm. The absorption values attained were used in calculating the micrograms of pigment, either chlorophyll-a or pheophytin, per liter (ug/L) using the following formulas:

$$\text{Chlorophyll-a, ug/L} = \frac{26.7 (664_b - 665_a) \times V_1}{V_2 \times L}$$

$$\text{Pheophytin-a, ug/L} = \frac{26.7 [1.7 (665_a) - 664_b] \times V_1}{V_2 \times L}$$

where V_1 is the volume of the extract in liters, V_2 is the volume of the sample in m^3 , L is the width of the cuvette, which is 1 cm in this case, 664_b is the difference between the readings at 750 nm and 664 nm, and 665_a is the difference between the readings at 750 nm and 665 nm, taken after acidification.

Identification and Enumeration

At the same time that water samples were collected for chemical analysis, four samples per site were collected separately and preserved in the field with Lugol's solution for later identification and enumeration. One of the four samples was shipped to Aquatic Taxonomy Specialists (ATS) in Malinta, Ohio for verification. The other three samples were analyzed using a Zeiss light microscope. A 1 ml subsample was placed in a Sedgewick-Rafter counting cell; the algae in five fields were enumerated at 125X, and each field was viewed at 500X to verify identifications. In

samples where phytoplankton densities were low, a portion of the sample was concentrated. This was accomplished by settling a 25 ml subsample for a minimum of four hours per centimeter depth of sample, or overnight. Fifty to 75% of this volume was carefully drawn from the surface with a vacuum pump at 5 to 10 psi. The number of cells counted was converted to the number of cells in a liter (cells/L) using the formula:

$$\text{Cells/L} = \frac{C \times V_1 \times 1000\text{mm}^2}{V_2 \times V_3}$$

where C = number of organisms counted, 1000 mm^2 = area of Sedgewick-rafter cell, V_1 = original volume of sample (200 ml), V_2 = volume of each field counted (0.00817 cm^3) times number of fields counted (5), and V_3 = volume of subsample (1 ml).

The keys used for identification of phytoplankton include Patrick et al. (1966 and 1975), Pennack (1989), Prescott (1978), Schumacher et al. (1973), Smith (1949), and Ward et al. (1959).

Periphyton

Collection

Periphyton was collected with an artificial substrate known as a periphytometer. This device consists of a plastic cartridge that holds eight glass slides just below the surface of the water (Figure 2).

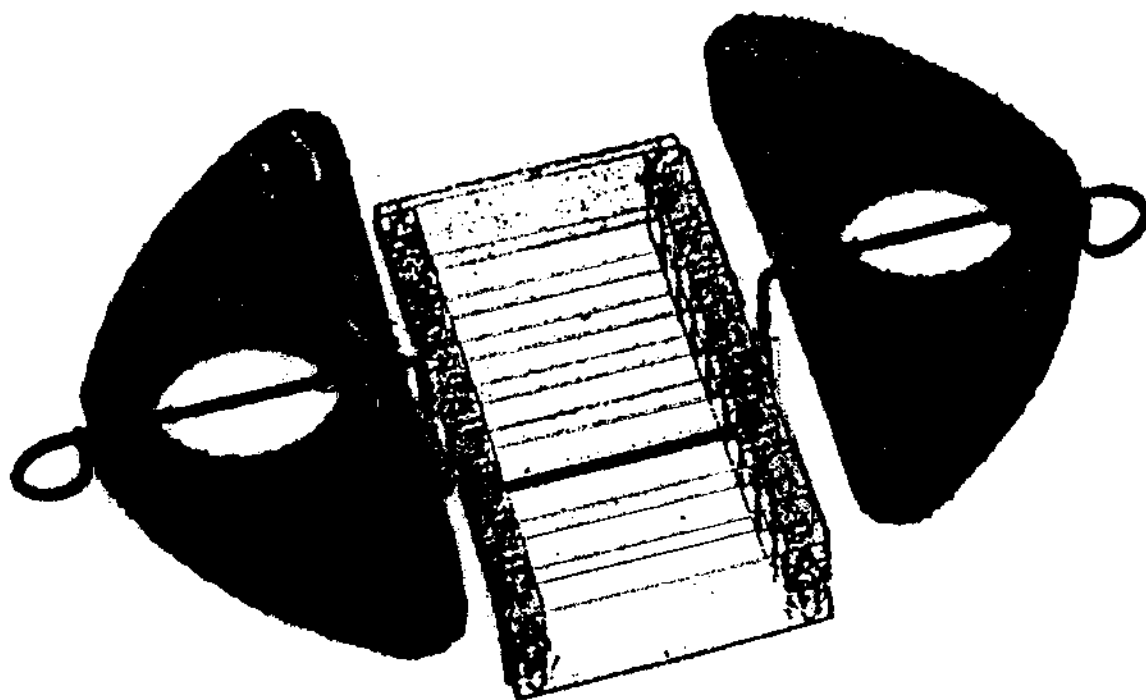


Figure 2. Periphytometer IITM. (Design Alliance, Cincinnati, Ohio).

Three periphytometers were placed at each site in the river and allowed to colonize for two weeks. Of the eight slides in each periphytometer, three slides were placed in deionized water and preserved with Lugol's solution. Three slides destined for chlorophyll-a analysis were placed in a Nalgene Coplin jar with a sufficient amount of the 90% acetone/deionized water/magnesium carbonate solution to completely cover the slides. The remaining two slides were allowed to air-dry as a part of the preparation for later ash-free dry weight analysis.

The periphytometers were placed in the river in inconspicuous places in an attempt to avoid vandalism. Vandalized periphytometers had to be excluded from analysis. Occasionally periphytometers were lost or slides within periphytometers were broken due to high water, or periphytometers were left stranded above the water line due to the water level suddenly dropping. In cases where some of the eight slides within a periphytometer were lost, priority was placed on which parameters would be analyzed first and which would be sacrificed: 1) enumeration of taxa, 2) chlorophyll a analysis, 3) ash-free dry weight analysis.

Ash-free Dry Weight

Two slides from each periphytometer were air-dried and stored to protect them from dust and loss of colonized

biomatter. Samples were burned in a muffle furnace at 500°C for one hour. The difference between the weight before and after the sample was burned represents the organic matter that accumulated on the slides in the river. The weights obtained from each sample were expressed as milligrams per meter² (mg/m²).

The samples collected in August 1990 and May 1991 were processed exactly according to Standard Methods (1974). The periphyton was scraped from each slide into a crucible. Each crucible represented one periphytometer, (two slides). This was time-consuming and it was difficult to avoid loss of some of the sample in the transfer. The samples collected on the subsequent dates were processed by a modified method: the slides from each periphytometer were placed in a labeled glass petri dish and dried, weighed, and burned. The modified method resulted in a savings of time and a potential reduction of sample loss.

Chlorophyll-a analysis

The method for obtaining chlorophyll-a concentrations for periphyton differed slightly from that for phytoplankton. The pigment from a minimum of two slides, (depending upon the number salvaged), was combined during extraction. The slides were placed in a Coplin jar and immersed in approximately 50 to 60 ml of the saturated MgCO₃, acetone, and DI water solution and then refrigerated

for a minimum of 24 hours at a maximum of 0°C. Prior to analysis, the volume of the acetone solution was recorded for each sample. The procedure for analyzing periphyton pigments with spectrophotometry was identical to the procedure for analyzing phytoplankton pigments.

The absorption values attained from analyzing the pigments in periphyton were converted to micrograms of chlorophyll-a per square meter ($\mu\text{g}/\text{m}^2$). The difference between the formulas for determination periphyton and phytoplankton chlorophyll-a concentrations is only in the units ($\mu\text{g}/\text{L}$ for phytoplankton, mg/m^2 for periphyton. The denominator in the following formula is different than that in the phytoplankton formula.

$$\text{Chlorophyll-a, mg/m}^2 = \frac{26.7 (664_{\text{b}} - 665_{\text{a}}) \times V_1}{\text{Area of slides, m}^2}$$

The volume of V_1 for periphyton in this study was between 50 and 60 mls for each sample.

Identification and Enumeration

In the lab, the material from the slides was scraped with a razor blade and rinsed into the deionized water/Lugol's solution. The volume of this suspension was and recorded. The suspension was shaken and a 1 ml aliquot was extracted with a graduated pipet and placed into a Sedgewick-Rafter cell. This was allowed to settle for at least 15 minutes. Five fields at 125X magnification were

examined for identification and enumeration. The algae in each of the five fields was also examined at 500X magnification for verification of identifications. Identification was made to genus whenever possible. These data were converted from number of cells counted to number per square millimeter (cells/mm²) using the following equation:

$$\text{Cells/mm}^2 = \frac{C \times V_1}{V_2 \times A}$$

where C = number of cells counted, V₁ = total volume of suspension (ml), V₂ = volume of fields counted (area x depth x number of fields = 0.206 cm x .1 cm x 5 fields), and A = area of colonized slides (3750 mm² x number of slides).

The keys used for identification of periphyton to the generic level included , Patrick et al. (1966 and 1975), Prescott (1978), Pennak (1989), Schumacher et al. (1973), Smith (1949), and Ward et al. (1959).

An attempt to recognize biases based on clumps of algae present in each sample was made by doing separate statistical analyses on samples without clump data.

Diatom identification was occasionally accomplished by the preparation of burn mounts. This was done whenever a discrepancy occurred between the identifications by this analyst and ATS that could not be explained by natural variation. A portion of the sample was settled and rinsed several times according to Standard Methods (1992). A

volume of the concentrate (1 or 2 ml) was placed on a clean slide, dried on a hot plate, then incinerated in a muffle furnace at 500°C for one hour. The diatoms on the cooled slide were preserved with Hyrax mounting medium. Each burn-mount slide was scanned at 1000X in strips until a minimum of 250 diatoms were counted, and densities per ml within genera were determined as proportions of the total number. It is impossible to distinguish diatoms that were live upon collection from those that were dead after they have been permanently mounted in this way (Owen et al. 1979). An unburned sample was analyzed in order to determine the proportion of diatoms with cellular contents to those with no cell contents.

The densities of rarer genera were sometimes calculated to be less than one per mm², but they were included as 1/mm² in order to be included in the determination of the diversity and taxa richness indices. Diatoms were enumerated exclusively by burn mounts only on two sample dates.

Zooplankton

Collection

On each sample date four zooplankton samples were collected from each site; one replicate was sent to (ATS) for verification. In September of 1990 only one sample was collected per site, and all of these were identified by ATS

Samples were concentrated by pouring 30 liters of river water through a Dolphin cup, a type of zooplankton sampling bucket equipped with a 35 micron screen. The bucket was rinsed with deionized (DI) water into a 250 ml bottle and the concentrated sample was preserved in the field with Lugol's solution.

Identification and enumeration

Zooplankton samples were collected directly from the effluent on some sample dates (May 1991, May 1992, and August 1992). There was frequently a high number of protozoa and rotifers in these samples, but most of them were dead upon collection, evidenced by reduced or absent internal contents. The number of organisms alive upon collection are reported in the Appendix.

In the lab, the volume of each sample was recorded and a 1 ml aliquot of sample was extracted with a Hensen-Stimple pipette, placed in a Sedgewick-rafter cell and examined at 125X. Organisms were counted by scanning the cell in vertical strips. The number of organisms counted was converted to the number of organisms per liter using the following formula:

$$\text{Organisms/L} = \frac{C \times V_1}{V_2 \times V_3}$$

where C is the number of organisms counted, V_1 is the volume of the concentrated sample, in mls, V_2 is the volume counted (1 ml), and V_3 is the original sample volume (30 L).

Several taxonomic keys were used to determine identifications at the generic level (Berner, (unpublished), Jahn, (1949), Pennak, (1989), Stemberger, (1979), and Ward et al., (1959)).

Many of the protozoa that were potentially in the river are small enough to pass through a 35 micron screen. The larger Protozoa as well as the infrequent Crustacea collected were identified and included in the Appendix.

ANALYSES

There was a possibility that the concentrations of chlorine present in the effluent at the point of discharge had no effect on the communities studied, or that the effect of chlorine at those concentrations was obscured by the effects of other chemicals in the effluent. A two-way approach was used to analyze separately the effects of chlorine or a lack of chlorine from the effects of other factors in the effluent, including dilution. First, data collected on each sample date were compared among sites to determine whether there was a statistical difference that could be relative to the effluent. Second, the data were compared among all sample dates in order to determine

whether there was a difference in community dynamics before and after dechlorination was implemented.

Chi-square and Shapiro-Wilks tests for normality were both used to analyze the data collected on parameters such as concentrations, dry-weights, and densities. Bartlett's test for homogeneity of variance was used when the sample sets had unequal replicate numbers and when the number of replicates was less than three, otherwise Hartley's test was used. A one-tailed Analysis of Variance (ANOVA) at an alpha level of 0.05 was performed when the data were normally distributed and the variance among the replicates from each site was homoscedastic. Tukey's multiple range test (MRT) was performed to determine the location of statistically significant differences. In cases where the data were non-parametric, Kruskal-Wallis analysis of variance on ranked data at an alpha level of 0.05 was performed and Dunn's multiple range test (MRT) determined the location of statistically significant differences. Toxstat (Gully et al., unpublished) is a computer software program that facilitates the selection of the appropriate tests. Structural analyses were accomplished using Brillouin's index for diversity and taxa richness for each sample of zooplankton, phytoplankton, and periphyton. Multivariate Statistical Package, or MVSP (Kovach, 1986), a computer software package that includes these indices, was used. Analysis of variance of diversity among the sites was

performed for each date. For a detailed explanation of the rationale for selecting appropriate Analysis of Variance and multiple range tests, see Zar (1984).

Differences in community structure among samples collected on each date were evaluated by subjecting the data to Sigtree, a computer program that combines the Bray-Curtis coefficient of similarity as a type of cluster analysis (Sneath et al., 1973) with a technique for applying statistical significance to the clusters, i.e. bootstrapping (Nemec 1991). For detailed explanations of bootstrapping, see Nemec and Brinkhurst (1988), Felsenstein (1985), and Efron and Gong (1983).

CHAPTER III

RESULTS

Chlorine

Chlorine concentrations were measured at each site in August 1990, etc. The chlorine concentration at TR3, downstream from the effluent discharge, was 1.1 mg/L (Figure 3). The concentrations dissipated further downstream. TR7 is 17.3 miles downstream from the sewage treatment plant, and residual amounts of chlorine persisted at this site. The detection level of the methods used for determining chlorine concentrations is 0.02 mg/L or greater, so the detection of chlorine at TR1 may have been a methodological artifact. On dates when chlorine was said to be removed from the effluent no chlorine was detected.

Nutrients

Nitrate concentrations were measured on all sample dates. In August 1990 the concentrations were 10 mg/L upstream from the effluent and 18 to 22 mg/L downstream from the effluent. The levels were highest at TR7 (Figure 4). In May 1991 the concentrations at TR1 and TR2 were 1.8 mg/L, 9.2 mg/L in the effluent, and 4.9 mg/L immediately downstream at TR3 (Figure 4). The higher concentrations

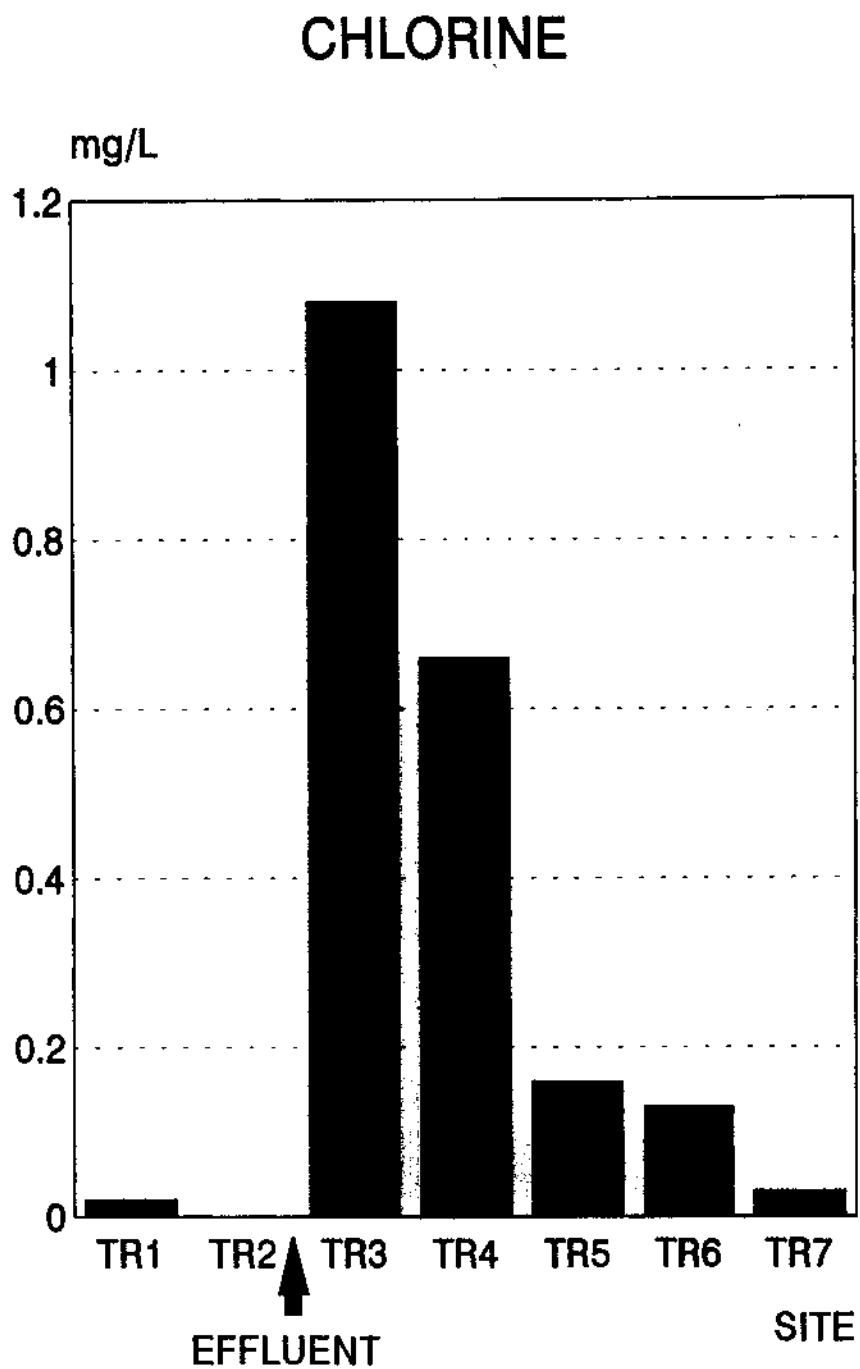
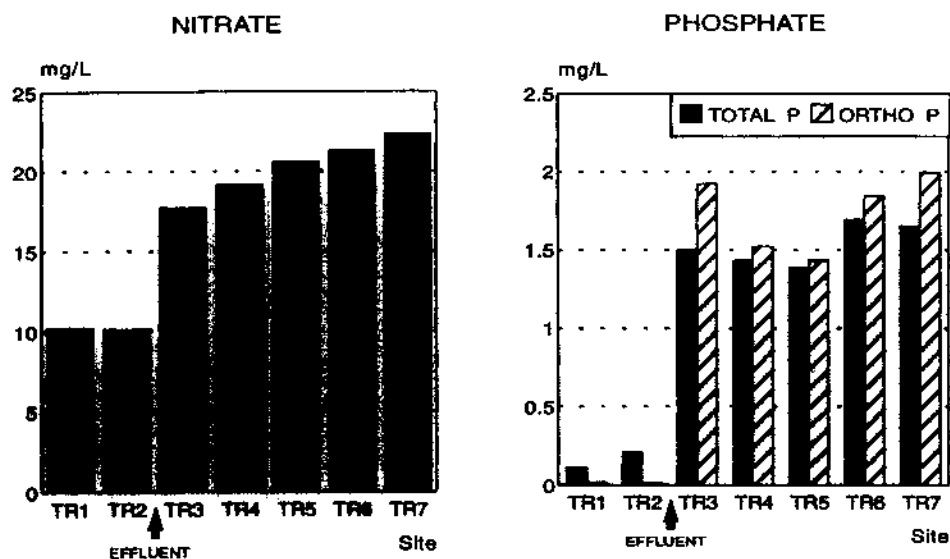


Figure 3. Chlorine concentrations (mg/L) for August 1990.

AUGUST 1990



MAY 1991

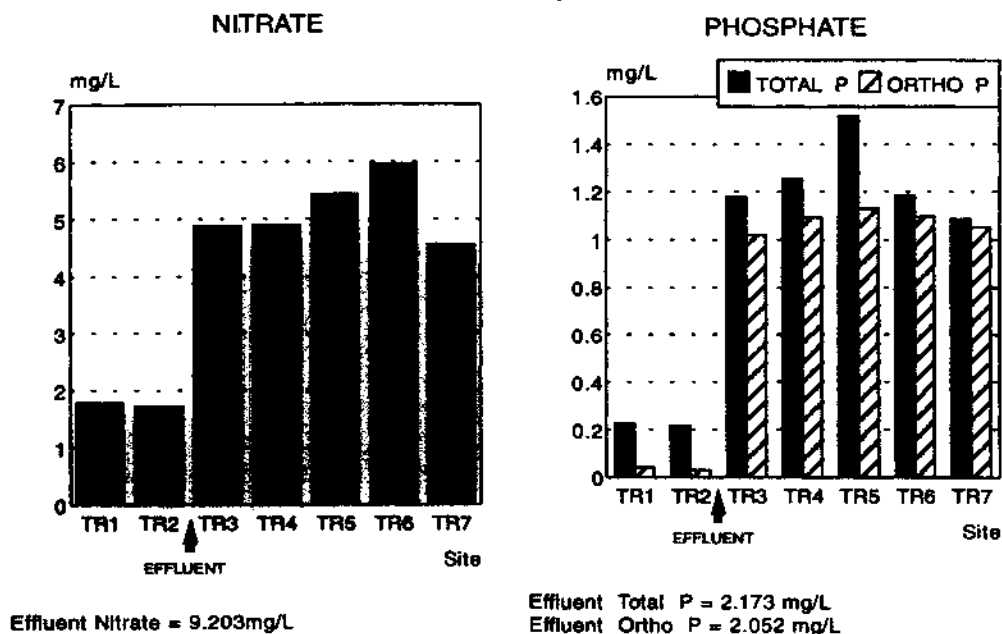
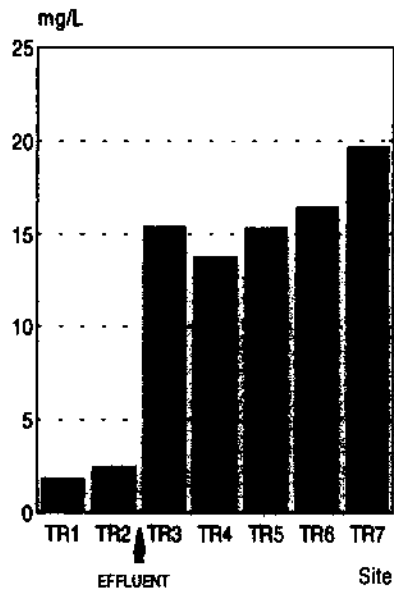


Figure 4. The concentrations of the inorganic nutrients, phosphate and nitrate, in ug/L, for August 1990 and May 1991.

persisted downstream at all sites. The nitrate concentrations in August 1991 were 2.5 mg/L at the reference sites, 16.1 mg/l in the effluent and immediately downstream at TR3, and persistently higher at all other sites (Figure 5). In May 1992 the concentrations ranged from less than 1 mg/L at the reference sites to 8.0 mg/L at TR3. The concentrations increased at the sites downstream (Figure 5). The trend was repeated in August 1992: the concentrations were less than 1 mg/L at the reference sites, 22.2 mg/L in the effluent, and 17.7 mg/L at TR3, with higher levels persisting downstream (Figure 5).

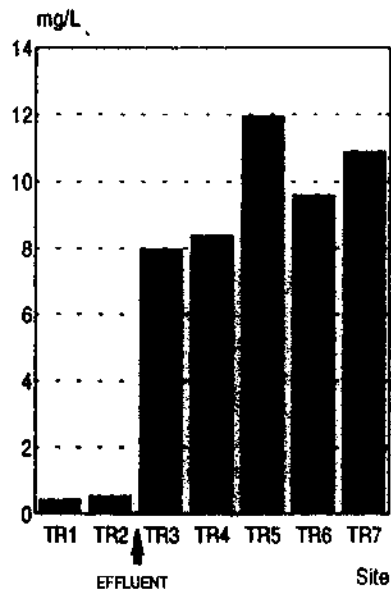
Phosphates were measured in the form of total phosphates and orthophosphates in August 1990 and May 1991. Total phosphate concentrations were around 0.2 mg/L at the reference sites in August 1990 and in May 1991 (Figure 4). Orthophosphate concentrations were less than 0.1 mg/L at the reference sites on both dates. In August 1990 the concentration of total phosphate was 1.5 mg/L at TR3, with levels persistently higher downstream. Orthophosphate concentrations increased to 1.9 mg/L at TR3. In May 1991 the total and orthophosphate levels were 2.2 and 2.1 mg/L, respectively, in the effluent, and 1.2 and 1.1 mg/L at TR3. Again, the increased phosphate levels persisted downstream to TR7 (Figure 4).

August 1991 NITRATE



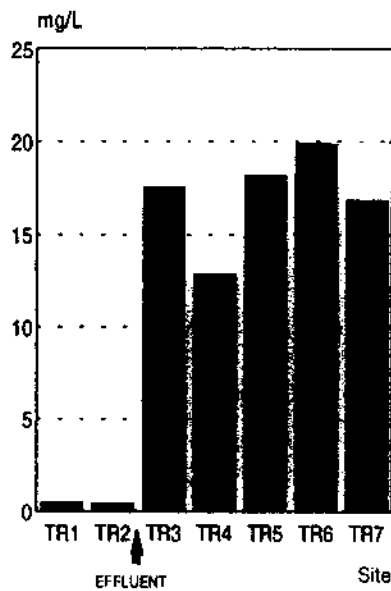
Effluent nitrate = 16.111 mg/L

May 1992 NITRATE



Effluent nitrate = 9.657 mg/L

August 1992 NITRATE



Effluent Total P = 22.167 mg/L

Phosphate analysis was not successful on these dates.

Figure 5. Nitrate concentrations (ug/L) for August 1991, May 1992, and August 1992.

Flow

Data for mean daily flow was collected by the US Geological Survey where the river crosses Beach Street in Ft Worth, upstream from TR1, and at a point downstream from TR7 (Figure 1). The daily flow rates in cubic meters/second from August 1 1990 to September 30 1991 are given in Figure 6. The daily flow rates from August 1 1991 to September 30 1992 are given in Figure 7. A summary of the flow rates are given in Table 2. The rate of discharge for the effluent was based on the projected daily load for the plant of 100 million gallons/day, which is equivalent to $8.76 \text{ m}^3/\text{second}$.

Phytoplankton

Chlorophyll a

Phytoplankton samples were collected directly from the outflow of the effluent on May 1991, May 1992, and August 1992. The chlorophyll-a concentrations from these samples were conspicuously lower than for the sites in the river. They were excluded from statistical analyses, but were retained in the data table for comparisons.

For September 1990 mean chlorophyll-a concentrations ranged from 2.80 ug/L at TR6 to 18.69 ug/L at TR1 (Figure 8). A statistically significant difference in concentrations existed between the reference sites and TR5, TR6, and TR7 (parametric ANOVA, $(0.005 > p > 0.002)$ with

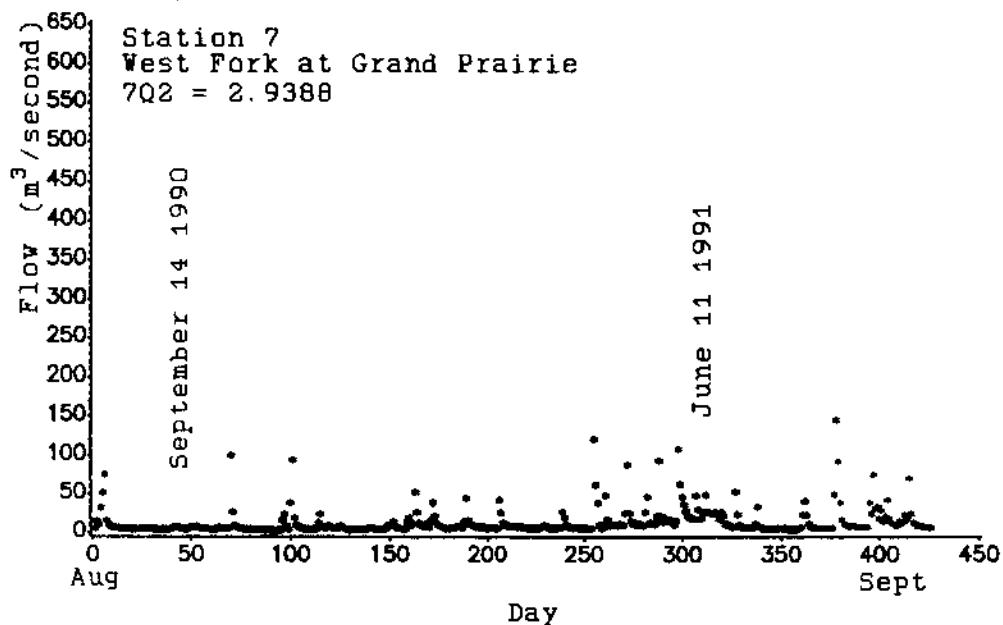
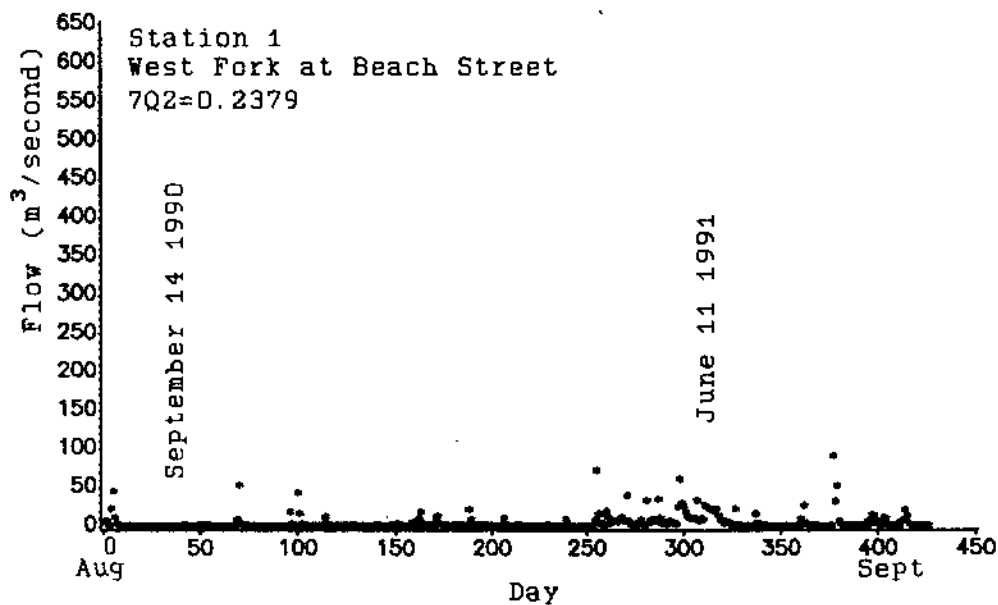


Figure 6. Flow rates at the U.S.G.S. monitoring stations upstream from TR1 (top graph) and downstream from TR7 (bottom graph) for the year from August 1 1990 to September 30 1991.

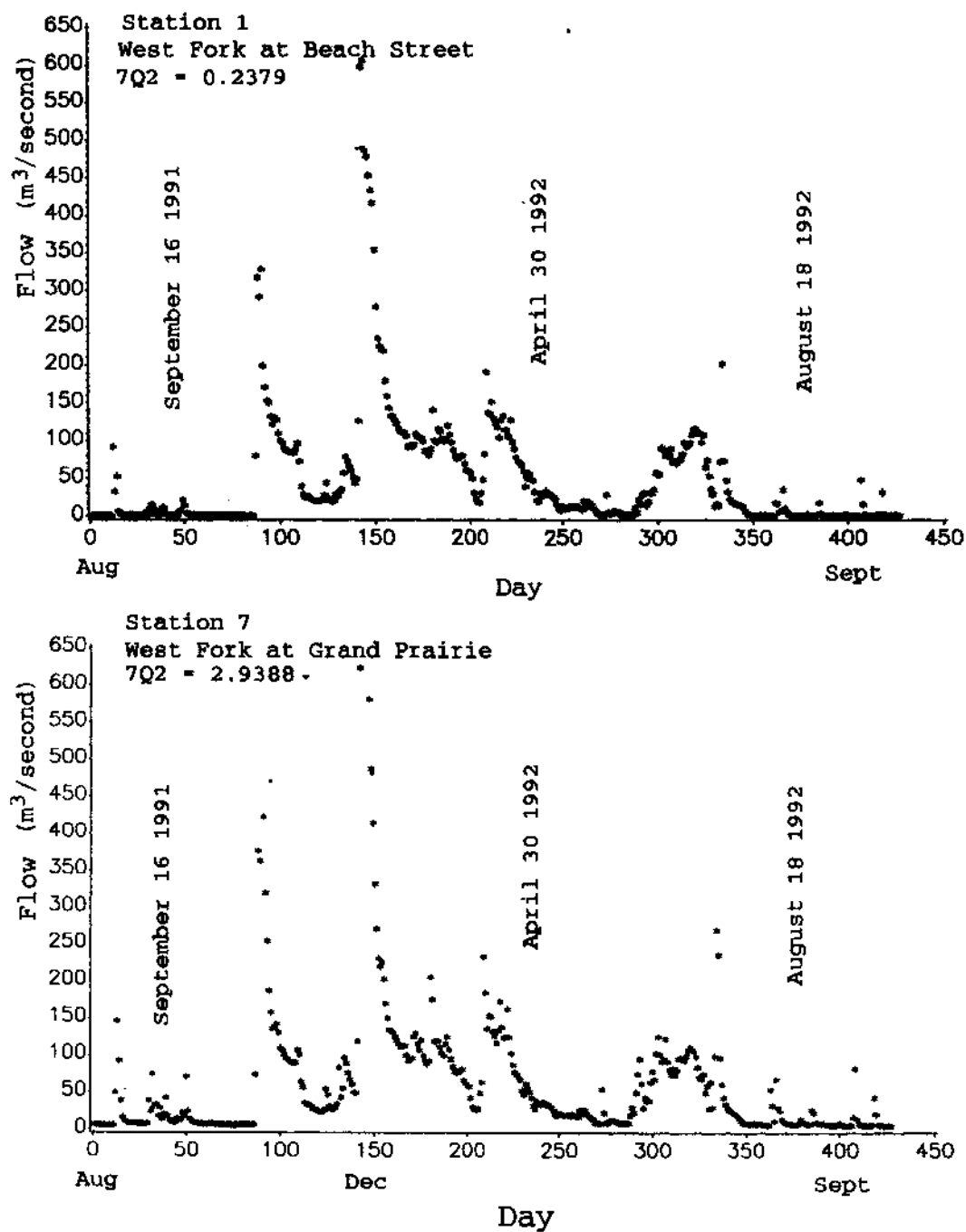


Figure 7. Flow rates at the U.S.G.S. monitoring stations upstream from TR1 (top graph) and downstream from TR7 (bottom graph) for the year from August 1 1991 to September 30 1992.

Chlorophyll-a August 1990

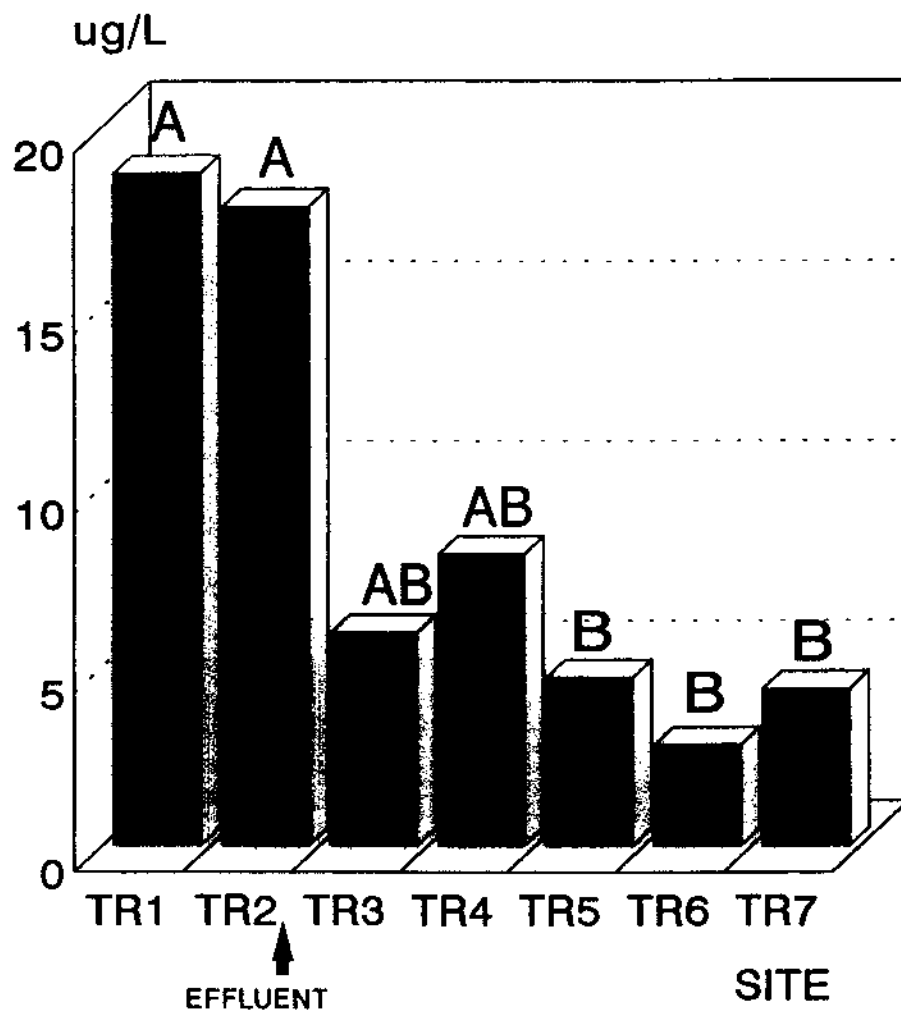


Figure 8. Phytoplankton chlorophyll-a concentrations (ug/L) for August 1990. The letters on top of the bars indicate statistical differences.

Table 2. Summary of flow rates for individual sample dates. Rates are given in cubic meters/second. The rate of discharge of the effluent was approximately 8.76 m³/second on all dates.

	<u>West Fork at Beach St.</u>	<u>West Fork at Grand Prairie</u>
August 30 1990	0.54	5.41
September 14 1990	0.42	6.15
May 22 1991	4.98	12.77
June 11 1991	21.47	25.60
August 14 1991	52.68	92.32
September 16 1991	6.23	13.96
April 30 1992	4.56	23.48
May 13 1992	2.04	8.58
August 14 1992	1.61	10.39
August 18 1992	2.52	6.54

Tukey's MRT). The maximum standard deviation was 6.61 at TR2 (Table 3).

The mean chlorophyll-a concentrations from phytoplankton collected in May 1991 ranged from 32.71 ug/L at TR6 to 54.83 ug/L at TR2 (Figure 9). The mean concentrations from TR2 were significantly different than those from TR3, TR4, TR6, and TR7 (parametric ANOVA ($0.02 > p > 0.01$) with Tukey's MRT). The maximum standard deviation was 7.49, for TR2 (Table 3).

Table 3. Phytoplankton chlorophyll-a concentrations (ug/L) for all sample dates. Sample replicates are in the columns labelled A, B, and C.

Phytoplankton Chlorophyll-a
9/90

	A	B	C	MEAN	STD
TR-1	19.62	21.49	14.95	18.69	2.75
TR-2	22.43	8.41	22.43	17.76	6.61
TR-3	11.23	0.00	6.54	5.92	4.61
TR-4	7.48	10.28	6.54	8.10	1.59
TR-5	1.87	4.67	7.48	4.67	2.29
TR-6	3.74	2.80	1.87	2.80	0.76
TR-7	0.94	4.67	7.48	4.36	2.68

Phytoplankton Chlorophyll-a
10/90

	A	B	C	MEAN	STD
TR-1	23.40	27.10	27.10	25.87	3.16
TR-2	33.60	29.90	29.90	23.35	1.74
TR-3	14.00	13.10	5.60	10.90	3.77
TR-4	4.70	3.70	4.70	4.37	0.47
TR-5	6.50	9.30	5.60	7.13	1.58
TR-6	7.50	4.70	4.70	5.63	1.32
TR-7	6.50	2.80	2.80	4.03	1.74

Phytoplankton Chlorophyll-a
5/91

	A	B	C	MEAN	STD
TR-1	42.99	53.27	43.92	46.73	4.64
TR-2	65.42	49.53	49.53	54.83	7.49
TR-3	30.84	31.77	43.92	35.51	5.96
TR-4	34.58	40.18	27.10	33.95	5.36
TR-5	44.86	57.94	41.12	47.97	7.21
TR-6	31.77	33.64	32.71	32.71	0.76
TR-7	37.38	30.84	39.25	35.82	3.61
TR-EFF	2.80	2.80	4.67	3.42	0.88

Table 3 (continued). Phytoplankton chlorophyll-a concentrations (ug/L). Sample replicates are in the columns labelled A, B, and C.

Phytoplankton Chlorophyll-a
8/91

	A	B	C	MEAN	STD
TR-1	30.87	30.87	30.87	30.87	0.00
TR-2	43.04	47.71	45.84	45.53	1.92
TR-3	15.90	15.90	4.68	12.16	5.29
TR-4	18.71	19.65	18.71	19.02	0.44
TR-5	20.58	23.39	27.13	23.70	2.68
TR-6	24.32	29.94	26.20	26.82	2.34
TR-7	40.23	43.97	46.78	43.66	2.68

Phytoplankton Chlorophyll-a
5/92

	A	B	C	MEAN	STD
TR-1	43.04	68.30	9.36	40.23	24.14
TR-2	63.62	64.55	72.04	66.74	3.77
TR-3	24.32	45.84	13.10	27.75	13.58
TR-4	31.81	24.32	22.45	26.19	4.04
TR-5	27.13	14.03	9.36	16.84	7.52
TR-6	30.87	61.75	43.97	45.53	12.65
TR-7	85.14	82.33	80.46	82.64	1.92
TR-EFF	3.74	5.61		4.68	0.93

Phytoplankton Chlorophyll-a
8/92

	A	B	C	MEAN	STD
TR-1	14.03	1.87	7.48	7.79	4.97
TR-2	19.65	27.13	28.07	24.95	3.77
TR-3	3.74	6.55	8.42	6.24	1.92
TR-4	6.55	10.29	10.29	9.04	1.76
TR-5	24.32	20.58	30.87	25.26	4.25
TR-6	6.55	6.55	6.55	6.55	0.00
TR-7	25.26	24.32	21.52	23.70	1.59
TR-EFF	2.81	2.81	0.00	1.87	1.32

Chlorophyll-a May 1991

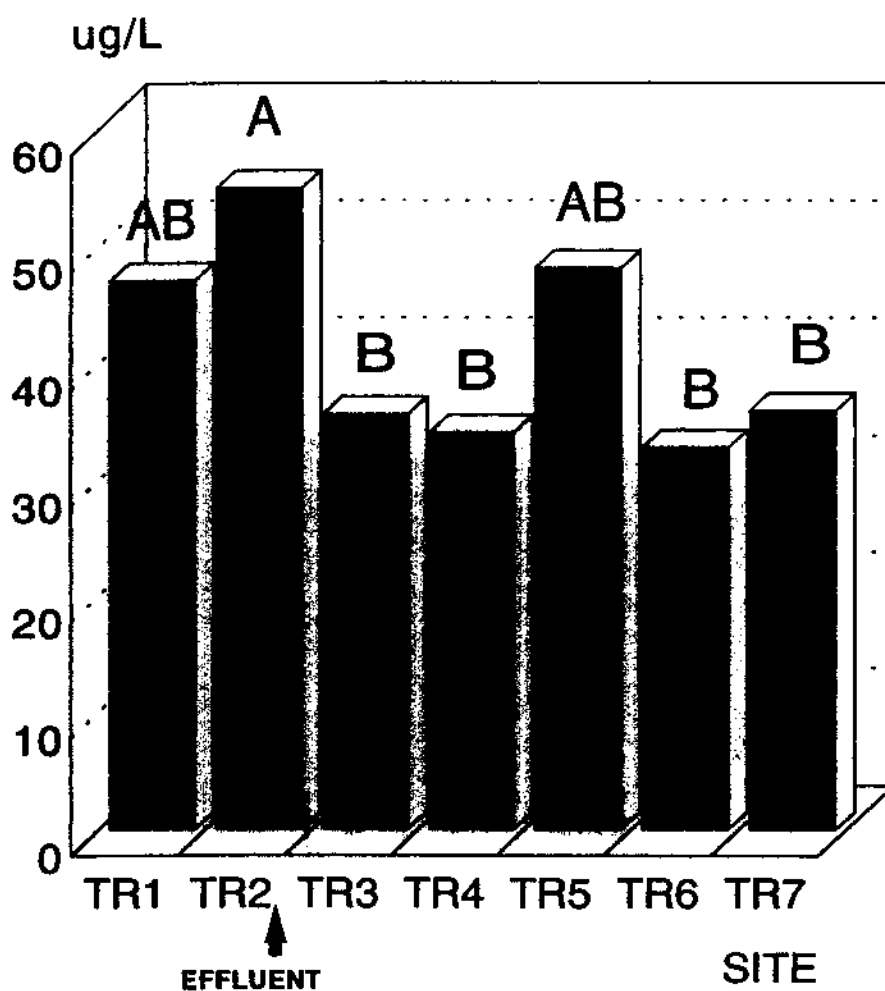


Figure 9. Phytoplankton chlorophyll-a concentrations (ug/L) for May 1991. The letters on top of the bars indicate statistical differences.

For August 1991 the mean chlorophyll-a concentration values ranged from a low of 12.16 ug/L at TR3 to a high of 45.53 ug/L at TR2 (Figure 10). There was a significant difference in mean concentrations between TR2 and TR3 (non-parametric Kruskal-Wallis ANOVA ($p < 0.001$) with Dunn's MRT). The maximum standard deviation of 5.29 was for TR3 (Table 3).

The mean concentrations for May 1992 ranged from 16.84 ug/L at TR5 to 82.64 ug/L at TR7 (Figure 11). A statistically significant difference existed between the concentrations at TR7 and all other sites except TR2 and TR6 (parametric ANOVA ($0.005 > p > 0.002$) with Tukey's MRT). The maximum standard deviation was 24.14, for TR1 (Table 3).

The samples collected in August 1992 yielded mean concentrations that ranged from 6.24 ug/L for TR3 to 25.26 ug/L for TR5 (Figure 12). There was a statistically significant difference in mean concentrations among sites (parametric ANOVA ($0.005 > p > 0.002$), and Tukey's MRT revealed that the mean concentrations at TR2, TR5 and TR7 were different than at TR1, TR3, TR4, and TR6. This is apparent in the histogram in Figure 14. The maximum standard deviation was 4.97, for TR1 (Table 3).

Enumeration

Mean phytoplankton densities are given in the Appendix and are summarized in Table 4.

Chlorophyll-a August 1991

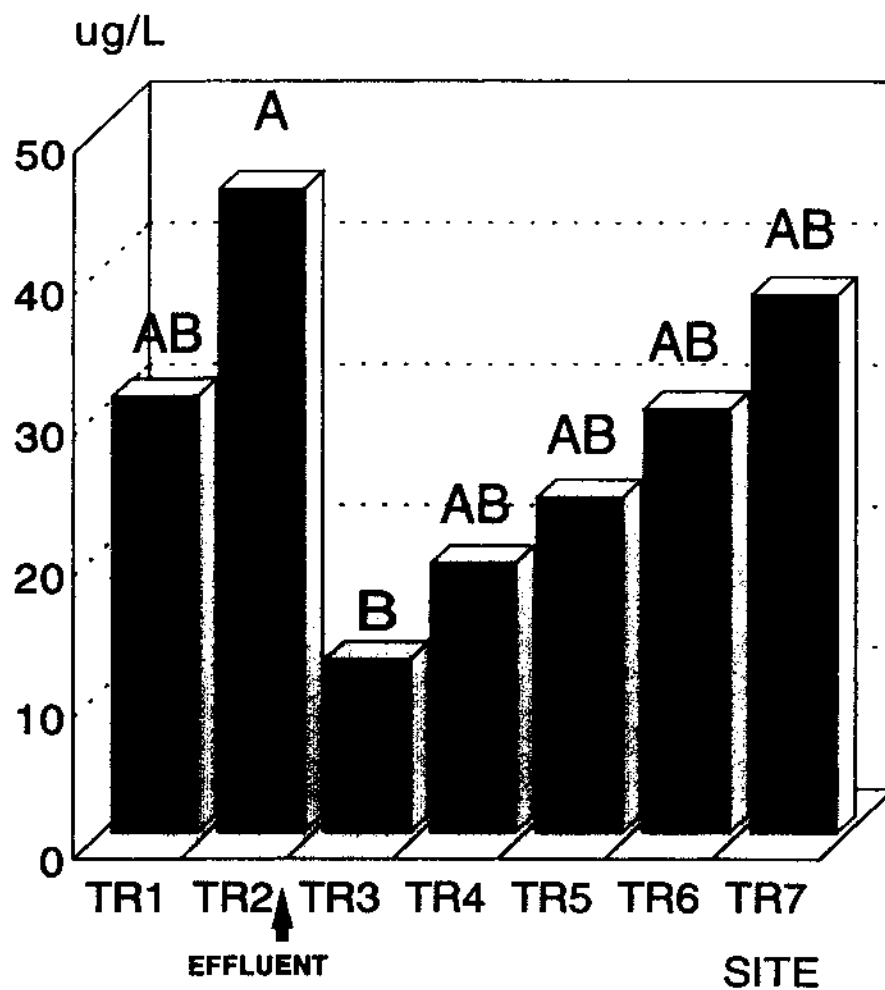


Figure 10. Phytoplankton chlorophyll-a concentrations (ug/L) for August 1991. The letters on top of the bars indicate statistical differences.

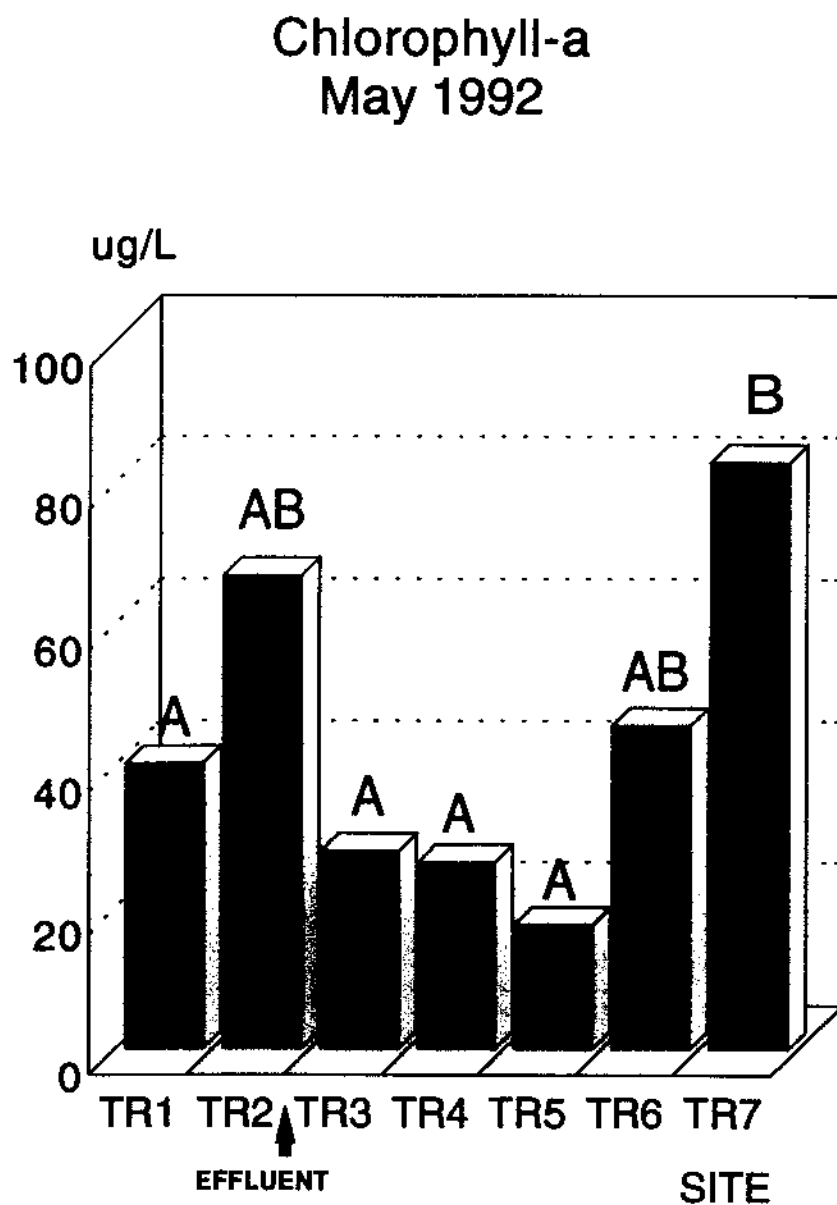


Figure 11. Phytoplankton chlorophyll-a concentrations (ug/L) for May 1992. The letters on top of the bars indicate statistical differences.

Chlorophyll-a August 1992

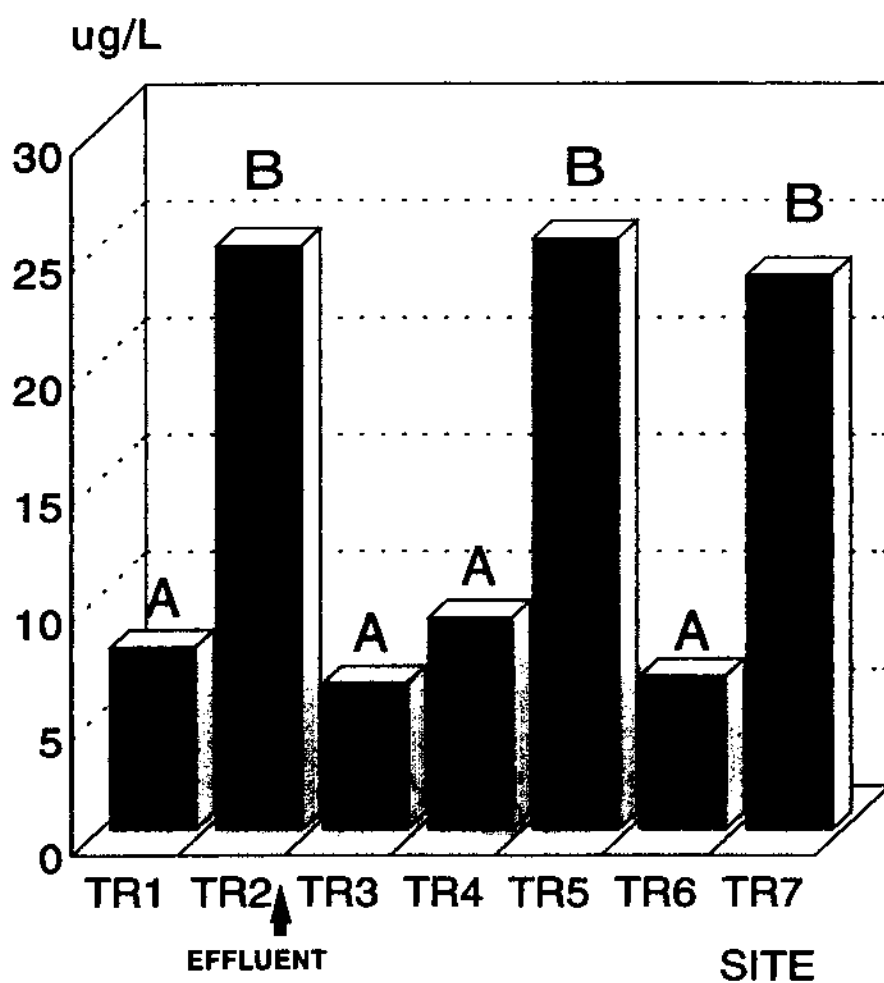


Figure 12. Phytoplankton chlorophyll-a concentrations (ug/L) for August 1992. The letters on top of the bars indicate statistical differences.

Table 4. Phytoplankton densities (cells/L) for each site and on each sample date. Ranges and means are given except for August 1990 when no replicate samples were collected.

August 1990

	<u>NUMBER/L</u>			
TR1	-	-	317458	-
TR2	-	-	393408	-
TR3	-	-	33820	-
TR4	-	-	57065	-
TR5	-	-	55574	-
TR6	-	-	47559	-
TR7	-	-	29862	-

May 1991

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	2325	31059	16806	14368
TR2	5482	17708	10317	6251
TR3	3977	8129	5684	2172
TR4	4753	7954	5982	1725
TR5	970	6089	3421	2567
TR6	3395	13871	8375	5257
TR7	4559	16218	8348	6711

August 1991

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	13787	14950	14369	2266
TR2	13463	17375	15420	2783
TR3	6891	16043	11468	6471
TR4	11743	13628	12686	1339
TR5	11439	36295	23868	17439
TR6	6233	20019	13121	9755
TR7	13504	16943	15224	2329

Table 4 (continued). Phytoplankton densities (cells/L). Ranges and means are given.

May 1992

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	79308	722291	393169	158923
TR2	118437	621667	362631	19836
TR3	71833	104142	84481	17062
TR4	29352	46673	39868	10764
TR5	22252	48209	35354	11166
TR6	45520	56780	50791	5915
TR7	45447	58239	52437	6115

August 1992

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	20506	115818	79390	42410
TR2	87816	116722	102226	15204
TR3	16165	29478	24977	7632
TR4	7785	45055	25841	18108
TR5	10889	32370	20762	11078
TR6	16333	44772	26564	16106
TR7	13342	27521	22045	8305

Phytoplankton samples were collected from the effluent discharge on May 1991, May 1992, and August 1992. These data are included in the Appendix but were not analyzed statistically.

In August 1990 mean phytoplankton densities ranged from 47,559 individuals/L at TR6 to between 300,000 and 400,000 individuals/L at the reference sites, (Table 4). Only one replicate was collected on this date, so no statistical analysis of data was performed. The diversity indices ranged from 0.2300 at TR5 to 0.4868 at TR7. The range in number of genera was from 14 at TR3 to 22 at TR5 (Figure 13).

Cyanophyta, the blue-green algae, was the most well-represented phytoplankton division at all stations (Figure 14), with Merismopedia and Microcystis being the dominant taxa (see Appendix). Bray-Curtis similarity coefficients indicated that the communities at TR4 and TR5 were most alike, with a similarity coefficient of 0.9502. The communities at TR1 and TR2 were clustered together, with a coefficient of 0.8664. The resemblance of the communities at TR1 and TR2 to the communities at the other sites was represented with a coefficient of 0.2172 (Figure 14).

In May of 1991, mean phytoplankton densities ranged from 3421 individuals/L at TR5 to 16806 individuals/L at TR1. There was no statistically significant difference in mean densities among sites (parametric ANOVA ($p > 0.25$)). The maximum standard deviation was 14368, for TR1 (Table 4).

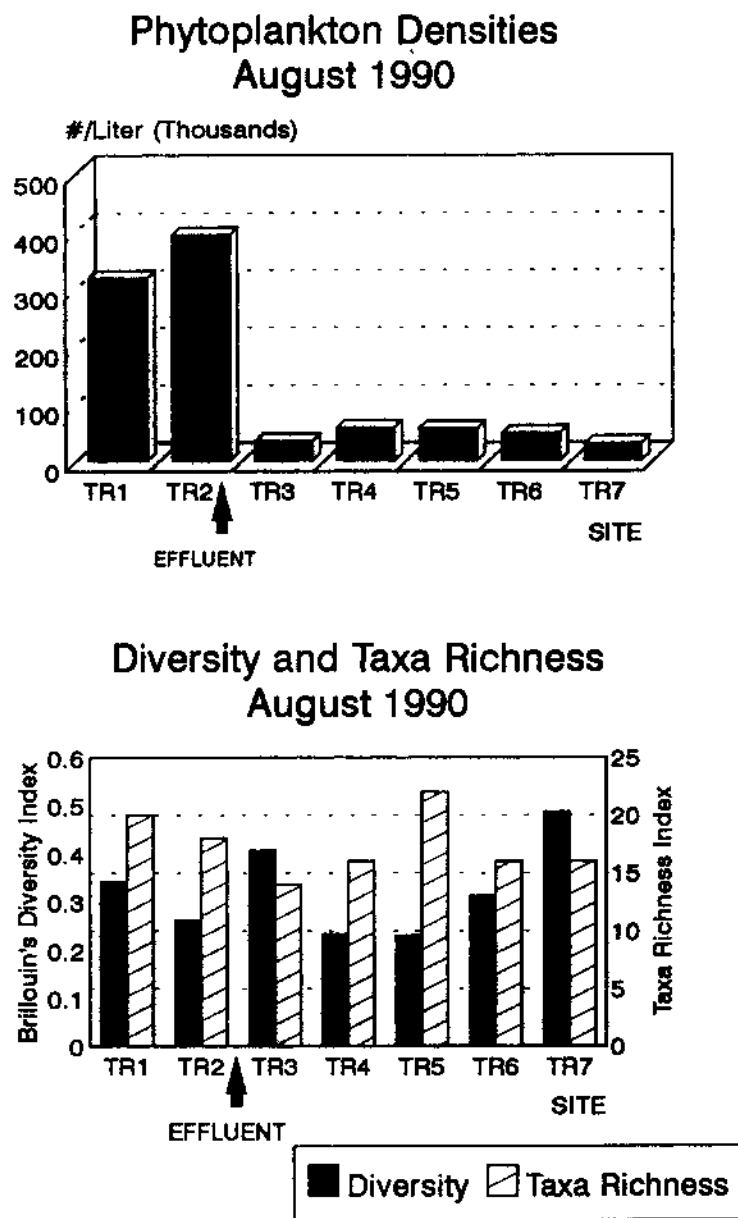


Figure 13. Phytoplankton mean densities (number/L) (top graph) and diversity and taxa richness (bottom graph) for August 1990.

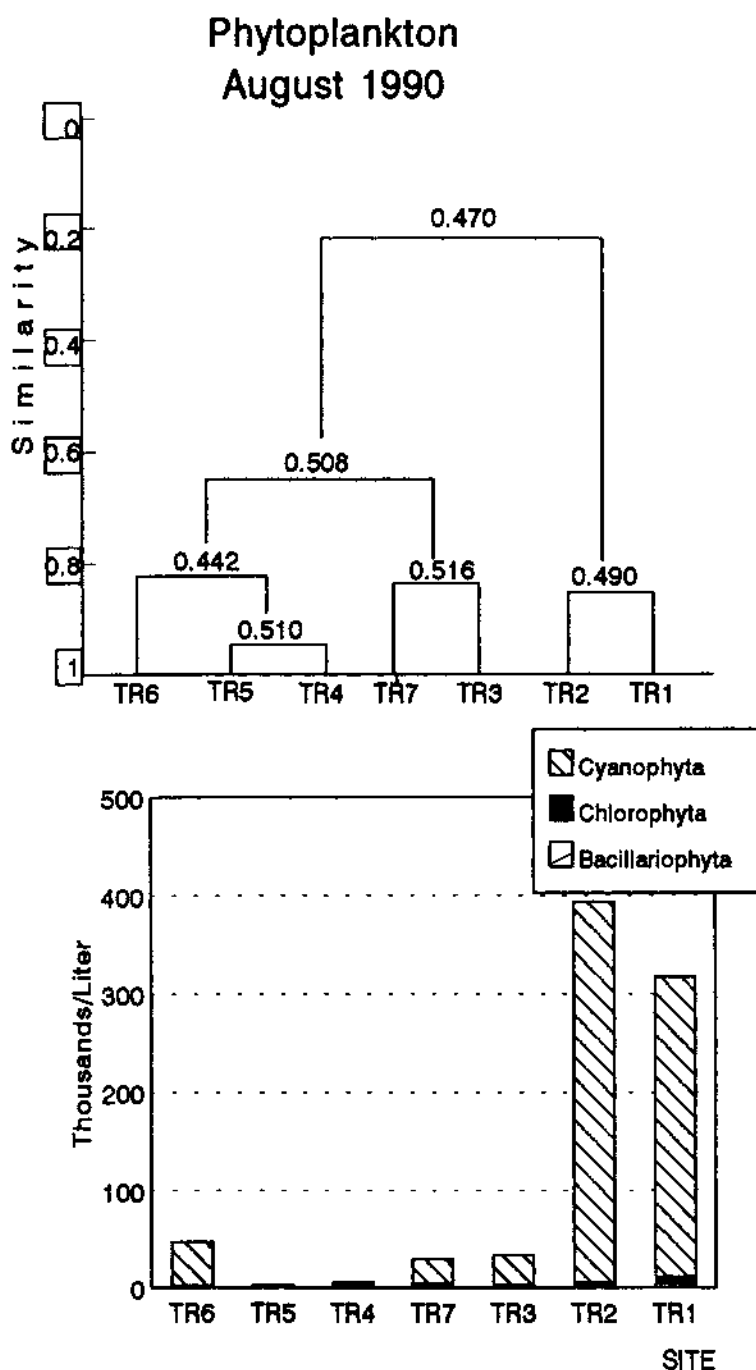


Figure 14. Phytoplankton community similarities and taxa densities within communities for August 1990. In the top graph the y-axis represents Bray-Curtis similarity coefficient, scaled from 1 to 0 with, with 1 being the most similar. The numbers on top of each cluster are the probabilities that the associations are based on true community similarities. Note the x-axes of both graphs are arranged in similar order.

The diversity indices ranged from a low of 0.8274 at TR6 to 1.0969 at TR7. The lowest number of taxa, 16, was from TR5, and the highest, 26, from TR7 (Figure 15). The dominant taxa represented each major division (Figure 16), with the three dominant genera being Cyclotella, Scenedesmus, and clumps of Microcystis (see Appendix). Bray-Curtis cluster analysis indicated that the communities at TR2 and TR4 were most similar, with a coefficient of 0.6626, and the similarity between these stations and TR3 was represented by a coefficient of 0.5796. The community at TR1 was most similar to the community at TR6, with a coefficient of 0.5134, and the similarity of this pair of communities to the rest of the communities was the smallest, with a coefficient of 0.3523. The probability that the distinction of clusters was not due to variability among replicate samples was well above the alpha level of 0.05 for each cluster (Figure 16).

The mean densities for samples collected on August 1991 ranged from 11468 individuals/L at TR3 to 23868 individuals/L at TR5. The maximum standard deviation was 17439, for TR5 (Table 4). The non-parametric Kruskal-Wallis ANOVA failed to detect a significant difference in mean densities among sites. The diversity indices ranged from 0.8729 at TR3 to 1.3118 at TR2 (Figure 17). Taxa richness varied from 32 genera at TR3 to 42 genera at TR7. Each of the major divisions was represented at each site, with

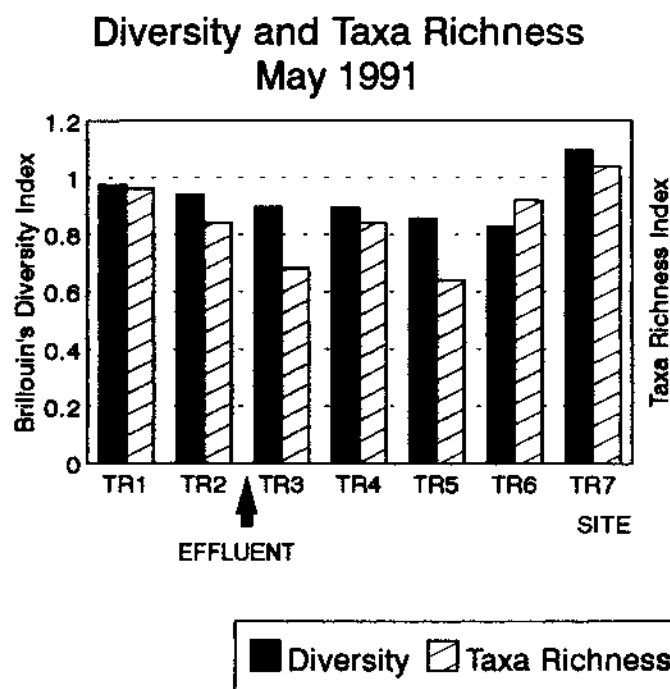
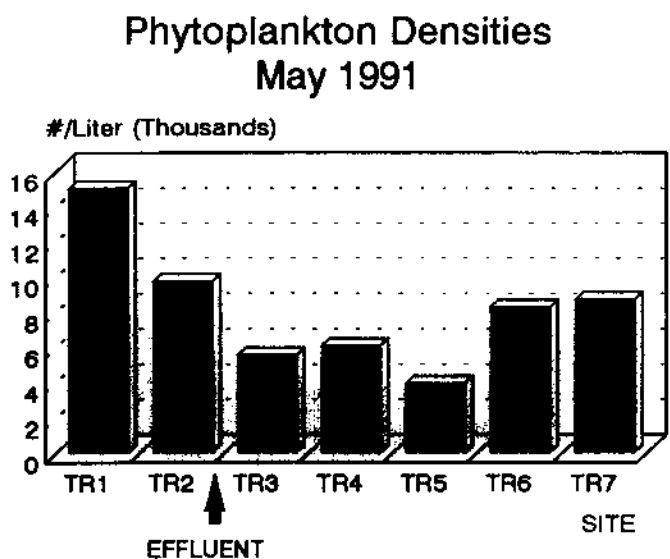


Figure 15. Phytoplankton mean densities (number/L) (top graph) and diversity and taxa richness (bottom graph) for May 1991.

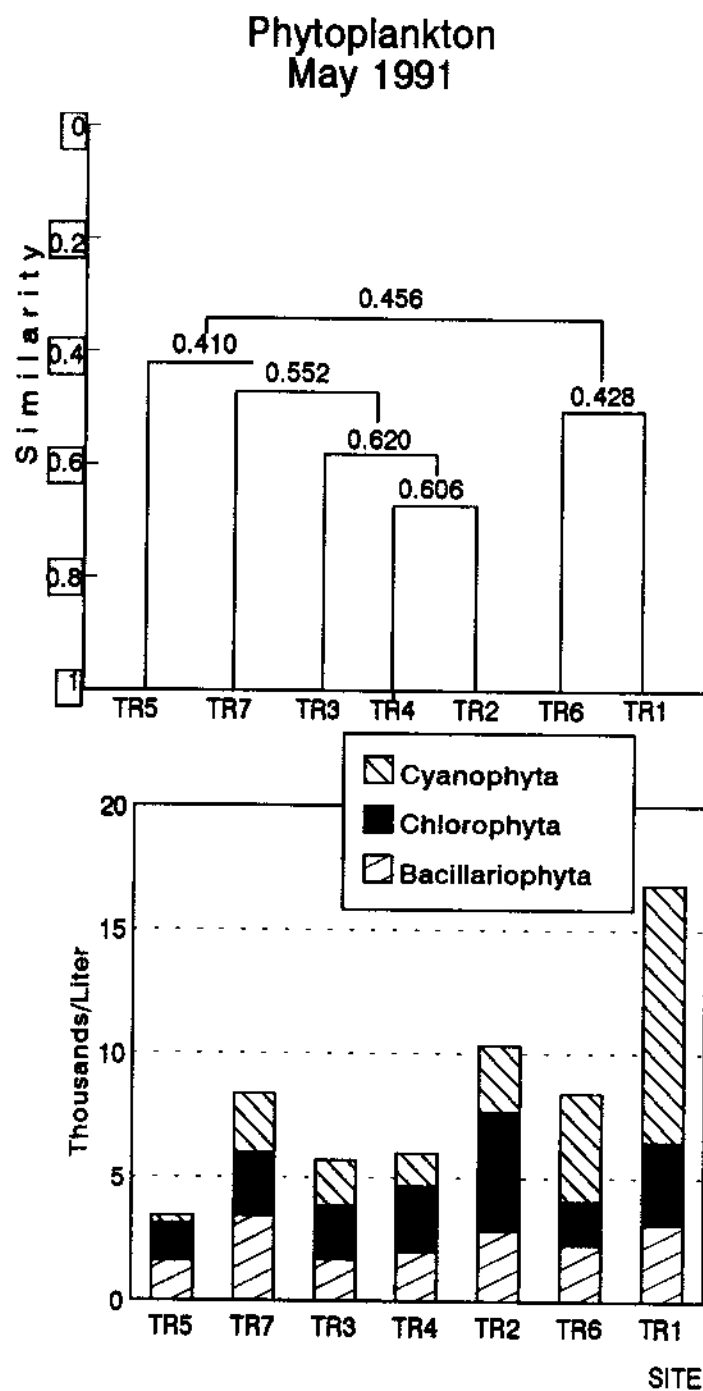
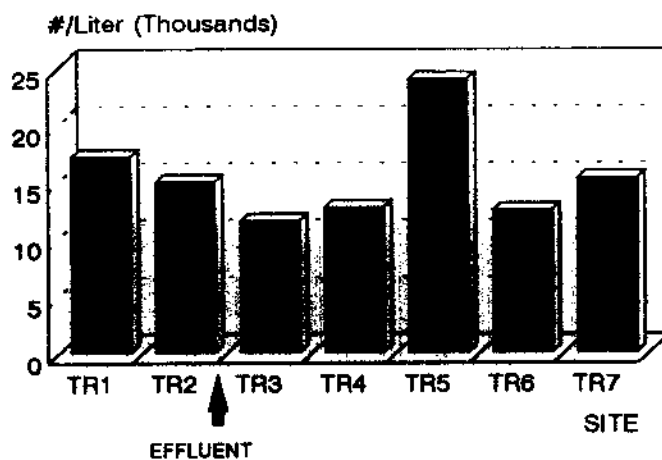


Figure 16. Phytoplankton community similarities and taxa densities within communities for May 1991.

Phytoplankton Densities August 1991



Diversity and Taxa Richness August 1991

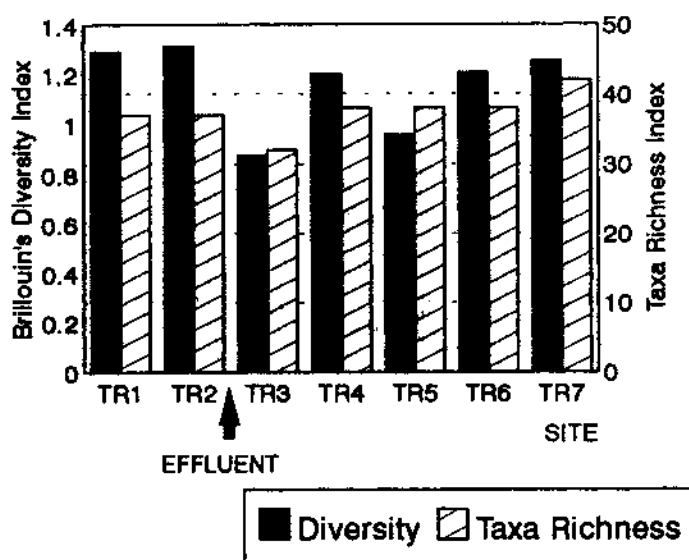


Figure 17. Phytoplankton mean densities (number/L) (top graph) and diversity and taxa richness (bottom graph) for August 1991.

Cyanophyta being noticeably dominant at TR5 (Figure 18). Bray-Curtis similarity analysis indicated that the communities at TR1 and TR2 were similar with a coefficient of 0.4756, the communities at TR3 and TR5 were clustered, having a coefficient of 0.5871, and the communities at TR4, TR6, and TR7 were alike, with a coefficient of 0.5101. The probability that these clusters were based on similarities and not on variability among replicate samples was well above the alpha level of 0.05 for each cluster (Figure 18).

For May 1992 the range in mean densities was from 35354 individuals/L at TR5 to 393169 individuals/L at TR1 (Table 4). There was a significant difference in mean densities among sites (parametric ANOVA ($0.05 > p > 0.02$)). Tukey's MRT revealed that mean densities at TR1 were significantly different from those at TR3 and TR5. Diversity was lowest at TR1 with an index of 0.6943 and highest at TR7 with an index of 1.1792. Taxa richness was lowest at TR3 with 34 and highest at TR2 and TR5 with a value of 42 at each of those sites (Figure 19). The higher densities at TR1 and TR2 were dominated by taxa within Cyanophyta (Figure 20), particularly Aphanocapsa and Microcystis (see Appendix). Bray-Curtis similarity analysis indicated that TR1 and TR2 were similar, with a coefficient of 0.6912, and TR4, TR5, and TR6 were similar, with a coefficient of 0.7267. The coefficient of similarity between TR1 and TR7 was 0.0000, and between TR1 and TR3 was 0.2436. The coefficient derived

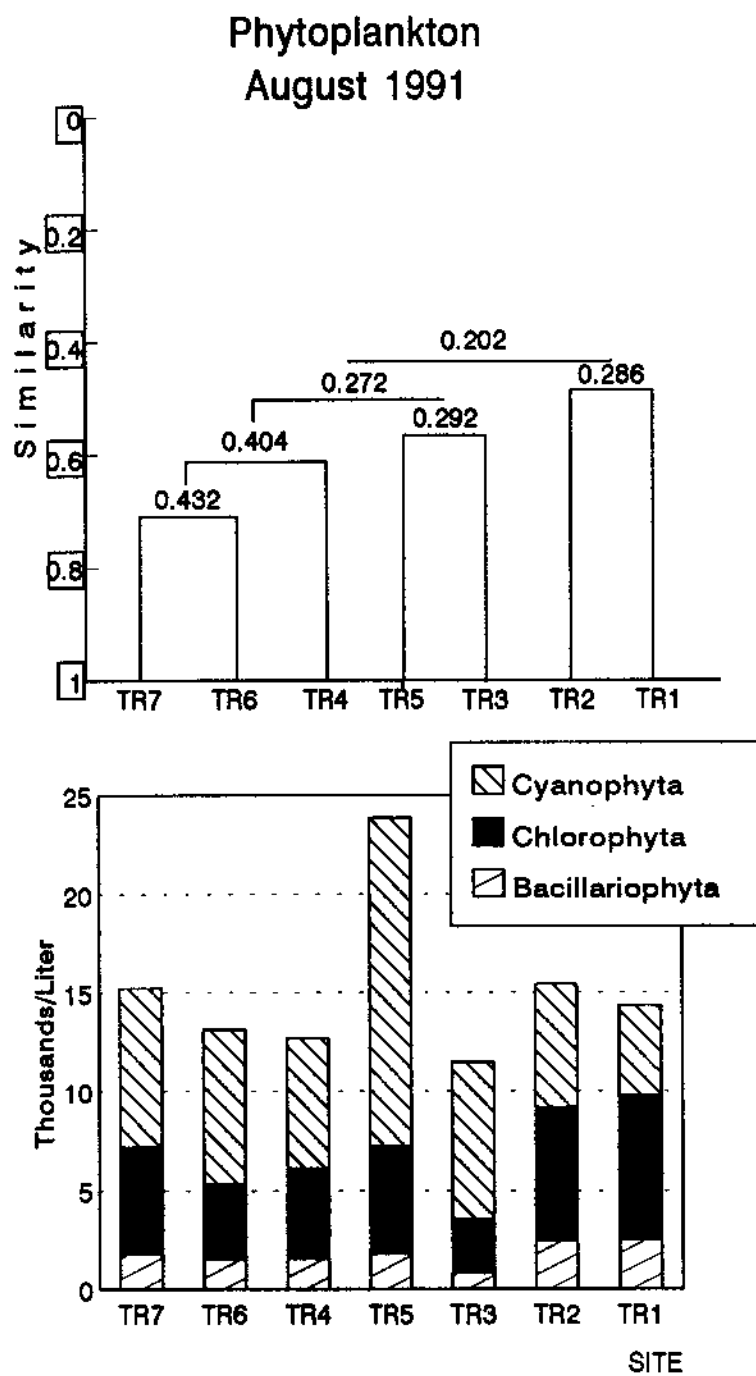
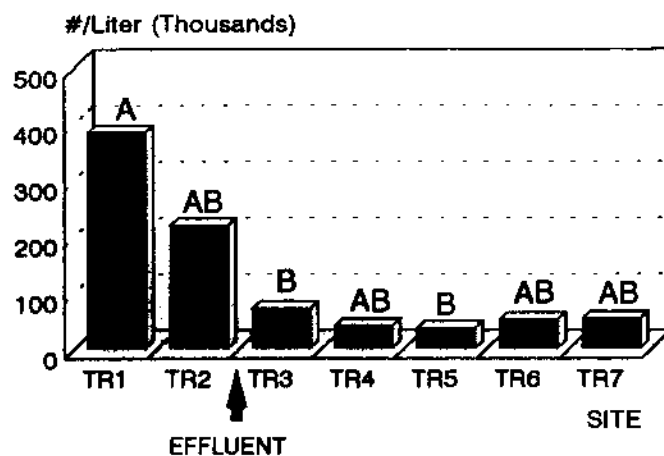


Figure 18. Phytoplankton similarity and taxa densities within communities for August 1991 (top graph).

Phytoplankton Densities May 1992



Diversity and Taxa Richness May 1992

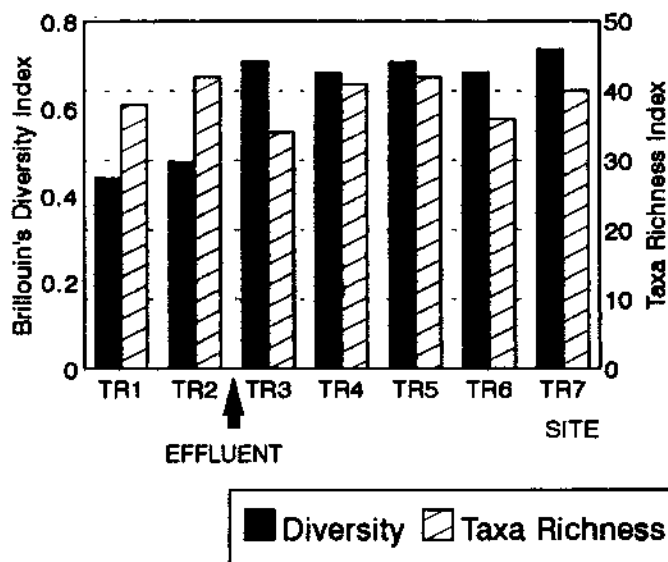


Figure 19. Phytoplankton mean densities (number/L) (top graph) and diversity and taxa richness (bottom graph) for May 1992. The letters on top of the bars indicate statistical differences.

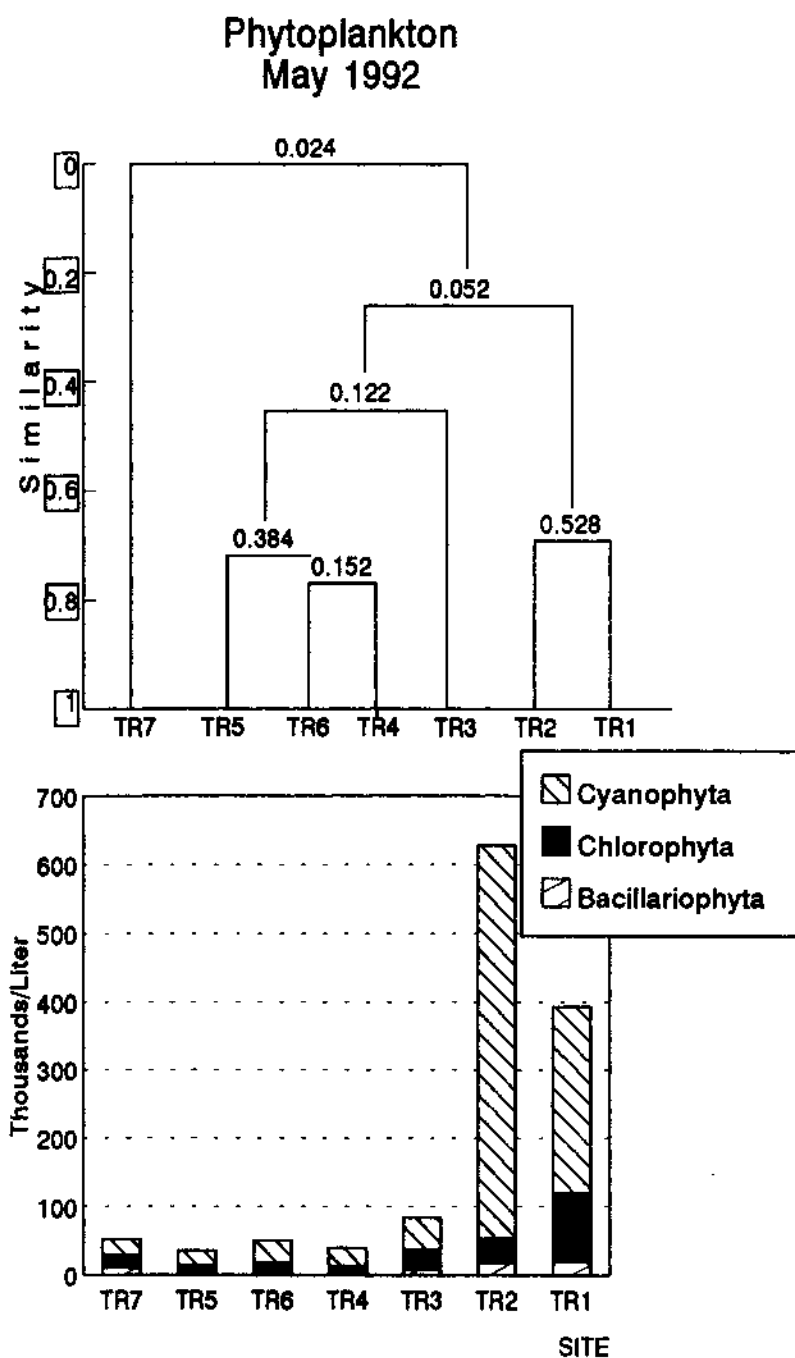
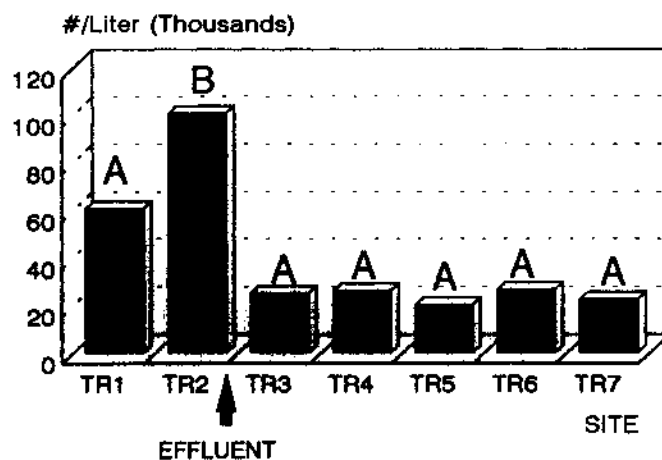


Figure 20. Phytoplankton similarities and taxa densities within communities for May 1992.

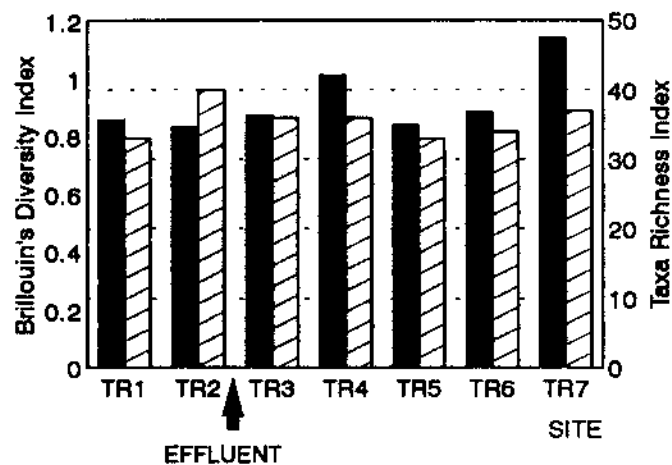
for the similarity of the communities at TR1 and TR7 may have been based on variability between replicates ($p = 0.024$) (Figure 20).

The mean phytoplankton densities from samples collected on August 1992 were higher at the two reference sites, with values of 79390 individuals/L for TR1 and 102226 individuals/L for TR2. The lowest value was 20726 individuals/L for TR5 (Table 4). The maximum standard deviation was 42410, for TR1. There was a significant difference in mean densities indicated between TR2 and all of the other sites (parametric ANOVA ($p < 0.0005$)). The diversity indices ranged from 0.8318 at TR2 to 1.1394 at TR7. The number of genera ranged from 33 at TR1 and TR5 to 40 at TR2 (Figure 21). The most abundant algae were in the divisions Chlorophyta and Cyanophyta at all sites. The taxa with the highest density was Microcystis. Bray-Curtis similarity analysis showed that communities at TR1 and TR2 were similar, with a coefficient of 0.6556, the rest of the communities were similar to each other with a coefficient of 0.6494, and the similarity between the former cluster and the latter cluster was 0.3688. There was a chance that the coefficient derived from the resemblance of the former cluster to the latter cluster was due to variability among replicate samples ($p = 0.0300$) (Figure 22).

Phytoplankton Densities August 1992



Diversity and Taxa Richness August 1992



■ Diversity ▨ Taxa Richness

Figure 21. Phytoplankton mean densities (number/L) (top graph) and diversity and taxa richness (bottom graph) for August 1992. The letters on top of the bars indicate statistical differences.

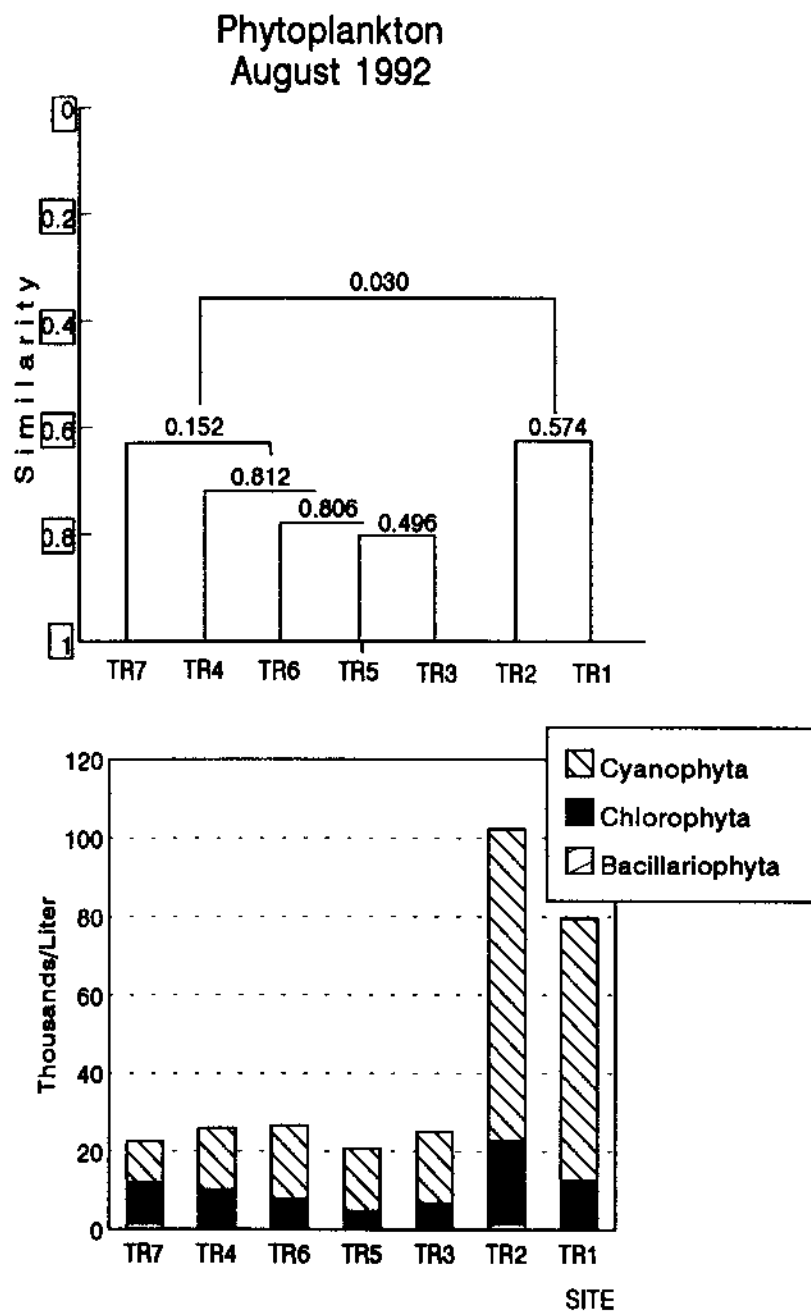


Figure 22. Phytoplankton similarities and taxa densities within communities for August 1992.

Periphyton

Ash-free Dry Weight

For September 1990 only two periphytometers were placed at each site. The mean dry weights ranged from 0.64 g/m² at TR3 to 5.57 g/m² at TR6. The maximum standard deviation was 0.96, found at TR5 and TR7 (Table 5). A significant difference in mean dry weights was found between TR3 and TR2, TR5, and TR6 (parametric ANOVA ($0.01 > p > 0.005$) with Tukey's MRT). Mean ash-free dry weight data are presented in Figure 23.

The periphytometers at TR3 were stranded out of the water on the June 1991 sample date. One periphytometer was lost at TR6 and one was lost at TR7. The dry weight values were low at all sites ($< 2\text{g/m}^2$) but were lowest with a value of 0.33 g/m² at TR7 and a value of 0.39 g/m² at TR1. The maximum standard deviation was 0.71, for TR5 (Table 5). A parametric ANOVA was performed on data from TR1, TR2, TR4, and TR5. There was no significant difference in mean dry weights among sites ($p > 0.50$). Data are presented in Figure 24.

For August 1991 there was either a partial or total loss of sample replicates for TR1, TR2, TR3, TR4, and TR7 due to flood damage (Table 5). Mean dry weights for TR3 and TR4 were between 2.0 and 2.4 g/m², and at TR5 the mean dry weight was 10.83 g/m². The maximum standard deviation is 5.01, for TR5 (Table 5). Statistical analysis could only be

Table 5. Periphyton ash-free dry weights (mg/m²) dates. Sample replicates are given in columns A, B, and C.

Periphyton Ash-free Dry Weight 9/90					
	A	B		MEAN	STD
TR1	2.50	3.41		2.96	0.46
TR2	4.32	3.62		3.97	0.35
TR3	0.74	0.55		0.64	0.10
TR4	0.78	1.68		1.23	0.45
TR5	3.53	5.44		4.49	0.96
TR6	5.68	5.47		5.57	0.10
TR7	0.66	2.58		1.62	0.96
Ash-free Dry Weight 6/91					
	A	B	C	MEAN	STD
TR1	0.20	0.20	0.20	0.20	0.20
TR2	0.46	0.46	0.46	0.46	0.46
TR3	-	-	-	-	-
TR4	0.21	0.30	0.61	0.37	0.17
TR5	0.57	1.99	-	1.28	0.71
TR6	1.95	-	-	*1.95	-
TR7	0.33	-	-	*0.33	-
Ash-free Dry Weight 9/91					
	A	B	C	MEAN	STD
TR1	-	-	-	-	-
TR2	-	-	-	-	-
TR3	0.74	0.31	5.26	2.11	2.24
TR4	3.02	1.74	-	2.38	0.64
TR5	15.83	5.82	-	10.83	5.01
TR6	9.17	-	-	*9.20	-
TR7	10.16	-	-	*10.20	-

* Single value, not a mean.

Table 5 (continued). Periphyton ash-free dry weights (mg/m²). Sample replicates are given in columns A, B, and C.

**Ash-free Dry Weight
10/91**

	A	B	C	MEAN	STD
TR1	2.54	-	-	*2.54	-
TR2	0.91	0.69	-	0.80	0.11
TR3	0.40	1.05	-	0.73	0.33
TR4	0.48	1.12	-	0.80	0.32
TR5	-	-	-	-	-
TR6	-	-	-	-	-
TR7	-	-	-	-	-

**Ash-free Dry Weight
4/92**

	A	B	C	MEAN	STD
TR1	0.55	0.97	-	0.76	0.21
TR2	0.39	0.52	-	0.46	0.07
TR3	0.96	0.23	0.26	0.49	0.36
TR4	0.23	-	-	*0.23	0.11
TR5	1.74	1.13	2.10	1.66	0.31
TR6	2.28	2.90	2.11	2.43	0.31
TR7	1.39	-	-	*1.39	-

**Ash-free Dry Weight
8/92**

	A	B	C	MEAN	STD
TR1	3.72	2.75	5.56	4.01	1.17
TR2	1.28	4.08	-	2.68	1.40
TR3	0.08	0.55	0.68	0.43	0.26
TR4	0.99	0.42	0.39	0.60	0.28
TR5	3.11	1.29	-	2.20	0.91
TR6	3.58	1.33	-	2.45	1.48
TR7	0.99	0.91	-	0.95	0.45

* Single value, not a mean.

ASH-FREE DRY WEIGHT September 1990

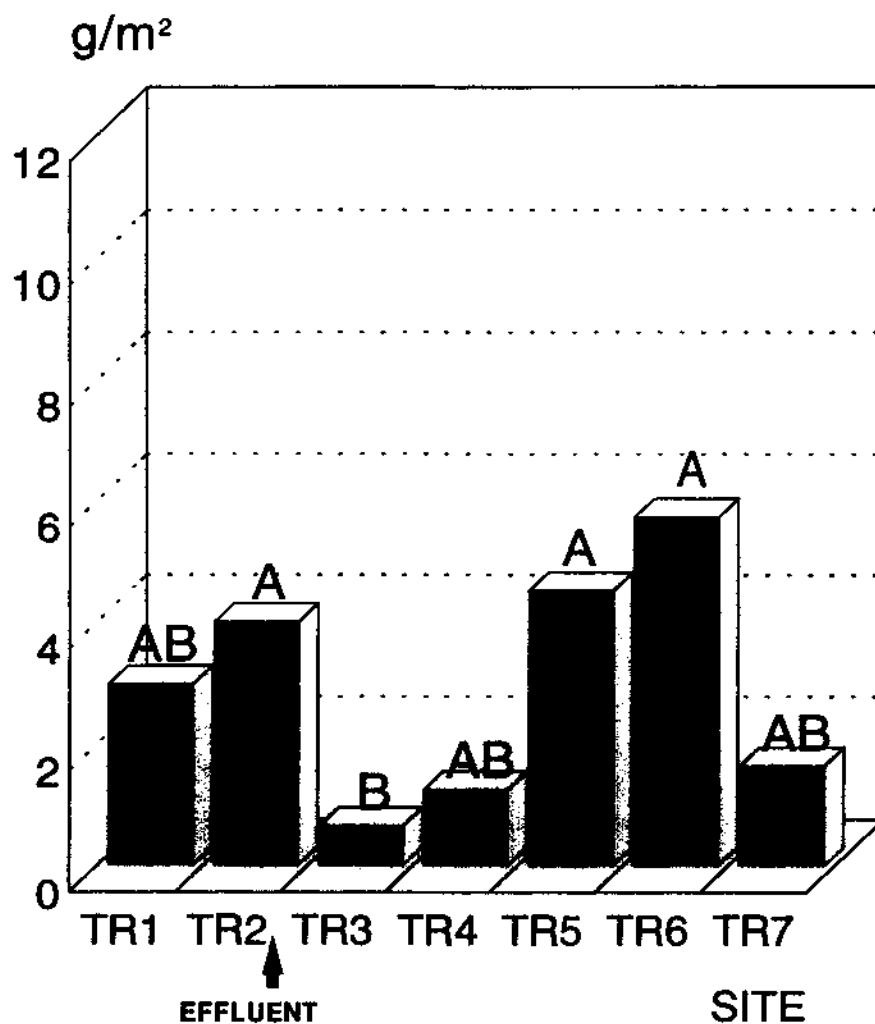
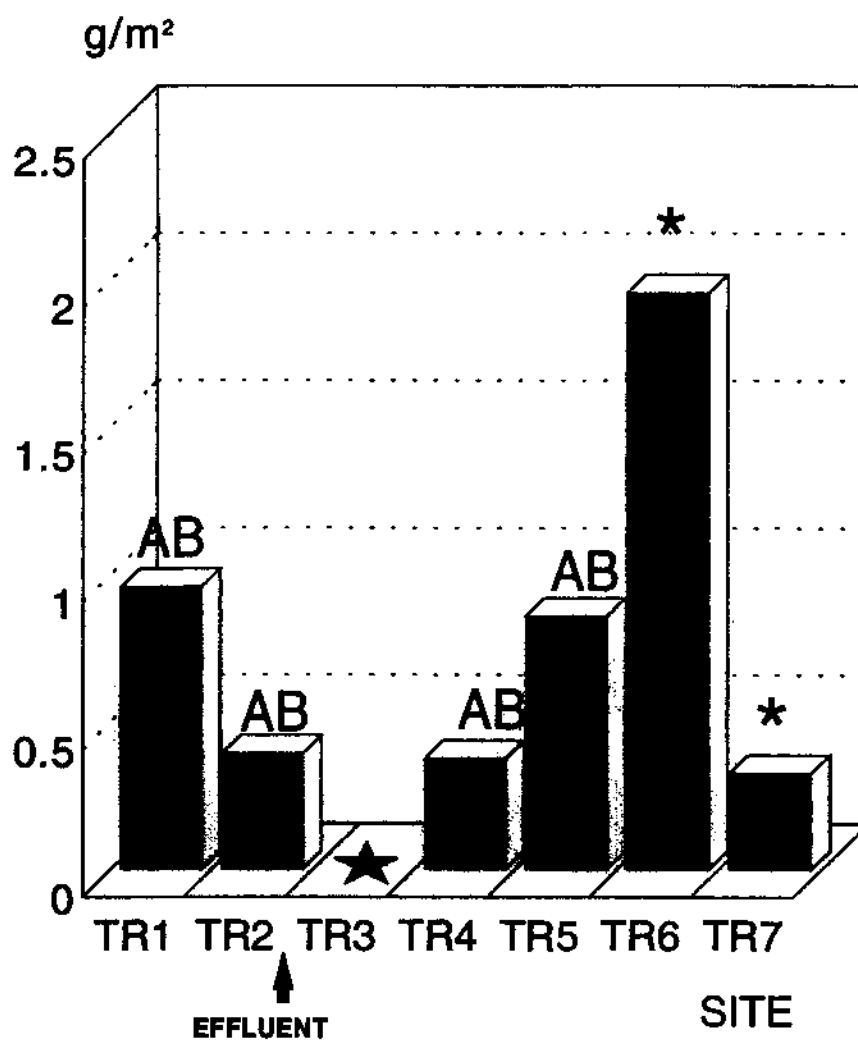


Figure 23. Periphyton mean ash-free dry weights (g/m^2) for September 1990. The letters on top of the bars indicate statistical differences.

ASH-FREE DRY WEIGHT June 1991



- ★ No data
- * One sample

Figure 24. Periphyton mean ash-free dry weights (g/m²) for June 1991. The letters on top of the bars indicate statistical differences.

performed on the sample replicates retrieved from TR3, TR4 and TR5. There was no statistically significant difference in mean dry weights among these sites (parametric ANOVA ($0.25 > p > 0.10$)). All available data are presented in Figure 25.

A second attempt was made to colonize periphytometers in October 1991, but again many of the samples were damaged or lost due to flooding. A sufficient number of replicates for statistical analysis was retrieved from TR2, TR3, and TR4. No significant difference in mean dry weights was determined among these sites (parametric ANOVA ($p > 0.50$)). Data are presented in Figure 25 to compliment the partial data collected in September 1991.

For April 1992, the range in ash-free dry weights was between 0.23 g/m^2 for TR4 and a mean of 2.44 g/m^2 for TR6. The maximum standard deviation was 0.36, for TR3 (Table 5). Mean dry weights were significantly different between TR3 and TR5 (parametric ANOVA ($0.0025 > p > 0.001$) with Tukey's MRT). Data are presented in Figure 26.

The mean ash free dry weights for samples collected on August 1992 ranged from a low value for TR3 of 0.43 g/m^2 to a high value for TR1 of 4.01 g/m^2 . The maximum standard deviation was 1.48, for TR6 (Table 5). The mean ash-free dry weights from TR3 and TR4 were significantly different from that at TR1 (parametric ANOVA ($0.05 > p > 0.025$)). Data are presented in graph form in Figure 27.

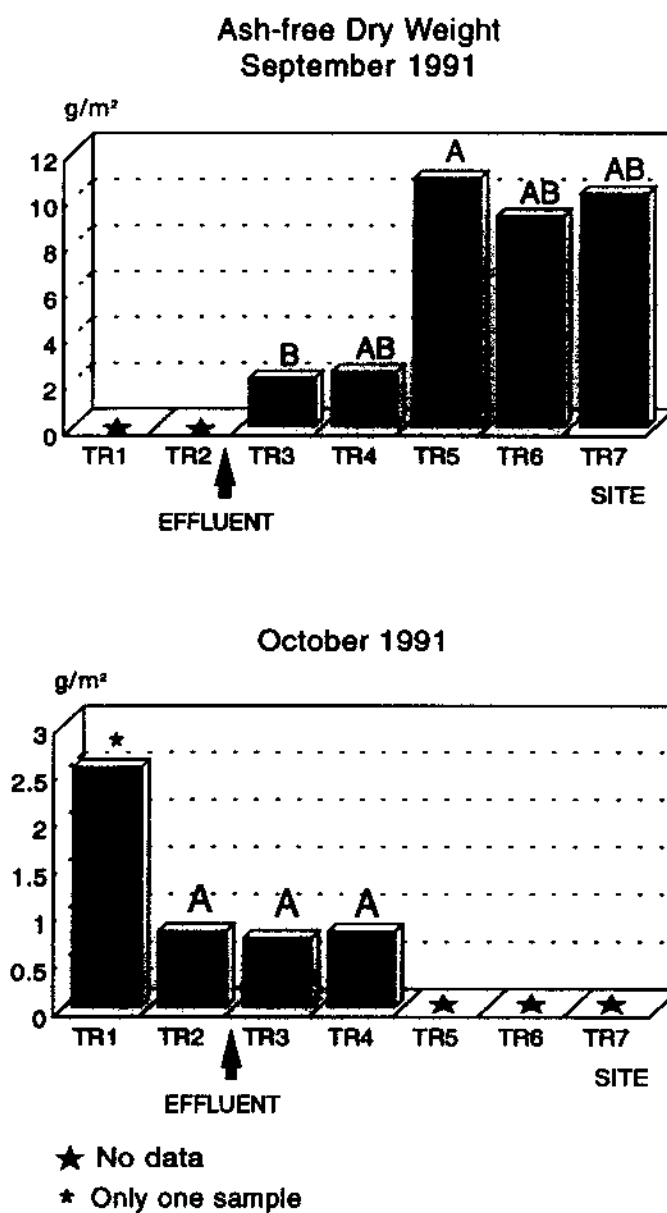
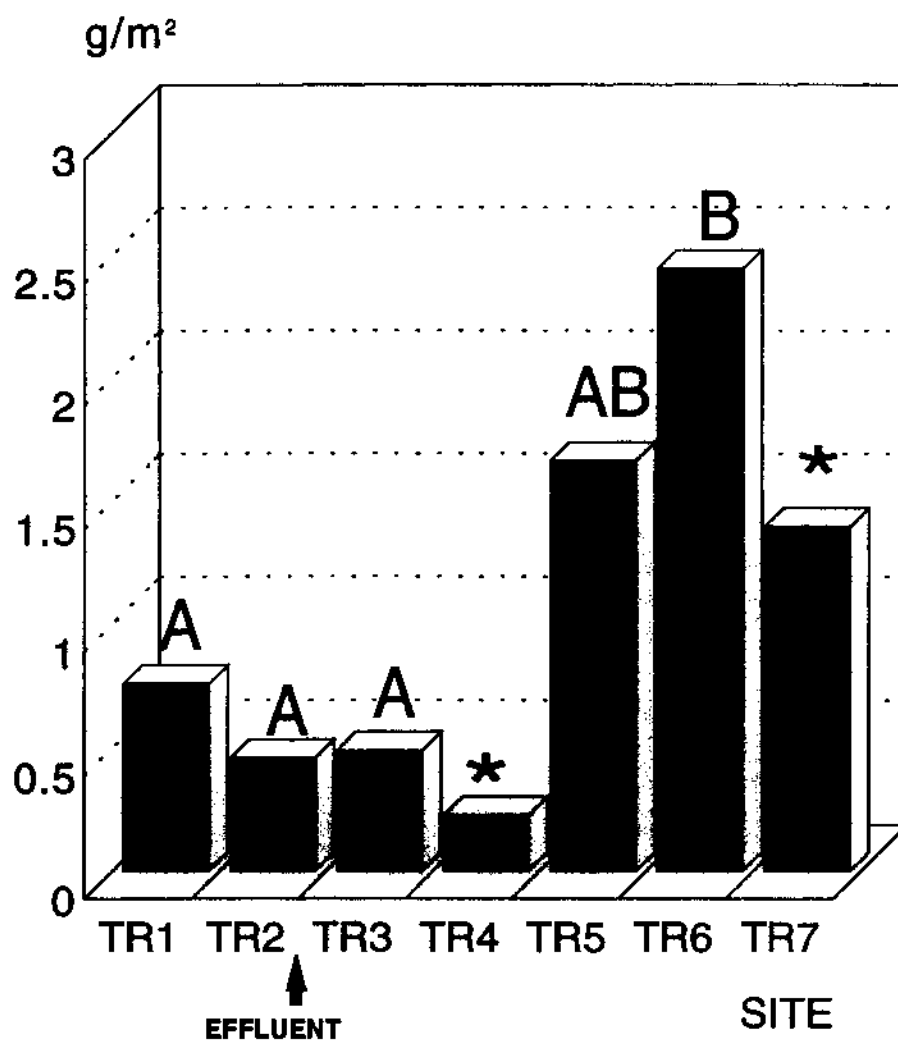


Figure 25. Periphyton mean ash-free dry weights (g/m^2) for September 1991 (top graph) and for October 1991 (bottom graph).

ASH-FREE DRY WEIGHT
April 1992



* Only one sample

Figure 26. Periphyton mean ash-free dry weights (g/m²) for April 1992. The letters on top of the bars indicate statistical differences.

ASH-FREE DRY WEIGHT August 1992

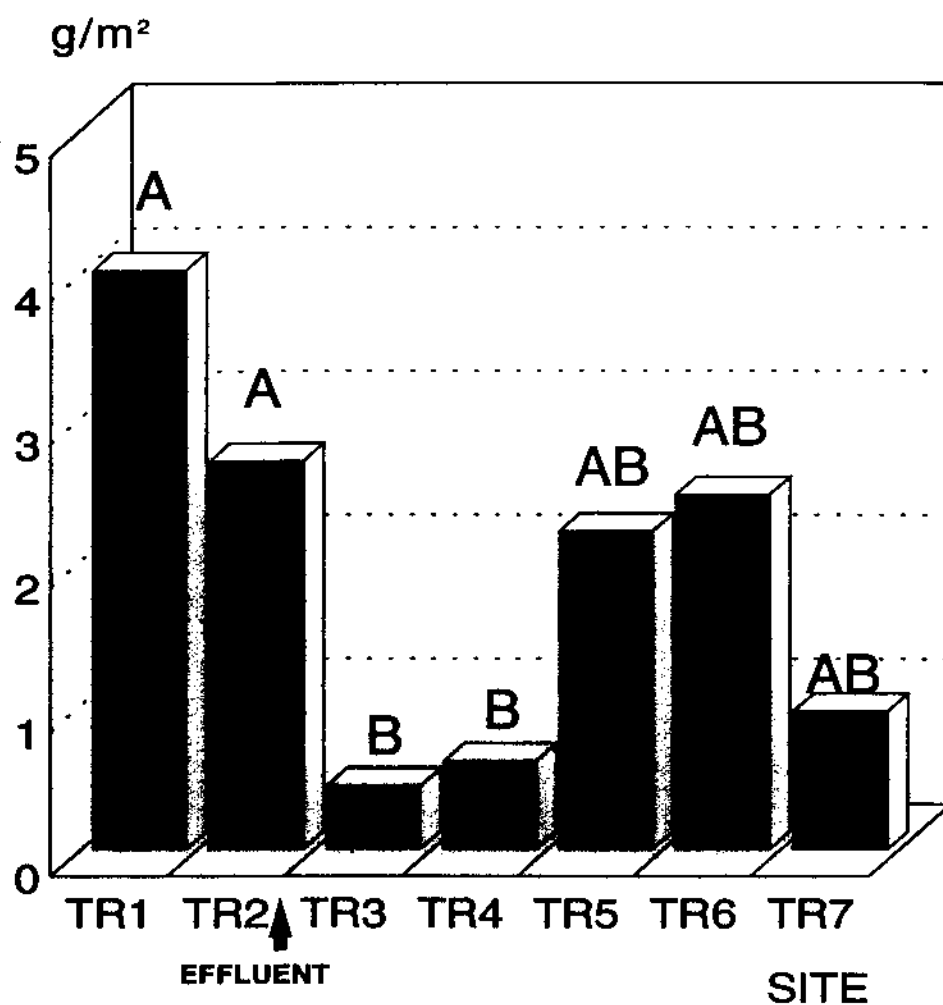


Figure 27. Periphyton mean ash-free dry weights (g/m^2) for August 1992. The letters on top of the bars indicate statistical differences.

Chlorophyll a

For September 1990 two periphytometers were colonized at each site. Mean chlorophyll-a concentrations were lowest at the reference sites, with values of 3.61 mg/m² for TR1 and 2.92 mg/m² for TR2, and were highest at TR6, with a value of 28.01 mg/m². The maximum standard deviation was 14.30, for TR5 (Table 6 and Figure 28). There was no statistically significant difference in mean concentrations among sites (non-parametric Kruskal-Wallis ANOVA).

The periphytometers placed at TR3 were stranded above water for the June 1991 sampling date. Only one periphytometer was retrieved from TR7, so this was not included in statistical analysis. The chlorophyll-a concentrations at the reference sites and TR6 were highest, with values ranging between 10.80 and 12.72 mg/m², and lowest at TR4, with a value of 0.89 mg/m². The maximum standard deviation was 3.50, for TR1 (Table 6 and Figure 29). TR1, TR2, TR6, and TR7 had significantly different mean concentrations than TR4 and TR5 (parametric ANOVA ($0.001 > p > 0.0005$)).

Due to flooding in September 1991, enough periphytometers were retrieved to perform statistical analysis only from TR2 and TR5. The chlorophyll-a concentrations for all sites ranged from 1.05 mg/m² at TR3 to 4.76 mg/m² at TR6 (Table 6). The existing data are presented in Figure 30.

Table 6. Periphyton chlorophyll-a concentrations (mg/m²). Sample replicates are given in columns A, B, and C.

Periphyton Chlorophyll-a
9/90

	A	B	MEAN	STD
TR-1	3.84	3.37	3.61	0.23
TR-2	2.81	3.02	2.92	0.11
TR-3	8.48	7.44	7.96	0.52
TR-4	8.44	11.27	9.86	1.41
TR-5	5.93	34.52	20.23	14.30
TR-6	30.22	25.80	28.01	2.21
TR-7	9.88	13.95	11.92	2.03

Periphyton Chlorophyll-a
6/91

	A	B	C	MEAN	STD
TR-1	12.83	5.87	13.70	10.80	3.50
TR-2	12.86	12.58	-	12.72	0.14
TR-3	-	-	-	-	-
TR-4	0.14	1.54	0.98	0.89	0.58
TR-5	4.33	1.54	1.82	2.56	1.25
TR-6	8.25	12.02	13.56	11.28	2.23
TR-7	5.03	-	-	*5.03	-

Periphyton Chlorophyll-a
9/91

	A	B	MEAN	STD
TR-1	2.32	-	*2.32	-
TR-2	0.93	0.81	1.12	0.36
TR-3	1.05	-	*1.05	-
TR-4	-	-	-	-
TR-5	0.81	3.49	2.15	1.34
TR-6	4.76	-	*4.76	-
TR-7	-	-	-	-

*Single value, not a mean.

Table 6 (continued). Periphyton ash-free dry weights (mg/m²). Sample replicates are given in columns A, B, and C.

Periphyton Chlorophyll-a
10/91

	A	B	C	MEAN	STD
TR-1	1.05	1.20	0.70	0.98	0.21
TR-2	0.26	0.78	2.90	1.31	1.14
TR-3	0.82	0.58	0.00	0.47	0.34
TR-4	2.79	1.40	-	2.10	0.69
TR-5	4.20	-	-	*4.20	-
TR-6	2.45	1.40	-	1.93	0.53
TR-7	7.69	2.33	-	5.01	2.68

Periphyton Chlorophyll-a
4/92

	A	B	C	MEAN	STD
TR-1	6.41	1.26	-	3.84	2.58
TR-2	2.23	0.84	-	1.54	0.70
TR-3	0.97	0.42	0.42	0.60	0.26
TR-4	0.84	0.84	-	0.84	0.00
TR-5	4.32	2.79	1.11	2.74	1.31
TR-6	11.85	10.32	8.37	10.18	1.42
TR-7	4.04	-	-	*4.04	-

Periphyton Chlorophyll-a
8/92

	A	B	C	MEAN	STD
TR-1	6.89	4.85	7.92	6.55	1.28
TR-2	1.07	2.06	-	1.57	0.49
TR-3	1.57	0.27	1.79	1.21	0.67
TR-4	4.07	0.40	1.82	2.10	1.51
TR-5	10.12	5.91	-	8.02	2.10
TR-6	10.69	4.32	-	7.51	3.18
TR-7	3.59	13.24	-	8.42	4.82

* Single value, not a mean.

Chlorophyll-a September 1990

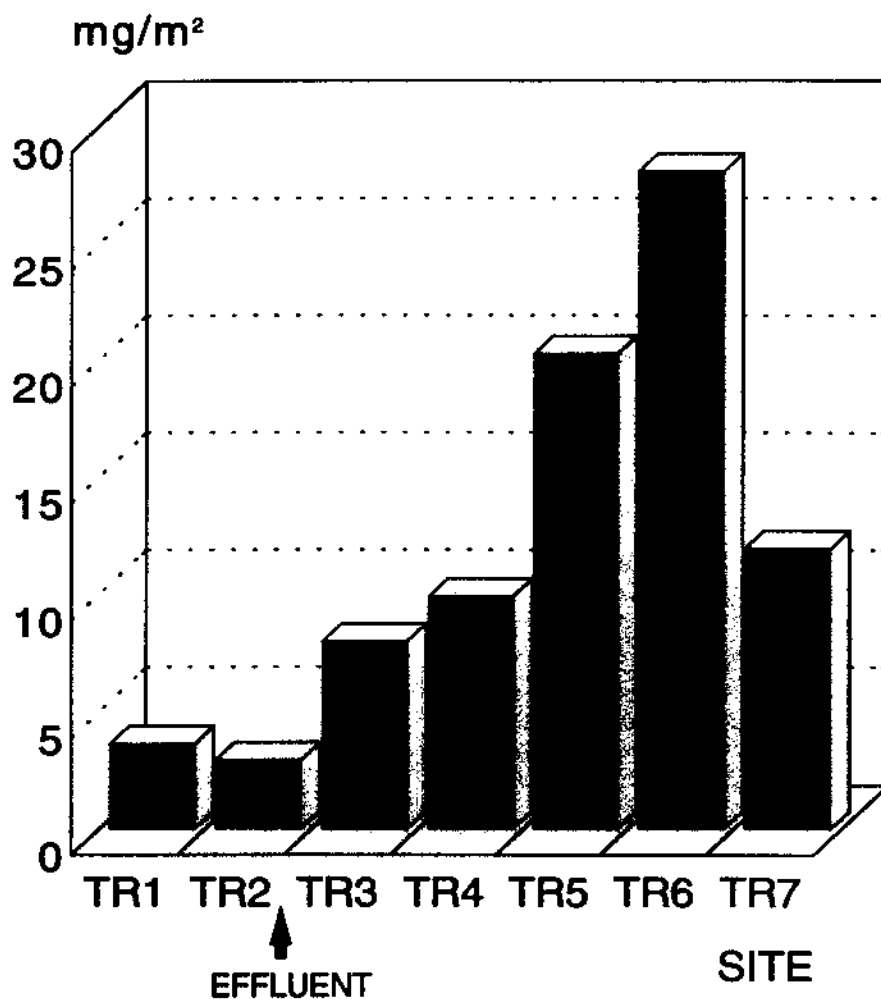


Figure 28. Periphyton chlorophyll-a concentrations (mg/m²) for September 1990.

Chlorophyll-a June 1991

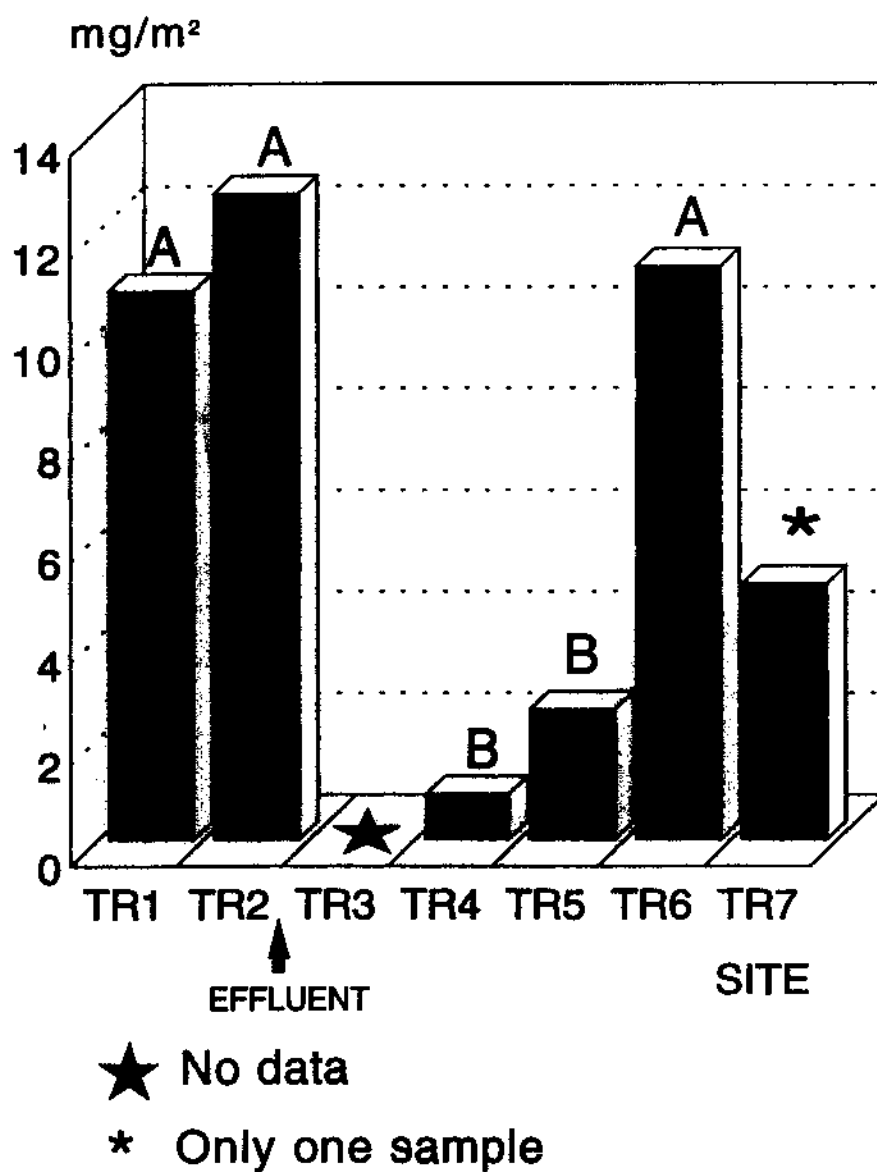
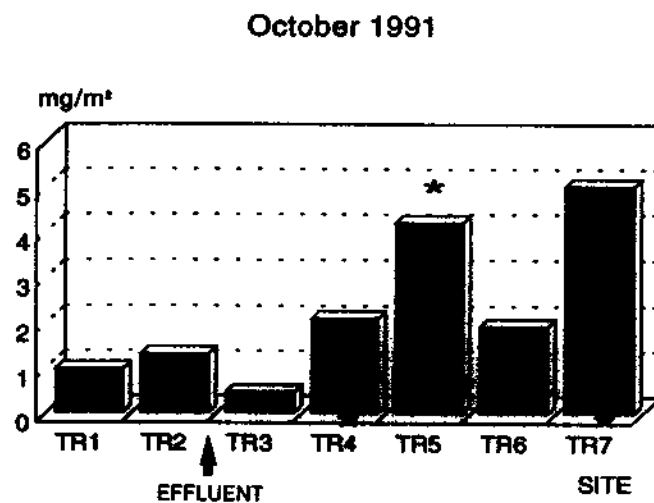
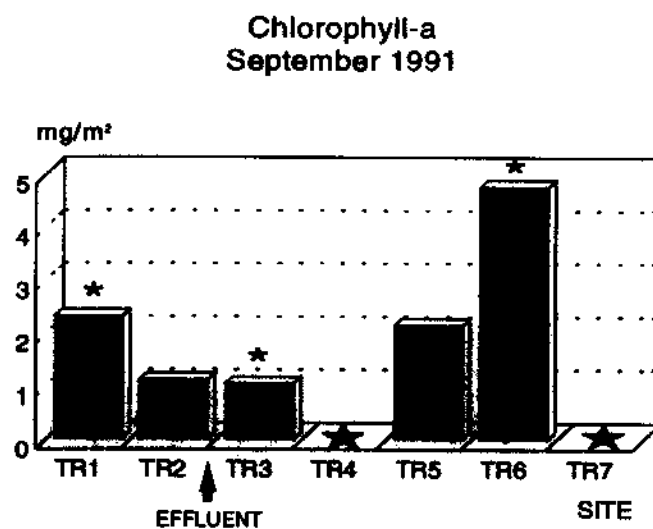


Figure 29. Periphyton chlorophyll-a concentrations (mg/m²) for June 1991. The letters on top of the bars indicate statistical differences.



★ No data
* Only one sample

Figure 30. Periphyton chlorophyll-a concentrations (mg/m²) for September 1991 (top graph) and for October 1991 (bottom graph).

The second attempt at obtaining periphyton samples in October 1991 resulted in enough data from some sites to make statistical analysis feasible. The lowest mean chlorophyll-a concentrations were 0.98 mg/m² at TR1 and 0.47 mg/m² at TR3. The highest concentration was 5.01 mg/m² at TR7, and the standard deviation for that site was 3.79 (Table 6). A statistically significant difference between sites was indicated (parametric ANOVA ($p = 0.05$)), but Tukey's MRT was unable to detect the location of the difference. Data are presented in graph form in Figure 30.

In April 1992 all but one periphytometer, missing from TR7, were retrieved. The mean concentrations were lowest at TR3, with a value of 0.60 mg/m², and highest at TR6, with a value of 10.18 mg/m². The maximum standard deviation was 2.58, for TR1 (Table 6). A statistically significant difference in concentrations was indicated between TR3 and TR6 (non-parametric Kruskal-Wallis ANOVA with Dunn's MRT). Data are presented in graph form in Figure 31.

For August, 1992, the mean concentrations varied from 1.21 mg/m² at TR3 to 8.42 mg/m² at TR7 (Table 6). The maximum standard deviation was 4.82, for TR7. No significant difference in mean concentrations among sites was indicated (parametric ANOVA ($0.1 > p > 0.05$)). Data are presented in graph form in Figure 32.

Chlorophyll-a April 1992

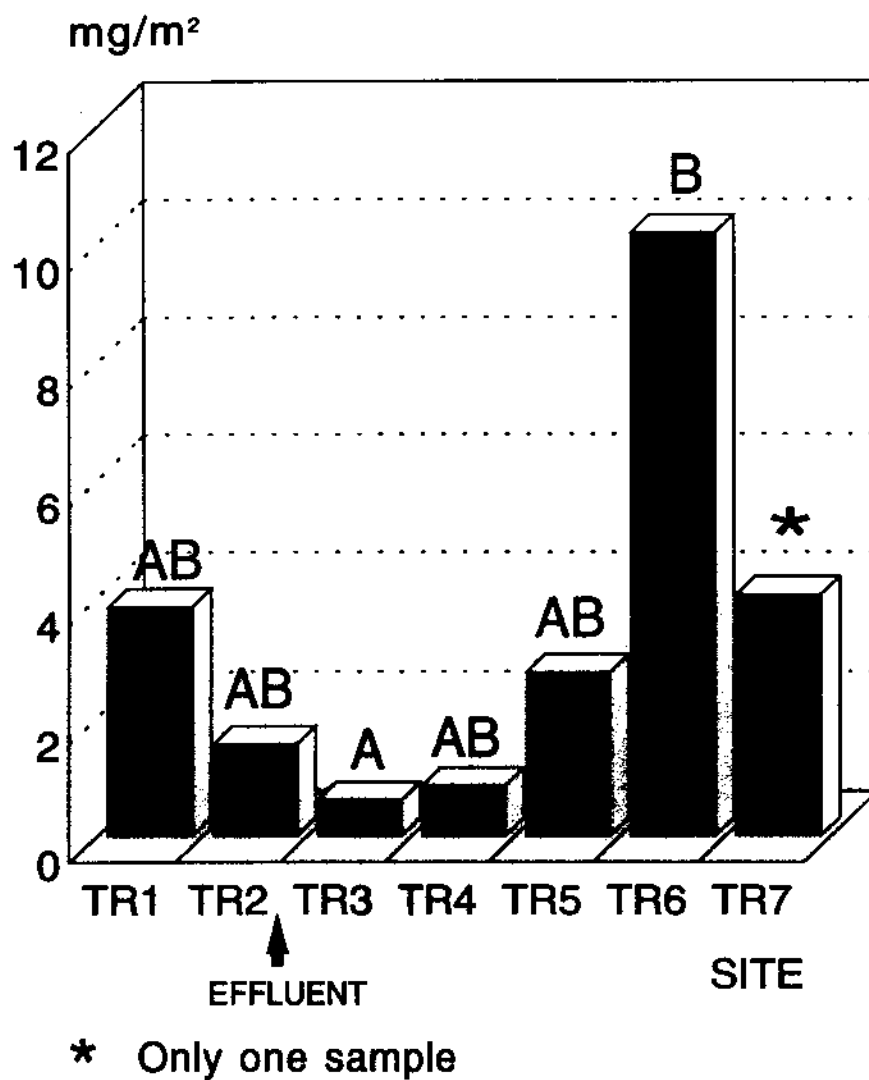


Figure 31. Periphyton chlorophyll-a concentrations (mg/m²) for April 1992. The letters on top of the bars indicate statistical differences.

Chlorophyll-a August 1992

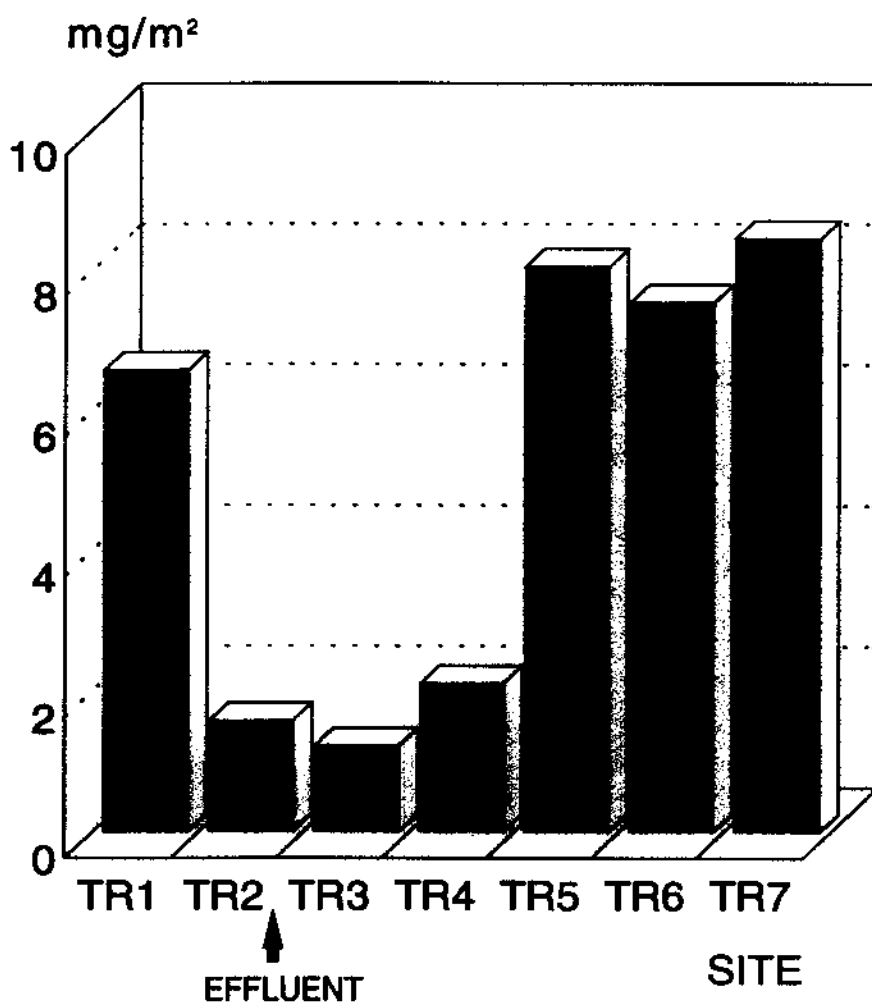


Figure 32. Periphyton chlorophyll-a concentrations (mg/m²) for August 1992.

Enumeration

The periphyton densities are presented in the Appendix and are summarized in Table 7.

In August 1990 two periphytometers were placed at each site in the river. All periphytometers were retrieved except one, from TR6. The mean densities were lowest at TR1 with a value of 2254 cells/mm², and highest at TR4 with a value of 25704 cells/mm². The maximum standard deviation was 6294, for TR3 (Table 7). TR4 had significantly different mean densities than TR1, TR2, TR5, and TR6 ($0.0025 < p < 0.001$). The diversity index was lowest for TR3 with a value of 0.0454, and highest for TR2 with a value of 0.9345. Taxa richness was lowest at TR3, with three genera, and highest at TR2, with 26 genera (Figure 33). Bray-Curtis similarity analysis indicated that the communities at TR3 and TR4 closely resembled each other with a coefficient of 0.7424. The communities at these sites were dominated by one species of Chlorophyta, Ankistrodesmus sigmoides. The communities at TR1 and TR2 also closely resembled each other, with a coefficient of 0.5151. Diatoms were the dominant components of the communities at these sites, Navicula and Nitzschia in particular (see Appendix). These two diatom species disappeared from TR3 but were the only diatom taxa present at TR4. Unidentified cells of green algae as well as several genera of Cyanophyta were present in high numbers. The communities at TR5 and TR6 were

Table 7. Periphyton densities (cells/mm³). Ranges and mean densities are given except when only one sample was collected.

August 1990

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	1644	2864	2254	863
TR2	3538	4327	3932	558
TR3	10404	19305	14855	6294
TR4	23338	28071	25704	3347
TR5	9471	10531	10001	750
TR6	-	-	*5242	-
TR7	5725	6082	5904	252

June 1991

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	1000	2939	1970	1451
TR2	1093	2253	1673	494
TR3	-	-	-	-
TR4	692	886	789	23
TR5	375	459	417	21
TR6	-	-	*433	-
TR7	-	-	*1026	-

September 1991

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	-	-	*1419	-
TR2	314	349	332	14
TR3	210	282	246	102
TR4	2198	3020	2609	581
TR5	4734	12548	8642	5525
TR6	-	-	*793	-
TR7	-	-	*158651	-

* Represents one sample. Value not a mean.

Table 7 (continued). Periphyton densities ($\#/mm^2$). Ranges and means are given except when only one sample was analyzed.

May 1992

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	796	1338	1067	383
TR2	-	-	*127	-
TR3	34	80	57	23
TR4	394	30	212	*100
TR5	2275	123244	62760	*416
TR6	1905	2537	2221	445
TR7	-	-	--	-

8/92

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	1185	1232	1209	33
TR2	-	-	*388	-
TR3	192	254	223	44
TR4	475	1274	875	565
TR5	-	-	*1299	-
TR6	-	-	*1226	-
TR7	-	-	*1250	-

* One sample analyzed. Value is not a mean.

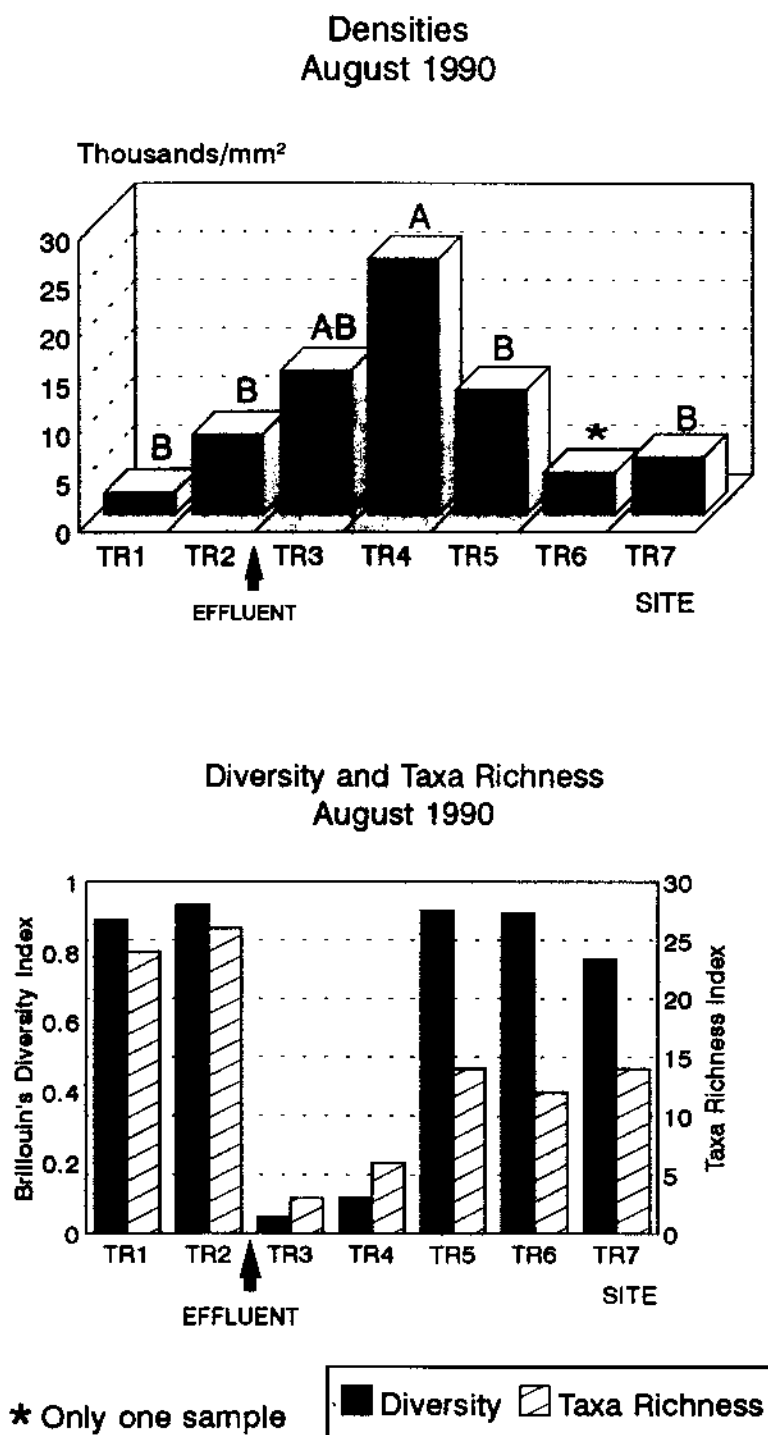


Figure 33. Periphyton densities (number/mm²) (top graph) and diversity and taxa richness (bottom graph) for August 1990. The letters on top of the bars indicate statistical differences.

clustered together with a similarity coefficient of 0.4985. This pair of communities resembled the cluster of TR1 and TR2, with high numbers of unidentified Chlorophyta and the Cyanophyta Lyngbya. The coefficient of similarity for these two pairs of communities was 0.2814. The community-similarity cluster of TR1 and TR2 resembled the TR3-TR4 cluster the least with a coefficient of 0.0929, but this distinction was obscured by possible replicate variability ($p = 0.0400$) (Figure 34).

The periphytometers were stranded out of the water at TR3 on June 1991. Only one replicate each was retrieved from TR6 and TR7. The range in densities was from a mean of 417 cells/mm² at TR5 to a mean of 1970 cells/mm² at TR1, with a standard deviation at this site of 1451 (Table 7). No significant difference in mean densities among sites was indicated (parametric ANOVA ($p > 0.25$)). The diversity index for TR7 was lowest at 0.6602 and highest for TR4 at 1.0056. Taxa richness was lowest at TR6 and TR7 with a value of 16 at each site, and highest at TR1 with a value of 28 (Figure 35). Bray-Curtis cluster analysis indicated that the similarity of communities at TR1 and TR2 was highest with a coefficient of 0.4377, followed by the similarity between TR4 and TR6 which had a coefficient of 0.4183. The range between the least similar and the most similar clusters was with coefficients of 0.2715 to 0.4377, and the probability that these clusters were based on community

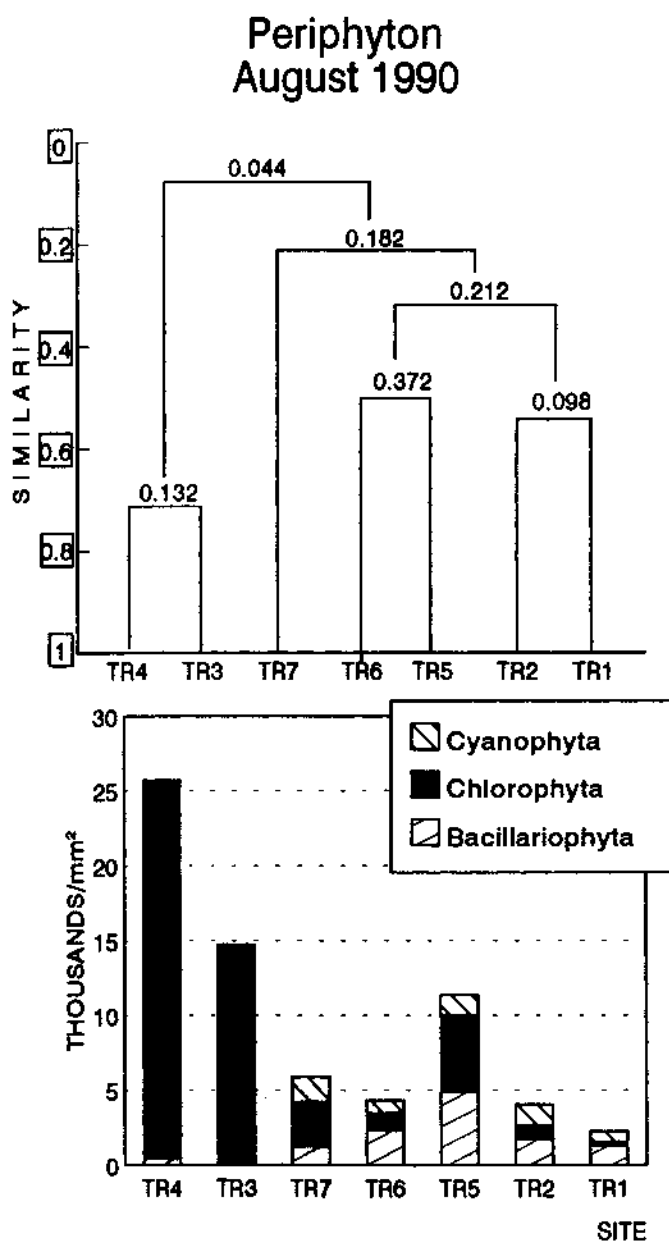


Figure 34. Periphyton similarities and taxa densities within communities for August 1990.

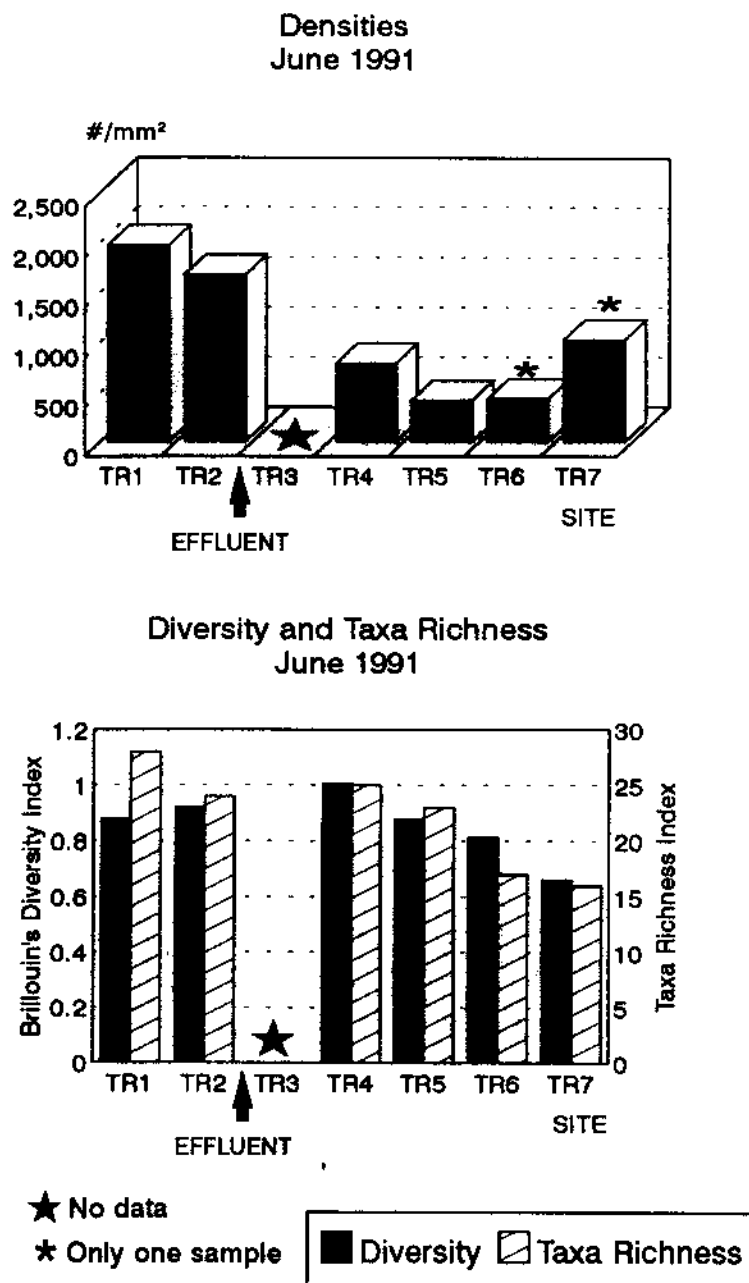


Figure 35. Periphyton densities (number/ mm^2) (top graph) and diversity and taxa richness (bottom graph) for June 1991.

structure and not variability among replicates was high at all sites ($p > 0.2660$) (Figure 36). The communities at each site were represented by high numbers of diatoms, particularly Navicula, Nitzschia, and Gomphonema, as well as several genera of Chlorophyta and Cyanophyta (see Appendix).

In August 1991 at least one replicate was retrieved from each site, and enough replicates for statistical analysis were retrieved from TR2, TR3, TR4, and TR5. There was no significant difference in densities between these sites (parametric ANOVA ($0.25 > p > 0.10$)). The range in densities was from a mean of 246 cells/mm² at TR3 to 158651 cells/mm² for the single sample retrieved from TR7 (Table 7). The high density of cells from TR7 was attributable to the enumeration of a clump which included 150000 cells of Leptosira and 6550 cells of Protoderma. Diversity indices ranged from 0.1263 at TR7 to 1.0640 at TR3. The number of taxa ranged from 12 at TR6 to 25 at TR5 (Figure 37). Bray-Curtis similarity coefficient was highest for the communities at TR2 and TR3 with a value of 0.4312. Even when the high numbers of Leptosira and Protoderma were not included the similarity between the communities at TR7 and the rest of the communities was lowest, with a coefficient of 0.0180 (Figure 38). There were smaller clumps of Leptosira at TR4 and TR5, and these sites were clustered together with a coefficient of 0.2649. Aside from the clumps, there were high numbers of Navicula and Nitzschia at

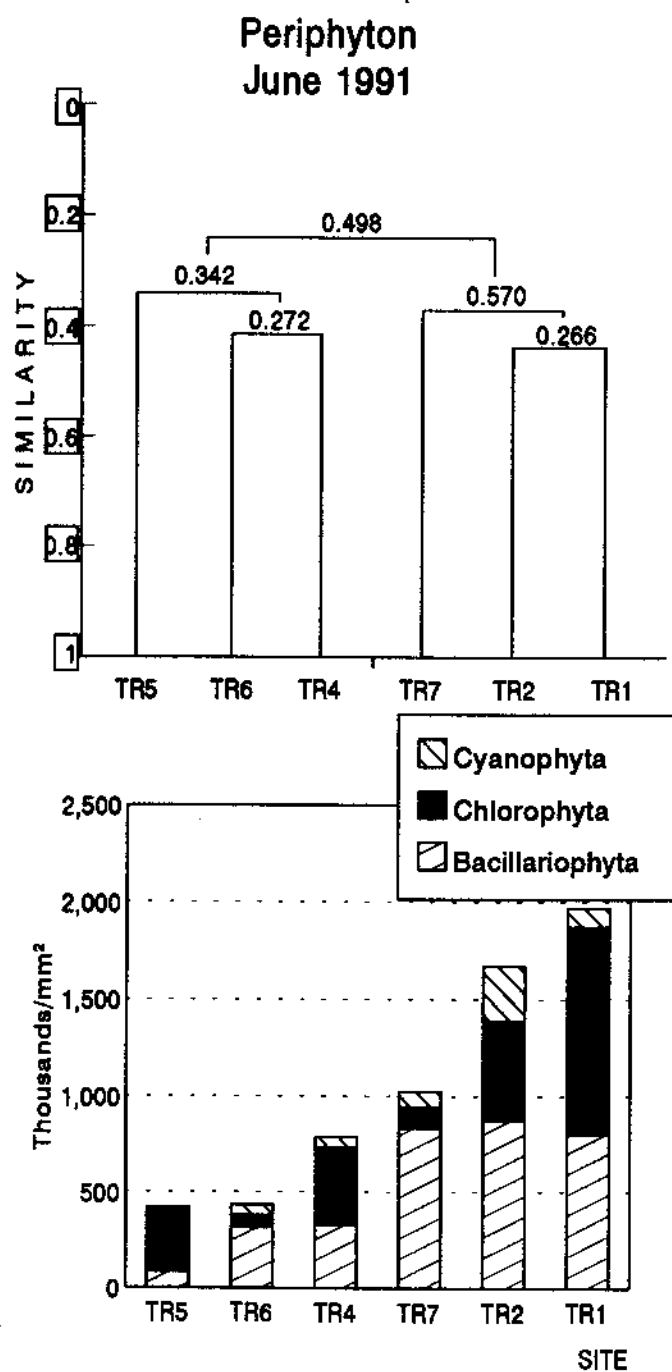


Figure 36. Periphyton similarities and taxa densities within communities for June 1991.

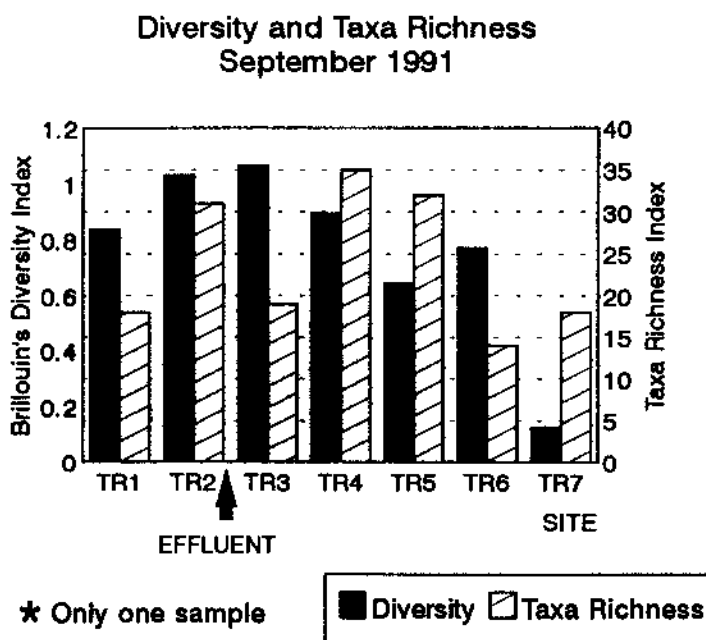
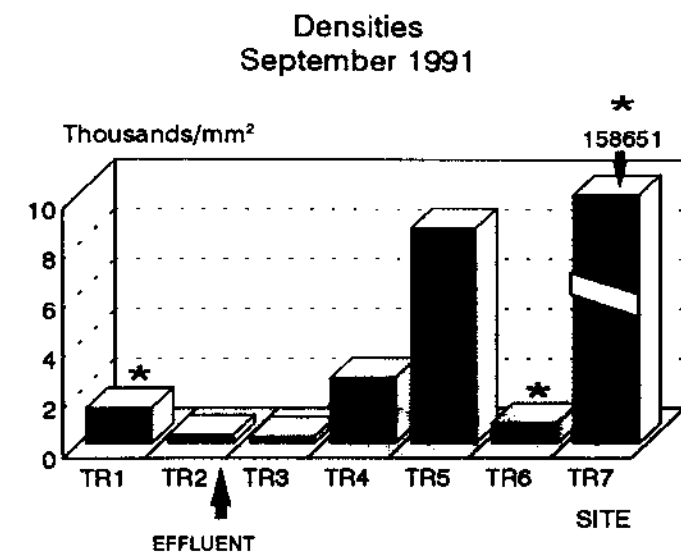


Figure 37. Periphyton densities (number/mm²) (top graph) and diversity and taxa richness (bottom graph) for September 1991.

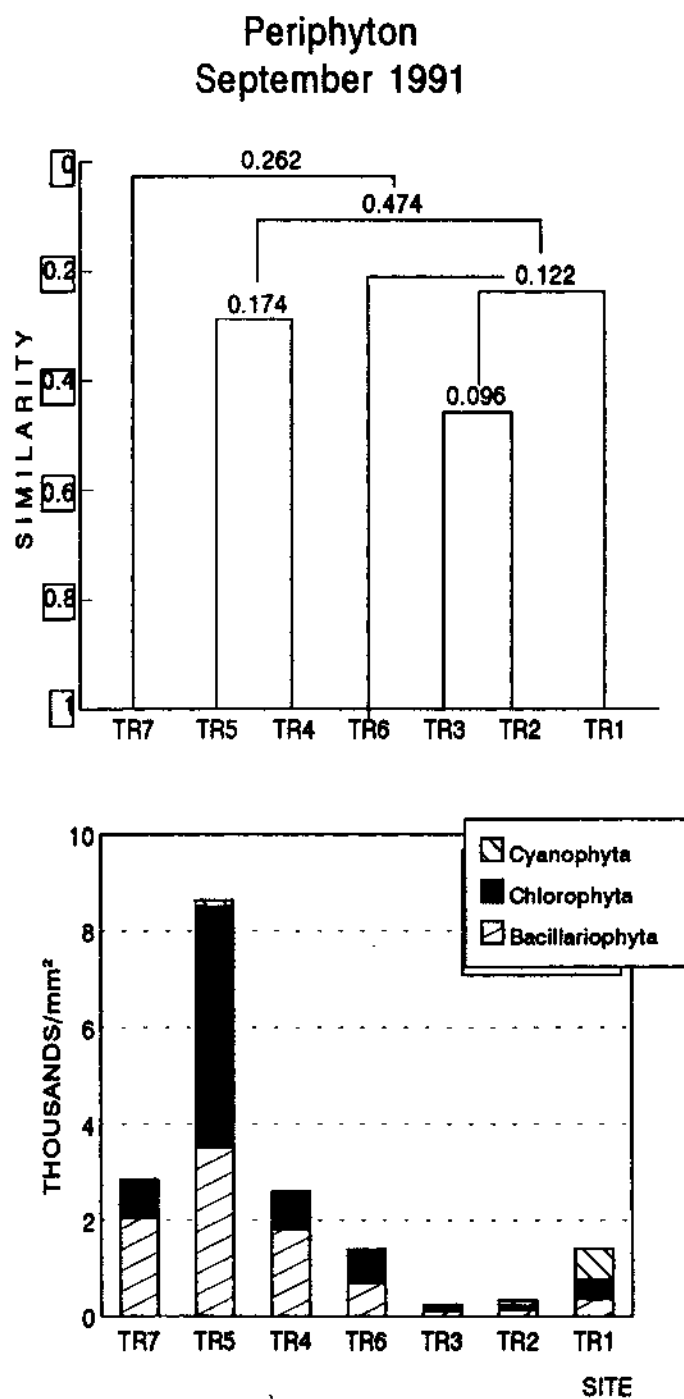
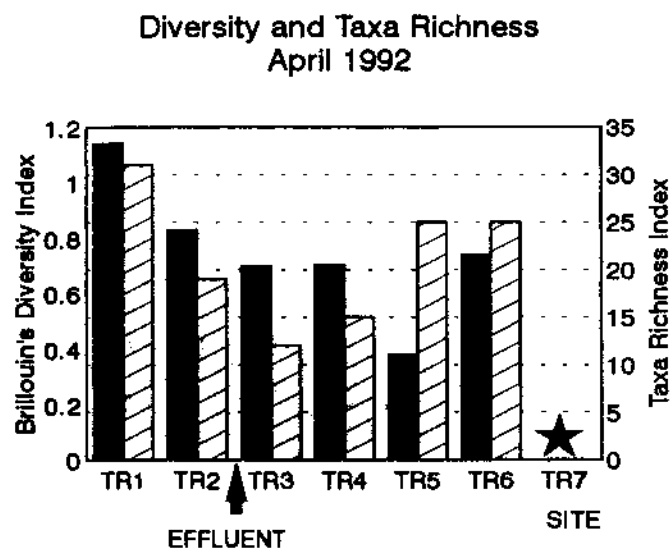
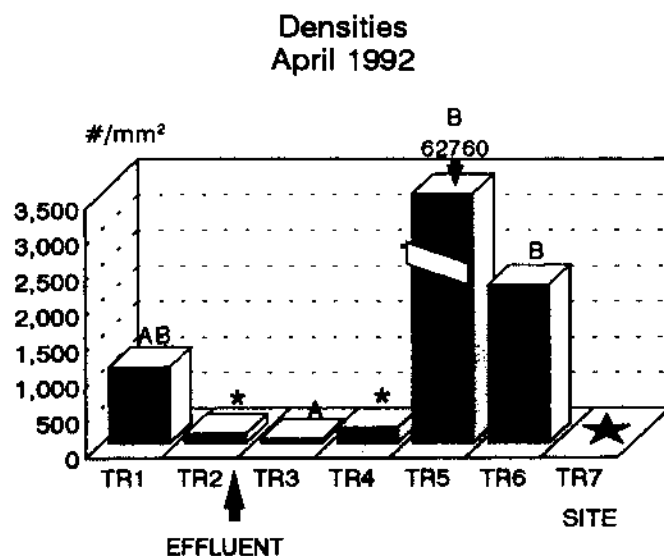


Figure 38. Periphyton similarities and taxa densities within communities for September 1991.

all sites (see Appendix). The probability that the coefficients reflected community similarities and not variability among replicates was greater than 0.09 for all clusters.

Only TR1, TR3, TR5, and TR6 yielded sufficient numbers of replicates for statistical analysis in April 1992. The single sample retrieved from TR7 developed fungus while in storage. The densities for all remaining samples ranged from 57 cells/mm² at TR2 to 62760 cells/mm² at TR5 (Table 7). A large clump of Rhizoclonium sp. and Oscillatoria sp. was enumerated in the sample from TR5 which greatly affected the statistical comparison of densities at this site with those at the other sites (parametric ANOVA ($p < 0.0001$)). When this clump was excluded from analysis the number of cells/mm² was reduced to 2687 cells/mm². When these data were statistically compared there was still a significant difference in mean densities among sites (parametric ANOVA ($0.025 > p > 0.01$)). Tukey's MRT revealed that the mean density at TR3 was significantly different than those for TR5 and TR6. Diversity indices ranged from 0.0119 at TR3 to 0.4152 at TR5. Taxa richness ranged from 19 genera at TR3 to 31 genera at TR1 (Figure 39). Bray-Curtis similarity analysis showed that the communities at TR2 and TR3 were most similar, with a coefficient of 0.5714, and the coefficient of similarity between these and TR4 was 0.4459. Even with the high number of Rhizoclonium ignored in the



★ No data

* Only one sample

■ Diversity ▨ Taxa Richness

Figure 39. Periphyton densities (number/mm²) (top graph) and diversity and taxa richness (bottom graph) for April 1992. The letters on top of the bars indicate statistical differences.

community at TR5, it was the least similar to the communities at the other sites, with a coefficient of 0.0161 (Figure 40).

In August 1992 there were enough samples collected only from TR1, TR3, and TR4 for statistical analysis, however at least one replicate was retrieved from each of the other sites. The densities ranged from a mean of 223 cells/mm² at TR3 to 1299 cells/mm² at TR5. There was no statistically significant difference in mean densities among sites (parametric ANOVA ($0.50 > p > 0.2$)). Diversity indices ranged from 0.6231 at TR4 to 0.9365 at TR7 (Figure 41). The number of genera ranged from 11 at TR2 to 23 at TR6. Bray-Curtis similarity analysis indicated that the communities at TR6 and TR7 were the most similar, with a coefficient of 0.6995. The communities at TR1 and TR2 had a similarity coefficient of 0.4203, and this pair of communities resembled the other communities the least, with a coefficient of 0.2363 (Figure 42). Bacillariophyta, especially Navicula and Nitzschia, was present at all sites, but with lowest numbers at TR3. Cyanophyta, particularly Oscillatoria and Phormidium, was present in high numbers at TR1 and TR2, with numbers declining downstream. The chlorophyte Chaetophora was present downstream from the effluent (see appendix).

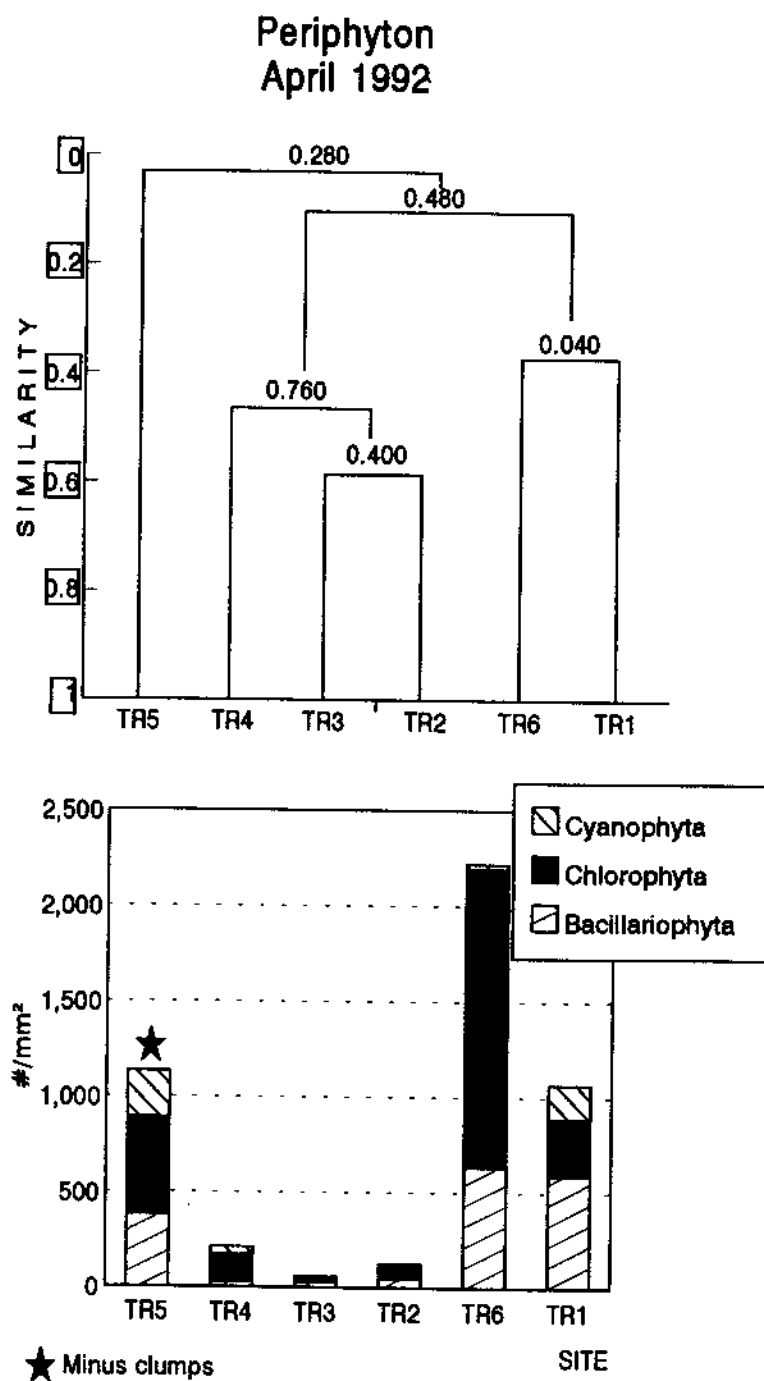


Figure 40. Periphyton similarities and taxa densities within communities for April 1992.

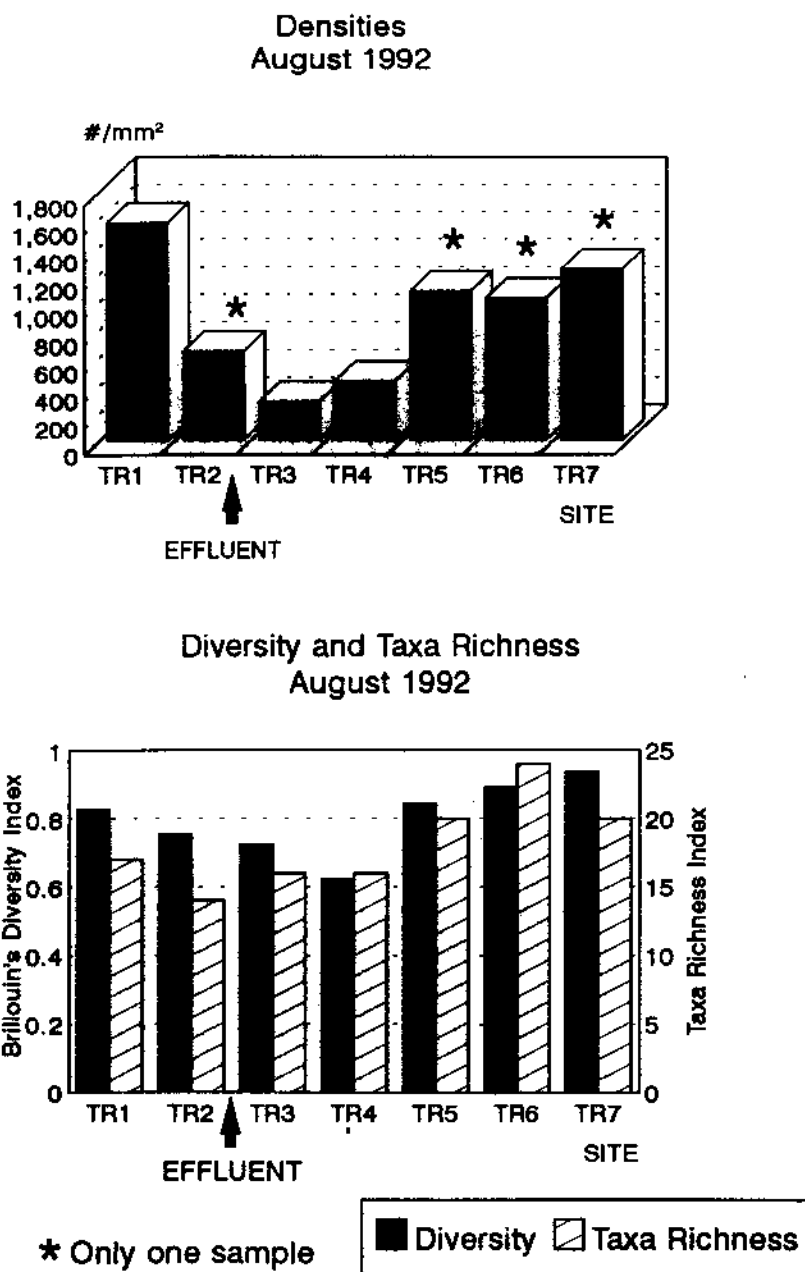


Figure 41. Periphyton densities (number/mm²) (top graph) and diversity and taxa richness (bottom graph) for August 1992.

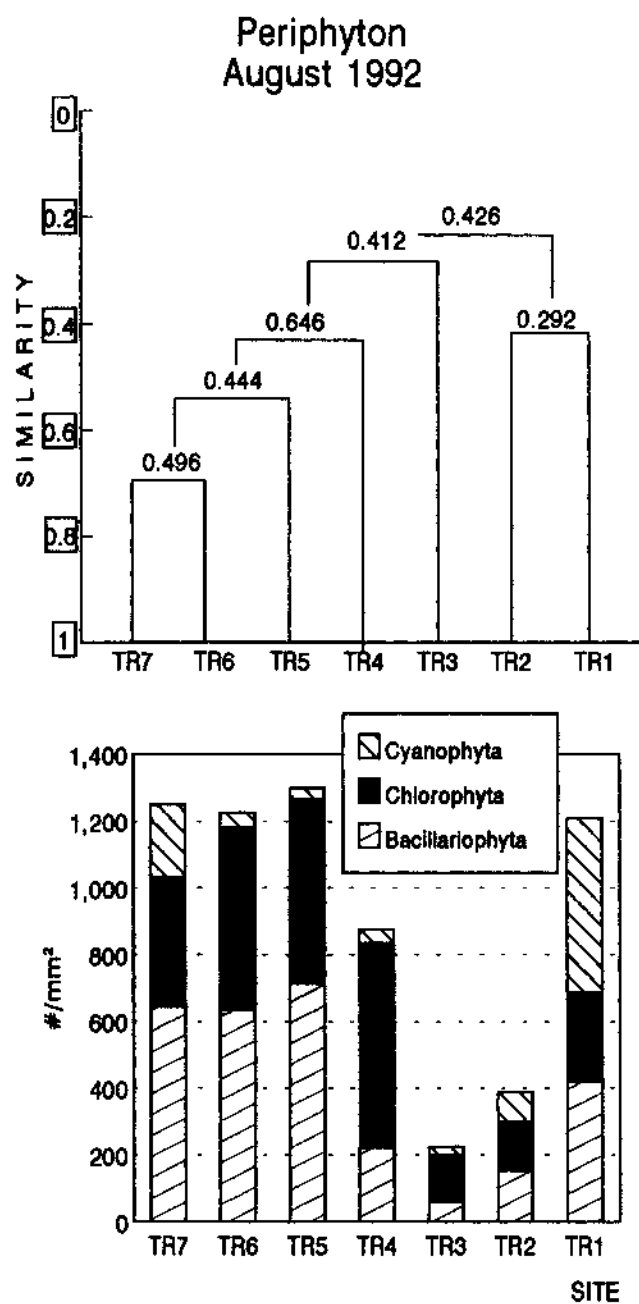


Figure 42. Periphyton similarities and taxa densities within communities for August 1992.

Zooplankton

Data for zooplankton densities are given in the appendix, and data specifically for rotifers are summarized in Table 8.

Zooplankton samples were collected directly from the outflow of the effluent on May 1991, May 1992, and August 1992. These data were excluded from statistical analyses, but were included in the appendix.

In September 1990 only one sample per site was collected. The range in densities was from 48 organisms/L at TR2 and 54 organisms/L at TR7 to a high value of 2712 organisms/L at TR3 (Table 8). Only one replicate was collected on this date, so no statistical analysis of data was performed. Diversity indices ranged from a low of 0.4036 at TR2 to a high of 0.8259 at TR3. Taxa richness varied from two at TR7 to 10 at site three (Figure 43). Bray-Curtis cluster analysis indicated that the communities at TR5 and TR6 resembled each other the closest, with a coefficient of 0.5742. The communities at TR3 and TR4 had a similarity coefficient of 0.5411. TR2 and TR7 had comparable communities, with a coefficient of 0.4706 (Figure 44). Notommata was present in high numbers only at TR1 while many rotifer taxa were present in high numbers at TR3 and TR4.

In May 1991, two of the samples collected from TR1 were lost (see appendix). The remaining sample was excluded from

Table 8. Rotifer densities (#/L) for each site and on each sample date. Ranges and means are given except when no replicates existed.

August 1990

<u>SITE</u>	<u>NUMBER/L</u>			
TR1	-	-	456	-
TR2	-	-	48	-
TR3	-	-	2712	-
TR4	-	-	1380	-
TR5	-	-	564	-
TR6	-	-	272	-
TR7	-	-	54	-

May 1991

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	-	-	*280	-
TR2	329	612	517	163
TR3	141	577	400	229
TR4	480	548	509	35
TR5	618	735	661	64
TR6	401	834	661	229
TR7	562	1092	886	284

August 1991

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	557	747	664	97
TR2	395	816	595	122
TR3	335	446	392	32
TR4	188	384	276	57
TR5	156	251	198	28
TR6	30	65	51	11
TR7	63	112	89	14

* Two of three samples lost, value not a mean.

Table 8 (continued). Rotifer densities (#/Liter).

May 1992

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	61	237	131	93
TR2	35	183	111	74
TR3	169	265	219	48
TR4	91	162	117	39
TR5	180	259	214	41
TR6	94	159	126	33
TR7	89	309	299	189

August 1992

<u>SITE</u>	<u>MIN</u>	<u>MAX</u>	<u>MEAN</u>	<u>STANDARD DEVIATION</u>
TR1	37	50	44	7
TR2	63	130	86	39
TR3	63	101	80	19
TR4	48	75	60	14
TR5	28	38	32	5
TR6	16	49	35	17
TR7	-	-	*9	-

* Two out of three
samples lost, value not a mean.

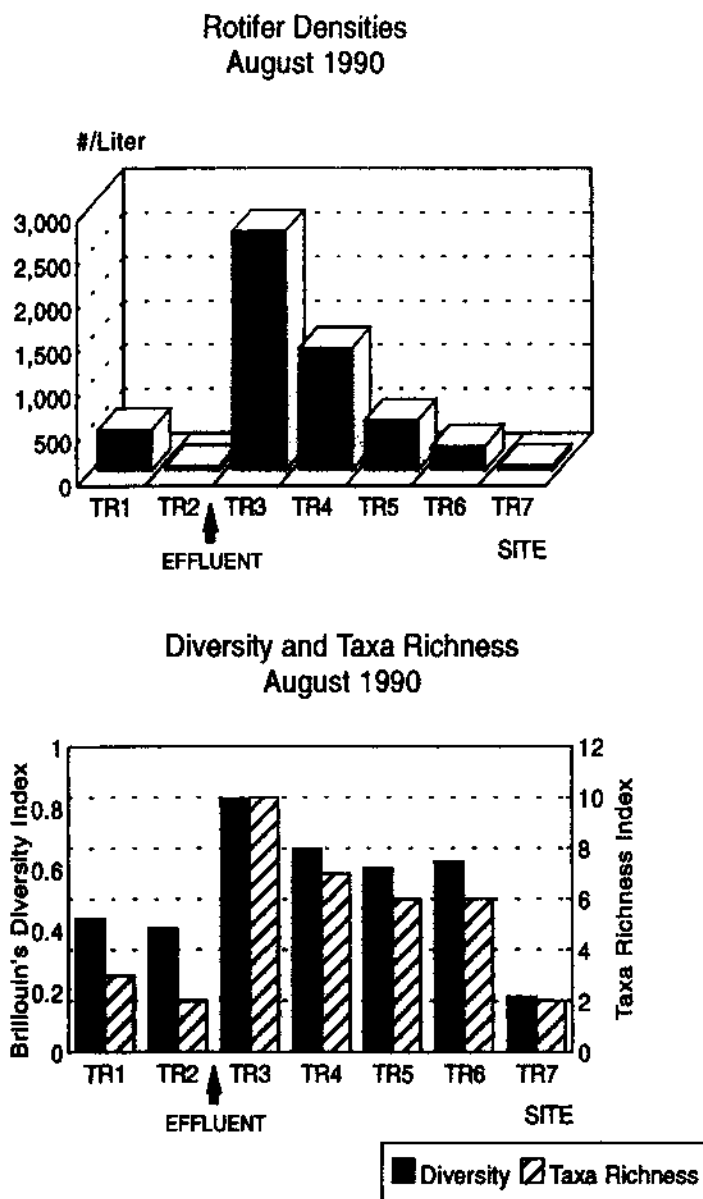


Figure 43. Rotifer mean densities (number/L) for August 1990 (top graph). Diversity and taxa richness indices (bottom graph).

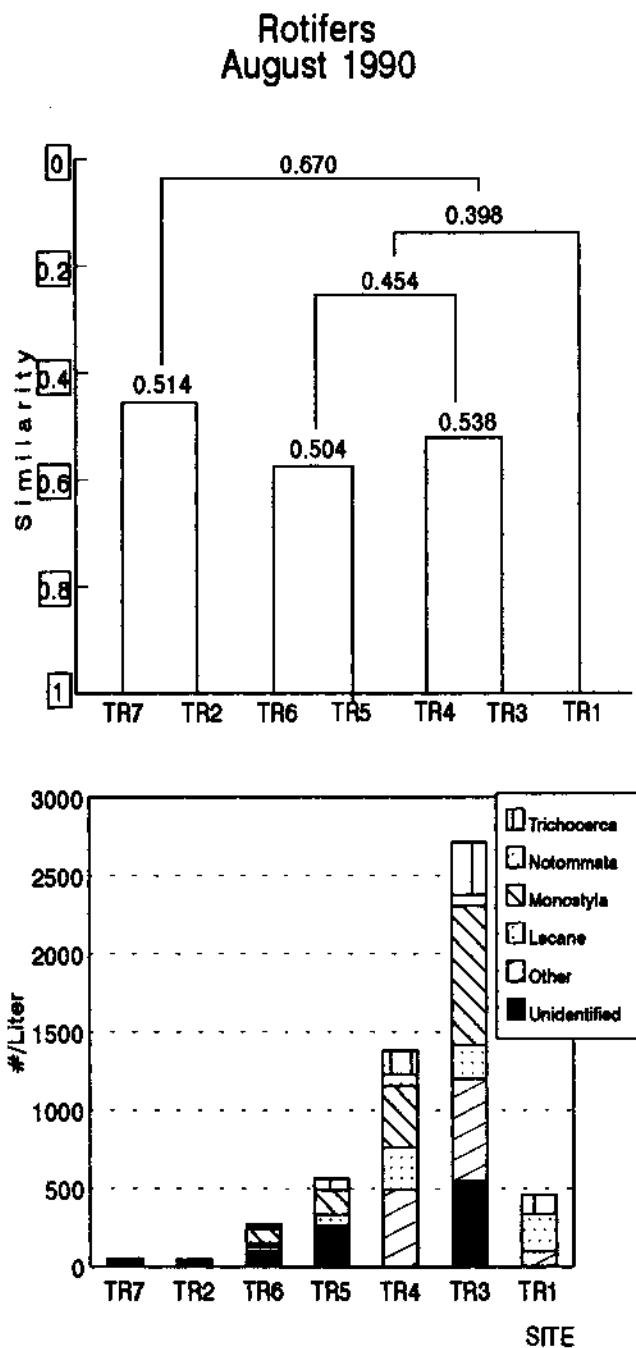


Figure 44. Rotifer similarities and taxa densities within communities for August 1990.

statistical analysis, but included in the histogram in Figure 45. The range in rotifer densities was from 280 individuals/L at TR1 to a mean of 886 individuals/L at TR7, with a standard deviation at this site of 284 (Table 8). Analysis of variance indicated there was no statistically significant difference in mean rotifer densities between sites (parametric ANOVA, $(0.50 > p > 0.20)$). The diversity index was lowest at TR1, with a value of 0.4680 and highest at TR4, with a value of 0.8700. The number of taxa ranged from 10 at TR1 to 20 at TR3 and TR4 (Figure 45). Bray-Curtis cluster analysis revealed that there was a high degree of similarity between all communities, with the smallest coefficient being 0.6057. The communities at TR5 and TR6 had a coefficient of 0.8092, the similarity between these and the community at TR7 was 0.7401, and the coefficient for the communities at TR2 and TR4 was 0.7386 (Figure 46). The two most abundant rotifer taxa on all dates were Brachionus and Keratella. Monostyla was absent from the reference sites, abundant in the effluent, and present at the downstream sites (see appendix).

The mean densities for August 1991 ranged from 51 individuals/L at TR6 to 664 individuals/L at TR1 (Table 8). Statistical analysis indicated that there was a significant difference in mean densities between sites. The mean densities at TR1, TR2, and TR3 were different than those at TR5, TR6, and TR7 (parametric ANOVA, $(p < 0.001)$ with

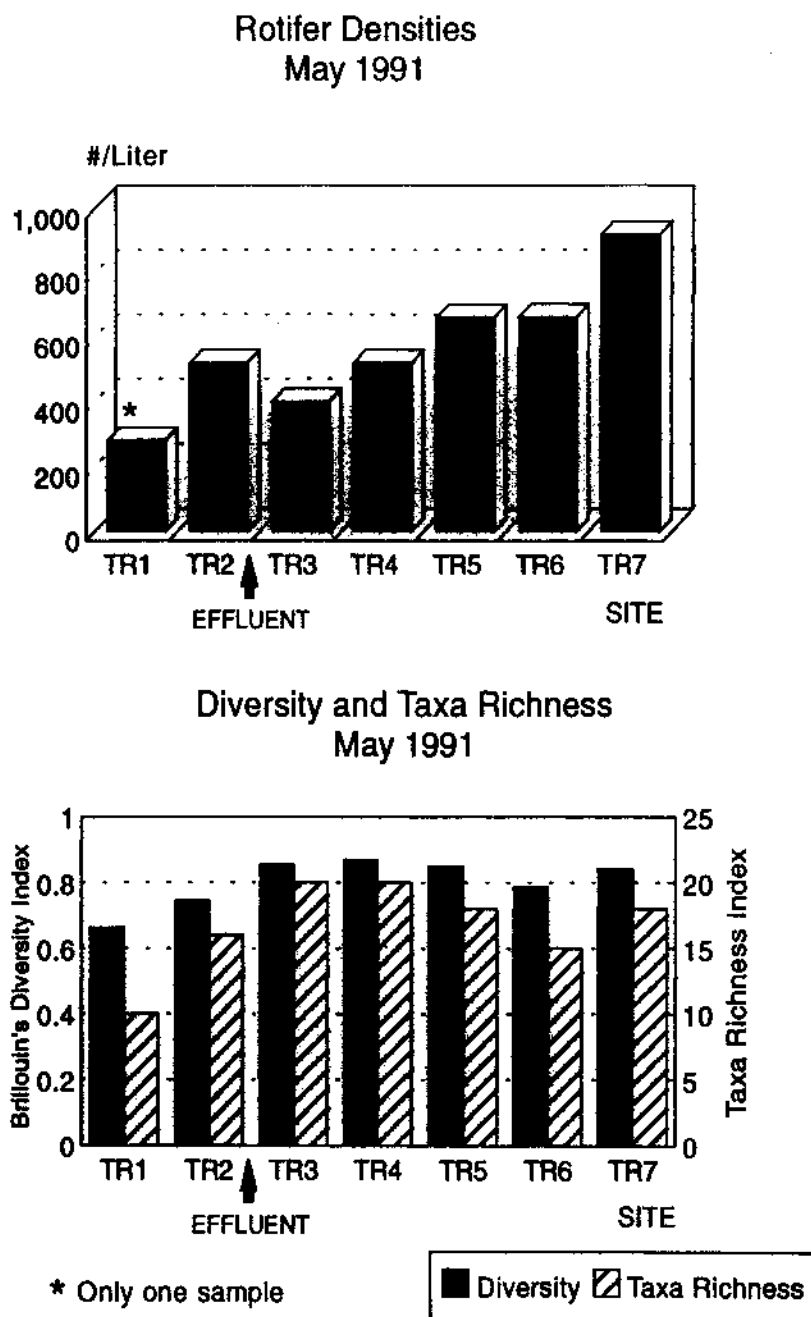


Figure 45. Rotifer mean densities (number/L) for May 1991 (top graph). Diversity and taxa richness indices (bottom graph).

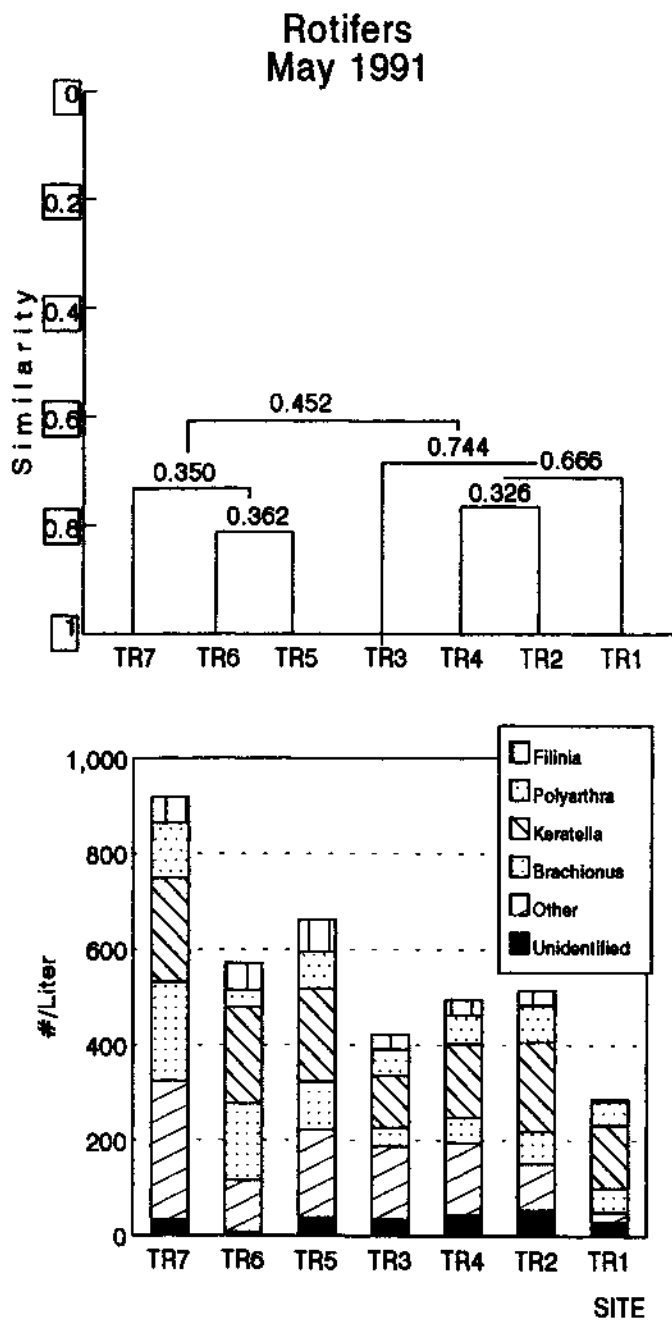


Figure 46. Rotifer similarities and taxa densities within communities for May 1991.

Tukey's MRT). Brillouin's diversity indices ranged from a low value of 0.4958 at TR6 to a high value of 0.8467 at TR1. The number of taxa fluctuated from 11 at TR6 and TR7 to 20 at TR1 (Figure 47). Bray-Curtis cluster analysis indicated that the communities at TR1 and TR2 were most alike, with a coefficient of 0.6917, followed by a coefficient of 0.6570 for the communities at TR3 and TR4. The similarities of the communities at TR6 and TR7 was reflected in a coefficient of 0.3732 (Figure 48). Brachionus, Keratella, Trichocerca and Filinia were present at all sites, as well as one variety of unknown rotifer. Monostyla was not present in the communities at the reference sites, but appeared in the communities downstream from the effluent (see Appendix).

The mean rotifer densities for May 1992 ranged from 111 individuals/L at TR2 to 299 individuals/L at TR7 (Table 8). There was no statistically significant difference in mean densities among sites (parametric ANOVA, ($p > 0.50$)). Diversity indices ranged from 0.3110 at TR1 to 0.7660 at TR3, and the number of genera ranged from 6/L at TR4 to 15/L at TR3 (Figure 49). Bray-Curtis cluster analysis revealed that the communities at TR1 and TR2 had were alike, with a coefficient of 0.6887, and the communities at TR5 and TR6 were alike, with a coefficient of 0.6347. The resemblance of the communities at TR1 and TR2 to the rest of the sites was represented by a coefficient of 0.3149 (Figure 50). Keratella was present at all the sites. Monostyla was

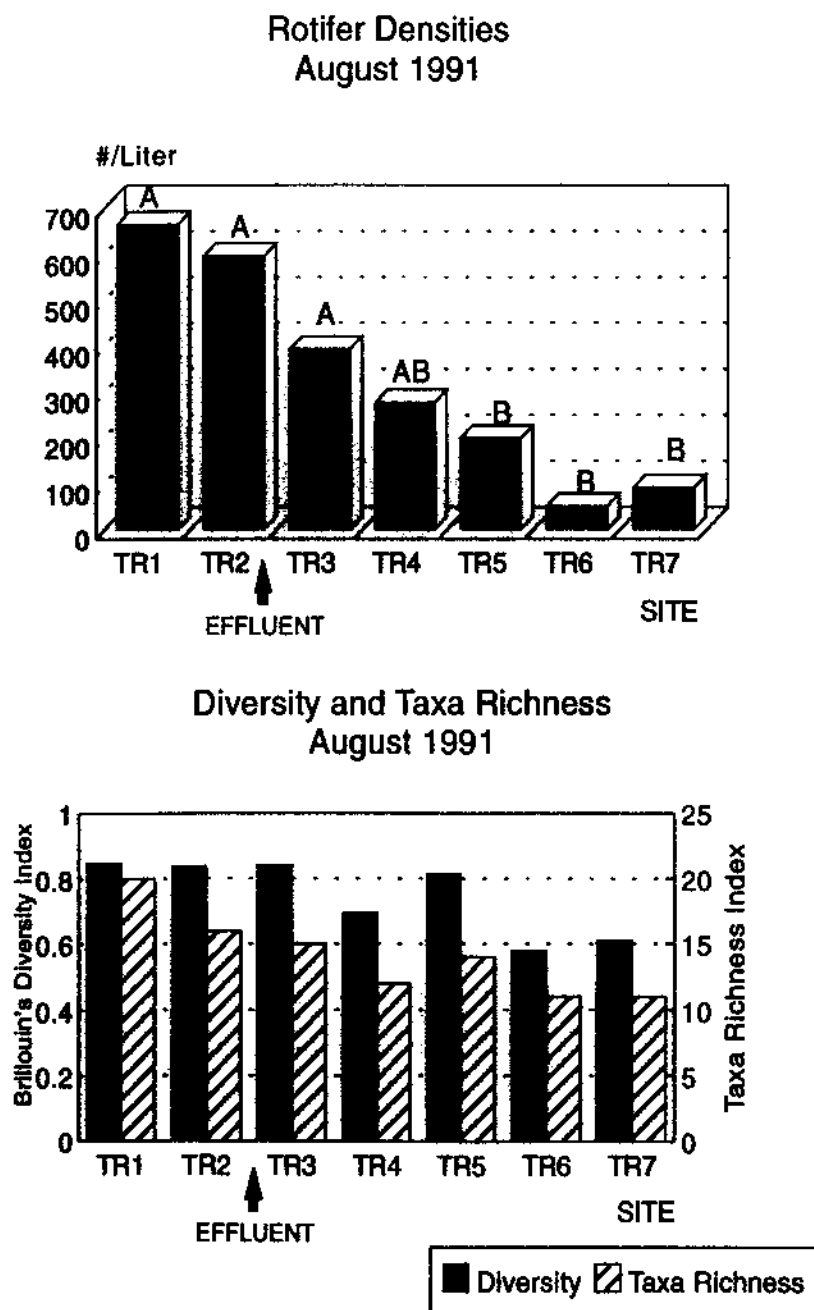


Figure 47. Rotifer mean densities (number/L) for August 1991 (top graph). The letters on top of the bars indicate statistical differences. Diversity and taxa richness

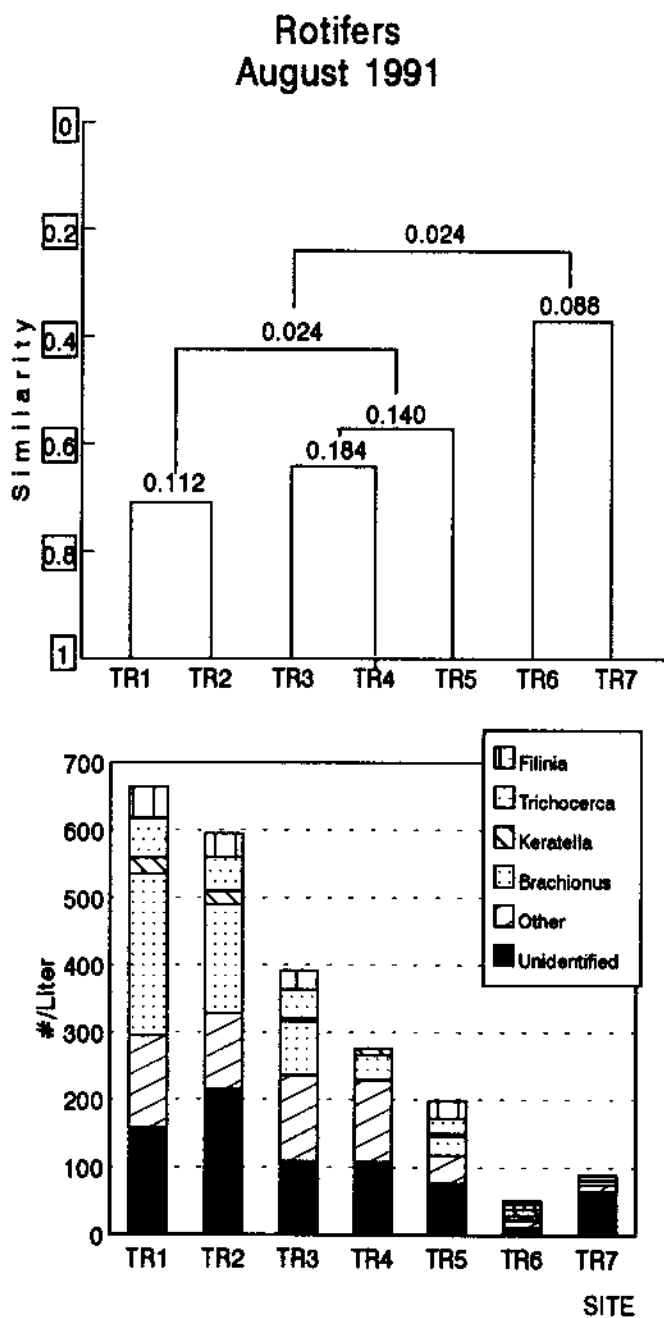


Figure 48. Rotifer similarities and taxa densities within communities for August 1991.

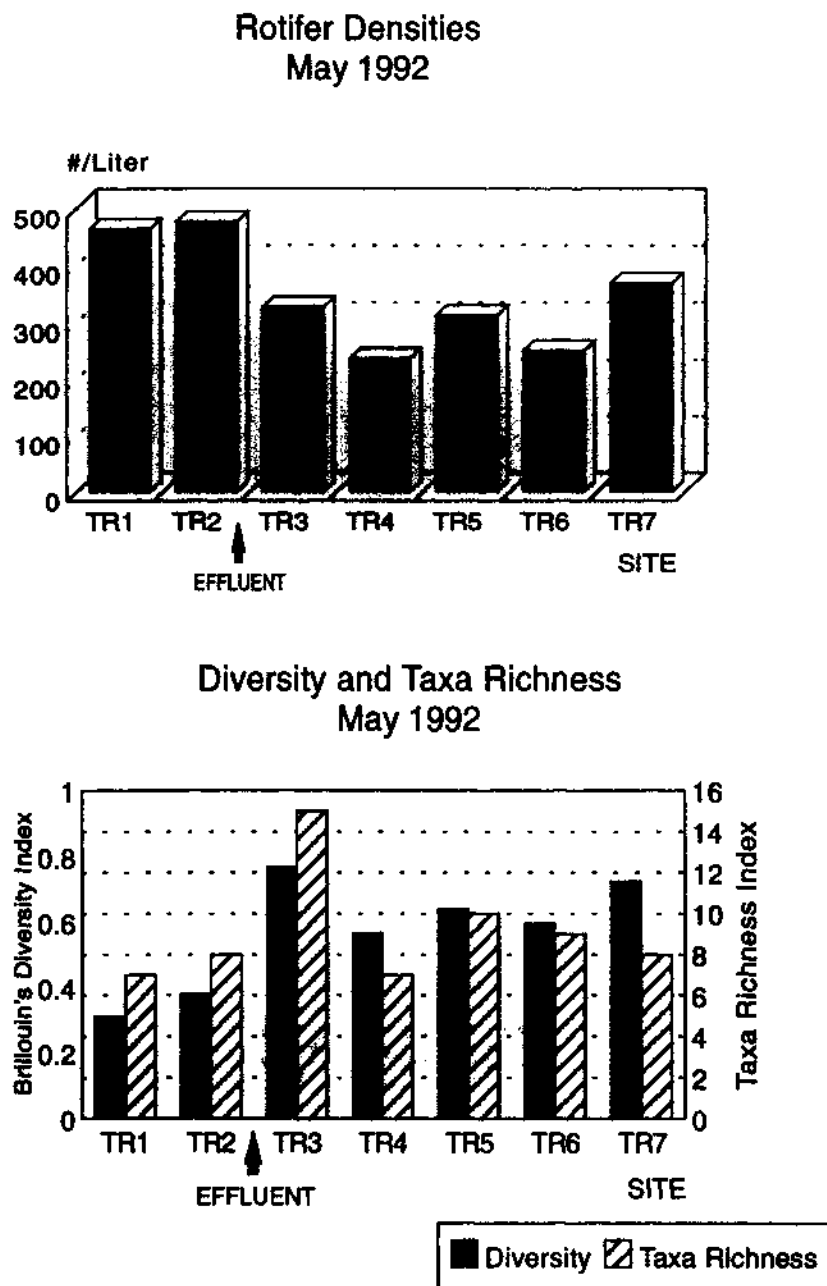


Figure 49. Rotifer mean densities (number/L) for May 1992 (top graph). Diversity and taxa richness indices (bottom graph).

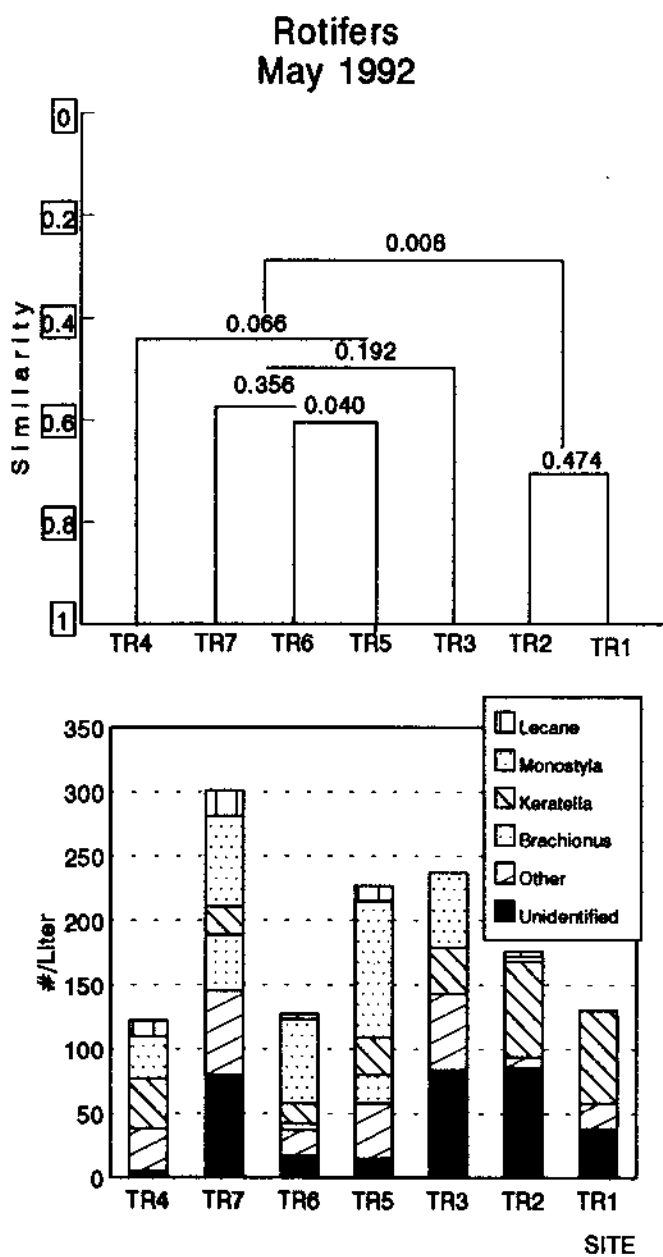


Figure 50. Rotifer similarities and taxa densities within communities for May 1992.

present in increased numbers at TR3 through TR7. There were several taxa of rotifers that were present only at TR3 (see Appendix).

For August of 1992 densities ranged from 9 individuals/L at TR7 to 85 individuals/L at TR2 (Table 8). There was a statistically significant difference in mean rotifer densities (parametric ANOVA, $(0.005 > p > 0.002)$). Tukey's MRT revealed that the mean densities at TR3 and TR4 were different than those at TR5 and TR7. Diversity indices were lowest at TR6 with a value of 0.5780, and highest at TR1, with a value of 0.8490. Taxa richness varied from 1 genera/L at TR7 to 16 genera/L at TR4 (Figure 51). Bray-Curtis cluster analysis showed that the communities at TR4 and TR5 were similar, with a coefficient of 0.6015, and these resembled the community at TR6 with a coefficient of 0.5294. The community at TR2 had a coefficient of similarity relative to the rest of the communities of 0.1717, and the coefficient for the relationship of the community at TR7 and the rest of the communities was the lowest at 0.0569. The probability that this last coefficient was not due to variability among replicate samples was 0.0080 (Figure 52). Brachionus was present at all sites, while Monostyla appeared in the effluent and was present at TR3, TR4, TR5, and TR6 (see Appendix).

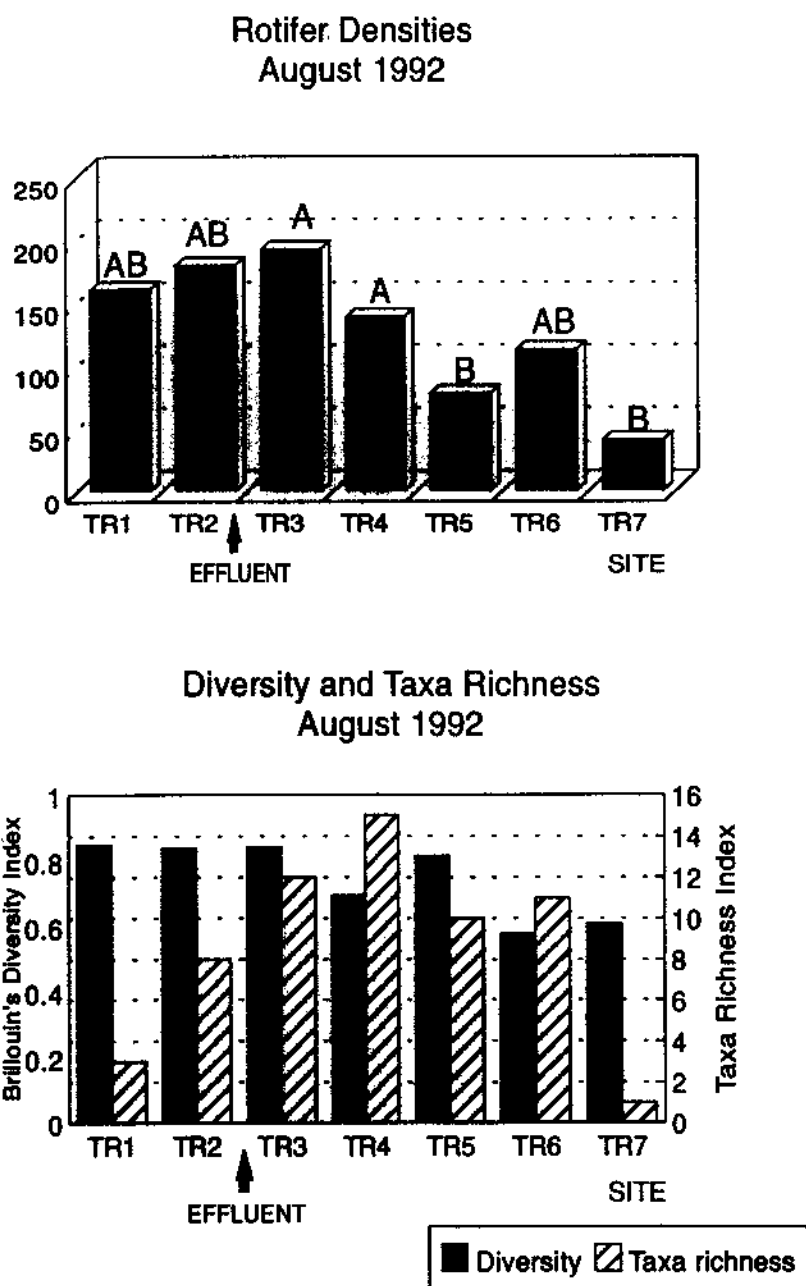


Figure 51. Rotifer mean densities (number/L) for August 1992 (top graph). The letters on top of the bars indicate statistical differences. Diversity and taxa richness indices (bottom graph).

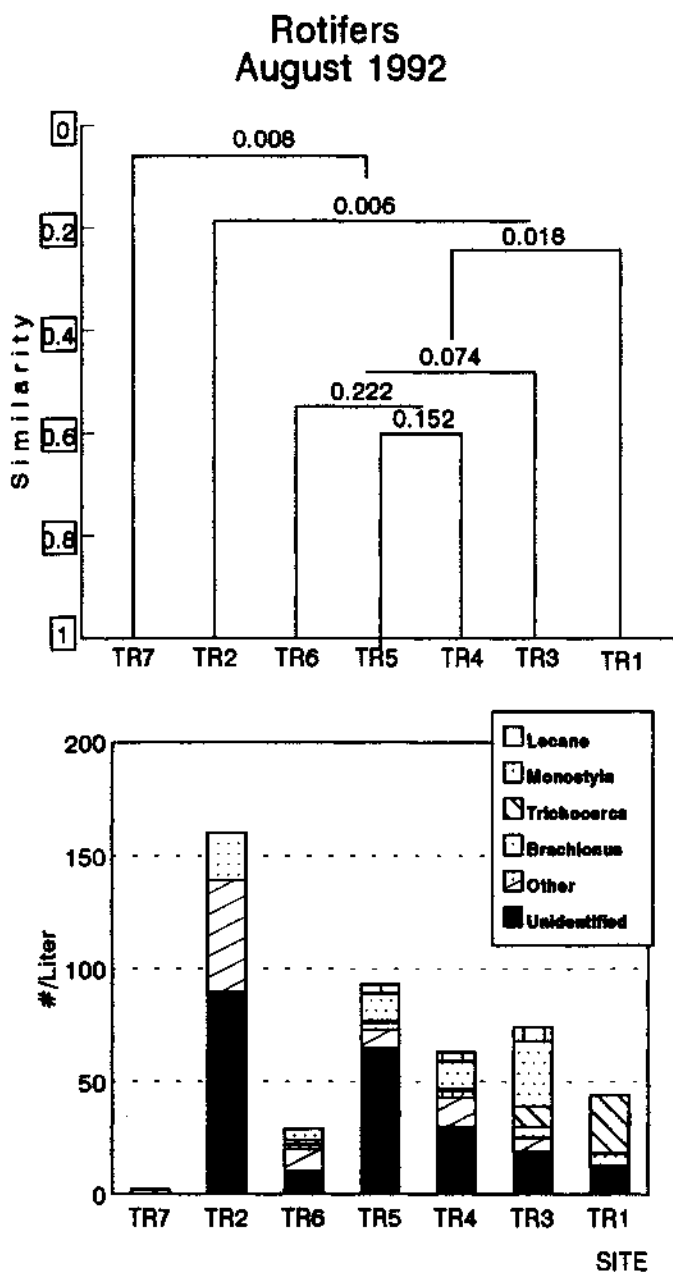


Figure 52. Rotifer similarities and taxa densities within communities for August 1992.

CHAPTER IV

DISCUSSION

The sewage treatment plant's effluent, aside from the presence or absence of chlorine, had the potential of affecting the communities in the river in several ways. The volume of effluent discharged increased the volume of water in the river (Table 2) and the velocity of the current downstream from the plant. The change in volume would likely alter the density of planktonic organisms per unit volume immediately downstream from the discharge. The increased velocity would likely have the effect of scouring the river bed. This effect was observed at TR3, just downstream from the discharge, on all sample dates. Scouring would have had the greatest potential effect on periphyton. The relationship between velocity and periphyton density was not apparent on all collection dates. In addition to increased water volume, the effluent also contributed an increase in concentrations of phosphate and nitrate. Higher concentrations of these nutrients did persist all the way downstream to TR7 on all dates (Figures 4 and 5). The relationship between nutrient levels and organism densities was not obvious on any collection date. This is likely due to an interplay between the effects of

nutrients, volume, velocity, and inputs of other toxicants via the effluent as well as non-point source runoff. In order to interpret the effects of dechlorination on the communities in the river, it is assumed that the effects of these other variables were similar at least on dates when flow rates in the river were similar.

Phytoplankton

The values for the phytoplankton chlorophyll-a concentrations collected in September 1990 were all low, but were lowest downstream from the effluent. A statistical difference was found between the reference sites and TR5, TR6, and TR7, but the histogram in Figure 8 indicates that the chlorophyll-a concentrations were depressed downstream from the effluent. The post-dechlorination concentrations were all higher than the pre-dechlorination concentrations. There was a statistically significant difference in mean chlorophyll-a concentrations on all of the subsequent sample dates, but this difference appeared to be in relation to the effluent only on August 1991. On this date there was a distinct trend of suppression of chlorophyll-a concentrations below the effluent with recovery downstream. There was evidence of suppression of concentrations downstream from the effluent on the other dates, but the relationship was obscured by variation among the other sites. When all of the post-dechlorination data were

combined into grand means this variation was still evident (Figure 53, striped bars). A trend of suppression of chlorophyll-a concentrations downstream from the effluent existed for pre-dechlorination and post-dechlorination data. The persistence of this trend on post-dechlorination dates may have been attributable to the dilution of the river by relatively algae-free effluent, or from some other toxic effect from the effluent besides chlorine.

There was only one sample from each site analyzed for phytoplankton densities in September 1990. The densities for the reference sites were considerably higher than for the downstream sites (Figure 13). Many of the taxa found at the reference sites were also present at the downstream sites, but the densities within these taxa decreased, particularly in the Scenedesmus, Merismopedia, and Microcystis populations. This could be explained by the effect of chlorine or some other toxicant on these organisms, or by dilution of the river with algae-free effluent. The density of Ankistrodesmus was higher downstream from the effluent, increasing from 316 cells/L at each of the reference sites to 1728 cells/L at TR3 (see Appendix). Ankistrodesmus was the dominant taxon in the periphyton community at this site on this date, and its presence in increased numbers in the phytoplankton could be as a result of sloughing from the substrata. Village Creek

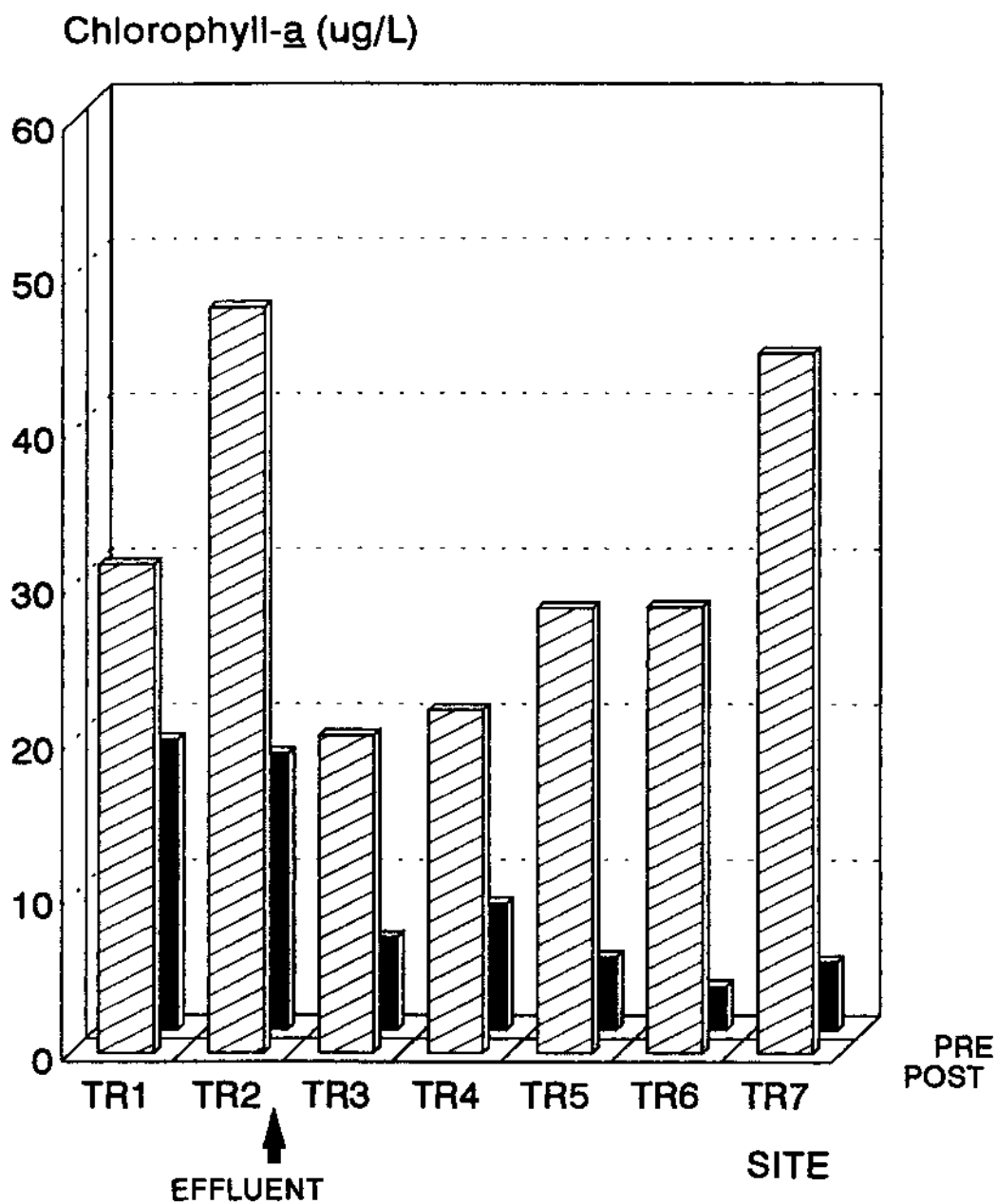


Figure 53. Comparison of pre-dechlorination phytoplankton mean chlorophyll-a concentrations (ug/L) to grand means of post-dechlorination concentrations.

enters the Trinity River just upstream from the sewage treatment plant but downstream from TR2, and it is possible that this tributary was the location of the proliferation of Ankistrodesmus. The number of Ankistrodesmus decreased to 312 cells/L at TR7, but in spite of this the communities at TR3 and TR7 were similar according to the Bray-Curtis cluster analysis.

The samples collected in 1991 did not show a statistically significant difference in mean phytoplankton densities among sites. In May 1991 the densities within some taxa, such as Cyclotella and Selenastrum, increased while the densities within many of the taxa decreased, but overall densities were at their lowest at TR5 (see Appendix and Figure 15). This may have been due to a chronic effect of some unknown factor in the effluent or from somewhere else along the river. TR1 and TR6 were similar to each other, as were TR2 and TR4, which implies that changes in the communities were not attributable to the effluent. In August 1991 the overall densities as well as diversity and taxa richness were lowest at TR3. The community at TR3 most resembled the one at TR5, which had the highest density but comparably low diversity. The high numbers of Cyanophyta, particularly Microcystis, most likely influenced the similar diversities of these two sites. The densities within many of the taxa of Chlorophyta decreased downstream from the effluent, with a few exceptions like Elakatothrix and

Chlorococcum. In May 1992 there was a significant difference in overall densities among sites and this difference was relative to the effluent. The high numbers of the Cyanophyta Microcystis and Aphanocapsa at TR1 and TR2 decreased at the sites downstream from the effluent (see Appendix). The higher densities within these two taxa resulted in lower diversity in these communities and these two communities were associated as being similar by the Bray-Curtis cluster analysis. Though the numbers were lower downstream from the effluent the diversity was higher than at the reference sites, thus the communities among the downstream sites were clustered based on similarity. In August 1992 the trends were similar to those in May 1992. The overall densities were significantly higher at TR1 and TR2 due to high numbers of Aphanocapsa and Microcystis, the diversity was lower at the reference sites, though not as much as in the spring, and the reference sites were similar to each other but distinct from the communities at the downstream sites. The trend of impact downstream from the effluent discharge for the 1992 dates was very similar to the trend of impact during dechlorination. When the data from 1992 were combined with the data from 1991 into grand means, a trend of impact downstream from the effluent was still in evidence, though not quite as pronounced (Figure 54, striped bars). There was no change in the trend of decreased densities downstream from the effluent over time,

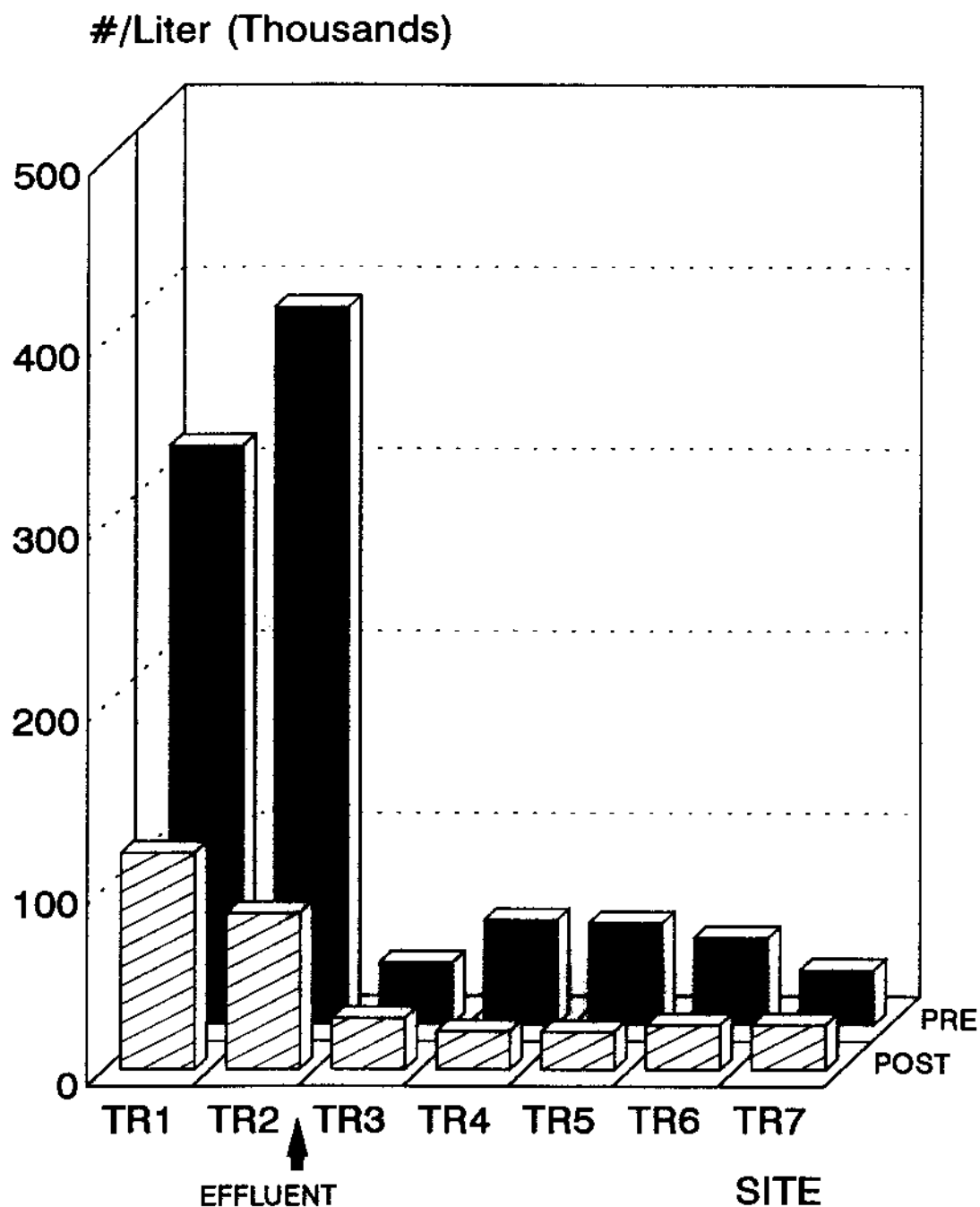


Figure 54. Comparison of pre-dechlorination phytoplankton mean densities (number/L) to grand means of post-dechlorination concentrations.

and thus no effect on community structure attributable to effluent dechlorination. Dilution of the river by the effluent may be the reason, as with phytoplankton chlorophyll-a concentrations. It is possible that the phytoplankton density at TR3 could have been comparable to the density of phytoplankton at the sites upstream from the effluent without the volume of virtually algae-free effluent entering the river at a rate of 8.76 m³/second. The phytoplankton community had the time and the environment to reestablish itself downstream, but this did not happen. The trend of lower numbers downstream all the way to TR7 may have been the result of a chronic effect from an unknown toxicant in the effluent. The levels of phosphate and nitrate were considerably higher downstream from the effluent than at the reference sites. Studies have shown that algal densities are typically enhanced by the presence of these nutrients, particularly when both are present in high concentrations (Hawes et al., 1993). Different algae species have ranges of requirements and tolerances for phosphate and nitrate levels (Bellinger, 1979). For instance, Scenedesmus and Ankistrodesmus have been noted to have optimal growth requirements and upper tolerance limits for phosphate-bound phosphorous greater than 20 ug/L, while many diatoms have optimal growth limits for phosphate at less than 20 ug/L. (Rodhe, 1948 in Bellinger (1979)). The overall densities of post-dechlorination phytoplankton did

not follow a trend of enhanced response to increased nutrient levels. Increased flow has been indicated as having the effect of suppressing phytoplankton production (Choudhary et al., 1991). The effluent is discharged into the river at a rate of 4730 m³/second, which is often orders of magnitude faster than the river's ambient flow rate. Note in Table 2 that on each sample date an increased flow rate, relative to the rate upstream from the effluent, persisted at the USGS monitoring station downstream from TR7.

Periphyton

Mean ash-free dry weights were significantly lower downstream from the effluent than at the reference sites in August 1990 (Figure 55, solid bars). There were also statistically significant differences in mean dry weights relative to the effluent on both 1992 sampling dates. Data for September and October of 1991 were incomplete due to flood damage to the periphytometers. Statistical relationships involving the effluent could not be inferred from these data. Nevertheless, these were combined with the mean dry weights from the other dechlorination dates into grand means (Figure 55, striped bars). The comparison of these grand means to the mean dry weights for 1990 revealed that a decrease in dry weights downstream from the effluent persisted on all sample dates. The chlorophyll-a

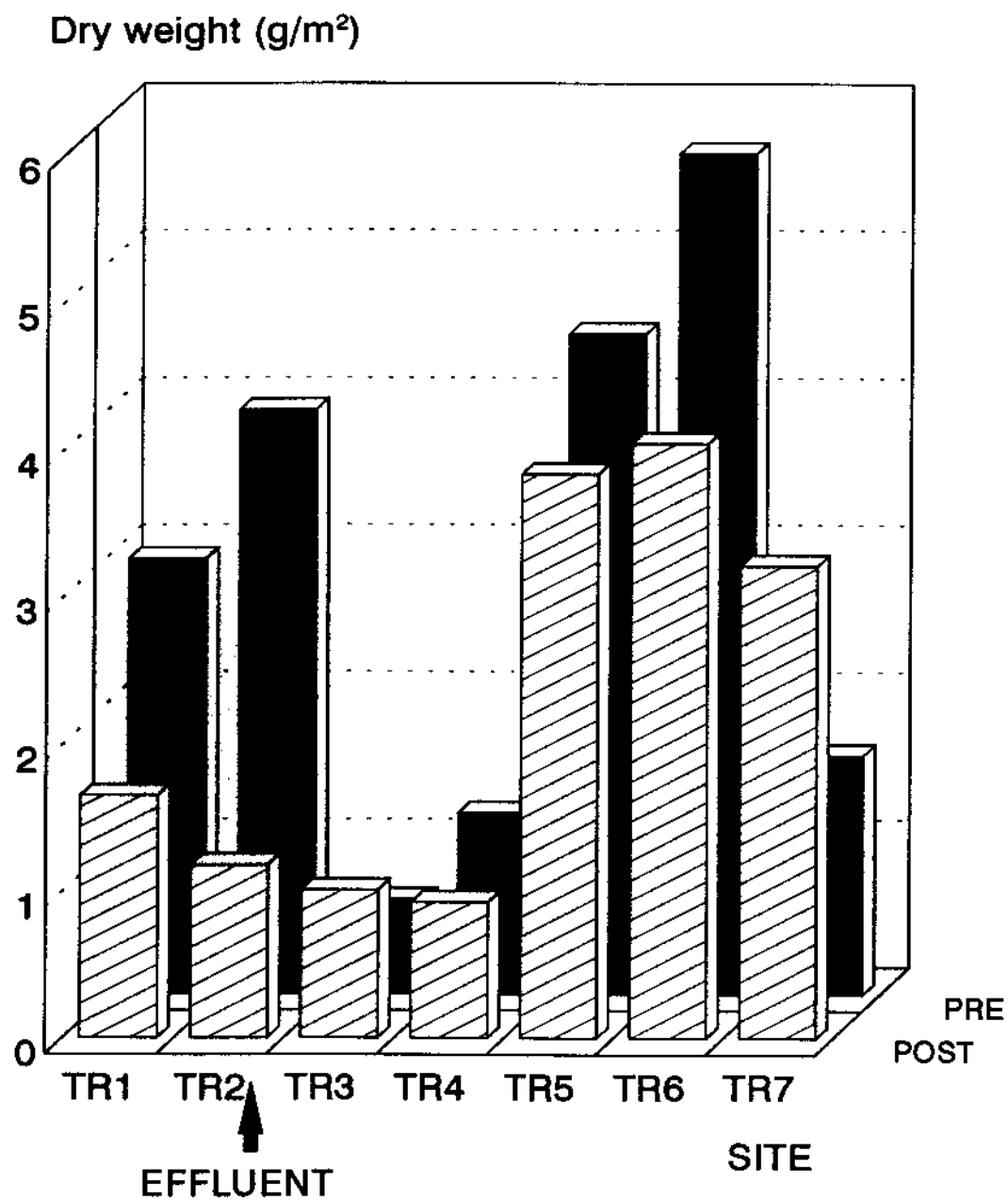


Figure 55. Comparison of pre-dechlorination periphyton mean ash-free dry weights (g/m²) to grand means of post-dechlorination weights.

concentrations for September 1990 were lowest at the reference sites, although not statistically lower than at the other sites. The values were highest at TR6, as were the ash-free dry weights for that site on this date, but not with the periphyton densities. Ash-free dry weight and chlorophyll-a concentrations are not similar at the reference sites, possibly due to a variable ratio of chlorophyll-a to non-algal organic matter on the slides.

In June 1991 the mean concentrations just downstream from the effluent were significantly different than those at the other sites, and in May 1992 the concentration was lowest at TR3, just downstream from the effluent. When the data from the post-dechlorination sampling dates were combined into grand means and compared to the mean concentrations collected in 1990 it is apparent that the trend of suppression of chlorophyll-a concentrations downstream from the effluent did not change over time, thus implying that there was no effect from effluent dechlorination (Figure 56, striped bars). Periphyton chlorophyll-a concentrations and ash-free dry weights were often dissimilar, perhaps because of variable ratios of alga to non-algal organic matter on the slides, or as Steinman (1992) suggests, chlorophyll-a production within individual cells may increase under the stressful condition of lower light levels.

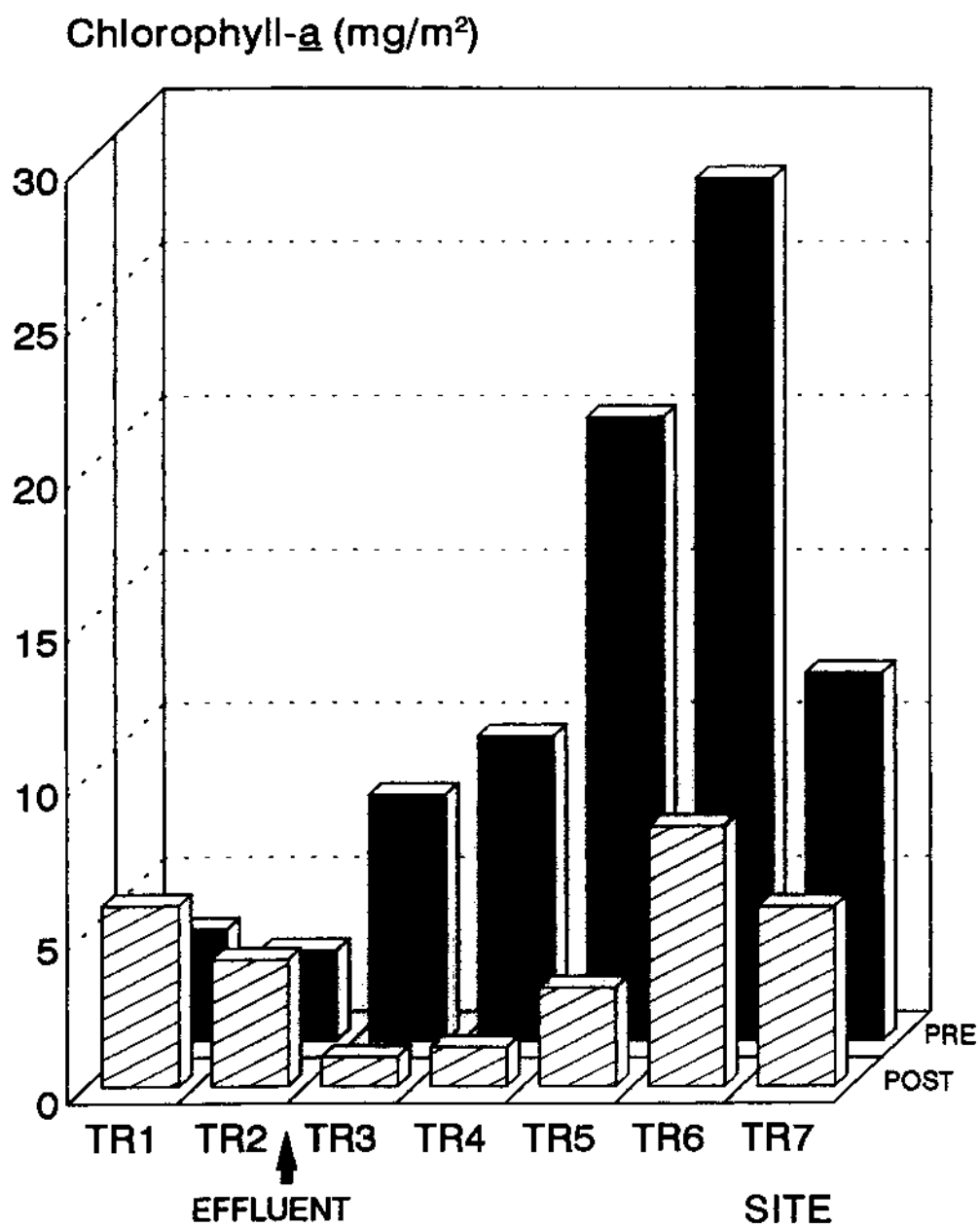


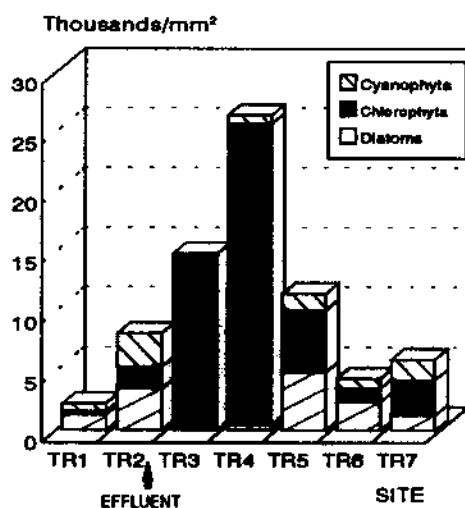
Figure 56. Comparison of pre-dechlorination periphyton mean chlorophyll-a concentrations (mg/m²) to grand means of post-dechlorination concentrations.

Pre-dechlorination periphyton densities were significantly different at the sites immediately downstream from the effluent. The numbers were considerably higher at these sites, represented almost entirely by one species of algae, Ankistrodesmus sigmoides. Diversity, taxa richness, and the degree of community similarity were high at the reference sites and from TR5 to TR7, relative to TR4 and TR5. Distribution of densities of organisms among taxa within communities is a valuable indicator of ecosystem health. Extensive studies of periphyton communities have shown that a healthy system is represented by numerous taxa with few individuals in most taxa, and systems represented by few taxa with high densities indicates the presence of pollutants (Patrick 1971). It would appear that Ankistrodesmus is resistant to the level of chlorine that was present in the river. In addition, Ankistrodesmus has been noted to favor high levels of inorganic nutrients. Most species of diatoms and blue-green algae are strict phototrophs and would not benefit from excess nutrients (Hutchinson (1967) in Bellinger 1979). Exceptions are certain diatom species within Nitzschia which are noted to indicate the presence of high concentrations of organic nitrogenous compounds (Whitton 1979) and Oscillatoria, a blue-green algae that is an obligate heterotroph (Bellinger 1979).

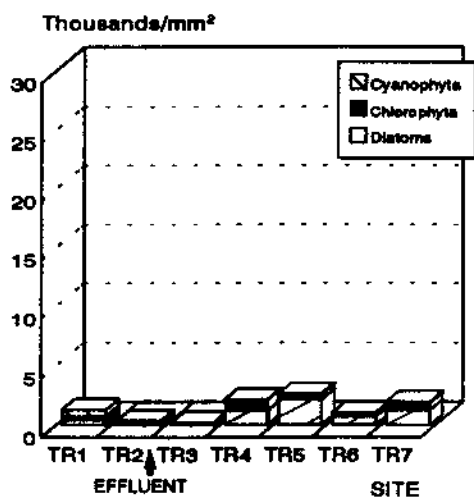
The data collected on each of the post-dechlorination sampling dates showed a decrease in periphyton density downstream from the effluent, though the differences were not always significant. Communities at the reference sites were distinct from the sites immediately downstream from the effluent in May 1991 and August 1992, but in September 1991 and April 1992 the communities at TR3 were similar to those at the reference sites. The grand mean of densities of the major groups of periphyton for the post-dechlorination samples can be compared to the distribution of the densities within major groups for the pre-dechlorination samples in Figure 57. The two graphs in this figure of grand means of post-dechlorination densities are of the same data. The one on the left is on the same scale as the top graph, and the one on the right is expanded so the distribution of the major periphyton groups is visible.

The number of periphyton enumerated in 1990 was higher than on any of the dates when the effluent was dechlorinated. There was a stark contrast in densities from 1990 and the grand means of densities from the other dates (Figure 58). When periphyton densities are compared to periphyton ash-free dry weights and chlorophyll-a concentrations the trends were completely dissimilar. Chlorophyll-a concentrations do not necessarily reflect densities probably because of variation among cell volumes

Pre-dechlorination



Post-dechlorination



Post-dechlorination

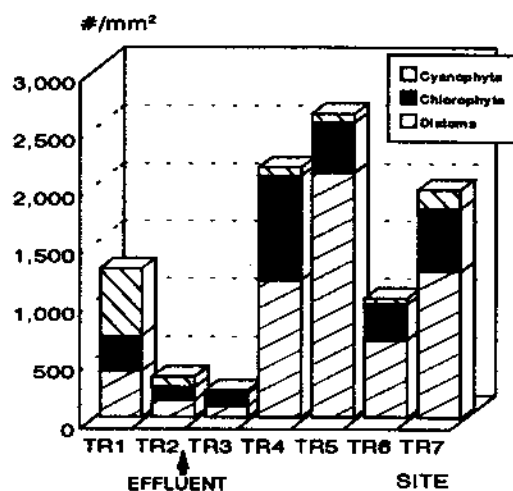


Figure 57. Pre- and post-dechlorination periphyton community structure differences. The post-dechlorination grand means are presented on a scale relative to the densities for 1990 (bottom left) and expanded to show the community distribution (bottom right).

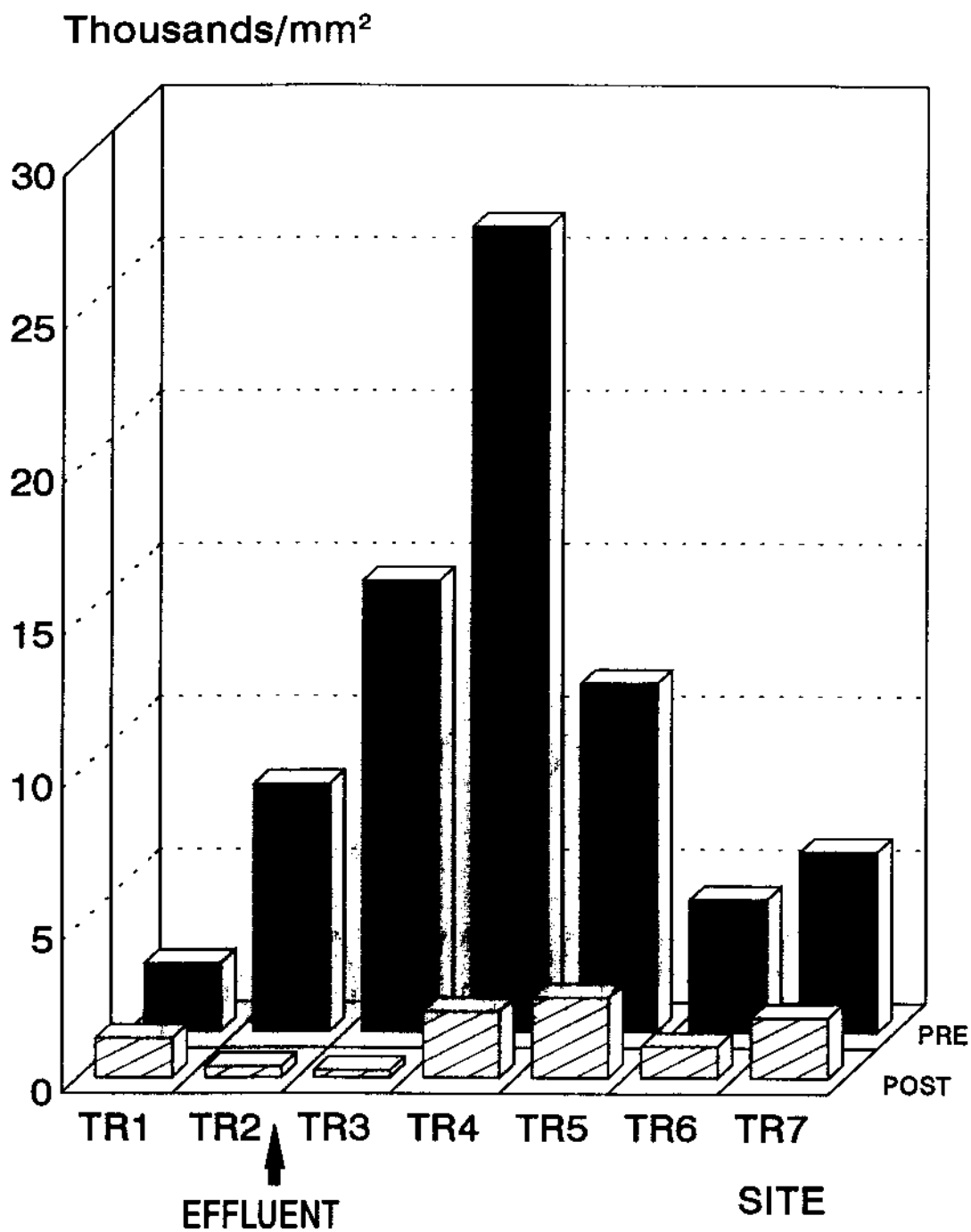


Figure 58. Comparison of pre-dechlorination periphyton mean densities (number/mm²) to grand means of post-dechlorination densities.

of different genera of algae. Ankistrodesmus sigmoides is a single-celled, small, slender algae with a high ratio of surface area to volume.

Zooplankton

In September 1990 only one replicate from each site was collected, therefore no statistical analyses were performed on these data. The response of the rotifer community to the chlorinated effluent was pronounced. There was a dramatic increase in numbers and taxa at TR3, and the higher Brillouin's diversity index for the rotifer community at TR3 corresponded with those data. The Bray-Curtis cluster analysis isolated the communities immediately downstream from the effluent as being different from the reference sites and TR7. There are several possible explanations. The rotifers may have been killed in the sewage treatment process and not had time to decompose. Rotifers have been noted to thrive in habitats rich in particulate organic matter such as domestic sewage (Barbhuyan 1992). The effluent was not sampled for rotifers on this date, but on subsequent dates when the effluent was sampled only Monostyla was present in numbers high enough to affect the communities downstream. Monostyla was the most abundant rotifer in the community at TR3, possibly arising from the effluent, but there were six taxa present and a 57-fold increase in overall rotifer numbers at TR3 that were not

present at the reference sites. An enhancement of community health possibly attributable to the effluent was indicated (Figure 59, solid bars). Apparently the rotifers in general were not immediately affected by the ambient concentrations of chlorine as the effluent mixed with and was diluted by the river. These organisms did not exhibit the pollution response of diversity decreasing with increased numbers (Patrick 1971 and Cairns 1975). The increase in rotifer densities could have been as a result of a response to the input of nutrients from the effluent, but the elevated nutrient concentrations persisted all the way to TR7 and high rotifer diversity and density did not. As rotifers are mainly filter feeders, the fact that there was a dramatic increase in the number of periphyton at TR3 and TR4, specifically of one species of algae represented by small individuals, Ankistrodesmus sigmoides, could have enhanced the community. Another possible explanation for this increase in numbers was that the rotifer's natural predators, the fish, were not able to cope with the ambient levels of chlorine and were not present at TR3 and TR4. A combination of these factors, an available food supply in the form of algae and a lack of predators, could have allowed for the rotifer community to thrive. More rotifers were present in the fastest flowing part of the river than in any of the other measured communities. This might be explained by rotifers proliferating for some unknown reason

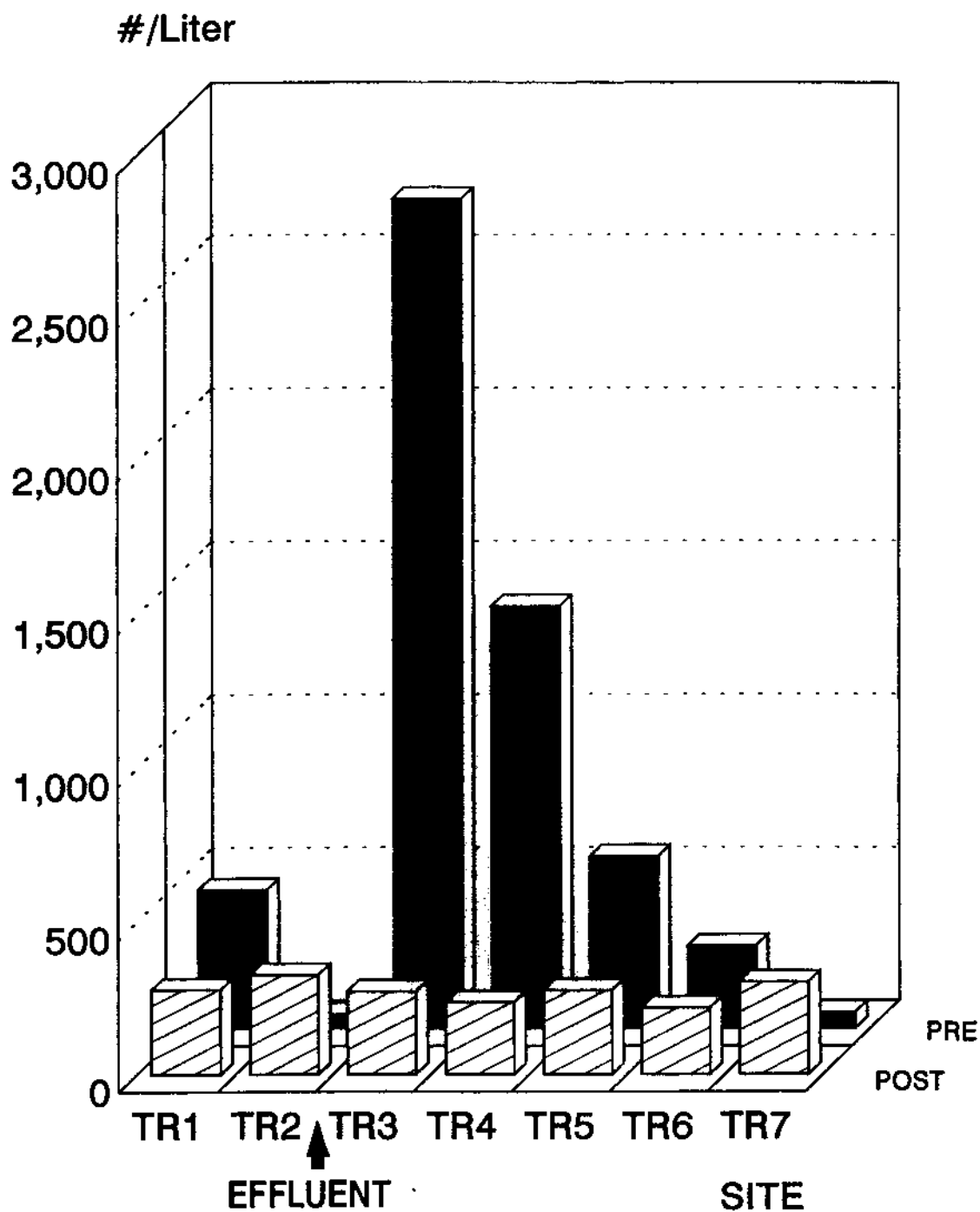


Figure 59. Comparison of pre-dechlorination rotifer densities (number/L) to grand means of post-dechlorination densities.

downstream from TR2 but upstream from the effluent, or from rotifers being supplied by the effluent. This latter explanation seems unlikely considering the evidence to the contrary on other sample dates. It is possible that rotifers were reproducing at a zone where the river and the nutrient-rich effluent were interfacing but where the flow rate was still relatively slow, and then being carried into the faster section of the river where they were sampled.

Of the post-dechlorination data, a statistically significant difference among sites in rotifer densities was found only in August 1991. This difference did not appear to be related to the effluent, as densities were highest at TR1, TR2, and TR3 (Figure 47). This was the only date when there was a decrease in overall rotifer density and taxa richness at TR3. On all other dates there was an increase in densities and diversity downstream from the effluent. The mean rotifer densities for the post-dechlorination samples were combined into grand means and compared to the pre-dechlorination densities (Figure 59). Where there was an effect apparent from the effluent before dechlorination was implemented, there did not appear to be an effect on the rotifer community from dechlorinated effluent.

CHAPTER V

CONCLUSIONS

Three communities of organisms, zooplankton, phytoplankton, and periphyton, were studied in order to test the hypothesis that there was no effect from dechlorination of the sewage treatment effluent. This was achieved by comparing samples collected on individual sample dates to determine if there was a response to the effluent, and then comparing data among all sample dates to determine if there was a response to removal of chlorine from the effluent.

Phytoplankton chlorophyll-a concentrations were significantly lower just downstream from the effluent compared to the reference sites when chlorine was still in the system in August 1990. On the post-dechlorination dates the concentrations were lower at the sites downstream from the effluent. When data from all dates were compared it appears that chlorine was not the major factor affecting chlorophyll-a concentrations downstream from the effluent, and that whatever was affecting the concentrations continued to affect them after chlorine was removed.

Phytoplankton densities followed trends similar to chlorophyll-a concentrations. The densities downstream from the chlorinated effluent in August 1990 were statistically

lower than those at the reference sites. The densities of phytoplankton on post-dechlorination sample dates were lower downstream from the effluent. There were no meaningful shifts in community structure among sites on any sample date.

Periphyton ash-free dry weights were lower downstream from the chlorinated effluent in September 1990 and on two of the post-dechlorination sampling dates. When the post-dechlorination data were combined and compared to the pre-dechlorination data, it appears that the response of periphyton in the form of ash-free dry weight did not change over time.

In September 1990 periphyton chlorophyll-a concentrations were lowest upstream at the reference sites and highest at sites several miles downstream from the effluent, which did not indicate an effect from the chlorinated effluent. On the sample dates when dechlorination was implemented lower mean concentrations downstream from the effluent existed. When all sample dates were compared there was no obvious effect on periphyton chlorophyll-a concentrations from dechlorination of the effluent.

Periphyton densities were statistically higher at the sites just downstream from the chlorinated effluent than from the other sites on September 1990, and in fact were considerably higher than those at any site on any sample

date. In addition, there was a dramatic shift in community structure at TR3 and TR4 as the high densities at these sites were represented almost entirely by one species of algae, Ankistrodesmus sigmoides, while the lower densities at the other sites were represented by several taxa. On the post-dechlorination sampling dates there was no difference in mean densities relative to the effluent and community structure was similar among sites. For periphyton it can be concluded that dechlorination had a definite effect on mean densities as well as on community structure.

Rotifer densities were higher just downstream from the effluent on the August 1990 sampling date. The distribution of densities among all taxa except Monostyla was the same for all sites, possibly indicating that all taxa were affected by the effluent. On the dates when dechlorination was in effect, no differences in mean densities relative to the effluent were found. When all dates were compared, it appears that dechlorination did not have an effect on rotifer community structure, but did have an effect on overall densities.

Of the three communities analyzed, only rotifers and periphyton appeared to have responded to removal of chlorine from the effluent. Both of these communities responded to chlorinated effluent with increased densities, but perhaps for different reasons. Rotifers seemed to have responded to an abundance of food and a lack of predators, not directly

to the chlorine except in that they were not inhibited by it. Most periphyton species did seem to be inhibited by the presence of chlorine in the river except for one species. This species perhaps thrived increased nutrients and the lack of competition from less resilient species.

If one were to look for positive effects in these communities from the removal of chlorine from the effluent, the zooplankton community would not be a good example. The whole zooplankton community seemed to have thrived in the conditions provided by the presence of chlorine in the system. When the chlorine was removed the whole community responded. Inhibition by natural stressors such as predation and food supply may have been the reason. The periphyton community, on the other hand, benefitted from the removal of chlorine from the system. When the chlorine was removed the communities downstream from the effluent more closely resembled those upstream at the reference sites.

The rotifer and periphyton communities both responded to the removal of chlorine from the effluent. The response was negative in the rotifer and positive in the periphyton communities. Both communities are potentially valuable tools in evaluating the effects of effluent dechlorination.

APPENDIX

Phytoplankton 8/90
Number/Liter

	TR1	TR2	TR3	TR4	TR5	TR6	TR7
<i>Cyclotella</i>	1242	0	165	331	110	220	55
<i>Navicula</i>	0	0	0	0	8	0	0
<i>Nitzschia</i>	2484	736	110	0	110	110	1546
<i>Synedra</i>	23	23	0	0	0	8	0
<i>Surirella</i>	0	0	0	0	0	0	8
<i>Cryptomonas</i>	429	294	68	36	15	15	15
<i>Rhodomonas</i>	0	0	0	110	15	0	0
<i>Gymnodinium</i>	0	0	0	0	8	0	0
<i>Euglena</i>	0	45	11	9	0	0	23
<i>Trachelomonas</i>	23	0	0	0	0	0	0
<i>Chrysoflagellate</i>	0	368	276	110	497	442	1159
<i>Chlamydomonas</i>	0	0	0	0	0	8	30
<i>Spermatozoopsis</i>	68	23	0	0	15	0	0
<i>Ankistrodesmus</i>	316	316	1728	1521	501	608	312
<i>Crucigenia</i>	700	904	45	285	122	91	122
<i>Dictyosphaerium</i>	452	339	136	178	114	91	84
<i>Kirchneriella</i>	248	452	0	36	0	0	0
<i>Oocystis</i>	249	45	0	0	8	0	0
<i>Pediastrum</i>	791	678	68	231	122	0	0
<i>Scenedesmus</i>	2373	1039	136	179	122	174	281
<i>Tetrastrum</i>	0	0	0	36	8	0	0
<i>Euastrum</i>	0	0	0	0	0	8	0
<i>Tetraedron</i>	0	0	0	18	23	0	0
<i>Keratococcus</i>	0	0	0	0	0	8	8
<i>Coelastrum</i>	181	0	0	0	0	0	0
<i>Micractinium</i>	90	0	0	0	0	0	0
Coccoid chlorophyta	2070	368	0	0	8	442	386
Chloroflagellate	0	0	0	0	55	0	0
Cells<5um	0	0	0	0	17	0	0
<i>Anabaenopsis</i>	113	90	0	0	0	0	0
<i>Merismopedia</i>	62115	73600	6514	3312	4637	7176	6182
<i>Microcystis</i>	240178	313352	24122	50563	48838	37992	19541
<i>Oscillatoria</i>	3313	736	55	0	0	0	0
Coccoid cyanophyta	0	0	386	110	221	166	110
Bacillariophyta	3749	759	275	331	228	338	1609
Chlorophyta	7990	4871	2468	2749	1650	1887	2420
Cyanophyta	305719	387778	31077	53985	53696	45334	25833
Total	316216	393408	33655	56734	55464	47339	29807

Phytoplankton 5/91
Number/Liter

	TR1			TR2			TR3			TR4		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Achnanthes</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cyclotella</i>	4171	2717	1213	1552	1164	4074	1358	1746	873	679	3007	1067
<i>Cymbella</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Melosira</i>	0	582	0	0	0	194	0	97	0	194	0	0
<i>Navicula</i>	0	194	0	0	0	0	0	0	0	0	0	0
<i>Nitzschia</i>	97	194	0	873	0	0	582	0	0	582	97	0
<i>Stephanodiscus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Synedra</i>	0	194	0	0	0	0	97	97	97	97	0	0
<i>Cocconeis</i>	0	0	0	97	0	0	0	0	0	97	0	0
<i>Surirella</i>	0	0	0	0	0	97	0	0	0	0	0	0
<i>Fragellaria</i>	0	0	0	0	0	291	0	0	0	0	97	0
<i>Gomphonema</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pinnularia</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Eunotia</i>	0	0	0	0	0	194	97	0	0	0	97	0
<i>Chlamydomonas</i>	291	0	0	194	0	291	194	194	97	194	0	97
<i>Cryptomonas</i>	194	194	81	97	97	582	194	97	97	194	0	0
<i>Rhodomonas</i>	0	0	0	0	0	97	0	0	0	0	0	0
<i>Peridinium</i>	0	0	0	97	0	0	0	0	0	0	0	0
<i>Euglena</i>	97	0	0	0	0	0	0	194	97	0	97	0
<i>Trachelomonas</i>	0	97	0	0	97	0	0	0	0	97	97	0
<i>Pandorina</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dinobryon</i>	0	0	0	0	0	0	0	0	0	0	97	0
<i>Ankistrodesmus</i>	194	582	0	0	0	0	0	0	0	0	0	0
<i>Chlorella</i>	582	261	0	582	3880	970	388	0	0	2134	388	1164
<i>Chlorococcum</i>	0	0	0	0	0	0	0	0	388	0	0	1261
<i>Cosmarium</i>	0	0	0	0	0	0	0	97	0	0	0	0
<i>Crucigenia</i>	388	388	323	0	0	776	97	0	0	388	0	0
<i>Kirchneriella</i>	388	0	0	0	0	0	0	0	0	0	0	0
<i>Oocystis</i>	97	0	0	0	0	0	0	0	0	0	0	0
<i>Pediastrum</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Scenedesmus</i>	388	776	647	1843	291	2328	194	291	194	388	776	0
<i>Selenastrum</i>	261	261	0	0	0	1358	0	2522	1067	0	0	388
<i>Staurastrum</i>	97	0	0	0	0	0	0	0	0	0	0	0
<i>Treubaria</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tetraedron</i>	0	0	81	0	0	0	0	97	0	0	0	97
<i>Schroederia</i>	0	0	0	0	0	97	0	0	0	97	0	0
<i>Coelastrum</i>	0	776	0	0	0	776	0	0	0	0	0	0
<i>Actinastrum</i>	194	0	0	0	0	0	0	0	0	0	0	0
<i>Tetrastrum</i>	388	0	0	0	0	0	0	0	0	0	0	0
<i>Bulbochaete</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Elakatothrix</i>	0	0	0	0	0	0	0	0	0	0	0	0
Beads	388	0	0	0	0	0	0	0	0	0	0	0
Reniform beads	1552	0	0	0	0	0	0	0	0	0	0	0
Cells<5um	0	0	0	0	0	0	0	0	0	0	0	0
<i>Raphidiopsis</i>	0	0	0	97	0	0	0	0	97	97	0	0
<i>Anabaena</i>	0	0	0	0	0	1649	0	0	0	0	0	0
<i>Aphanocapsa</i>	0	9700	0	0	0	0	776	0	0	0	0	0
<i>Merismopedia</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Microcystis</i>	21340	0	0	0	0	3880	0	1940	1940	0	0	3880
<i>Oscillatoria</i>	49	0	0	50	2134	0	0	0	0	0	0	0
<i>Phormidium</i>	0	0	0	0	0	0	0	757	0	0	0	0

Phytoplankton 5/91 (continued)

	TR1			TR2			TR3			TR4		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Aphanizomenon</i>	0	0	0	0	0	151	0	0	0	0	0	0
Bacillariophyta	4268	3881	1213	2522	1164	4850	2134	1940	970	1649	3298	1067
Chlorophyta	5499	3335	1132	2813	4365	7275	1067	3492	1940	3492	1455	3007
Cyanophyta	21389	9700	0	147	2134	5680	776	2697	2037	97	0	3880
Total	31156	16916	2345	5482	7663	17805	3977	8129	4947	5238	4753	7954

Phytoplankton 5/91
Number/Liter

	TR5			TR6			TR7		
	A	B	C	A	B	C	A	B	C
			fungus						
<i>Achnanthes</i>	0	0	0	0	97	97	97	97	0
<i>Cyclotella</i> :	1064	2813	582	1455	2037	1746	2522	485	970
<i>Cymbella</i>	0	0	0	0	0	0	0	0	0
<i>Melosira</i> :	97	0	0	291	97	0	194	0	0
<i>Navicula</i> :	97	0	0	0	291	97	1358	1455	679
<i>Nitzschia</i> :	97	0	97	194	0	194	1067	194	679
<i>Stephanodis</i>	0	0	0	0	0	0	0	0	0
<i>Synedra</i> :	0	0	0	0	97	97	291	0	97
<i>Cocconeis</i> :	0	0	0	0	0	0	0	0	0
<i>Surirella</i> :	0	0	0	0	0	97	0	0	0
<i>Fragellaria</i> :	0	0	0	0	0	0	0	0	97
<i>Gomphonema</i> :	0	0	0	0	0	0	0	0	0
<i>Pinnularia</i> :	0	0	0	0	0	0	0	0	0
<i>Eunotia</i> :	0	0	0	0	0	0	0	0	0
<i>Chlamydomonas</i> :	291	0	97	0	0	291	97	97	97
<i>Cryptomonas</i> :	97	194	0	97	194	194	194	97	0
<i>Rhodomonas</i> :	0	0	0	0	0	0	0	0	0
<i>Peridinium</i> :	0	0	0	0	0	0	0	0	0
<i>Euglena</i> :	0	0	97	0	0	0	0	0	0
<i>Trachelomonas</i> :	97	0	97	194	0	97	0	0	97
<i>Pandorina</i> :	0	0	0	776	0	0	0	0	0
<i>Dinobryon</i> :	0	0	0	0	0	0	0	0	0
<i>Ankistrodesmus</i> :	0	0	0	97	0	0	291	0	388
<i>Chlorella</i> :	776	0	0	0	0	194	0	0	0
<i>Chlorococcum</i> :	0	0	0	0	0	0	0	0	0
<i>Cosmarium</i> :	0	0	0	97	97	0	0	97	0
<i>Crucigenia</i> :	0	0	0	0	1164	388	97	0	388
<i>Kirchneriella</i> :	0	0	0	0	0	0	0	0	0
<i>Oocystis</i> :	0	0	0	0	0	0	388	0	0
<i>Pediastrum</i>	0	0	0	0	0	0	1552	0	0
<i>Scenedesmus</i> :	0	0	0	0	194	0	194	0	0
<i>Selenastrum</i> :	0	194	0	0	194	291	388	0	0
<i>Staurastrum</i>	0	0	0	0	0	0	0	0	0
<i>Treubaria</i> :	0	0	0	0	0	0	0	97	0
<i>Tetraedron</i> :	97	0	0	97	97	0	97	0	0
<i>Schroederia</i> :	0	0	0	97	0	0	291	0	0
<i>Coelastrum</i> :	970	0	0	0	0	0	776	0	0
<i>Actinastrum</i> :	0	0	0	0	0	0	0	0	0
<i>Tetrastrum</i> :	0	0	0	0	0	0	0	0	0
<i>Bulbochaete</i> :	0	0	0	0	0	0	0	388	0
<i>Elakatothrix</i> :	0	0	0	0	0	0	0	1552	0
Beads:	0	0	0	0	388	0	0	0	0
Reniform beads:	0	0	0	0	0	0	0	0	0
Cells<5um	1552	0	0	0	0	0	0	0	0
<i>Raphidiopsis</i> :	97	0	0	0	194	194	0	0	0
<i>Anabaena</i> :	0	0	0	0	0	0	0	0	0
<i>Aphanocapsa</i> :	0	0	0	0	8730	3880	0	0	776
<i>Merismopedia</i> :	0	0	0	0	0	0	0	0	0
<i>Microcystis</i> :	0	0	0	0	0	0	5820	0	0
<i>Oscillatoria</i> :	0	0	0	0	0	0	504	0	0
<i>Phormidium</i> :	757	0	0	0	0	0	0	0	0

Phytoplankton 5/91 (continued)

	TR5			TR6			TR7		
	A	B	C	A	B	C	A	B	C
<i>Aphanizomenon</i>	0	0	0	0	0	0	0	0	0
Bacillariophyta	1355	2813	679	1940	2619	2328	5529	2231	2522
Chlorophyta	3880	388	291	1455	2328	1455	4365	2328	970
Cyanophyta	854	0	0	0	8924	4074	6324	0	776
Total	6089	3201	970	3395	13871	7857	16218	4559	4268

Phytoplankton 8/81
Number/Liter

	TR1		TR2		TR3		TR4	
	A	B	A	B	A	B	A	B
<i>Achnanthes</i>	0	0	0	0	24	0	24	40
<i>Cyclotella</i>	291	243	315	388	49	0	97	141
<i>Cymbella</i>	97	0	0	0	0	0	0	0
<i>Melosira</i>	194	315	437	970	490	218	485	424
<i>Navicula</i>	0	0	0	194	0	0	24	0
<i>Nitzschia</i>	2619	776	873	873	243	582	946	728
<i>Stephanodiscus</i>	0	0	0	0	0	0	0	0
<i>Synedra</i>	97	340	194	291	0	49	97	101
<i>Cocconeis</i>	0	0	24	0	0	0	0	0
<i>Gyrosigma</i>	0	24	0	0	0	0	0	0
<i>Fragellaria</i>	0	0	0	97	0	0	0	0
<i>Gomphonema</i>	0	0	0	0	0	0	0	0
<i>Pinnularia</i>	0	0	0	0	0	0	0	0
Diatom sp.	0	0	0	194	0	0	0	0
<i>Cryptomonas</i>	1261	801	1092	2425	776	776	704	323
<i>Rhodomonas</i>	582	267	315	1455	194	243	267	222
<i>Gymnodinium</i>	0	0	24	97	0	0	0	0
<i>Peridinium</i>	0	49	0	0	0	0	24	0
<i>Euglena</i>	194	24	73	291	49	0	121	101
<i>Lepocinclis</i>	0	0	0	97	0	0	0	0
<i>Trachelomonas</i>	0	0	24	97	73	24	49	20
<i>Carterias</i>	0	0	0	0	0	49	0	0
<i>Chlamydomonas</i>	485	461	267	194	121	170	121	40
<i>Ankistrodesmus</i>	582	73	73	97	194	49	218	121
<i>Chlorella</i>	0	0	0	0	24	24	0	0
<i>Chlorococcum</i>	0	0	0	0	194	97	0	0
<i>Closteriopsis</i>	0	0	24	0	0	0	0	0
<i>Cosmarium</i>	0	24	0	0	24	0	24	0
<i>Crucigenia</i>	0	291	291	776	194	388	679	1132
<i>Elakatothrix</i>	0	0	0	0	0	607	49	0
<i>Kirchneriella</i>	0	97	0	0	0	0	49	0
<i>Oocystis</i>	0	73	0	0	0	0	0	81
<i>Pediastrum</i>	0	388	0	0	0	0	0	0
<i>Protococcus</i>	0	0	490	0	0	0	0	0
<i>Scenedesmus</i>	970	631	534	1164	170	388	582	81
<i>Selenastrum</i>	1358	243	24	970	0	121	995	505
<i>Staurastrum</i>	0	0	24	0	0	0	0	20
<i>Treubaria</i>	0	0	0	97	0	0	0	0
<i>Tetraedron</i>	291	73	24	0	0	24	73	20
<i>Tetrastrum</i>	0	0	0	0	0	0	0	0
<i>Golenkinia</i>	291	0	24	0	24	0	0	20
<i>Gloeocystis</i>	0	0	364	0	0	0	0	0
<i>Schroederia</i>	0	24	24	0	24	0	0	20
<i>Coelastrum</i>	1552	0	0	0	0	146	194	161
<i>Chodatella</i>	97	0	0	0	0	0	0	0
<i>Franceia</i>	0	24	0	0	0	0	73	20

Phytoplankton 8/91 (continued)
Number/Liter

	TR1		TR2		TR3		TR4	
	A	B	A	B	A	B	A	B
<i>Actinastrum</i>	0	243	0	0	0	0	0	40
<i>Micractinium</i>	0	73	0	0	24	49	0	20
<i>Dictyosphaerium</i>	0	1892	170	388	0	97	679	970
<i>Dimorphococcus:</i>	0	1213	0	388	0	0	0	0
Cells<5um	0	0	0	1164	0	97	194	61
Cells>5um	0	0	0	0	0	0	73	0
<i>Raphidiopsis</i>	0	73	0	388	0	73	97	61
<i>Anabaena</i>	1358	97	0	0	0	194	0	0
<i>Anabaenopsis</i>	0	0	0	0	0	0	752	3497
<i>Aphanocapsa</i>	776	1456	0	1455	0	485	485	1112
<i>Chroococcus</i>	1164	0	49	0	0	0	170	0
<i>Merismopedia</i>	0	534	1553	0	0	2135	121	485
<i>Coelosphaerium</i>	0	728	1456	0	0	0	0	0
<i>Microcystis</i>	0	1383	437	0	3396	8491	1746	2183
<i>Oscillatoria</i>	0	0	1110	2825	604	467	1482	0
<i>Phormidium</i>	691	854	0	0	0	0	0	557
<i>Aphanizomenon:</i>	0	0	3154	0	0	0	49	321
Bacillariophyta	3298	1698	1843	3007	806	849	1673	1434
Chlorophyta	7663	6964	3861	9700	2085	3349	5168	3978
Cyanophyta	3989	5125	7759	4668	4000	11845	4902	8216
Total	14950	13787	13463	17375	6891	16043	11743	13628

Phytoplankton 8/91 (continued)
Number/Liter

	TR5		TR6		TR7	
	A	B	A	B	A	B
<i>Achnanthes</i>	24	51	0	0	0	0
<i>Cyclotella</i>	97	256	69	267	340	437
<i>Cymbella</i>	0	0	0	24	0	0
<i>Melosira</i>	388	718	35	582	825	243
<i>Navicula</i>	0	0	0	24	73	49
<i>Nitzschia</i>	1213	513	468	995	315	776
<i>Stephanodiscus</i>	24	0	17	24	24	0
<i>Synedra</i>	146	154	208	291	267	194
<i>Cocconeis</i>	0	51	0	0	24	0
<i>Gyrosigma</i>	0	0	0	0	0	0
<i>Fragellaria</i>	0	0	0	0	0	0
<i>Gomphonema</i>	0	0	0	24	0	24
<i>Pinnularia</i>	0	0	0	0	0	24
<i>Diatom sp.</i>	0	0	0	0	0	0
<i>Cryptomonas</i>	679	1282	710	558	776	970
<i>Rhodomonas</i>	243	513	156	194	194	121
<i>Gymnodinium</i>	0	0	0	49	0	0
<i>Peridinium</i>	0	51	17	0	0	0
<i>Euglena</i>	97	154	69	146	121	266
<i>Lepocinclis</i>	0	0	0	0	0	0
<i>Trachelomonas</i>	24	51	17	49	24	73
<i>Carterias</i>	0	0	0	0	0	0
<i>Chlamydomonas</i>	170	103	52	49	121	243
<i>Ankistrodesmus</i>	121	205	260	194	291	243
<i>Chlorella</i>	0	0	0	0	0	0
<i>Chlorococcum</i>	0	0	0	243	0	0
<i>Closteriopsis</i>	24	0	0	49	24	0
<i>Cosmarium</i>	0	0	0	0	0	0
<i>Crucigenia</i>	97	821	139	970	365	194
<i>Elakatothrix</i>	0	0	0	0	49	0
<i>Kirchneriella</i>	49	0	0	340	49	461
<i>Oocystis</i>	0	102	35	97	121	49
<i>Pediastrum</i>	388	0	606	0	0	0
<i>Protococcus</i>	0	0	0	0	0	49
<i>Scenedesmus</i>	582	923	208	340	655	752
<i>Selenastrum</i>	267	718	104	316	340	291
<i>Staurostrum</i>	0	0	0	0	0	0
<i>Treubaria</i>	0	51	0	0	0	0
<i>Tetraedron</i>	73	51	17	0	49	73
<i>Tetrastrum</i>	0	0	0	0	97	0
<i>Golenkinia</i>	0	0	17	73	73	49
<i>Gloeocystis</i>	146	0	156	340	946	0
<i>Schroederia</i>	24	0	17	73	24	24
<i>Coelastrum</i>	0	0	0	0	485	0
<i>Chodatella</i>	24	0	0	0	0	0
<i>Franceia</i>	0	0	0	24	49	0

Phytoplankton 8/91 (continued)
Number/Liter

	TR5		TR6		TR7	
	A	B	A	B	A	B
<i>Actinastrum</i>	0	0	0	0	0	0
<i>Micractinium</i>	170	51	0	0	170	97
<i>Dictyosphaerium</i>	480	0	0	364	1286	364
<i>Dimorphococcus</i>	0	0	0	0	0	0
Cells<5um	0	2103	329	243	170	24
Cells>5um	0	0	0	0	0	0
<i>Raphidiopsis</i>	24	205	0	73	73	121
<i>Anabaena</i>	0	0	0	1334	0	0
<i>Anabaenopsis</i>	0	564	312	364	1820	0
<i>Aphanocapsa</i>	0	4205	0	1989	194	0
<i>Chroococcus</i>	0	308	69	0	97	0
<i>Merismopedia</i>	0	1436	416	4852	1747	4658
<i>Coelosphaerium</i>	0	513	0	0	0	1164
<i>Microcystis</i>	5143	18462	936	3519	3833	1092
<i>Oscillatoria</i>	177	827	469	588	782	278
<i>Phormidium</i>	217	480	171	194	50	101
<i>Aphanizomenon</i>	328	373	144	164	0	0
Bacillariophyta	1892	1743	797	2231	1868	1747
Chlorophyta	3658	7179	2909	4711	6479	4343
Cyanophyta	5889	27373	2517	13077	8596	7414
Total	11439	36295	6223	20019	16943	13504

Phytoplankton 5/82
Number/Liter

	TR1			TR2		Effluent				TR3		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Cyclotella</i>	8077	8077	14196	16154	5880	5635	61	0	61	2695	5145	4900
<i>Cymbella</i>	0	0	490	734	0	0	0	0	0	0	0	0
<i>Melosira</i>	1469	2448	1713	2937	2695	2205	61	0	0	1225	490	980
<i>Navicula</i>	5874	4406	4895	3185	0	0	0	0	61	1470	0	0
<i>Nitzschia</i>	0	0	734	245	6125	2695	0	161	303	490	2205	490
<i>Stephanodiscus</i>	0	0	0	0	0	490	0	0	0	245	0	245
<i>Synedra</i>	734	245	3182	245	1224	490	0	81	0	245	245	0
<i>Cocconeis</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Surirella</i>	245	0	0	0	0	0	0	0	0	0	0	0
<i>Fragellaria</i>	0	0	0	734	490	0	0	0	0	245	245	0
<i>Gomphonema</i>	0	0	245	245	0	245	0	0	0	245	0	0
<i>Pinnularia</i>	245	0	0	0	0	0	0	0	0	0	0	0
<i>Eunotia</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Diatoma</i>	0	0	245	0	0	0	0	0	0	0	0	0
<i>Rhoicosphenia</i>	0	0	0	245	0	0	0	0	0	0	0	0
<i>Chlamydomonas</i>	1469	1469	2203	1225	980	490	61	81	0	245	1470	490
<i>Cryptomonas</i>	1469	734	979	1960	1715	1715	0	243	0	1469	490	1225
<i>Rhodomonas</i>	0	245	0	734	245	980	0	161	61	735	1470	980
<i>Peridinium</i>	0	0	0	0	0	490	0	0	0	0	0	0
<i>Euglena</i>	3671	734	3916	4655	245	245	0	0	61	490	245	245
<i>Phacus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Trachelomonas</i>	245	0	245	245	0	490	0	0	0	0	490	490
<i>Pandorina</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Carteria</i>	490	0	0	0	0	0	0	0	0	0	0	0
<i>Dinobryon</i>	245	0	1469	0	0	0	0	0	0	0	0	0
<i>Chilomonas</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Spermatozoopsis</i>	0	0	0	0	0	0	0	0	0	0	0	0
Gr. flagellate sp.	0	0	0	0	0	0	0	0	0	0	0	0
Chrysophagellate sp	0	0	0	0	0	0	0	0	122	0	0	0
<i>Chromulina</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ankistrodesmus</i>	490	0	490	245	0	0	61	0	243	980	0	245
<i>Chlorella</i>	979	245	3916	245	0	0	0	0	0	735	0	0
<i>Chlorococcum</i>	0	0	0	245	0	0	0	0	0	0	0	0
<i>Cosmarium</i>	0	0	245	245	0	245	61	161	0	0	0	245
<i>Crucigenia</i>	980	1960	21539	4895	2940	1960	0	0	0	0	2940	4410
<i>Kirchneriella</i>	4895	7343	2448	2448	0	0	0	0	0	0	7350	2448
<i>Oocystis</i>	0	0	979	0	2940	0	0	0	0	0	980	2940
<i>Pediastrum</i>	187975	0	979	0	0	0	0	0	0	0	0	0
<i>Protococcus</i>	0	490	0	2448	0	0	0	0	0	0	0	0
<i>Scenedesmus</i>	2692	2448	17623	12728	10769	7832	243	647	485	5880	1960	3916
<i>Selenastrum</i>	7832	2203	5384	2937	0	490	0	0	0	1715	0	0
<i>Treubaria</i>	0	0	0	0	0	245	0	0	0	0	490	490
<i>Tetraedron</i>	979	245	490	1470	0	735	61	0	0	245	0	490
<i>Golenkinia</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Schroederia</i>	0	245	734	245	0	0	0	0	0	0	245	245
<i>Actinastrum</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tetrastrum</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cerasterias</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dictyosphaerium</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphaerocystis</i>	0	0	0	0	0	7343	0	0	0	0	0	0
<i>Dimorphococcus</i>	0	0	0	979	0	0	0	0	0	2940	0	0
<i>Coelastrum</i>	2692	1958	1958	3916	0	3916	0	0	0	0	0	0
<i>Closterium</i>	245	245	0	0	0	0	0	0	61	0	245	0
<i>Closteriopsis</i>	0	245	0	245	490	0	0	0	0	0	0	0
<i>Elakatothrix</i>	0	0	979	0	0	0	0	0	0	0	0	0
<i>Chodatella</i>	0	0	0	245	0	0	0	0	0	245	0	0

Phytoplankton 5/92 (continued)
Number/Liter

	TR1			TR2		Effluent				TR3		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Gloeocystis</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Radiococcus</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Eutetramorus</i>	0	0	490	0	0	0	0	0	0	0	0	0
Paired rectangles	0	0	0	0	0	0	0	0	0	0	0	0
Cells>5um	0	0	0	1470	3427	0	0	0	0	0	0	3671
Cells<5um	0	0	0	2937	12238	0	0	161	667	0	0	35001
Colony cells<5um	0	0	979	0	0	0	0	0	0	0	0	0
<i>Raphidiopsis</i>	1958	2203	3916	490	980	1470	0	0	0	0	245	1470
<i>Anabaena</i>	0	0	2450	490	0	0	0	0	0	0	245	0
<i>Anabaenopsis</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphanocapsa</i>	19581	39162	83218	9790	318188	0	0	0	0	0	245	34266
<i>Merismopedia</i>	0	0	0	4895	3916	3916	0	0	0	0	0	3916
<i>Coelosphaerium</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Microcystis</i>	122380	0	538472	73428	244760	73428	2430	0	0	48952	48952	0
<i>Oscillatoria</i>	0	0	490	3182	245	685	0	0	0	343	343	343
<i>Phormidium</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphanizomenon</i>	0	0	0	0	685	1	0	0	0	0	735	0
<i>Holopedium</i>	0	1958	0	0	0	0	0	0	0	0	0	0
<i>Aphanothece</i>	0	0	0	0	490	0	0	0	0	0	0	0
Bacillariophyta	16644	15176	25700	24724	16414	11760	122	242	425	6860	8330	6615
Chlorophyta	217348	20809	68044	46762	35989	27176	487	1454	1700	15679	18375	57531
Cyanophyta	143919	43323	628546	92275	569264	79501	2430	0	0	49295	50765	39996
Total	377911	79308	722291	163761	621667	118437	3039	1696	2125	71833	77470	104142

Phytoplankton 5/92
Number/Liter

	TR4			TR5			TR6			TR7		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Cyclotella</i> :	485	2328	970	2037	1261	1746	3234	2619	4268	8148	6499	9118
<i>Cymbella</i>	0	97	0	0	0	0	0	0	0	0	0	0
<i>Melosira</i> :	0	388	97	776	97	194	566	97	679	194	97	291
<i>Navicula</i> :	194	97	97	97	0	0	81	0	97	0	0	0
<i>Nitzschia</i> :	485	970	388	1649	582	970	728	3589	388	2037	1552	2619
<i>Stephanodiscus</i> :	0	97	0	97	0	194	0	194	97	291	194	0
<i>Synedra</i> :	97	97	194	194	97	388	323	291	97	291	388	388
<i>Cocconeis</i> :	0	0	0	0	0	0	0	0	0	0	0	0
<i>Surirella</i> :	0	0	0	0	0	97	81	97	0	0	0	97
<i>Fragellaria</i> :	0	0	0	0	0	194	0	0	0	0	0	0
<i>Gomphonema</i> :	0	0	0	97	0	0	0	0	0	97	0	0
<i>Pinnularia</i> :	0	0	0	0	0	0	0	0	0	0	0	0
<i>Eunotia</i> :	0	0	97	0	0	0	0	0	0	0	194	0
<i>Diatoma</i> :	0	0	0	0	0	0	0	0	0	0	0	0
<i>Rhoicosphenia</i> :	0	0	0	0	0	0	0	0	0	0	0	0
<i>Chlamydomonas</i> :	97	776	194	873	1649	485	728	679	679	970	485	970
<i>Cryptomonas</i> :	485	1067	873	776	97	291	1375	1164	1649	1649	1933	1940
<i>Rhodomonas</i> :	194	97	97	291	776	679	647	388	388	388	194	388
<i>Peridinium</i> :	0	0	0	0	0	0	0	0	0	0	0	97
<i>Euglena</i> :	97	194	291	194	194	291	485	679	97	291	873	0
<i>Phacus</i> :	0	0	0	0	0	0	0	0	0	0	0	0
<i>Trachelomonas</i> :	291	194	0	194	194	97	162	97	0	97	0	97
<i>Pandorina</i> :	0	0	0	1552	0	0	0	0	0	1164	0	0
<i>Carteria</i> :	0	0	97	97	0	0	0	0	97	194	0	0
<i>Dinobryon</i> :	0	0	0	0	0	0	0	0	0	97	0	0
<i>Chilomonas</i> :	0	0	0	0	0	0	0	0	194	0	0	97
<i>Spermatozoopsis</i> :	0	0	0	0	0	0	0	0	97	0	0	0
<i>Gr. flagellate sp.</i> :	0	0	0	97	0	0	0	97	0	0	0	0
<i>Chrysosphaera sp.</i> :	0	97	0	0	0	0	0	0	0	0	0	0
<i>Chromulina</i> :	0	0	0	0	0	0	0	0	0	0	97	0
<i>Ankistrodesmus</i> :	194	388	388	485	388	388	1213	291	970	1552	1067	970
<i>Chlorella</i> :	1261	0	97	0	0	0	809	0	970	0	0	388
<i>Chlorococcum</i> :	0	0	0	0	0	0	0	0	0	485	0	0
<i>Cosmarium</i> :	0	0	97	0	776	0	0	0	0	97	0	0
<i>Crucigenia</i> :	776	1940	776	2328	2716	388	1617	3492	1164	3104	1940	5432
<i>Kirchneriella</i> :	0	388	0	0	0	873	0	0	0	0	0	0
<i>Oocystis</i> :	0	388	388	582	0	0	1941	388	388	388	776	291
<i>Pediastrum</i> :	776	0	1552	0	0	0	1294	0	970	776	485	0
<i>Prolococcus</i> :	0	0	776	0	485	485	0	0	0	0	0	0
<i>Scenedesmus</i> :	1940	582	970	3492	1164	970	1132	2134	1358	2910	4947	4559
<i>Selenastrum</i> :	194	970	776	582	776	485	2102	679	1358	2134	582	2328
<i>Treubaria</i> :	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tetraedron</i> :	0	0	291	0	0	97	0	0	97	0	0	0
<i>Golenkinia</i> :	0	97	97	0	97	0	0	0	0	97	0	97
<i>Schroederia</i> :	0	97	97	0	0	0	0	0	0	194	0	0
<i>Actinastrum</i> :	388	776	0	0	0	0	0	0	0	0	0	0
<i>Tetrastrum</i> :	0	388	0	0	0	388	0	0	388	0	0	0
<i>Cerasterias</i> :	0	0	0	0	0	97	0	0	0	0	0	0
<i>Dictyosphaerium</i> :	0	0	0	0	0	1164	0	0	0	0	0	0
<i>Sphaerocystis</i> :	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dimorphococcus</i> :	0	0	0	0	0	0	0	0	0	0	0	0
<i>Coelastrum</i> :	4074	0	970	0	0	2910	1455	776	0	970	776	776
<i>Closterium</i> :	0	0	0	0	0	97	0	0	97	0	0	97
<i>Closteriopsis</i> :	0	0	97	0	0	97	0	0	0	97	0	194
<i>Elakatothrix</i> :	0	0	0	388	0	0	0	0	0	0	0	0
<i>Chodatella</i> :	291	582	194	0	0	0	647	0	0	0	97	0

Phytoplankton 5/92 (continued)
Number/Liter

	TR4			TR5			TR6			TR7		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Gloeocystis</i> :	0	0	0	0	0	388	0	291	0	0	0	0
<i>Radiococcus</i> :	0	0	0	0	0	0	0	0	388	0	0	0
<i>Eutetramorus</i> :	0	0	0	0	0	0	0	0	0	0	0	0
Paired rectangles:	0	0	0	0	0	0	0	582	970	1358	1261	1746
Cells>5um	0	291	0	97	0	388	0	0	0	0	0	0
Cells<5um	97	291	0	194	0	388	81	582	582	1067	679	1649
Colony cells<5um	0	3880	0	388	0	0	0	0	0	0	0	0
<i>Raphidiopsis</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Anabaena</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Anabaenopsis</i>	0	0	2328	2910	0	0	0	0	0	0	0	0
<i>Aphanocapsa</i>	776	1358	1940	3880	2522	3104	1779	5626	3007	10282	8924	7954
<i>Merismopedia</i>	6208	776	0	0	0	0	3234	0	0	0	0	3104
<i>Coelosphaerium</i>	9603	11543	3783	14647	4462	3104	14474	7760	4850	11931	3395	3880
<i>Microcystis</i>	0	15035	10088	9215	2910	14065	16172	16975	18430	3880	7760	2910
<i>Oscillatoria</i>	2546	404	252	0	1009	0	420	504	706	1009	252	757
<i>Phormidium</i>	0	0	0	0	0	97	0	0	0	0	0	0
<i>Aphanizomenon</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Holopedium</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Aphanothece</i>	0	0	0	0	0	0	0	0	0	0	0	0
Bacillariophyta	1261	4074	1843	4947	2037	3783	5013	6887	5626	11058	8924	12513
Chlorophyta	11155	13483	9118	12610	9312	11446	15688	12319	12901	20079	16192	22116
Cyanophyta	19133	29116	18391	30652	10903	20370	36079	30865	26993	27102	20331	18605
Total	31549	46673	29352	48209	22252	35599	56780	50071	45520	58239	45447	53234

Phytoplankton 8/92
Number/Liter

	TR1			TR2			TR3			TR4
	A	B	C	A	B	C	A	B	C	A
<i>Achnanthes</i>	0	0	0	0	0	0	0	0	0	0
<i>Cyclotella</i>	97	291	194	679	485	485	73	49	121	0
<i>Melosira</i>	0	0	0	194	0	0	0	0	0	10
<i>Navicula</i>	0	0	0	0	0	0	0	0	0	0
<i>Nitzschia</i>	97	485	1261	873	582	291	97	146	121	363
<i>Stephanodiscus</i>	0	0	0	97	0	0	0	0	0	0
<i>Synedra</i>	97	97	0	97	97	97	97	0	97	10
<i>Surirella</i>	0	0	0	0	0	0	0	0	0	0
<i>Gomphonema</i>	0	0	0	0	0	0	0	0	0	0
<i>Gyrosigma</i>	0	0	0	0	0	0	0	0	0	10
<i>Pinnularia</i>	0	0	0	0	97	97	0	0	0	0
<i>Eunotia</i>	0	0	0	97	0	0	0	0	0	0
<i>Chlamydomonas</i>	97	291	485	679	776	485	170	194	534	62
<i>Cryptomonas</i>	194	679	2328	1649	1843	873	582	461	412	532
<i>Rhodomonas</i>	194	291	0	679	679	873	73	170	0	1358
<i>Peridinium</i>	0	0	679	0	194	291	0	49	0	10
<i>Euglena</i>	97	0	281	194	0	0	24	49	73	93
<i>Phacus</i>	0	0	0	0	0	97	0	0	24	0
<i>Trachelomonas</i>	0	97	0	0	97	388	24	49	97	10
<i>Pandorina</i>	0	0	0	0	0	0	388	0	194	41
<i>Eudorina</i>	0	0	0	0	0	0	0	0	0	165
<i>Carteria</i>	0	0	97	0	0	0	0	0	0	0
<i>Phacotus</i>	0	0	0	0	97	194	0	0	0	0
<i>Spermatozoopsis</i>	0	0	0	97	0	194	73	0	73	0
<i>Chrysosphaerella</i>	0	0	0	0	0	0	0	0	0	21
<i>Ankistrodesmus</i>	194	388	485	1358	1552	776	437	267	364	51
<i>Chlorella</i>	0	0	0	0	0	0	0	0	0	0
<i>Chlorococcum</i>	1940	0	0	0	0	0	0	0	0	0
<i>Closterium</i>	0	0	0	97	0	0	0	0	0	0
<i>Closteriopsis</i>	0	0	0	0	0	0	0	0	0	0
<i>Cosmarium</i>	0	0	194	0	0	0	24	0	0	0
<i>Crucigenia</i>	388	3104	2328	1552	3492	1164	194	388	776	123
<i>Kirchneriella</i>	0	776	0	776	873	388	0	73	170	0
<i>Oocystis</i>	0	388	281	388	0	388	0	0	0	0
<i>Pediastrum</i>	0	1552	776	776	776	0	0	1747	194	165
<i>Protococcus</i>	0	0	0	0	0	0	0	0	0	0
<i>Scenedesmus</i>	776	582	2328	1552	1358	2716	1261	1262	1189	988
<i>Selenastrum</i>	97	776	970	1552	3686	1067	315	243	1698	858
<i>Tetraedron</i>	0	0	0	0	0	0	24	24	49	10
<i>Golenkinia</i>	0	0	0	97	0	194	24	0	24	97
<i>Chodatella</i>	0	97	0	0	0	97	0	24	0	0
<i>Schroederia</i>	0	0	0	0	0	0	24	24	0	0
<i>Coelastrum</i>	0	0	0	0	0	0	0	194	776	0
<i>Actinastrum</i>	485	0	0	0	0	679	0	0	194	82
<i>Micractinium</i>	0	0	0	0	0	0	0	0	0	0
<i>Tetrastrum</i>	0	0	0	0	0	0	0	0	0	0
<i>Dimorphococcus</i>	0	2231	3298	0	0	0	0	0	0	0
<i>Dictyosphaerium</i>	485	0	0	5044	3298	6790	194	728	509	185
<i>Gloeocystis</i>	0	0	3880	970	4268	3880	0	0	1940	0
<i>Pleurotaenium</i>	0	0	0	0	0	0	0	0	0	0
<i>Tetrastrum</i>	0	0	0	0	0	0	0	0	0	0
<i>Dimorphococcus</i>	0	2231	3298	0	0	0	0	0	0	0
<i>Dictyosphaerium</i>	485	0	0	5044	3298	6790	194	728	509	185
<i>Gloeocystis</i>	0	0	3880	970	4268	3880	0	0	1940	0

Phytoplankton 8/92 (continued)
Number/Liter

	TR1			TR2			TR3			TR4
	A	B	C	A	B	C	A	B	C	A
<i>Pleurotaenium</i>	0	0	0	0	0	0	0	0	0	0
<i>Dispora</i>	0	0	0	0	0	0	0	0	194	0
Gr. frm TR 4d	0	0	0	0	0	0	0	0	0	0
Cells<5um	291	291	291	776	582	194	0	0	0	41
<i>Raphidiopsis</i>	0	582	388	0	97	0	0	0	49	0
<i>Anabaena</i>	0	0	0	0	291	0	0	194	0	0
<i>Aphanocapsa</i>	970	42195	7760	1164	9215	9118	194	1480	5774	0
<i>Chroococcus</i>	0	7566	582	8924	1940	1358	0	97	388	0
<i>Merismopedia</i>	0	3104	1552	13192	15714	9312	1941	1747	2135	247
<i>Coelosphaerium</i>	1940	12610	0	0	0	776	0	0	490	0
<i>Microcystis</i>	8730	33465	66930	69355	48015	43165	9339	19165	10212	2006
<i>Oscillatoria</i>	0	0	0	0	0	0	593	0	419	247
<i>Phormidium</i>	1785	3880	2150	3814	2037	1389	0	290	0	0
<i>Aphanezomenon</i>	0	0	0	0	0	0	0	0	0	0
<i>Gomphosphaeria</i>	0	0	1164	0	0	0	0	0	0	0
Strand, paired cells	1552	0	1164	0	0	0	0	0	0	0
<i>Aphanothece</i>	0	0	0	0	0	0	0	0	0	0
<i>Gloeotheca</i>	0	0	0	0	0	0	0	364	0	0
Bacillariophyta	291	873	1455	2037	1261	970	267	195	339	393
Chlorophyta	5723	13774	25879	24250	31137	32398	4025	6674	11933	5077
Cyanophyta	14977	103402	81690	96449	77309	65118	12067	23337	19467	2500
Total	20991	118049	109024	122736	109707	98486	16359	30206	31739	7970

Phytoplankton 8/92 (continued)
Number/Liter

	TR4		TR5			TR6			TR7		
	B	C	A	B	C	A	B	C	A	B	C
<i>Achnanthes</i>	97	0	0	0	0	0	0	0	0	0	54
<i>Cyclotella</i>	97	194	97	194	146	291	97	146	194	218	269
<i>Melosira</i>	0	0	0	0	0	0	49	0	0	97	108
<i>Navicula</i>	0	0	49	0	0	0	0	0	0	0	0
<i>Nitzschia</i>	485	97	437	534	679	679	437	631	1067	776	970
<i>Stephanodiscus</i>	0	0	0	0	0	0	0	49	0	24	0
<i>Synedra</i>	0	0	0	0	0	0	49	0	97	24	0
<i>Surirella</i>	0	0	0	0	0	0	0	0	97	24	1
<i>Gomphonema</i>	0	0	0	0	97	0	0	49	0	0	0
<i>Gyrosigma</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Pinnularia</i>	0	0	0	0	0	97	0	0	0	24	54
<i>Eunotia</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Chlamydomonas</i>	485	388	146	49	388	485	388	388	1455	412	701
<i>Cryptomonas</i>	679	873	437	243	485	776	1940	1019	1358	922	1455
<i>Rhodomonas</i>	1164	485	582	194	146	679	534	243	388	170	701
<i>Peridinium</i>	97	0	49	0	0	97	388	0	97	0	54
<i>Euglena</i>	0	194	0	146	146	97	0	97	97	49	54
<i>Phacus</i>	0	0	49	0	0	0	0	0	0	1	0
<i>Trachelomonas</i>	0	0	0	97	194	194	49	49	0	73	269
<i>Pandorina</i>	0	0	0	0	0	0	0	776	0	0	0
<i>Eudorina</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Carteria</i>	0	0	0	0	0	0	0	0	0	24	54
<i>Phacotus</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Spermatozoopsis</i>	0	0	0	97	97	0	0	49	0	24	0
<i>Chrysotagellate</i>	0	0	0	0	0	194	0	0	0	0	0
<i>Ankistrodesmus</i>	388	194	388	485	243	485	0	97	776	243	647
<i>Chlorella</i>	0	0	194	0	0	0	0	0	0	0	0
<i>Chlorococcum</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Closterium</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Closteriopsis</i>	0	0	49	0	0	0	0	0	0	0	0
<i>Cosmarium</i>	291	97	0	0	0	97	0	0	0	24	54
<i>Crucigenia</i>	1164	1552	388	388	1552	1164	388	0	1940	291	431
<i>Kirchneriella</i>	0	0	194	0	0	0	0	0	194	0	0
<i>Oocystis</i>	0	0	0	0	485	776	0	0	0	0	108
<i>Pediastrum</i>	1552	0	194	0	0	0	0	0	0	0	0
<i>Protococcus</i>	388	0	0	0	0	0	0	0	0	364364	0
<i>Scenedesmus</i>	2522	1164	97	194	0	388	194	194	1261	534	970
<i>Selenastrum</i>	291	776	243	873	146	970	728	340	291	917	1347
<i>Tetraedron</i>	291	97	49	49	97	97	97	0	97	97	0
<i>Golenkinia</i>	97	194	0	0	49	0	0	0	0	0	0
<i>Chodatella</i>	0	0	49	0	0	0	0	0	0	0	0
<i>Schroederia</i>	0	0	0	0	0	97	0	49	97	0	54
<i>Coelastrum</i>	970	1164	0	0	0	0	0	0	0	388	1293
<i>Actinastrum</i>	0	0	0	0	0	0	0	0	0	121	431
<i>Micractinium</i>	0	0	0	0	0	0	0	0	194	49	0
<i>Tetrastrum</i>	388	0	0	0	0	0	0	0	0	0	0
<i>Dimorphococcus</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Dictyosphaerium</i>	1164	1552	0	0	194	1358	388	388	776	1067	754
<i>Gloeocystis</i>	2910	0	0	0	970	0	0	3880	4850	485	970
<i>Pleurotaenium</i>	0	97	0	0	0	0	0	0	0	0	0
<i>Tetrastrum</i>	388	0	0	0	0	0	0	0	0	0	0
<i>Dimorphococcus</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Dictyosphaerium</i>	1164	1552	0	0	194	1358	388	388	776	1067	754
<i>Gloeocystis</i>	2910	0	0	0	970	0	0	3880	4850	485	970

Phytoplankton 8/92 (continued)
Number/Liter

	TR4		TR5		TR6			TR7				
	B	C	A	B	C	A	B	C	A	B	C	
<i>Pleurotaenium</i>	0	97	0	0	0	0	0	0	0	0	0	
<i>Dispora</i>	0	0	0	0	0	0	0	0	0	0	0	
Gr. frm TR4C	0	388	0	0	0	0	0	0	0	0	0	
Cells<5um	0	0	49	0	679	97	243	49	291	243	808	
<i>Raphidiopsis</i>	194	194	0	49	0	0	0	0	0	0	0	
<i>Anabaena</i>	0	0	0	49	0	1940	679	0	0	97	0	
<i>Aphanocapsa</i>	0	776	485	4559	0	970	194	0	776	0	216	
<i>Chroococcus</i>	0	582	582	776	0	0	97	97	0	49	0	
<i>Merismopedia</i>	6208	7760	0	3880	1940	1552	388	5917	4656	194	862	
<i>Coelosphaerium</i>	0	0	0	0	0	0	2231	0	0	0	0	
<i>Microcystis</i>	21825	5335	5578	18682	8245	30940	6548	3982	5820	5216	9161	
<i>Oscillatoria</i>	1211	532	504	386	1940	252	0	97	652	101	0	
<i>Phormidium</i>	0	0	0	446	0	0	227	0	0	0	3503	
<i>Aphanizomenon</i>	97	0	0	0	0	0	0	0	0	0	0	
<i>Gomphosphaeria</i>	0	0	0	0	0	0	0	0	0	0	0	
Strand, paired cells	0	0	0	0	0	0	0	0	0	0	0	
<i>Aphanothece</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Gloeotheca</i>	0	0	0	0	0	0	0	0	0	0	0	
Bacillariophyta	679	291	583	728	922	1067	632	875	1455	1187	1456	
Chlorophyta	19303	10864	3157	2815	7035	9409	5725	11886	19788	372051	12879	
Cyanophyta	29535	15179	7149	28827	12125	35654	10364	10093	11904	5657	13742	
Total	49517	26334	10889	32370	20082	46130	16721	22854	33147	378895	28077	

Periphyton 9/90
Number/mm2

	TR1		TR2		TR3		TR4		TR5		TR6		TR7	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
<i>Achnanthes</i>	0	0	0	11	0	0	0	0	0	45	364	302	205	
<i>Caloneis</i>	0	6	0	22	0	0	0	0	0	0	0	0	0	0
<i>Cyclotella</i>	17	6	20	11	0	0	0	0	0	0	11	0	0	0
<i>Cymbella</i>	17	24	10	11	0	0	0	0	0	0	0	0	0	0
<i>Gomphonema</i>	176	186	29	11	0	0	0	0	693	3661	492	551	130	
<i>Gyrosigma</i>	17	24	0	0	0	0	0	0	0	0	0	0	0	0
<i>Melosira</i>	0	0	0	11	0	0	0	0	0	0	0	0	0	0
<i>Navicula</i>	176	216	49	313	0	0	0	0	987	2758	1424	498	195	
<i>Nitzschia</i>	1050	660	1537	1406	0	0	330	554	441	1039	470	357	216	
<i>Pinnularia</i>	0	6	0	22	0	0	47	0	0	90	0	0	0	0
<i>Rhopalodia</i>	8	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Surirella</i>	0	0	0	0	0	0	0	0	0	0	0	43	0	0
<i>Synedra</i>	0	0	0	11	0	0	0	0	0	0	0	0	0	0
<i>Ankistrodesmus</i>	0	0	20	22	18962	9972	26894	22150	5124	2305	364	227	130	
<i>Cosmarium</i>	25	24	10	22	0	0	0	0	0	0	0	0	0	0
<i>Crucigenia</i>	0	0	0	43	0	0	0	0	0	0	0	0	0	0
<i>Characium</i>	0	0	0	0	0	0	0	0	0	0	0	2408	2581	
<i>Closterium</i>	0	0	0	0	0	0	0	0	0	0	0	11	11	
<i>Dydimocystis</i>	34	0	0	22	0	0	0	0	0	0	0	0	0	0
<i>Gloeocystis</i>	0	0	0	173	0	0	0	0	0	0	0	0	0	0
<i>Mougeotia</i>	0	0	0	11	0	0	0	0	0	0	0	0	0	0
<i>Monoraphidium</i>	0	0	0	22	0	0	0	0	0	0	0	0	0	0
<i>Oedogonium</i>	0	18	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pediastrum</i>	0	0	68	216	0	0	0	0	0	0	0	0	0	0
<i>Pseudovella</i>	0	0	0	0	0	0	0	0	0	746	0	0	0	0
<i>Scenedesmus</i>	84	78	211	86	0	0	0	106	0	90	0	0	0	0
<i>Sphaerocystis</i>	0	0	0	86	0	0	0	0	0	0	0	0	0	0
<i>Tetraedron</i>	0	0	0	11	0	0	0	0	0	0	0	0	0	0
Cells<5um	92	24	240	151	129	288	659	502	504	407	802	324	54	
Cells>5um	84	102	240	162	0	0	0	0	609	565	180	54	140	
<i>Anabaena</i>	0	6	10	22	0	0	0	0	0	0	0	0	0	0
<i>Aphanocapsa</i>	0	0	0	648	0	0	0	0	630	0	0	0	0	0
<i>Chaemaesiphon</i>	0	0	0	0	0	0	0	0	0	0	0	810	2020	
<i>Chroococcus</i>	0	0	173	86	0	144	0	0	0	452	0	0	0	0
<i>Merismopedia</i>	0	0	0	173	0	0	0	0	0	181	171	0	0	0
<i>Microcystis</i>	706	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Oscillatoria</i>	25	24	0	0	0	0	0	0	0	0	75	0	0	0
<i>Phormidium</i>	244	78	480	303	0	0	0	0	42	271	96	76	43	
<i>Lyngbya</i>	0	120	297	346	0	0	0	0	0	0	0	0	0	0
<i>Cryptomonas</i>	17	6	10	0	0	0	0	0	0	0	0	0	0	0
<i>Euglena</i>	0	6	0	0	0	0	0	0	0	0	0	11	0	0
<i>Strombomonas</i>	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Cells<5um	84	24	144	119	0	0	141	0	420	723	813	410	0	
Chrysotagellate	8	0	0	0	0	0	0	0	0	0	0	0	0	0
Coccolid chrysococcus	0	0	19	0	214	0	0	26	0	0	0	0	0	0
Bacillariophyta	1461	1128	1645	1829	0	0	377	554	2121	7593	2761	1751	746	
Chlorophyta	319	246	789	1027	19091	10260	27553	22758	6237	4113	1326	3024	2916	
Cyanophyta	1076	270	1114	1697	0	144	141	0	1092	1627	1155	1307	2063	
Total	2864	1644	3567	4553	19305	10404	28071	23338	9450	13333	5242	6082	5725	

Periphyton 5/91
Number/mm2

	TR1		TR2		TR4		TR5		TR6	TR7
	A	B	A	B	A	B	A	B	A	A
<i>Achnanthes</i>	47	37	56	19	5	3	1	1	61	10
<i>Cyclotella</i>	22	15	5	4	3	4	1	2	19	7
<i>Cymbella</i>	7	15	23	4	5	3	1	1	23	3
<i>Melosira</i>	4	0	35	0	8	5	0	0	6	0
<i>Navicula</i>	528	372	347	508	169	215	50	41	167	736
<i>Nitzschia</i>	132	85	96	140	58	106	28	18	6	47
<i>Stephanodiscus</i>	0	0	0	0	0	0	0	0	0	0
<i>Synedra</i>	4	0	6	0	3	5	1	1	0	4
<i>Surirella</i>	11	4	8	0	1	0	0	1	3	0
<i>Eunotia</i>	4	2	0	12	1	0	0	0	0	0
<i>Gomphonema</i>	130	82	219	159	20	33	8	5	6	10
<i>Gyrosigma</i>	4	4	23	0	0	0	0	2	6	0
<i>Pinnularia</i>	29	4	0	4	0	3	0	1	6	3
<i>Amphora</i>	40	9	5	0	3	4	0	1	13	5
<i>Cocconeis</i>	11	2	21	54	1	0	0	0	0	10
<i>Ooscinodiscus</i>	0	0	0	0	0	0	0	0	0	0
<i>Rhoicosphenia</i>	0	0	3	0	0	0	0	0	0	0
<i>Cryptomonas</i>	9	7	12	0	0	0	0	0	3	12
<i>Rhodomonas</i>	0	0	0	0	0	6	0	11	0	8
<i>Chlamydomonas</i>	0	7	6	0	0	0	3	4	0	24
<i>Euglena</i>	0	7	0	0	0	0	0	0	0	0
<i>Trachelomonas</i>	0	0	0	0	0	6	0	0	0	0
<i>Pandorina</i>	0	0	0	0	0	0	0	0	0	32
<i>Ankistrodesmus</i>	9	7	0	0	0	0	0	0	0	0
<i>Chlorella</i>	0	0	0	0	0	0	0	38	0	0
<i>Cosmarium</i>	0	0	23	0	13	6	3	4	3	0
<i>Closterium</i>	0	7	0	0	0	0	0	4	0	0
<i>Desmidiium</i>	0	0	0	0	81	0	0	0	0	0
<i>Kirschneriella</i>	0	0	0	0	0	0	15	0	0	0
<i>Oocystis</i>	0	21	0	0	0	0	0	0	0	0
<i>Pediastrum</i>	0	0	0	124	0	0	0	0	0	0
<i>Protococcus</i>	0	0	158	0	0	0	0	0	0	0
<i>Protoderma</i>	0	720	0	0	0	0	0	282	0	0
<i>Scenedesmus</i>	0	0	0	0	0	23	0	0	0	4
<i>Staurastrum</i>	0	0	0	0	13	0	0	0	0	0
<i>Tetraedron</i>	0	0	0	0	0	6	0	0	0	0
<i>Treubaria</i>	0	0	18	0	13	0	27	8	16	32
<i>Tribonema</i>	0	0	0	0	25	0	0	0	0	0
<i>Pseudovellum</i>	0	1246	0	0	0	0	0	0	0	0
<i>Chaetophora</i>	0	0	0	0	0	266	0	0	0	0
<i>Characium</i>	0	0	0	0	0	0	0	0	0	0
<i>Clostridium</i>	0	9	0	0	0	0	0	0	0	0
<i>Rhizoclonium</i>	9	0	575	0	71	0	0	0	0	0
<i>Selenastrum</i>	0	7	0	0	19	11	0	0	0	0
Cells<5um	0	7	112	0	95	91	165	8	6	0
Cells>5um	0	70	6	0	64	0	60	11	35	0
<i>Oscillatoria</i>	0	0	0	0	10	35	12	8	6	79
<i>Phormidium</i>	0	193	47	65	10	55	0	7	0	0
<i>Microcystis</i>	0	0	0	0	0	0	0	0	0	0
<i>Chaemaesiphon</i>	0	0	178	0	0	0	0	0	0	0
<i>Coelastphaerium</i>	0	0	270	0	0	0	0	0	48	0
Bacillariophyta	973	631	848	904	277	381	90	74	316	835
Chlorophyta	27	2115	910	124	394	415	273	370	64	112
Cyanophyta	0	193	495	65	20	90	12	15	54	79
Total	1000	2939	2253	1093	692	886	375	459	433	1026

Periphyton 9/91
Number/mm2

	TR1	TR2		TR3		TR4		TR5		TR6	TR7
	A	A	B	A	B	A	B	A	B	A	A
<i>Achnanthes</i>	0	0	14	1	2	6	2	34	413	288	79
<i>Amphora</i>	0	0	0	1	0	45	0	11	0	0	0
<i>Bipulphia</i>	0	0	0	0	0	0	0	0	3	14	47
<i>Cocconeis</i>	8	6	35	8	19	45	413	789	3358	119	947
<i>Cyclotella</i>	61	3	7	2	2	45	34	57	8	18	0
<i>Cymbella</i>	0	0	0	1	4	6	19	0	3	0	4
<i>Desmogonium</i>	0	0	2	2	0	6	0	0	0	0	0
<i>Eunotia</i>	0	0	0	0	0	375	386	286	42	0	108
<i>Gomphonema</i>	23	18	21	9	60	910	246	17	22	0	7
<i>Gyrosigma</i>	30	3	2	1	0	0	7	11	3	5	7
<i>Melosira</i>	0	0	2	1	0	0	13	11	3	27	7
<i>Navicula</i>	175	44	74	15	26	279	166	566	288	87	520
<i>Nitzschia</i>	46	9	28	30	42	427	127	606	299	128	286
<i>Pinnularia</i>	8	0	2	1	1	6	33	57	8	5	0
<i>Rhoicosphenia</i>	0	0	0	3	0	0	0	0	0	0	0
<i>Rhopalodia</i>	0	0	0	0	0	0	3	11	0	0	0
<i>Stephanodiscus</i>	0	0	0	0	0	6	0	0	0	0	0
<i>Surirella</i>	0	0	0	0	0	0	7	23	14	0	8
<i>Stauroneis</i>	0	0	0	2	0	0	0	0	0	0	0
<i>Synedra</i>	8	0	2	1	0	0	7	40	36	5	22
<i>Cryptomonas</i>	8	0	2	0	0	6	0	0	0	0	0
<i>Rhodomonas</i>	0	0	5	0	2	0	0	12	0	5	0
<i>Euglena</i>	15	3	0	0	0	6	0	17	0	0	0
<i>Trachelomonas</i>	15	12	0	0	0	0	0	0	3	0	0
<i>Haematococcus</i>	0	3	0	0	0	0	0	0	0	0	0
<i>Chlamydomonas</i>	15	6	7	2	2	12	0	23	5	5	0
<i>Ankistrodesmus</i>	8	0	0	5	4	17	0	23	5	0	0
<i>Chaetophora</i>	0	0	0	0	0	267	546	9327	0	0	150000
<i>Chaetophora</i> sp. #2	0	0	0	0	0	0	0	0	0	0	3450
<i>Chaetophora</i> sp. #3	0	0	0	0	0	0	0	0	0	0	3100
<i>Characium</i>	0	18	0	0	0	0	0	0	5	78	7
<i>Chlorella</i>	0	0	0	0	0	6	0	0	0	0	0
<i>Closterium</i>	0	0	2	0	0	0	3	6	3	0	4
<i>Cosmarium</i>	0	3	0	0	0	28	19	17	5	0	0
<i>Crucigenia</i>	0	0	0	0	0	6	0	0	0	0	0
<i>Hyalotheca</i>	0	58	0	0	0	0	0	0	0	0	0
<i>Oedogonium</i>	0	0	0	0	0	0	33	0	0	0	0
<i>Oedocladium</i>	0	0	0	0	0	0	0	435	0	0	0
<i>Oocystis</i>	0	0	0	0	0	0	0	0	11	0	0
<i>Pediastrum</i>	0	0	0	0	0	0	107	0	0	0	0
<i>Raphidoneima</i>	0	0	0	0	0	17	0	0	0	0	0
<i>Scenedesmus</i>	23	15	0	2	0	0	0	46	11	0	0
<i>Schroederia</i>	0	0	2	0	0	0	0	0	0	0	0
<i>Selenastrum</i>	0	0	0	36	78	375	0	63	0	0	0
<i>Spirotaenia</i>	0	0	0	0	0	0	0	11	0	0	0
<i>Tetraedron</i>	38	12	25	7	8	11	7	0	0	0	0
Cells<5um	0	0	0	7	6	63	0	0	0	0	0
Cells>5um	0	9	0	5	0	0	0	0	0	0	0
Unknown filament	297	0	0	0	0	0	0	0	0	0	0
<i>Anabaena</i>	0	23	0	0	0	0	0	46	0	0	0

Periphyton 9/91
Number/mm2

	TR1	TR2		TR3		TR4		TR5		TR6	TR7
	A	A	B	A	B	A	B	A	B	A	A
<i>Aphanizomenon</i>	0	1	0	0	0	0	0	0	0	0	0
<i>Chroococcus</i>	0	0	27	34	24	0	0	0	0	0	0
<i>Merismopedium</i>	182	46	46	0	0	0	0	0	0	0	0
<i>Lyngbya</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Oscillatoria</i>	459	19	18	34	2	50	3	0	124	0	41
<i>Phormidium</i>	0	0	14	0	0	0	4	3	62	9	0
<i>Raphidiopsis</i>	0	3	12	0	0	0	13	0	0	0	7
Bacillariophyta	359	83	189	78	156	2156	1463	2519	4500	696	2042
Chlorophyta	419	139	43	64	100	814	715	9980	48	88	156561
Cyanophyta	641	92	117	68	26	50	20	49	186	9	48
Total	1419	314	349	210	282	3020	2198	12548	4734	793	158651

Periphyton 4/92
Number/mm2

	TR1		TR2	TR3	TR4		TR5		TR6		
	A	B	A	A	B	A	B	A	B	A	B
<i>Achnanthes</i>	9	267	4	10	2	1	1	7	80	68	10
<i>Amphora</i>	2	0	0	0	0	0	0	0	1	0	2
<i>Caloneis</i>	0	0	0	0	0	0	0	0	0	2	0
<i>Cocconeis</i>	20	6	1	0	1	1	0	4	55	31	23
<i>Cyclotella</i>	22	6	10	3	2	3	1	18	17	15	24
<i>Coscinodiscus</i>	0	0	1	0	0	0	0	0	0	0	2
<i>Cymbella</i>	16	43	2	1	1	0	1	0	3	2	5
<i>Eunotia</i>	25	117	3	2	1	1	1	0	0	0	25
<i>Gomphonema</i>	5	56	1	3	1	4	1	58	91	317	285
<i>Gyrosigma</i>	0	4	0	0	0	0	0	0	0	2	0
<i>Melosira</i>	22	11	4	1	1	1	1	8	0	3	16
<i>Navicula</i>	204	220	9	5	9	9	12	165	171	176	170
<i>Nitzschia</i>	39	36	6	2	5	5	5	36	36	45	35
<i>Stauroneis</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Stephanodiscus</i>	2	0	0	0	0	0	0	0	0	0	0
<i>Surirella</i>	3	0	0	0	0	0	0	1	1	0	3
<i>Synedra</i>	11	4	0	0	0	0	1	4	1	2	0
<i>Pinnularia</i>	5	0	1	0	0	0	0	1	1	0	0
<i>Rhoicosphenia</i>	13	13	1	1	0	0	0	2	2	3	3
<i>Chlorella</i>	5	0	0	0	0	0	0	0	0	0	0
<i>Chodatella</i>	0	0	0	0	7	0	0	0	0	0	0
<i>Characium</i>	24	107	58	1	51	184	0	448	504	757	676
<i>Closterium</i>	0	0	4	0	0	0	0	0	0	0	0
<i>Cosmarium</i>	0	18	0	0	0	0	0	0	0	0	0
<i>Crucigenia</i>	0	0	4	0	0	0	0	5	0	0	0
<i>Oocystis</i>	0	0	0	0	0	0	0	18	0	0	0
<i>Rhizoclonium</i>	0	0	0	0	0	0	0	0	46698	0	0
<i>Selenastrum</i>	34	0	4	0	0	9	0	9	0	0	0
<i>Scenedesmus</i>	5	9	0	0	0	0	0	0	0	0	0
<i>Protococcus</i>	0	0	0	0	0	0	0	0	5	49	0
<i>Protoderma</i>	97	179	0	0	0	87	0	1462	1646	977	596
<i>Tetraedron</i>	19	9	4	0	0	4	0	0	0	0	0
<i>Chlamydomonas</i>	24	9	0	0	0	4	1	9	0	24	10
<i>Cryptomonas</i>	10	9	4	0	0	0	0	5	0	5	10
<i>Rhodomonas</i>	0	9	0	0	0	4	5	0	10	5	0
<i>Trachelomonas</i>	10	18	0	0	0	0	0	9	0	5	5
<i>Raphidhiop</i>	5	0	0	0	0	0	0	0	0	0	0
<i>Aphanocapsa</i>	97	0	0	0	0	0	0	0	0	0	0
<i>Coelaspherium</i>	0	0	0	0	0	0	0	0	484	0	0
<i>Anabaena</i>	49	179	0	0	0	4	0	0	0	49	0
<i>Oscillatoria</i>	19	9	4	5	0	73	0	5	73440	0	5
Bacillariophyta	398	783	46	28	22	25	24	305	457	666	603
Chlorophyta	228	367	78	1	58	292	6	1965	48863	1822	1297
Cyanophyta	170	188	4	5	0	77	0	5	73924	49	5
Total	796	1338	127	34	80	395	30	2275	123244	2537	1905

Periphyton 8/92
Number/mm2

	TR1		TR2		TR3		TR4		TR5		TR6	TR7
	A	B	A	A	B	A	B	A	A	A	A	
<i>Achnanthes</i>	0	0	0	0	0	0	2	9	131	18		
<i>Amphora</i>	0	0	0	0	0	0	0	0	2	2		
<i>Cocconeis</i>	0	0	0	4	0	5	14	12	46	115		
<i>Cyclotella</i>	8	7	4	0	0	2	0	15	9	4		
<i>Cymbella</i>	0	7	2	0	2	0	0	9	2	2		
<i>Eunotia</i>	0	0	0	24	9	14	34	7	23	12		
<i>Gomphonema</i>	0	3	4	8	0	47	86	43	142	175		
<i>Gyrosigma</i>	8	10	2	2	0	0	2	10	5	0		
<i>Melosira</i>	0	0	6	0	0	0	0	0	0	0		
<i>Navicula</i>	104	88	23	20	6	59	38	190	80	113		
<i>Nitzschia</i>	348	193	112	28	15	88	50	403	188	185		
<i>Stephanodiscus</i>	0	0	0	0	0	0	0	0	0	0		
<i>Surirella</i>	4	0	0	2	0	0	0	0	2	2		
<i>Synedra</i>	31	26	0	0	0	0	0	0	4	0		
<i>Pinnularia</i>	0	3	0	0	0	0	0	17	2	17		
<i>Ankistrodesmus</i>	3	0	0	0	0	0	2	46	5	0		
<i>Chlorella</i>	49	39	33	0	0	0	0	0	0	0		
<i>Chaetophora</i> sp. #1	0	0	0	125	98	126	74	256	404	257		
<i>Chaetophora</i> sp. #2	0	0	0	0	0	0	870	227	0	0		
<i>Characium</i>	0	0	0	6	6	77	45	7	110	74		
<i>Closterium</i>	0	0	0	0	0	0	0	2	0	0		
<i>Cosmarium</i>	0	0	0	0	0	0	0	3	7	0		
<i>Crucigenia</i>	0	0	0	0	0	0	9	0	0	0		
<i>Pediastrum</i>	23	155	0	0	0	0	0	0	0	0		
<i>Selenastrum</i>	3	0	0	0	0	0	0	0	5	0		
<i>Scenedesmus</i>	65	155	70	28	16	23	5	10	7	8		
<i>Dimorpho</i>	0	0	44	0	0	0	0	0	0	0		
<i>Xanthidium</i>	0	0	0	0	2	0	0	0	0	0		
<i>Tetraedron</i>	0	0	0	0	0	0	0	0	0	0		
Unknown	0	0	0	0	0	0	0	0	7	46		
<i>Chlamydomonas</i>	0	0	0	0	0	0	0	0	0	2		
<i>Euglena</i>	0	0	0	0	0	0	0	0	2	0		
<i>Trachelomonas</i>	0	3	0	0	0	0	0	0	0	0		
<i>Pandorina</i>	0	39	0	0	0	0	0	0	0	0		
<i>Raphidiod</i>	10	23	2	0	4	7	2	3	2	2		
<i>Aphanocapsa</i>	0	0	0	0	12	0	0	0	0	0		
<i>Merismopedia</i>	0	0	0	0	0	0	0	0	0	0		
<i>Oscillatoria</i>	136	279	15	7	16	21	39	27	19	94		
<i>Phormidium</i>	393	202	71	0	6	6	2	3	22	5		
<i>Chaemaesiphon</i>	0	0	0	0	0	0	0	0	0	117		
Bacillariophyta	503	337	153	88	32	215	226	715	636	645		
Chlorophyta	143	391	147	159	122	226	1005	551	547	387		
Cyanophyta	539	504	88	7	38	34	43	33	43	218		
Total	1185	1232	388	254	192	475	1274	1299	1226	1250		

Zooplankton 9/90
Number/Liter

	TR1	TR2	TR3	TR4	TR5	TR6	TR7
<i>Arcella</i>	0	0	216	30	0	24	0
<i>Centropyxis</i>	0	0	0	0	36	8	9
<i>Cyclidium</i>	1236	540	1032	0	172	16	416
Ciliate #4	515	810	0	0	172	0	256
<i>Ciliate sp.</i>	103	0	48	15	12	16	27
<i>Codonella</i>	0	0	0	0	0	16	0
<i>Didinium</i>	0	0	258	0	0	0	0
<i>Diffugia</i>	48	40	0	105	60	432	153
<i>Euglypha</i>	0	0	0	0	0	8	0
<i>Holophyrid ciliate</i>	0	0	0	0	0	24	0
<i>Mesodinium</i>	0	0	0	0	0	54	0
<i>Strombidium</i>	1545	162	258	0	344	108	0
<i>Tintinnopsis</i>	336	272	240	75	0	8	36
<i>Vorticella</i>	1344	752	1776	1545	444	168	306
<i>Anuraeopsis</i>	96	0	0	0	0	0	0
<i>Asplanchna</i>	0	0	0	0	12	0	0
<i>Brachionus</i>	0	0	0	0	12	0	0
<i>Colurella</i>	0	0	0	15	0	24	9
<i>Conochilus</i>	0	0	48	0	0	0	0
<i>Keratella</i>	0	0	0	0	0	0	0
<i>Lepadella</i>	0	0	120	0	0	0	0
<i>Lecane</i>	0	0	216	270	72	24	0
<i>Monostyla</i>	0	8	884	390	156	88	0
<i>Notommata</i>	240	16	72	75	0	8	0
<i>Polyarthra</i>	0	0	24	0	0	0	0
<i>Trichocerca</i>	120	0	336	150	72	24	0
<i>Synchaeta</i>	0	0	192	15	0	0	0
Rotifer #1	0	0	264	465	0	0	0
Rotifer sp.	0	24	552	0	240	104	45
Cyclo. Copepodite	0	2.4	0	0	0.8	0	0
Nauplii	1.8	3	0.2	0	2.8	0.8	1
Protozoa	5127	2576	3828	1770	1240	882	1203
Rotifera	456	48	2708	1380	564	272	54
Crustacea	1.8	5.4	0.2	0	3.6	0.8	1

Highlighted taxa are rotifers. Only one sample from each site was collected on this date.

Zooplankton 5/91
Number/Liter

	TR1			TR2			EFF			TR3		
	A	B	C	A	B	C	A	B	C	A	B	C
Arcella	0	14	F	33	11	0	17	31	7	28	0	33
Centropyxis	6	0	U	0	0	0	17	0	0	71	0	0
Diffugia	19	173	N	0	34	36	17	10	0	71	0	33
Lesquereusia	0	0	G	0	6	0	3	0	0	0	0	0
Codonella	0	0	U	0	0	0	0	0	0	0	0	42
Tintinnopsis	74	0	S	66	0	29	0	0	0	183	157	145
Tintinnidium	6	0		0	0	0	0	0	0	0	0	0
Strombidium	25	14		17	0	7	0	0	3	0	17	19
Strombilidium	0	0		0	0	0	0	5	0	0	0	5
Holophyrid ciliate	0	0		0	0	0	0	0	0	0	0	19
Epistylus	0	0		0	0	0	123	343	140	357	70	247
Vorticella	6	0		0	0	7	23	0	0	0	17	23
Suctatoria sp. #1	6	0		17	0	7	0	0	0	0	0	9
Suctatoria sp. #2	0	0		0	0	0	0	0	0	0	0	5
Cyclidium	0	0		0	0	0	0	0	0	0	6	9
Paramecium	0	0		0	0	0	0	0	0	0	0	0
Urceolaridae	0	0		0	0	0	0	0	0	0	0	0
Ciliate sp. #a	0	14		0	0	0	0	0	0	0	0	0
Ciliate sp. #b	0	0		0	0	0	0	5	7	0	0	5
Ciliate sp. #c	0	0		0	0	0	0	0	0	0	0	0
Ciliate sp. #d	0	0		0	0	0	0	0	0	0	0	0
Ciliate sp. #g	0	0		0	0	0	0	0	0	0	0	5
Coleps	0	0		0	0	0	0	0	0	18	0	0
Vase, flagellate	0	0		0	0	0	0	5	0	0	0	0
Chaos	0	0		0	0	0	0	5	0	0	0	5
Protozoa sp.	0	0		0	0	0	0	0	10	0	6	9
Brachionus	99	0		50	79	72	13	26	3	36	12	70
Keratella	248	14		232	142	187	27	31	33	143	17	168
Asplanchna	0	0		0	0	0	10	0	0	36	0	0
Ascomorpha	0	0		33	0	0	23	0	0	71	0	0
Conochilus	0	0		83	17	7	13	0	3	36	0	0
Proales	0	0		0	0	0	17	0	0	0	0	0
Lecane	0	0		0	0	0	0	0	3	0	0	5
Lepadella	0	0		33	0	0	3	0	0	0	0	0
Monostyla	0	0		0	0	0	70	62	60	71	12	65
Trichocerca	6	0		0	6	0	7	5	3	0	0	5
Filinia	12	0		0	0	94	3	16	0	36	41	19
Hexarthra	0	0		32	0	7	0	0	0	0	0	0
Polyarthra	99	0		132	0	101	7	10	20	36	35	93
Colurella	6	0		0	0	7	0	0	0	0	6	0
Platyias	0	0		17	0	0	0	0	0	0	0	23
Synchaeta	19	0		0	11	57.6	0	10	0	0	0	9
Trichotria	0	0		0	0	0	0	0	3	0	0	0
Gastropus	0	0		0	0	0	0	0	7	0	0	23
Cephalodella	0	0		0	0	0	0	0	0	18	0	9
Manfredia	0	0		0	0	0	0	0	3	0	0	0
Rotifer sp. #1	6	0		0	0	0	0	10	0	0	0	28
Rotifer sp. #2	0	0		0	11	0	7	0	0	0	12	19
Rotifer sp. #3	25	0		0	23	36	0	5	0	0	0	0
Rotifer sp. #4	12	14		0	40	43	0	0	0	0	0	23
Rotifer sp. #5	0	0		0	0	0	7	0	0	0	0	9
Rotifer sp. #6	0	0		0	0	0	0	16	0	0	6	9
Bosmina	0	0		0	0	0	0	0	0	0	0	5
Ceriodaphnia	0	14		0	0	0	0	0	0	0	0	0

Zooplankton 5/91 (continued)
Number/Liter

	TR1			TR2			EFF			TR3		
	A	B	C	A	B	C	A	B	C	A	B	C
Rotifer sp. #3	25	0		0	23	36	0	5	0	0	0	0
Rotifer sp. #4	12	14		0	40	43	0	0	0	0	0	23
Rotifer sp. #5	0	0		0	0	0	7	0	0	0	0	9
Rotifer sp. #6	0	0		0	0	0	0	16	0	0	6	9
<i>Bosmina</i>	0	0		0	0	0	0	0	0	0	0	5
<i>Ceriodaphnia</i>	0	14		0	0	0	0	0	0	0	0	0
Calanoid copepod	0	0		0	0	0	0	0	0	0	0	0
Cyclopoid copepod	30	0		0	0	0	0	0	0	0	0	0
Nauplii	19	0		0	6	0	0	0	3	0	0	9
Copepodite	0	0		17	0	0	0	0	0	36	0	0
Crustacean sp.	0	0		0	0	0	0	0	3		6	0
Protozoa		215		133	51	86	200	404	167	728	273	613
Rotifers	569	56		612	392	690	214	212	138	483	147	623
Crustacea	49	14		17	6	0	0	0	6	36	6	14
TOTAL	760	285		762	449	776	414	616	311	1247	426	1250

Highlighted rows represent members of Rotifera.

*TR1B was full of silt, possibly affected numbers of rotifers

Zooplankton 5/91 (continued)
Number/Liter

	TR4			TR5			TR6			TR7		
	A	B	C	A	B	C	A	B	C	A	B	C
Arcella	26	11	24	21	6	14	32	11	22	4	9	0
Centropyxis	0	0	0	179	0	0	0	0	11	0	0	14
Diffugia	34	79	63	159	38	29	82	11	34	47	80	14
Lesquereusia	0	0	0	60	0	0	35	0	0	0	0	0
Codonella	0	6	0	0	0	0	23	11	11	0	0	0
Tintinnopsis	309	215	252	160	190	215	96	120	168	12	179	252
Tintinnidium	0	0	0	0	0	0	0	0	0	0	0	0
Strombidium	0	6	8	0	38	0	47	11	11	0	0	0
Strombilidium	0	0	0	0	6	0	0	0	0	0	9	0
Holophryid ciliate	17	0	16	0	0	0	12	0	0	0	0	0
Epistylus	344	385	275	0	63	14	0	57	45	0	27	0
Vorticella	0	0	0	0	6	0	23	0	0	35	27	0
Suctatoria sp. #1	17	6	0	0	0	0	0	6	0	0	9	14
Suctatoria sp. #2	0	0	0	0	0	0	0	0	0	0	0	0
Cyclidium	0	0	0	0	0	0	0	0	0	0	9	0
Paramecium	0	0	8	0	0	0	0	0	0	0	0	0
Urceolariidae	0	0	0	0	0	0	0	0	0	0	0	0
Ciliate sp. #a	0	0	0	0	0	14	0	0	0	0	0	0
Ciliate sp. #b	0	0	0	0	0	0	0	0	0	0	0	0
Ciliate sp. #c	0	0	0	0	0	0	0	0	0	0	0	0
Ciliate sp. #d	0	0	0	0	0	0	0	0	0	0	0	0
Ciliate sp. #g	0	0	0	0	0	0	0	0	0	0	0	0
Coleps	0	0	0	0	0	0	0	0	0	0	0	0
Vase, flagellate	0	0	0	0	0	0	0	0	0	0	0	0
Chaos	0	0	0	0	0	0	0	0	0	0	9	14
Protozoa sp.	0	0	0	0	13	0	0	11	0	0	0	0
Brachionus	0	85	71	80	120	100	198.3	103	180	117	223	280
Keratella	138	147	181	199	184	201	233	126	246	82	304	266
Asplanchna	0	0	0	20	0	0	0	0	0	12	0	0
Ascomorpha	0	0	0	40	0	0	0	0	0	12	0	0
Conochilus	34	0	0	0	0	0	12	0	0	12	0	0
Proales	34	0	0	0	0	0	0	0	0	12	0	0
Lecane	17	0	0	0	0	14	12	0	0	0	0	0
Lepadella	17	0	0	0	0	0	0	0	0	0	0	0
Monostyla	120	40	55	159	32	43	105	29	56	93	63	0
Trichocerca	0	0	0	0	6	29	0	0	11	0	18	0
Filinia	34	23	39	40	89	72	152	46	123	12	54	96
Hexarthra	0	11	24	0	0	0	12	11	11	35	18	0
Polyarthra	103	62	16	40	133	57	70	29	78	23	143	182
Colurella	0	0	0	0	0	0	0	6	0	0	9	0
Platylas	0	11	0	0	19	14	0	17	11	0	0	28
Synchaeta	17	17	31	0	76	57	12	17	11	58	197	210
Trichotria	0	0	0	0	6	0	0	0	0	0	0	14
Gastropus	0	23	0	0	6	29	0	17	0	0	54	28
Cephalodella	0	0	0	0	0	0	5	0	0	0	0	0
Manfredia	0	0	0	0	0	0	0	0	0	0	0	0
Rotifer sp. #1	0	6	0	0	13	0	0	0	0	0	0	0
Rotifer sp. #2	0	17	0	0	0	0	0	0	0	0	0	0
Rotifer sp. #3	0	0	31	0	19	14	0	0	0	0	0	0
Rotifer sp. #4	0	28	8	0	13	0	0	0	0	0	0	0
Rotifer sp. #5	34	28	8	40	13	0	23	0	22	82	9	0
Rotifer sp. #6	0	0	16	0	6	0	0	0	0	12	0	0
Bosmina	0	0	0	0	6	0	0	0	11	0	0	0
Ceriodaphnia	0	0	0	0	0	0	0	0	0	0	0	0

Zooplankton 5/91 (continued)
Number/Liter

	TR4			TR5			TR6			TR7		
	A	B	C	A	B	C	A	B	C	A	B	C
Rotifer sp. #3	0	0	31	0	19	14	0	0	0	0	0	0
Rotifer sp. #4	0	28	8	0	13	0	0	0	0	0	0	0
Rotifer sp. #5	34	28	8	40	13	0	23	0	22	82	9	0
Rotifer sp. #6	0	0	16	0	6	0	0	0	0	12	0	0
Bosmina	0	0	0	0	6	0	0	0	11	0	0	0
Ceriodaphnia	0	0	0	0	0	0	0	0	0	0	0	0
Calanoid copepod	17	0	0	0	6	0	0	0	0	0	0	0
Cyclopoid copepod	0	0	0	0	0	0	0	6	0	0	0	0
Nauplii	0	11	8	0	38	14	23	11	34	0	18	42
Copepodite	0	0	0	0	0	0	12	0	0	0	0	0
Crustacean sp.	0	0	0	0	0	0	0	0	0	0	0	0
Protozoa	747	708	646	579	360	286	350	238	302	98	358	308
Rotifera	582	554	543	658	792	644	857	401	782	656	1101	1104
Crustacea	17	11	8	0	50	14	35	17	45	0	18	42
TOTAL	1346	1273	1197	1237	1202	944	1242	656	1129	754	1477	1454

Highlighted rows represent members of Rotifera.

Zooplankton 8/91
Number/Liter

	TR1			TR2			EFF			TR3		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Arcella</i>	12	0	16	0	0	0		N		207	0	11
<i>Diffugia</i>	12	40	128	39	86	56		O		48	22	33
<i>Lesqueræusia</i>	0	0	16	0	11	0		T		0	11	0
<i>Codonella</i>	12	0	0	0	0	0				0	0	0
<i>Nuclearia</i>	25	0	0	13	0	0		C		0	0	0
<i>Tintinnopsis</i>	1	12	0	0	43	34		O		95	0	0
<i>Strombidium</i>	25	12	0	26	86	56		L		16	22	44
<i>Strombilidium</i>	0	6	0	297	0	23		L		32	34	0
Holophyrid ciliate #1	124	63	16	0	97	68		E		64	45	11
H. C. #2	0	12	0	0	0	0		C		16	45	0
<i>Paramecium</i>	0	0	0	0	0	0		T		0	0	0
<i>Epistylus</i>	0	0	0	0	0	0		E		48	90	0
<i>Vorticella</i>	0	0	0	52	22	56		D		32	34	11
<i>Suctatoria</i> sp. #1	25	0	0	0	11	23				0	78	11
<i>Suctatoria</i> sp. #3	0	0	0	0	0	0				0	0	0
<i>Pleuronematidae</i>	0	0	0	0	0	34				0	22	0
<i>Cyclidium</i>	0	0	0	0	0	0				0	56	22
<i>Mesodinium</i>	0	0	0	0	0	11				0	0	0
<i>Didinnidae</i>	0	0	0	13	0	0				16	0	0
<i>Euplotes</i>	0	0	0	0	11	0				0	22	11
<i>Ciliate</i> sp. #a	50	6	0	26	43	11				16	0	0
<i>Ciliate</i> sp. #b	27	6	48	13	0	0				0	0	0
<i>Ciliate</i> sp. #c	12	0	0	0	0	0				0	0	0
<i>Ciliate</i> sp. #d	87	6	0	0	0	0				0	0	0
<i>Ciliate</i> sp. #f	0	66	0	0	0	23				0	0	0
<i>Ciliate</i> sp. #g	0	0	0	0	0	0				0	0	0
<i>Flagellate</i> sp.	4	0	0	0	0	0				0	0	0
<i>Chaos</i>	0	0	16	0	32	0				0	0	0
<i>Brachionus</i>	198	236	288	220	173	90				95	56	88
<i>Keratella</i>	37	17	16	39	22	0				16	0	0
<i>Asplanchna</i>	0	6	16	0	0	0				0	0	0
<i>Ascomorpha</i>	0	6	16	129	22	23				0	11	0
<i>Conochilus</i>	0	12	32	0	0	0				0	0	0
<i>Proales</i>	0	6	0	0	0	0				0	0	0
<i>Lecane</i>	0	12	0	0	0	0				32	22	0
<i>Monostyla</i>	0	0	0	0	0	0				127	0	88
<i>Monommata</i>	12	0	0	0	0	0				0	0	0
<i>Trichocerca</i>	37	29	112	39	43	68				16	90	22
<i>Filinia</i>	50	87	0	52	43	11				16	45	22
<i>Polyarthra</i>	37	98	80	65	32	23				16	0	11
<i>Colurella</i>	0	0	0	0	0	0				0	0	0
<i>Platyias</i>	0	0	0	0	0	0				0	0	0
<i>Synchaeta</i>	0	35	0	13	32	0				0	22	22
<i>Gastropus</i>	12	0	0	0	0	0				0	0	11
<i>Cephalodella</i>	0	12	16	0	0	0				0	0	11
<i>Rotifer</i> sp. #1	0	6	16	0	22	0				0	0	0
<i>Rotifer</i> sp. #2	0	29	16	26	43	11				0	0	0
<i>Rotifer</i> sp. #3	0	0	0	0	0	0				0	0	0
<i>Rotifer</i> sp. #4	50	17	0	13	0	23				32	11	11
<i>Rotifer</i> sp. #5	12	127	48	181	130	135				64	67	88
<i>Rotifer</i> sp. #6	112	6	0	26	0	0				32	11	0
<i>Rotifer</i> sp. #7	0	6	32	13	0	0				0	0	0
<i>Rotifer</i> sp. #8	0	0	0	0	0	11				0	0	0
<i>Rotifer</i> sp. #9	0	0	0	0	11	0				0	0	0

Zooplankton 8/91 (continued)
Number/Liter

	TR1			TR2			EFF			TR3		
	A	B	C	A	B	C	A	B	C	A	B	C
Rotifer sp. #10	0	0	0	0	0	0				0	0	11
<i>Bosmina</i>	0	0	0	0	0	0				0	0	0
<i>Ceriodaphnia</i>	0	0	0	0	0	0				0	0	0
Calanoid copepod	0	0	0	0	11	0				0	0	0
Cyclopoid copepod	0	0	0	0	0	0				0	0	0
Nauplii	0	6	16	0	0	0				0	0	11
Copepodite	0	0	0	0	0	0				0	0	0
Protozoa	416	229	240	479	442	395				590	481	154
Rotifera	557	747	688	816	573	395				446	335	385
Crustacea	0	6	16	0	11	0				0	0	11
Total	973	982	944	1295	1026	790				1036	816	550

Highlighted rows are members of Rotifera

Zooplankton 8/91 (continued)
Number/Liter

	TR4			TR5			TR6			TR7		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Rotifer</i> sp. #10	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bosmina</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceriodaphnia</i>	0	0	0	0	0	0	0	0	0	0	0	0
Calanoid copepod	0	0	0	0	0	0	0	0	0	0	0	0
Cyclopoid copepod	0	0	0	0	0	0	0	0	0	0	0	0
Nauplii	14	0	34	0	0	0	0	0	0	0	0	0
Copepodite	0	0	0	0	0	0	0	0	0	0	0	0
Protozoa	247	181	188	192	158	222	235	88	110	139	105	93
Rotifera	384	257	188	156	186	251	30	65	57	91	112	60
Crustacea	14	0	34	0	0	0	0	0	0	0	0	0
Total	645	438	410	348	344	473	265	153	167	230	217	153

Zooplankton 5/92
 Number/Liter

	TR1			TR2			EFF			TR3		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Arcella</i>	22	0	0	0	0	0	103	131	126	39	71	57
<i>Diffugia</i>	202	0	0	4	23	39	28	28	0	13	10	5
<i>Lesquereusia</i>	37	0	0	0	0	0	0	0	0	0	0	0
<i>Codonella</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Assulina</i>	0	0	0	0	0	0	0	0	15	0	0	0
<i>Tintinnopsis</i>	299	85	61	140	308	157	0	0	0	22	10	5
<i>Tintinnidium</i>	0	0	0	0	0	0	0	0	0	0	0	5
<i>Strombidium</i>	37	0	0	26	39	118	9	0	0	0	0	0
<i>Strombilidium</i>	60	20	6	31	54	26	0	0	0	26	10	10
Holophyr. cil. #1	75	0	0	0	0	39	0	0	0	0	0	0
<i>Epistylus</i>	0	0	0	0	0	0	541	632	481	0	10	0
<i>Vorticella</i>	7	0	0	0	0	13	0	0	0	0	0	0
Suctorioria sp. #1	0	0	0	0	0	13	0	0	0	0	0	0
<i>Cyclidium</i>	0	0	0	0	0	65	0	0	0	0	10	0
<i>Euplotes</i>	0	0	0	0	0	0	0	0	0	0	0	0
Ciliate sp. #3	75	0	6	0	0	0	0	0	0	0	0	0
Ciliate sp. #4	0	0	0	0	0	0	0	0	0	4	0	0
Flagellate sp.	0	0	0	0	0	0	0	0	0	0	0	0
<i>Chaos</i>	0	0	0	0	0	0	0	0	15	0	0	0
Foraminifera	0	0	0	0	0	0	9	9	0	0	0	0
<i>Brachionus</i>	15	0	0	4	31	0	0	0	0	0	0	0
<i>Keratella</i>	90	75	50	22	69	131	0	0	0	22	30	36
<i>Asplanchna</i>	7	0	0	0	0	0	0	0	0	0	0	0
<i>Ascomorpha</i>	0	0	0	0	0	0	0	9	0	0	0	0
<i>Conochilus</i>	0	0	0	0	0	0	0	0	22	0	0	0
<i>Proales</i>	0	0	0	0	0	0	19	56	0	9	0	0
<i>Lecane</i>	0	0	0	0	0	13	0	28	30	0	0	0
<i>Lepadella</i>	0	0	0	0	0	0	0	0	0	4	0	0
<i>Monostyla</i>	0	0	0	0	0	13	280	439	340	52	71	52
<i>Manfredium</i>	0	0	0	0	0	0	9	0	0	0	10	0
<i>Trichocerca</i>	7	0	0	9	0	0	9	0	0	0	10	36
<i>Filinia</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Polyarthra</i>	7	20	0	0	15	0	0	0	0	13	10	0
<i>Colurella</i>	22	0	0	0	0	0	0	0	0	0	0	0
<i>Synchaeta</i>	0	0	0	0	0	0	0	0	0	17	10	0
<i>Trichotria</i>	0	0	0	0	0	0	0	0	0	0	20	0
<i>Gastropus</i>	0	0	0	0	0	0	0	0	0	13	0	16
<i>Cephalodella</i>	0	0	0	0	0	0	0	0	0	0	0	0
Rotifer sp. #2	0	0	0	0	0	13	0	0	0	0	10	0
Rotifer sp. #3	0	0	0	0	0	0	0	0	0	17	0	0
Rotifer sp. #4	0	0	0	0	0	0	9	47	0	22	0	16
Rotifer sp. #5	0	0	0	0	0	0	0	0	0	0	0	0
Rotifer sp. #6	104	0	11	0	0	13	0	0	30	0	51	104
<i>Tylotrocha</i>	0	0	0	0	0	0	0	0	0	0	0	5
<i>Bosmina</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceriodaphnia</i>	0	0	0	0	0	0	0	0	0	0	0	0
Calanoid copepod	0	0	0	0	0	0	0	0	0	0	0	0
Cyclopoid copepod	0	0	0	0	0	0	0	0	0	0	0	0
Nauplii	0	5	0	0	0	0	0	0	0	0	10	5
Copepodite	0	0	0	0	0	0	0	0	0	0	0	0
Protozoa	814	105	73	201	424	470	690	800	637	104	121	82
Rotifera	252	95	61	35	115	183	326	579	422	169	222	265
Crustacea	0	5	0	0	0	0	0	0	0	0	10	5
Total	1066	205	134	236	539	653	1016	1379	1059	273	353	352

Zooplankton 5/92 (continued)
 Number/Liter

	TR4			TR5			TR6			TR7		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Arcella</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Diffugia</i>	12	22	10	13	38	52	25	22	33	227	109	
<i>Lesqueræusia</i>	0	0	0	0	0	0	0	0	0	7	0	
<i>Codonella</i>	0	0	0	0	0	0	10	0	0	0	0	
<i>Assulina</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Tintinnopsis</i>	66	13	6	33	9	38	39	54	65	48	73	
<i>Tintinnidium</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Strombidium</i>	6	13	10	18	9	33	15	10	0	0	0	
<i>Strombilidium</i>	12	4	3	0	5	0	25	0	9	3	0	
Holophyr. cil. #1	6	0	0	4	9	10	0	19	0	3	36	
<i>Epistylus</i>	54	82	29	0	0	5	0	6	0	0	0	
<i>Vorticella</i>	0	0	0	0	0	5	0	16	0	0	0	
<i>Suctorina</i> sp. #1	0	0	0	0	0	0	0	0	0	0	0	
<i>Cyclidium</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Euplotes</i>	0	0	0	0	0	0	0	0	0	0	0	
Ciliate sp. #3	0	0	0	0	0	0	0	0	0	0	0	
Ciliate sp. #4	0	0	0	0	0	0	0	0	0	0	0	
Flagellate sp.	0	0	0	4	5	0	5	0	5	0	0	
<i>Chaos</i>	0	0	3	0	0	0	0	0	0	0	0	
<i>Foraminifera</i>	0	4	0	0	0	0	0	0	0	0	0	
<i>Brachionus</i>	0	0	0	18	33	14	10	6	0	14	73	
<i>Keratella</i>	42	39	36	22	33	33	15	13	19	7	36	
<i>Asplanchna</i>	0	0	0	22	28	14	0	10	23	7	109	
<i>Ascomorpha</i>	0	0	0	0	0	5	0	13	0	10	0	
<i>Conochilus</i>	0	0	0	0	9	0	5	3	0	0	0	
<i>Proales</i>	42	4	26	4	24	14	0	0	0	3	0	
<i>Lecane</i>	24	13	0	13	19	5	0	6	5	3	36	
<i>Lepadella</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Monostyla</i>	36	34	29	97	108	114	44	61	89	31	109	
<i>Manfredium</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Trichocerca</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Filinia</i>	6	0	0	0	0	0	0	0	0	0	0	
<i>Polyarthra</i>	6	0	0	4	5	0	5	0	0	0	0	
<i>Colurella</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Synchaeta</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Trichotria</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Gastropus</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Cephalodella</i>	0	0	0	0	0	0	0	0	0	0	0	
Rotifer sp. #2	0	0	0	0	0	0	0	0	0	0	0	
Rotifer sp. #3	0	0	0	0	0	0	0	0	0	0	0	
Rotifer sp. #4	6	9	0	0	0	0	0	0	0	0	0	
Rotifer sp. #5	0	0	0	0	0	0	0	0	0	0	0	
Rotifer sp. #6	0	0	0	0	0	5	15	13	23	14	145	
<i>Tylotrocha</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Bosmina</i>	0	0	0	0	0	0	0	0	0	0	0	
<i>Ceriodaphnia</i>	0	0	0	0	0	0	0	0	0	0	0	
Calanoid copepod	0	0	0	0	0	0	0	0	0	0	0	
Cyclopoid copepod	0	0	0	0	0	0	0	0	0	0	0	
Nauplii	0	0	0	0	0	0	10	0	5	0	0	
Copepodite	0	0	0	0	0	0	0	0	0	0	0	
Protozoa	156	138	61	72	75	143	119	127	112	288	218	0
Rotifera	162	99	91	180	259	204	94	125	159	89	508	0
Crustacea	0	0	0	0	0	0	10	0	5	0	0	0
Total	318	237	152	252	334	347	223	252	276	377	726	0

Zooplankton 8/92
Number/Liter

	TR1			TR2			EFF			TR3		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Arcella</i>	0	17	25	9	0	0	6	4	5	35	21	18
<i>Diffugia</i>	60	33	37	9	13	9	0	0	0	9	7	0
<i>Lesquereusia</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Codonella</i>	0	0	0	0	0	0	0	0	0	0	0	6
<i>Rhizopodia</i>	0	0	0	0	0	0	3	0	0	0	0	0
<i>Tintinnopsis</i>	30	17	37	36	78	27	0	0	0	13	14	12
<i>Strombidium</i>	0	0	0	0	13	0	0	0	0	0	21	12
<i>Strombilidium</i>	15	0	12	9	0	0	0	0	0	0	7	6
Holophyrid ciliate #1	15	0	25	0	65	0	0	0	0	4	0	18
H. C. #2	0	0	0	0	0	0	0	0	0	0	0	18
<i>Epistylus</i>	0	0	0	0	0	0	25	63	41	35	14	29
<i>Vorticella</i>	0	0	0	0	0	0	0	4	27	0	0	0
<i>Suctatoria</i> sp. #1	0	0	12	0	0	0	0	0	0	0	14	0
<i>Sphaerophrya</i>	0	0	0	0	0	0	0	0	0	0	0	0
Ciliate sp. #1	0	0	0	0	0	0	3	4	0	0	0	0
Ciliate sp. #2	0	0	12	0	0	0	0	0	0	9	0	6
Ciliate sp. #3	0	0	0	0	0	0	0	0	0	0	7	0
<i>Kerona</i>	0	0	0	0	13	0	0	0	0	0	0	0
<i>Coleps octospinus</i>	0	0	0	0	0	0	0	0	0	0	0	0
Flagellate sp.	0	0	0	0	0	0	0	0	0	0	0	0
<i>Chaos</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Brachionus</i>	15	0	0	9	26	27	0	0	8	9	0	6
<i>Keratella</i>	0	0	0	18	0	0	0	0	0	0	7	6
<i>Ascomorpha</i>	0	0	0	0	0	9	0	0	0	4	0	0
<i>Conochilus</i>	0	0	0	0	13	0	0	0	0	0	0	0
<i>Proales</i>	0	0	0	0	0	0	0	7	5	4	0	0
<i>Lecane</i>	0	0	0	0	0	0	9	0	5	4	14	0
<i>Monostyla</i>	0	0	0	0	0	0	13	26	14	31	21	35
<i>Trichocerca</i>	15	50	12	0	0	0	0	0	0	0	14	12
<i>Filinia</i>	0	0	0	18	52	18	0	0	0	4	0	6
<i>Hexarthra</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Polyarthra</i>	0	0	0	18	0	9	0	0	0	4	0	0
<i>Colurella</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Synchaeta</i>	0	0	0	0	13	0	0	0	0	0	0	0
Rotifer sp. #1	15	0	0	0	0	0	0	0	0	13	0	6
Rotifer sp. #2	0	0	25	0	0	0	0	0	0	4	0	12
Rotifer sp. #3	0	0	0	0	0	0	0	0	0	0	7	18
Rotifer sp. #4	0	0	0	0	26	0	0	4	3	0	0	0
Rotifer sp. #5	0	0	0	0	0	0	6	11	0	0	0	0
Rotifer sp. #6	0	0	0	0	0	0	15	22	3	0	0	0
<i>Bosmina</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceriodaphnia</i>	0	0	0	0	0	0	0	0	0	0	0	0
Calanoid copepod	0	0	0	0	0	0	0	0	0	0	0	0
Cyclopoid copepod	0	0	0	0	0	0	0	0	0	0	0	0
Nauplii	0	0	0	0	0	0	0	0	0	0	0	0
Copepodite	0	0	0	0	0	0	0	0	0	0	0	0
Protozoa	120	67	160	63	182	36	37	75	73	105	105	125
Rotifera	45	50	37	63	130	63	43	70	38	77	63	101
Crustacea	0	0	0	0	0	0	0	0	0	0	0	0
Total	165	117	197	126	312	99	80	145	111	182	168	226

Highlighted rows represent members of Rotifera

Zooplankton 8/92 (continued)
Number/Liter

	TR4			TR5			TR6			TR7		
	A	B	C	A	B	C	A	B	C	A	B	C
<i>Arcella</i>	21	3	31	0	20	9	15	24	0	5	0	0
<i>Diffugia</i>	12	9	16	0	16	18	5	32	13	5	18	0
<i>Lesquereusia</i>	0	0	0	3	4	0	0	0	0	0	0	0
<i>Codonella</i>	0	0	0	22	0	0	0	0	0	0	0	0
<i>Rhizopodia</i>	0	0	0	0	0	0	0	8	7	0	0	0
<i>Tintinnopsis</i>	5	22	31	6	4	9	15	8	33	25	24	0
<i>Strombidium</i>	7	0	0	0	0	0	10	8	0	0	6	0
<i>Strombilidium</i>	0	0	0	0	4	0	5	0	0	0	0	0
Holophyrid ciliate #	0	0	0	0	0	0	0	8	0	5	0	0
H. C. #2	0	0	0	0	0	0	0	0	0	0	0	0
<i>Epistylus</i>	30	16	0	6	8	0	5	0	0	0	0	0
<i>Vorticella</i>	12	0	0	0	0	0	0	0	0	0	0	0
Suctorina sp. #1	0	0	0	0	4	0	0	0	0	0	18	0
<i>Sphaerophrya</i>	0	0	0	0	0	0	0	0	7	0	0	0
Ciliate sp. #1	0	0	0	0	0	0	0	0	0	0	0	0
Ciliate sp. #2	0	3	16	0	0	0	5	8	0	0	0	0
Ciliate sp. #3	0	0	0	0	0	0	0	8	0	0	0	0
<i>Kerona</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Coleps octospinus</i>	0	0	0	0	0	0	0	0	0	0	0	0
Flagellate sp.	0	0	0	0	0	0	0	0	7	0	0	0
<i>Chaos</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Brachionus</i>	5	3	0	0	0	9	0	0	7	0	0	0
<i>Keratella</i>	2	0	0	0	0	0	0	0	7	0	0	0
<i>Ascomorpha</i>	2	3	0	0	8	0	0	0	0	0	0	0
<i>Conochilus</i>	0	0	0	0	0	0	0	0	7	0	0	0
<i>Proales</i>	5	3	0	0	0	0	0	0	0	0	0	0
<i>Lecane</i>	0	3	8	0	8	5	0	0	0	0	0	0
<i>Monostyla</i>	16	13	8	13	8	14	0	8	7	0	0	0
<i>Trichocerca</i>	2	0	0	0	4	0	5	0	0	0	0	0
<i>Filinia</i>	5	6	0	3	0	5	5	8	0	0	0	0
<i>Hexarthra</i>	2	0	0	0	0	0	0	0	0	0	0	6
<i>Polyarthra</i>	2	3	0	3	0	0	0	0	7	0	0	0
<i>Colurella</i>	0	0	0	0	0	0	5	0	0	0	0	0
<i>Synchaeta</i>	0	3	0	0	0	0	0	0	0	0	0	0
Rotifer sp. #1	2	0	0	0	0	0	0	0	7	0	0	0
Rotifer sp. #2	14	13	8	0	0	0	5	0	0	0	0	0
Rotifer sp. #3	0	0	0	0	0	0	0	0	0	0	0	0
Rotifer sp. #4	0	0	8	3	0	0	0	0	0	0	0	0
Rotifer sp. #5	2	0	0	3	0	5	5	0	7	0	0	0
Rotifer sp. #6	16	6	16	6	0	0	5	0	0	0	0	0
<i>Bosmina</i>	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceriodaphnia</i>	0	0	0	0	0	0	0	0	0	0	0	0
Calanoid copepod	0	0	0	0	0	0	0	0	0	0	0	0
Cyclopoid copepod	0	0	0	0	0	0	0	0	0	0	0	0
Nauplii	0	0	0	0	0	0	0	0	0	0	0	0
Copepodite	0	0	0	0	0	0	0	0	0	0	0	0
Protozoa	87	53	94	37	60	36	60	104	67	40	66	0
Rotifera	75	56	48	31	28	38	30	16	49	0	0	6
Crustacea	0	0	0	0	0	0	0	0	0	0	0	0
Total	162	109	142	68	88	74	90	120	116	40	66	6

Highlighted rows represent members of Rotifera

BIBLIOGRAPHY

- Barbhuyan S. I. and Khan A. A. (1992) Studies of Structure and Function of Benthic Ecosystem in an Eutrophic Body of Water: Temporal and Spatial Distribution of Benthos. In Journal of Freshwater Biology Vol. 4. pp. 239-247.
- Bellinger E. G. (1979) The Response of Algal Populations to Changes in Water Quality. In Biological Indicators of Water Quality (Edited by James, A. and Evison, L.) pp. 9-1 to 9-27. John Wiley and Sons, Chichester.
- Berner D. B. (no date) Key to Cladocera of Par Pond on the Savannah River Plant. National Environmental Research Park Program, U.S. Department of Energy, publication no. NERP-SRO-11. 62 PP.
- Brower J. E., and Zar J. H. (1977) Field and Laboratory Methods for General Ecology. Wm. C. Brown Company, Dubuque, Iowa. 194 pp.
- Buikema A. L. Jr., B. R. Niederlehner, and J. Cairns Jr. (1982) Biological Monitoring Part IV -- Toxicity Testing. In Biological Monitoring in Water Pollution, (Edited by Cairns, J. Jr.), pp. 239-262. Pergamon Press, Oxford.
- Cairns J. Jr. (1971) In The Structure and Function of Fresh-Water Microbial Communities (Edited by Cairns, J. Jr.), pp. 219-247. Research Division Monograph 3, VA Polytechnic Inst. and State University Press, Blacksburg, VA.
- Cairns J. Jr., Kuhn D. L., and Plafkin J. L. (1979) Protozoan colonization of artificial substrates. In Methods and Measurements of Periphyton Communities: A review, (Edited by Weitzel, R. L.), pp. 34-57. American Society for Testing and Materials. ASTM STP 690.
- Cairns J. Jr., and Van Der Schalie, W. H. (1980) Biological Monitoring Part I -- Early Warning Systems. In Biological Monitoring in Water Pollution, (Edited by Cairns, J. Jr.), pp. 1179-1195. Pergamon Press, Oxford

- Choudhary S. K. and Bilgrami K. S. (1991) Studies on Phytolankton Productivity of River Ganga at Sultanganj and Bhagalpur, India. In Polskie Archiwum Hydrobiologii Vol. 38. pp. 375-379.
- EPA (1984) Water quality standards handbook, Office of Water Regulations and Standards, US EPA, Wash, DC, USA.
- EPA (1988a) WQS draft framework for the water quality standards program. Office of Water Regulations and Standards, US EPA, Wash, DC, USA.
- EPA (1990) Biological Criteria: National Program Guidance for Surface Waters. Office of Water Regulations and Standards, US EPA, Wash, DC. USA
- Efron B. and Gong G. (1983) A leisurely look at the bootstrap, the jackknife, and cross-validation. In American Statistician Vol. 37:36-48.
- Felsenstein J. (1985) Confidence Limits on Phylogenies: An Approach Using the Bootstrap. In Evolution Vol. 39(4). pp. 783-791.
- Gully D. D., Boelter A. M. and Bergman H. L. (unpublished) TOXSTAT (software package) fish Physiology and Toxicology Laboratories, Department of Zoology and physiology, P.O. Box 3166, Univeristy of /wyoming, Laramie, WY 82071.
- Hawes I. and Smith R. (1993). Effect of localised nutrient enrichment on the shalow epilithic periphyton of oligotrophic Lake Taupo, New Zealand. In New Zealand Journal of Marine and Freshwater Research Vol. 27. pp. 365-372.
- Hawkes H. A. (1979) Invertebrates as Indicators of River Water Quality. In Biological Indicators of Water Quality (Edited by James, A. and Evison, L.). pp. 2-1 to 2-. John Wiley and Sons, Chichester.
- Herricks E. E., and Cairns, J. Jr. (1982) Part III -- Receiving System Methodology Based on Community Structure. In Biological Monitoring in Water Pollution, (Edited by Cairns, J. Jr.) pp. 141-153. Pergamon Press, Oxford.
- Jahn T. L. (1949) How to Know the Protozoa. Wm. C. Brown Co., Dubuque, Iowa. 234 pp.

- James A. (1979) The Value of Biological Indicators in relation to other Parameters of Water Quality. In Biological Indicators of Water Quality (Edited by James, A. and Evison, L.) pp. 1-1 to 1-16. John Wiley and Sons, Chichester.
- Jowett I. G. and Duncan M. J. (1990) Flow variability in New Zealand rivers and its relationship to in-stram habitat and biota. In New Zealand Journal of Marine and Freshwater Research Vol. 24. pp. 305-317.
- Karr J. R., Fausch K. D., Angermeier, P. L., Yant, P. R., and Schlosser, I. J. (1986) Assessing Biological Integrity in Running Waters: A Method and it's Rationale. Illinois Natural History Survey, Champaigne, Illinois, Special Publication 5.
- Karr J. R. (1991) Biological Integrity: A long-Neglected Aspect of Water Resource Management. In Ecological Applications, pp.66-84.
- Kovach W. L. (1989) M.V.S.P. (software package) Department of Biology, Indiana University, Bloomington, IN 47405
- Ludwig J. A. and Reynolds J. F. (1989) Statistical Ecology. John Wiley and Sons, Inc., New York. pp. 159-189 .
- Nemec A. F. L. (1991) Sigtree, Version 3.4. International Statistics and Research Corp., Canada. (software package)
- Nemec A. F. L. and Brinkhurst R. O. (1988) Using the Bootstrap to Assess Statistical Significance in the Cluster Analysis of Species Abundance Data. In Journal of Fisheries and Aquatic Science Vol. 45. pp. 965-970.
- Newbry B. W., Lee G. F., Jones R. A., and Heinmann T. J. (unpublished) Studies on the Water Quality Hazard of Domestic Wastewater Treatment Plant Effluent Chlorine. 19 pp. Department of Civil Engineering, Colorado State University, Fort Collins, CO 80523
- Owen B. B. Jr., Afzal M. and Cody W. R. (1979) Distinguishing Between Live and Dead Diatoms in Periphyton Communities. In Methods and Measurements of Periphyton Communities: A Review (Edited by Weitzel R. L.). American Society for Testing and Materials. pp. 70-76.

- Patrick R. (1971) Ecology of Freshwater Diatoms and Diatom Communities. In The Biology of Diatoms, (Edited by Werner D.), pp. 285-323. University of California Press, Berkeley and Los Angeles
- Patrick R. and Reimer C.W. (1966) The Diatoms of the United States Exclusive of Alaska and Hawaii Vol. 1
Fragellaria, Eunotiaceae, Achnanthaceae, Naviculaceae No. 13. The Academy of Natural Sciences of Philadelphia.
- Patrick R. and Reimer C. W. (1975) The Diatoms of the United States Exclusive of Alaska and Hawaii Vol. 2 part 1
Cymbellaceae, Gomphonemaceae, Epithemiaceae No. 13. The Academy of Natural Sciences of Philadelphia.
- Patrick R. (1971) Diatom Communities. In The Structure and Function of Fresh-water Microbial Communities, (Edited by Cairns J. Jr.), pp. 151-164. Research Division Monograph 3, Virginia Polytechnic Institute and State University, Blacksburg, VA
- Pennak R. W. (1989) Freshwater invertebrates of the United States, 3rd Ed. Protozoa to Mollusca. John Wiley and Sons, Inc., New York.
- Prescott G. W. (1978) How to Know the Fresh-water Algae. Wm. C. Brown Co., Dubuque, Iowa. 293 pp.
- Schumacher G. J., and Whitford L. A. (1973) A Manuel of Fresh-water Algae. Sparks Press, Raleigh, N.C.
- Sneath P. H. A. and Sokal R. R. (1973) Numerical Taxonomy: The Principles and Practice of Numerical Classification. W. H. Freeman, San Francisco, CA. 573 pp.
- Stemberger R. S. (1979) A Guide to Rotifers of the Laurentian Great Lakes. EPA-600/4-79-021. 185 pp.
- Standard Methods for the Examination of Water and Wastewater 16th ed. (1992), (edited by Franson M. A., Greenberg A. E., Clesceri L. S., and Eaton A. D.) American Public Health Association, Washington D.C. pp. (10-1) to (10-40).
- Standard Methods for the Examination of Water and Wastewater 13th ed. (1972), (edited by Taras M. J., Greenburg A. E., Hoak R. D., and Rand M. C.), American Public Health Association, Washington D.C. pp. 725-754