# Report for 2002ND10B: Physical and environmental factors influencing the periphyton communities of the Sheyenne River, North Dakota

- Dissertations:
  - Jaskowiak, Megan Aileen. 2002. Ph.D., "Periphytic Algae in the Sheyenne River, North Dakota." Department of Biological Sciences, College of Science and Mathematics, North Dakota State University. Major Professor: Dr. Marvin W. Fawley.

Report Follows:

# Physical and environmental factors influencing the periphyton communities of the Sheyenne River, North Dakota

ND WRRI Graduate Research Fellowship Project
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## Abstract

The physical factors affecting the periphyton communities of the shallow, turbid Sheyenne River (North Dakota) have been a focus of our research group for the past five years. Periphyton samples from both artificial and natural substrates at eight sites along the river were collected from 1997-1999. Major ions and other chemical parameters for these sites were determined by the North Dakota Department of Health. The algal species present in these samples have already been identified and enumerated, and some analyses have been completed. Our initial analyses (using only artificial substrate data) have indicated that certain physical factors do affect the periphyton community of this river. However, these analyses suggest that one of the most important factors affecting the periphyton communities of the Sheyenne is the presence of a reservoir, Lake Ashtabula. In this study, we plan to expand upon our analyses by critically examining the impact of Lake Ashtabula on the periphyton communities of the Sheyenne River. In addition, we will complete additional analyses of the periphyton communities found on natural substrates. Results of these analyses should enable more effective water management in the Sheyenne Basin, especially Lake Ashtabula. In addition, we plan to conclude the periphyton survey of the Sheyenne River by completing the descriptions of three potentially new species of the diatom genus Nitzschia. The complete periphyton flora of the Sheyenne River will provide an important basis for understanding the impacts of changes in the river, such as the proposed Devils Lake emergency outlet.

**Description of critical regional or state water problem being investigated**

This research project began as part of the environmental impact statement for the U.S. Army Corps of Engineers Devils Lake emergency outlet project. In order to moderate flooding in the closed Devils Lake Basin, an outlet to the Sheyenne River was proposed. However, components of the river biota were likely to be impacted by this diversion. The effects of the Devils Lake outlet on the Sheyenne River include increased total dissolved solids (TDS), increased flow rate, and possibly increased nutrients. In the first part of this study, periphytic algae were collected using artificial substrates at several sites along the Sheyenne River. The first goal of this study was to relate the periphyton communities to environmental factors that may be potentially affected by a Devils Lake outlet (Phillips et al. 2000). While completing this research, several additional questions arose.

One question that still needs to be answered is how the regulation of waterflow impacts the periphyton communities in this river. The Sheyenne river has been regulated since 1950, when

the Baldhill Dam was built on the Sheyenne just north of Valley City to create Lake Ashtabula. Our earlier research suggested that the periphyton communities in the downstream sites are quite different from those communities found upriver of Lake Ashtabula. Research on other rivers has shown profound changes in the algal community after a dam was built (Blinn et al.1998, Baier et al.1998, Skulberg 1982). These variations in communities are due to changes in two broad environmental areas: water quality and geomorphology (Ward and Stanford 1982). An example of the first is a higher level of ammonia downstream from the dam. Erosion or changes in the shape of the river channel are an example of the second (Blinn et al. 1998). Although our earlier research has shown a difference in the periphyton communities, it is not known if these differences are statistically significant and which type of environmental change may cause the difference. The main goal of this project is to determine if Lake Ashtabula alters the algal communities of the Sheyenne River and if this shift is related to water quality or geomorphology.

A second goal of this project is the description of the periphyton of the Sheyenne River. Although over 300 taxa of periphytic algae have been identified from our samples, three of the diatoms could not be identified to species. These three diatoms are in the genus *Nitzschia*. It is likely that these diatoms are new *Nitzschia* species. These three diatoms have already been characterized by light and scanning electron microscopy. However, critical comparison with type material of closely related species still needs to be completed. Complete descriptions of these new taxa must be made to complete the descriptions of the periphyton communities of the Sheyenne River. A thorough understanding of the periphyton communities of the river will enable the assessment of the effects of future changes in the river.

**Statement of results or benefits**

The results of this study are expected to be significant at multiple levels. First, the impact of Lake Ashtabula on a portion of the biota of the Sheyenne River will be assessed. This assessment will provide information that can potentially be used to better manage the outflow from the reservoir. Second, there is a lack of knowledge of the algal communities of the Sheyenne River, as well as any similar river in the Red River of the North drainage. This study will provide information on the periphyton communities that will be useful for estimating the effects of other perturbations to the Sheyenne River system, as well as similar river systems in the area.

The applied aspects of this proposal will be of potential importance for the management and control of Lake Astabula. In addition, this study could provide additional information on the impact of diverting water from Devils Lake into the Sheyenne. Both the North Dakota Dept. of Health and the US Corp of Engineers have expressed interest in this study.

**Nature, scope and objectives of the project, including a timeline of activities**

Periphyton samples have already been collected from the Sheyenne River and Lake Ashtabula (see Section 16). Taxa have been identified and enumerated from these samples, and the North Dakota Department of Health and the U.S. Army Corps of Engineers have provided the results of water chemistry analyses from these sites. Statistical analyses (canonical correspondence analysis, etc.) these data with the specific goals of determining the impact of Lake Ashtabula on the periphyton communities of the river, and to determine if the impact of the reservoir is due to

changes in water quality or geomorphology have been completed. In addition, the three potentially new *Nitzschia* taxa will be examined by scanning electron microscopy. The primary objective of this project is to complete these various analyses and prepare material for publication. Some additional sampling will also be performed to provide additional material for the characterizations of new species.

**Timeline**

March 2002 - October 2002. Complete all analyses and sampling for the Sheyenne River projects. Compare type material of *Nitzschia* species to the new species found in the Sheyenne River. Submit manuscripts describing 1) the new *Nitzschia* species; 2) the periphyton flora of the Sheyenne River; 3) analysis of the physical factors controlling community structure in the Sheyenne; and 4) the influence of Lake Astabula on the periphyton communities of the Sheyenne.

**Methods, procedures and Facilities**

**Periphyton Samples**

Eight sites along the Sheyenne River have been intensively sampled. Site 1 is at the Highway 30 bridge south of Maddock, ND which is located upstream of the proposed diversion inflow site for Devils Lake water. Site 2 is 3.3 miles south of Warwick, ND. Site 3 is located at the Highway 200 bridge east of Cooperstown, ND. Site 4 is the dock at the south end of Lake Ashtabula near the recreation area. The four sites downstream from Lake Ashtabula are at the 8th Ave bridge in Valley City, ND (5), at the southernmost bridge in Lisbon, ND(6), at the bridge south of Kindred, ND (7), and 0.5 miles west of Harwood, ND (8). These sites were sampled biweekly from late April through early November for the period September, 1997 through November, 1999.

Because of the clay and silt substrate that is present at the sample sites, artificial substrates were used for periphyton sampling (Aloi 1990). Acrylic substrates were suspended 0.3 m below the surface of the water (Phillips et al. 2000). These acrylic plates were placed in straight sections of the river where deep pools were not present. The periphyton was removed using a razor blade and the plate was rinsed with 25 ml of river water. An artificial substrate was not used at Lake Ashtabula. At this site, the side of the dock was scraped with a razor blade. A portion of each sample was retained for examination of live material and the remainder of the sample was preserved with Lugol's and formalin. The examination of live material determined if the diatoms present in the sample were actually alive.

Modified Taft's Syrup Medium slides were made to identify all the algae expect for the diatoms (Peterson and Stevenson 1989). Clearing methods and slide preparation were used for diatom determinations and enumeration, as described in Griffith and Perry (1995). These prepared slides were viewed at 960x magnification with oil immersion. All the algae were identified to the lowest taxonomic group possible using available keys (Prescott 1978 and 1982, Krammer and Lange-Bertalot 1986, 1988, 1991a and 1991b).

**Water Chemistry**

One 1 L sample and one 500 ml sample were collected from all sites except Lake Astabula for water chemistry analysis. Nitrate and phosphate levels were determined with the Cadmium

reduction method (Hach Company 1984) and the Ascorbic Acid and Amino Acid Method (Clesceri et al. 1989) respectively. Major ions were analyzed by the North Dakota Department of Health. pH was determined with a pH meter. Data on water chemistry for Lake Astabula was provided by the U.S. Army Corps of Engineers. River flow data will be obtained from the United States Geological Survey webpage.

**Evaluation and Statistical Analysis**

The data that have already been generated from the above methods will be used to perform statistical analyses. Redundancy Analysis (RDA, reviewed in ter Braak and Verdonschot 1995) will be used to determine if the sites downstream are more statistically similar with Lake Ashtabula than with the upstream sites. Also, canonical correspondence analysis (CCA, reviewed in ter Braak and Verdonschot 1995) will be used to examine which environmental variables explain the most variance in Lake Ashtabula and the downstream sites. CANOCO (ter Braak 1990) will be used to perform both types of analyses.

**Description of new *Nitzschia* taxa**

Throughout the identification process, several organisms could not be identified to species. Three of these organisms belong to the diatom genus, *Nitzschia*. Before species descriptions for these organisms can be completed, it must be determined if these organisms are actually new species. The collected specimens will be compared with type species in the collection at either the Philadelphia Academy of Sciences or the California Academy of Sciences.

If these organisms are undescribed species, the new species description can be made. The first step is to take measurements on 100 specimens. These measurements include but are not limited to length of the valve, width of the valve and striae count. Second, the specimen should be examined with scanning electron microscopy. After the specimens have been extensively studied, an appropriate name will determined and a species description in Latin will be written. The steps completed in the species description will follow the nomenclature rules adopted by the International Botanical Congress (1994).

**Related research**

Our on-going research on the Sheyenne River includes several projects related to this proposal. In our initial project, funded by the U.S. Army Corps of Engineers, we examined both the periphyton and the phytoplankton of the Sheyenne River to estimate the potential impact of the Devils Lake emergency outlet on the algae of the River. This project resulted in a report to the Corps (Phillips et al. 2000) describing the results of our survey and a CCA of the species distribution with water chemistry. Our basic conclusion was that the algal communities of the Sheyenne River are affected by water chemistry parameters that will be altered by the diversion of Devils Lake water into the river. The relative abundance data for species of periphytic algae and environmental data were used for the assessment. This analysis was completed using canonical correspondence analysis (CCA). The environmental variables that explained the most variance in the periphyton communities were pH, orthophosphate, hardness, arsenic, sulfate and nitrite+nitrate.

This analysis included all species that were identified. An analysis was repeated after the species considered to be phytoplankton were removed. This evaluation showed different environmental

variables that explained the most variance. These environmental variables were percent sodium, calcium, pH, arsenic, and sulfate. This analysis was more statistically significant. The phytoplankton species are not really part of the periphyton community and therefore, the variation seen in these species is coincidental. Therefore, the removal of these species makes the analysis more precise. These results were presented at the 2000 North American Benthological Society meeting in Keystone, CO (Jaskowiak et al. 2000), as a report to the Corps of Engineers (Phillips et al. 2000), at the Phycological Society of America Annual Meeting in Estes Park, CO. (Jaskowiak et al. 2001a), and the North American Diatom Symposium at Elly, MN (Jaskowiak et al. 2001b).

In addition, we are investigating the periphyton communities of natural substrates versus the artificial substrates used in our analysis for the Corps as well as the utility of presence/absence data for the analyses. Natural substrate communities appear to be quite different from the artificial substrate communities. These differences include several species that were not found at all on the artificial substrates. An example of these additional species is the diatom, *Navicula mutica*. However, analyses must be completed to see if these differences are statistically significant. These analyses and the analysis of the presence/absence data were completed in 2001.

Also in 2001, we initiated a new study in cooperation with the North Dakota Department of Health to investigate nutrient criteria for the Sheyenne River in order to set these criteria for North Dakota rivers and streams. This project is funded by the EPA. Our part of this study is the selection of sites representing high and low nutrient conditions, collection of periphyton and water samples, and identification and enumeration of the periphyton (both diatoms and soft algae). This project is expected to continue in 2002 with sampling from sites with intermediate nutrient loading.

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**Research Findings**

Aquatic systems with flowing water have very dynamic environments that produce complex periphytic algal communities. These communities are sensitive to changes in their environment. Therefore, changes in these communities can be used in water quality assessment. Historically, problems have been associated with this use of these algae. Some of these problems have been solved. In current research, these algal communities are used to monitor the quality of these systems. However, some problems still exist. These problems are that no standard sampling method has been established, identification of these organisms is difficult and requires extensive training, and the identification in existing studies may not be either consistent or correct. However, even with these difficulties, scientists have found that these communities can still be used to assess the conditions of the environment. Therefore, if the problems are overcome, then these communities would provide an accurate biological assessment of water quality.

The periphytic algae of the Sheyenne River in North Dakota were examined. This research consisted of several different studies. In the first study the distribution of the periphytic algae was examined. In the second, the distribution of the periphytic algae was correlated to changes the environmental conditions. In the third study, two species of diatoms that could not be identified to species were described as new species. Also, the differences between natural substrates and artificial substrates were compared using canonical correspondence analysis (CCA). The relative abundance data from these studies were compared to presence/absence data using multiple dimensional scaling (MDS). Last, the effects of Lake Ashtabula, a reservoir, on the down river algal populations were examined.

The objectives of the first study were to identify the periphytic algae in the Sheyenne river and to examine the distribution of the periphytic algae throughout the river. These data will be used as a baseline for further ecological studies. Altogether 132 artificial substrate samples were collected. Two hundred twenty-one periphytic algal taxa were identified and the relative abundance of each taxon was determined. Several potentially new species were detected. The distribution of periphytic algal taxa was closely examined for both seasonal and spatial patterns.

In the second study, the objective was to determine which environmental variable correlate with the distribution patterns of the periphytic algae in the Sheyenne River. Direct ordination, a type of multivariate statistics, was used. Nineteen environmental variables were used in the analysis. This analysis found that the variables that explained the most variance in the periphytic algal communities were magnesium, manganese, chloride, calcium, nitrite-nitrate, sulfate and pH ($p<0.05$).

During the examination of the periphytic algae in the Sheyenne River, 59 taxa could not be identified to species. Two of these organisms were originally identified as *Nitzschia* sp. 4 and *Nitzschia* sp. 5. The objective of the third study was to determine if these organisms are new species and to describe them. *Nitzschia* sp. 4 was compared with its possibly closest related species, *Nitzschia filiformis*. *Nitzschia* sp. 5 was compared with its possibly closest related species, *Nitzschia amphibia* and *seimrobusta*. *Nitzschia* sp. 4 and *Nitzschia* sp. 5 are differ from these described species. Therefore, *Nitzschia sheyennensis* Jaskowiak sp. nov. and *Nitzschia dakotensis* Jaskowiak sp. nov. were described from the periphytic algae of the Sheyenne River, North Dakota.

This research also included a comparison of the natural substrates and artificial substrates and a comparison of the use of presence/absence data versus relative abundance data in CCA. Natural substrate communities appear to be quite different from the artificial substrate communities. These differences include several species which were not found at all on the artificial substrates. An example of these additional species is the diatom, *Navicula mutica*. The artificial substrates appear to be a better representation of some natural substrates, e.g., rocks. Presence/absence data seem to produce the same results statistically as the relative abundance data. Further study may show that presence/absence is a viable type of species examination for water quality studies.

The effects of Lake Ashtabula on the down river algal populations are considerable. Studies have shown that sites within a river have a large year to year variation. The year to year variation within the sites in the Sheyenne River is high. However, the effects of Lake Ashtabula have a greater effect. Several species of algae that are common in the sites upriver from the reservoir are not at the sites down river. Also, species that are usually found in lakes are in the down river sites, but are not upriver from the reservoir. Close examination of the species will help determine if this effect is due to nutrient influx from the reservoir or from effects of erosion caused by the controlled flow of the river.

These studies were the first investigation of the periphytic algae in the Sheyenne River. This research found a diverse community that is in part controlled by nine environmental variables. Also, the growth of these algae is affected by year to year changes and by the influence of Lake Ashtabula. In this research, quite a few taxa could not be identified to species. Description of these new species will help to use the periphytic algae for water quality assessment. These results of this research provide the information needed to use the periphytic algae of the Sheyenne River for water quality assessment.