SPECIES COMPOSITION AND DIVERSITY OF PHYTOPLANKTON IN THE GRAND RIVER DAM AREA, OKLAHOMA

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A total of 245 phytoplankton taxa were collected with a plankton net from the Grand River, Chouteau Creek, Pryor Creek, and ponds located on GRDA property in Mayes County, Oklahoma, from February 1977 to August, 1977. Several of these taxa represent new state records. On the basis of species diversity Chouteau Creek, Pryor Creek and the Grand River are said to be lightly to moderately polluted.

INTRODUCTION

Considerable taxonomic work has been completed on the algal flora of Oklahoma including that of Gabel (1), Taft (2-9), Transeau *et al.* (10), Leake (11-13), Booth (14, 15), Maloney (16), Jenkins (17), Ophel (18-20), Vinyard (21-22), Cooper (23), Schlicting and Gearhart (24), Bermudez (25), Koch and Risser (26), Pfiester (27, 28), Pfiester and Felkner (29), Pfiester and Terry (30), Pfiester *et al.* (31), Wright (32, 33), Taylor (34), Wilhm *et al.* (35, 36), Seyfer and Wilhm (37), and Troeger (38, 39). The purpose of this paper is to report on changes in phytoplankton assemblage from February, 1977 to August, 1977 in Chouteau Creek, Pryor Creek, Grand River, and three ponds located on the Grand River Dam Authority (GRDA) property in Mayes County, Oklahoma.

MATERIALS AND METHODS

Study Area

Seven sampling stations were studied monthly (Fig. 1). Three were located on the Grand River. Station G-1 was at the present intake for the GRDA Generating Station, G-2 below the inflow of Pryor Creek where Highway 33 crosses the Grand River, and G-3 below the inflow of Chouteau Creek. Stations C-2 and C-3 were located on Chouteau Creek, C-2 near Highway 33 above where it converges with Grand River. Station P-1 was located on Pryor Creek north of where it joins Grand River and P-2 on Pryor Creek where it converges with Grand River. Three ponds located on GRDA property near the Highway 33 Bridge were sampled once in May.

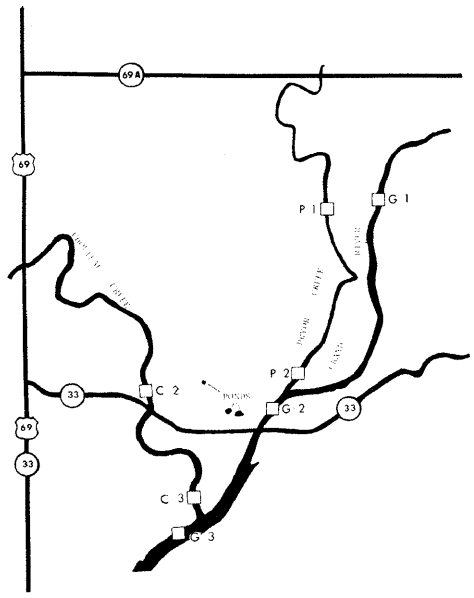

FIGURE 1. Collecting stations on GRDA study site.

Collection

Three samples were collected at each station by towing a No. 20 plankton net through 38.97 *l* of water on each sampling date. The plankton was concentrated into a 25-m*l* container. Samples were stored in an ice chest and 25 m*l* Transeau's solution (6 parts water, 3 parts ethanol, 1 part formalin) added upon return to the laboratory. These samples were used for identification of the algae exclusive of diatoms.

Identification and Diversity

Species identification of phytoplankton (exclusive of diatoms) was made by plac-

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ing a drop on a glass slide which was then examined with an oil immersion lens. After species identification was accomplished at this magnification, a Sedwick-Rafter counting chamber was filled with 1 m*l* of the sample and organisms in the entire field counted at 10 × magnification.

Samples used for diatom identification and counts were cleaned by adding potassium dichromate and concentrated H_2O_2 to each sample. The contents were concentrated to 50 m*l* and permanent slides were prepared by adding a 1-m*l* aliquot to a cover slip which was dried and mounted permanently with Hyrax onto a slide. All algal samples are in the University of Oklahoma Bebb Herbarium.

Species diversity (d) was determined by using the formula of Shannon and Weaver (40).

RESULTS

Two hundred and forty-five taxa of phytoplankters were collected from the Grand River Dam Study Area (Table 1). Of this number 136 were diatoms (Bacillariophy-

TABLE 1. *Phytoplankton collected from GRDA study area.*[a]

BACILLARIOPHYTA
Pennales:
Achnanthes affinis Grun. G, C, P
Achnanthes lanceolata (Bréb.) Grun. C
Achnanthes lanceolata var. *dubia* Grun. G, P
Achnanthes linearis (W. Smith) Grun. G, C, P, Po
Achnanthes microcephala (Kuetz.) Grun, P, Po
Achnanthes minutissima Kuetz. G, C, P, Po
Amphora ovalis (Kuetz.) Kuetz. C, Po
Amphora veneta Kuetz. P
Asterionella formosa Hass. G, C, P
Caloneis bacillaris (Greg.) Cleve Po
Caloneis bacillum (Grun.) Cl. P
Caloneis lewisii Patr. C
Caloneis ventricosa (Ehr.) Meist. G, Po
Cocconeis pediculus Ehr. G, C, P, Po
Cocconeis placentula Ehr. G, C, Po
Cymatopleura solea (Bréb.) W. Smith P
Cymbella sp. C
Cymbella cymbiformis Ag. Po
Cymbella lunata Smith C, P, Po
Cymbella minuta Hilse *ex.* Rabh. G, C, P, Po
Cymbella prostrata (Berk.) Cl. C, P
Cymbella triangulum (Ehr.) Cl. C, Po
Cymbella tumida (Bréb.) V. H. G, C, P
Cybella turgidula Grun. P
Diatoma elongatum Ag. G
Diatoma vulgare (Bory) G, C, P
Diploneis sp. C
Diploneis elliptica (Kuetz.) Cl. C
Epithemia sp. P.
Eunotia curvata (Kuetz.) Lagerst. P, Po
Fragilaria sp. P, Po
Fragilaria lapponica Grun. Po
Fragilaria vaucheriae (Kuetz.) Peters. C, P
Frustulia vulgaris (Thwaites) DeT. G, P
Gomphonema sp. Po
Gomphonema affine Kuetz. G. C, P, Po
Gomphonema angustatum (Kuetz.) Rabh. G, C, Po
Gomphonema Augur Ehr. P
Gomphonema consector Hohn. & Hellerm. G, C, Po
Gomphonema gracile Ehr. Po
Gomphonema olivaceum (Lyngb.) Kuetz, G, C, P
Gomphonema parvulum Kuetz. G, C, Po
Gomphonema sphaerophorum Ehr. C
Gomphonema subclavatum (Grun.) Grun. G, C
Gomphonema tenellum Kuetz. G, C
Gomphonema tergestinum (Grun.) Fricke G
Gomphonema truncatum Ehr. C
Gyrosigma sp. G
Gyrosigma acuminatum (Kuetz.) Rabh. G, C, P, Po
Gyrosigma eximum (Thwaites) Boyer G, P
Hantzschia amphioxys (Ehr.) Grun. C, P
Meridion circulare var. *constrictum* Ralfs G, C, P
Navicula sp. G, C, P
Navicula accommoda Hust. P
Navicula capitata Ehr. G, C, P
Navicula cryptocephala Kuetz. G, C, P, Po
Navicula cuspidata Kuetz. Po
Navicula decussis Destr. G
Navicula gottlandica Grun. C, P, Po
Navicula graciloides Mayer G
Navicula jaernfelti Hust. P
Navicula lanceolata (Ag.) Kuetz. G
Navicula menisculus Schum. G, C, P
Navicula minima Grun. G
Navicula mutica Kuetz. G, C, P
Navicula mutica var. *undulata* (Hilse) Grun. G
Navicula pseudoreinhardtii Patr. P
Navicula pupula Kuetz. G, C, P, Po
Navicula pygmaea Kuetz. G
Navicula radiosa Kuetz. Po
Navicula rhyncocephala Kuetz. G, P
Navicula subtilissima Cleve Po
Navicula symmetrica Patr. G, P
Navicula tripunctata (O.F.Muell.) Bory G, C, P, Po
Navicula tripunctata var. *schizonemoides* (V.H.) Patr. C, P
Neidium affine (Ehr.) Pfitz. P
Nitzschia sp. C
Nitzschia acicularis W. Smith Po
Nitzschia acuta Hantzsch C, P
Nitzchia amphibia Grun. G, C, P, Po
Nitzschia apiculata (Greg.) Grun. C
Nitzschia capitellata Hust. C
Nitzschia Clausii Hantzsch C, P
Nitzschia dissipata (Kuetz.) Grun. G, C, P
Nitzschia filiformis (W. Smith) Hust. G, C, P
Nitzschia frustulum (Kuetz.) Grun. G, P
Nitzschia gracilis Hantzsch G, C, P
Nitzschia hungarica Grun. G, P
Nitzschia palea (Kuetz.) W. Smith G, C, P, Po
Nitzschia parvula Lewis P
Nitzschia sigma (Kuetz.) W. Smith G

Nitzschia sublinearis Hust.
Nitzschia thermalis Kuetz. C
Nitzschia thermalis var. *minor* Hilse G, C, P
Nitzschia tryblionella Hantzsch G, C, P, Po
Pinnularia sp. C, P
Pinnularia abaujensis (Pant.) Ross G, Po
Pinnularia acrosphaeria W. Smith Po
Pinnularia acuminata W. Smith P
Pinnularia borealis Ehr. P
Pinnularia braunii var. *amphicphala* (Mayer) Hust. Po
Pinnularia burkii Patr. Po
Pinnularia legumen (Ehr.) Ehr. Po
Pinnularia maior (Kuetz.) Rabh. P
Pinnularia mesogongyla Ehr. Po
Pinnularia substomatophora Hust. Po
Rhoicosphenia curvata (Kuetz.) Grun. G
Rhopalodia gibba (Ehr.) O. Muell. P, Po
Rhopalodia musculus (Kuetz.) O. Muell. C
Stauroneis nobilis Schum. Po
Surirella sp. Po
Surirella linearis W. Smith G, P
Surirella ovata Kuetz. G, C, P
Surirella robusta Ehr. P, Po
Synedra sp. P
Synedra delicatissima W. Smith Po
Synedra fasciculata (Ag.) Kuetz. G, C, P, Po
Synedra minuscula Grun. G
Synedra rumpens Kuetz. C, P, Po
Synedra ulna (Nitz.) Ehr. G, C, P, Po

Centrales:
Biddulphia laevis Ehr. C
Coscinodiscus sp. G
Coscinodiscus lineatus Ehr. Po
Coscinodiscus Rothii (Ehr.) Grun. G
Cyclotella atomus Hust. G, P
Cyclotella comta (Ehr.) Kuetz. G, P
Cyclotella Meneghiniana Kuetz. G, C, P, Po
Cyclotella stelligera Cl. & Grun. G, C
Cyclotella striata (Kuetz.) Grun. G, C, P, Po
Melosira ambigua (Grun.) O.F.Muell. G, C, P, Po
Melosira distans (Ehr.) Kuetz. G, C, P, Po
Melosira granulata (Ehr.) Ralfs G, C, P, Po
Melosira italica (Ehr.) Ralfs G, C, P
Melosira varians Ag. G, C, P, Po
Stephanodiscus astrea (Ehr.) Grun. G, C, P, Po
Stephanodiscus Hantzschii Grun. G, C

CHLOROPHYTA

Chlorococcales:
Ankistrodesmus falcatus (Corda) Ralfs G, C, P
Ankistrodesmus fractus (West & West) Brunthaller G, C, P
Chlorococcum sp. G, P
Coelastrum microporum Naeg. in Braun C
Coronastrum aestivale Thompson G
Crucigenia rectangularis (A. Br.) Gay Po
Crucigenia tetrapedia (Kirch.) West & West C
Crucigenia truncata Smith G, C, P
Dictyosphaerium pulchellum Wood P
Dictyosphaerium Ehrenbergianum Naeg. C
Franceia Droescheri (Lemn.) Smith C
Golenkinia radiata (Chod.) Wille C, P
Kirchneriella elongata Smith P
Kirchneriella obesa (West) Schmidle P
Kirschneriella subsolitaria West C
Lagerheimia sp. C
Micractinium pusillum Fresenius G, C, P
Nephrocytium obesum West & West P
Oocystis pusilla Hansg. G, C, P, Po
Pediastrum duplex var. *reticulatum* Lager. C, P
Pediastrum tetras (Ehr.) Ralfs P
Scenedesmus sp. P
Scenedesmus acuminatus (Lag.) Chod. C
Scenedesmus anomalus (Smith) Ahlstrom & Tiffany P
Scenedesmus arcuatus var. *platydisca* Smith G
Scenedesmus brasiliensis Bohlin Po
Scenedesmus dimorphus (Turp.) Kuetz. C, P
Scenedesmus quadricauda (Turp.) Bréb. G, C, P
Scenedesmus serratus (Corda) Bohlin
Schroederia Judayi Smith G
Schroederia setigera (Turp.) Bréb. P
Tetraëdron constrictum Smith P
Tetraëdron trigonum (Naeg.) Hansg. C, P
Tetrastrum elegans Playfair C

Oedogoniales:
Oedogonium sp.

Tetrasporales:
Sphaerocystis Schroeteri Chod. G, P, Po

Ulotrichales:
[b]*Radiofilum conjunctivum* Schmidle Po

Volvoccales:
Chlamydomonas sp. G, C, P
Chlamydomonas Cienkowskii Schmidle P
[b]*Chlamydomonas Snowii* Printz C, P
Pteromonas sp. C

Zygnematales:
Arthoaesmus convergens Ehr. Po
Arthrodesmus michiganesis Johnson C, Po
Closterium acerosum (Schrank) Ehr. C
Closterium calosporum Witt. G, P
Closterium leiblenii Kuetz. Po
Closterium moniliforme (Bory) Ehr. P
Cosmarium spp. G, Po
Cosmarium denatum Wolle P
Cosmarium nobile (Turner) Kreiger Po
Cosmarium porrectum Nordst. Po
Desmidium sp. Po
Desmidium Aptogonum Bréb. G
Desmidium Baileyi (Ralfs) Nordst. Po
Desmidium Grevillii (Kuetz.) B. By. Po
Euastrum sp. G, C, Po
Micrasterias radiata Hass. Po
Mougeotia sp. Po
Onychonema filiforme (Ehr.) Roy & Biss. Po
Pleurotaenium Trabecula (Ehr.) Naeg. Po
Spirogyra sp. G, P, Po
Spondylosium sp. Po
Staurastrum sp. Po
Staurastrum quadricuspidatur Turner Po
Staurastrum turgescens de Wok Po
Xanthidium sp. Po

CHRYSOPHYTA

Heterotrichales:
Tribonema affine West C

CYANOPHYTA

Chroococcales:
Aphanocapsa muscicola (Menegh.) Wolle Po
Chroococcus sp. G, Po
Chroococcus limneticus Lemm. P
Chroococcus minor (Kuetz.) Naeg. Po
Coelosphaerium confertum G. S. West Po

ta), 62 green algae (Chlorophyta), 23 bluegreens (Cyanophyta), 19 euglenophytans, 3 pyrrhophytans, 1 chrysophytan, and 1 unidentified red alga. Several of these represent new state records.

Species diversity in the Grand River ranged from 0.49 at Station G-1 in March to 3.44 in August (Table 2). Number of taxa present at any one sampling time ranged from 5 at G-3 in May to 27 at G-2 in June. The diatoms *Melosira granulata* and *Cymbella minuta* were the most abundant algae in the Grand River during this study. Other important algae include *Ankistrodesmus falcatus, Oocystis pusilla,* and *Gymnodium* sp.

Species diversity in Chouteau Creek ranged from 1.56 in March at Station C-3 to 3.82 in May at the same station. The lowest number of taxa present at any one sampling time was in March at C-3 and the highest was 45 at the same station in June. *Melosira granulata* and *Chlamydomonas Snowii* were the most abundant algae at Chouteau Creek. *Cymbella minuta, Crucigenia truncata,* and *Trachelomonas volvocina* were also common.

Species diversity ranged from 0.30 at station P-1 in February in Pryor Creek to 3.40 at the same station in March. The number of taxa present varied from four in August at P-2 to 41 in June at P-1. *Euglena gracilis* was the most abundant alga observed in Pryer Creek with *Melosira granulata* the second most abundant. Other common algae were *Trachelomonas volvocina, Ankistrodesmus falcatus,* and *Scenedesmus quadricauda.*

Species diversity in the ponds ranged from 2.52 in Pond 3 to 4.10 in Pond 2. Taxa present varied from 42 in Pond 1 to 53 in Pond 3. All three ponds had large numbers of desmids such as *Desmidium Baileyi, Cosmarium* sp., *Arthrodesmus convergens,* and *Pleurotaenium Trabecula* as well as filamentous members of the *Zygnematales* such as *Mougeotia* and *Spirogyra.*

Coelosphaerium dubium Grun. in Rabh. Po
Glaucocystis sp. Po
Gloecapsa sp. P
Gomphosphaeria lacustris Chod. P
Marssoniella elegans Lemm. P
Merismopedia tenuissima Lemm. C
Microcystis flos-aquae (Wittr.) Kirch. C

Oscillatoriales:
Lyngbya limnetica Lemm. G.
Lyngbya Nordgaardii Wille G, C
Oscillatoria angusta Koppe C, P, G, Po
Oscillatoria angustissima West & West Po
Oscillatoria limnetica Lemm. C
Oscillatoria limosa (Roth) Ag. G
Oscillatoria subbrevis Schmidle G
Oscillatoria tenuis Ag. C, P
Oscillatoria terebriformis Ag. C
Tolypothrix tenuis Kuetz. emend. J. Schmidt Po

EUGLENOPHYTA

Euglenales:
Euglena sp. G, C, P
Euglena acus Ehr. C, P
Euglena gracilis Klebs G, C, P
Euglena polymorpha Dangeard C
Lepocinclis ovum (Ehr.) Lemm. C
Phacus acuminatus Stokes C
Phacus chloroplastes Prescott P
Phacus longicauda (Ehr.) Dujardin C, P
Phacus pseudoswirenkoi Prescott P
Phacus pyrum (Ehr.) Stein C
Trachelomonas abrupta (Swir.) Deflandre C
Trachelomonas dubia (Swir.) Deflandre C
Trachelomonas Dybowskii Drezpolski P
Trachelomonas hexangulata Swirenko C, P
Trachelomonas hispida (Perty) Stein C, P
Trachelomonas intermedia Dangeard G, C, P
Trachelomonas robusta Swirenko C
Trachelomonas speciosa Deflandre P
Trachelomonas volvocina Ehr. C, P, Po

PYRROPHYTA

Gymnodiniales:
Gymnodium sp. G, P

Peridinales:
Ceratium hirundinella (O.F. Muell.) Dujardin G, Po
Peridinium sp. Po

RHODOPHYTA
Unidentified filament (Chantransia stage) P

[a]G = Grand River; C = Chouteau Creek; P = Pryor Creek; Po = ponds
[b]New state record

DISCUSSION

The Grand River is typical of larger rivers in that the plankton was composed mainly of diatoms. Diatoms were also the dominant planktonic algae in Pryor and Chouteau creeks with the exception of Station P-1 in February.

Planktonic diatoms found in this study include the genera *Melosira, Asterionella, Fragilaria, Cyclotella,* and *Stephanodiscus* (41). Benthic diatoms found include the genera *Synedra, Nitzschia, Navicula, Diatoma,* and *Surirella.* As the water became warmer Chlorophycean phytoplankters such as *Scenedesmus, Ankistrodesmus,* and *Dictyosphaerium* became common. Numbers of benthic algae in the open water generally

TABLE 2. *Species diversity for phytoplankton of GRDA sites in 1977.*

Stream (Station)	2/26	3/26	4/30	5/24	6/11	7/15	8/16
Grand (G-1)	1.2	0.5	2.6	2.2	2.8	2.4	3.0
Grand (G-2)	2.9	0.8	2.6	1.8	3.0	2.2	3.0
Grand (G-3)	2.3	3.0	2.2	0.6	2.3	2.6	3.4
Chouteau (C-2)	2.3	1.9	3.0	3.2	3.2	3.2	3.2
Chouteau (C-3)	2.8	1.6	2.5	3.8	2.5	2.9	2.1
Pryor (P-1)	0.3	3.4	3.3	2.7	3.3	2.4	2.8
Pryor (P-2)	2.9	1.7	2.8	3.2	3.0	3.3	1.5
Pond 1				3.6			
Pond 2				4.1			
Pond 3				2.5			

vary with the composition of the stream bed. As populations attached to the substrate mature, layers become unstable, are detached, and float away. Shallower streams tend to have larger numbers of benthic algae. This is true of Chouteau and Pryor creeks.

Species diversity values in the Grand River ranged from 0.49 to 3.44. Using the categories of Staub (42) the Grand River would range from slightly to heavily polluted at all three stations. The present intake appears to have a decided effect on the phytoplankton population. This probably occurs in several ways: 1) large numbers of plankters are removed from the open water through the intake, 2) decay of fish and other animals trapped by the intake and low water dam contribute to organic pollution and thus abundance of pollution-tolerant algal genera to the exclusion of less tolerant taxa, and 3) frequent and severe fluctuations in water level affect the number and kinds of organisms capable of thriving. Station G-2 is most likely affected by organic pollutants coming from Pryor Creek, an industrialized stream.

The greatest variety of phytoplankton taxa occurred in Chouteau Creek in February, while the lowest occurred in March. As in the Grand River, diatom taxa are common in Chouteau Creek. According to Staub's (42) classification system, species diversity values for Chouteau Creek indicate that it is only moderately to lightly polluted. The lowest value for species diversity in Pryor Creek occurred in February at P-1 (0.30). The potential for such a low species diversity indicates substantial pollution. The presence of cattle at Station P-1 and industrial wastes add considerable organic nitrogen to the water and contribute to heavy pollution found there in some months, which increases the pollution found at Station P-2.

The algae found in the three ponds are those typically found in quiet, acid environments.

CONCLUSIONS

Two hundred and forty-five taxa of phytoplankters were collected from the Grand River Dam Study area. Of this number 136 were diatoms, 62 green algae, 23 bluegreens, 19 euglenophytans, 3 pyrrhophytans, 1 chrysophytan, and 1 unidentified red alga. The sites on the GRDA Study Site indicate some potential problem areas such as in P-1. In general, however, the study indicates that Chouteau Creek, Pryor Creek, and the Grand River are lightly to moderately polluted.

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