Report for 2004ME31B: Nutrient cycling within the Meduxnekeag River and the use of periphytic algae as an indicator of nutrient loading

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Report Follows

Progress Report 2004

Nutrient cycling within the Meduxnekeag River and the use of periphytic algae as an indicator of nutrient loading

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Period covered by this report: April 2004-April 2005

ABSTRACT

A 20-mile segment of the Meduxnekeag River in Aroostook County, Maine, that traverses Houlton Band of Maliseet Indian (HBMI) tribal lands is experiencing substantial filamentous algal blooms in summer months. The algal blooms have lowered dissolved oxygen (DO) levels in the river to the extent that a 6-mile stretch within the segment has been deemed “impaired” by the Department of Environment Protection (DEP).

Water chemistry data collected by the HBMI are available from 1995 to the present for this stretch of the river and indicate that the blooms may be phosphorus (P) limited, but that the algae are moderating stream chemistry and responding to flow dynamics to an extent that controls over algal production are unclear. A Watershed Protection Plan/Environmental Assessment for the Main Branch of the Meduxnekeag River was published in 1993, a Total Maximum Daily Load (TMDL) Report was published by the Department of Environmental Protection (DEP) in 2000, and the U.S. Geological Survey (USGS) is finalizing a sediment study it conducted this summer (2003).

Currently, no research has linked the existing water quality data to nutrient dynamics in the river, or pinpointed the relative input contributions from point and non-point sources, of which there are many. These including unbuffered agricultural stream inputs, wetland, and lake recharge as well as industrial and wastewater effluent and proximity to impermeable surface inputs; all of these inputs are upstream of the Maliseet tribal lands. We proposed to evaluate the underlying cause of the eutrophication by compiling and analyzing the existing data, investigating nutrient cycling in the river (including sediment and the water column), identifying nutrient loading areas and relative contributions of point and non-point sources, and determining temporal and spatial changes in the algae. Our overarching goal is to identify the causes of the problem, or to prioritize the likely causes, and thus provide supportive data that may lead to recommendations for remedy.

State Water Quality Problem and Research Objectives

Although environmental regulations have drastically reduced point source pollution, non-point source pollution remains a leading cause of water quality problems nationwide. State inventories indicate that agriculture impacts 48 percent of impaired rivers and streams (EPA, 2002). One of the major constituents of non-point source pollution is sediment, which is transported from agricultural and urban areas and carries heavy metals, pesticides, oils, and nutrients. High nutrient concentrations are a leading cause of impairment and eutrophication, a symptom of which is oxygen-depleting algal blooms.

The algal blooms in the Meduxnekeag River depress dissolved oxygen (DO) levels and alter the habitat of fish and other biota. Throughout the state, rivers are being altered to such an extent that they are losing native fish populations. Tribal members have observed non-native fish (bass, sucker, pickerel) becoming dominant while native trout numbers are declining (Ellis, pers. comm. 2003). The Maine State Planning Office's River Study lists the Meduxnekeag River as having natural and recreational values of statewide significance. However, the algal blooms and resulting low DO levels are threatening this status. A 6-mile segment of the river downstream of Houlton is listed on the state's 303d and 305b list for non-attainment of water quality standards because of high nutrient loads and low DO levels.

Although its presence on the impaired list legally requires corrective measures to be taken, so little is known about nutrient sources and cycling in the Meduxnekeag River that the any solution would be speculative at this point in time. Moreover, an evaluation of the Meduxnekeag River eutrophication, which is rare for Maine, will be useful for our understanding of processes statewide, because of increasing pressures on many Maine waters. Also, since the project will quantify the relative inputs from point and non-point sources, our research will be applicable to other areas with non-quantified point and non-point sources of nutrient enrichment.

Several states are battling eutrophication problems that became widespread before they were well understood, forcing a reactive approach; Maine, on the other hand, has an opportunity to be proactive and address the issue while it is still relatively small scale. We can gain an understanding of nutrient cycling in the river and use that knowledge to drive a restoration plan that will be a model for other areas of the state and beyond.

Research Goal:

To determine the spatial and temporal relationships between nutrients, algal growth, and land use in the Meduxnekeag River corridor?

This goal is bring addressed by three general research objectives:

1) **What are the spatial and temporal phosphorus and nitrogen trends in the Meduxnekeag River, and how do they correlate to nutrient sources in the watershed?**

2) **Are spatial and temporal patterns in the algal growth an indicator of nutrient concentrations?**

3) **Do the water column and algae have unique δ15N stable isotope signatures that we can relate to specific point source and non-point source nutrient sources within the watershed?**

METHODS

The watershed will be divided into three zones as shown in the conceptual model below (Fig. 1). Zone 1 will extend from the headwaters at Meduxnekeag Lake to just upstream of AE Staley's (a starch plant) and contains predominantly agricultural land. Zone 2 contains AE Staley's, the confluence with the South Branch of the Meduxnekeag River, and downtown Houlton. Zone 3 contains the WWTP and HBMI tribal lands.

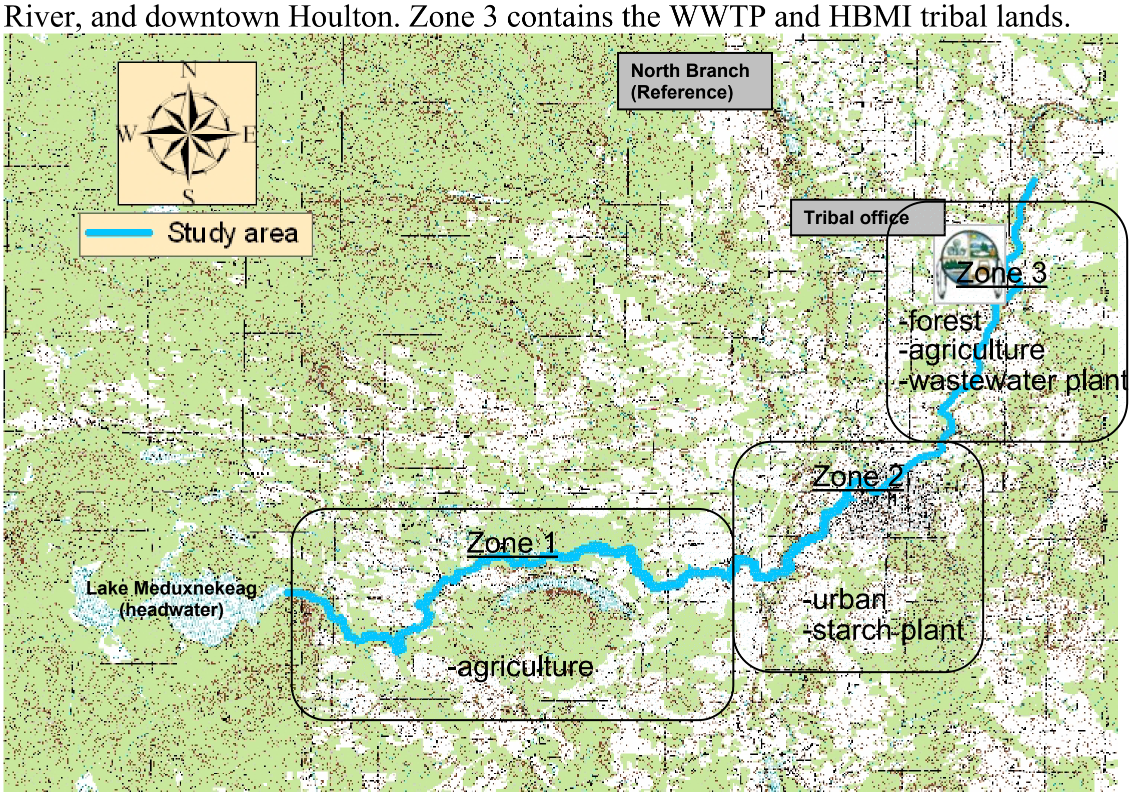

Fig. 1 Conceptual diagram of the Meduxnekeag Study Reach.

We compiled and analyzed existing data, and determine gaps in sampling regimes as they fit within the general framework of the conceptual river chemistry influences in Fig 1. We then devised a detailed sampling plan for the Spring of 2004 which added a substantial number of sampling areas to those already analyzed on a regular basis by the Maliseet Tribe's water quality specialists.

Assessing water chemistry and Algal cover patterns

At each sampling area along the 20 mile reach, we established permanent bank markers to delineate a water sampling plan and an algal assessment plan. The basic features of the water chemistry and algal assessment plan are shown in Fig. 2. Nutrient sampling and algal assessments were performed biweekly from May through September and algal grab samples for identification and natural abundance isotope forensics were obtained twice.

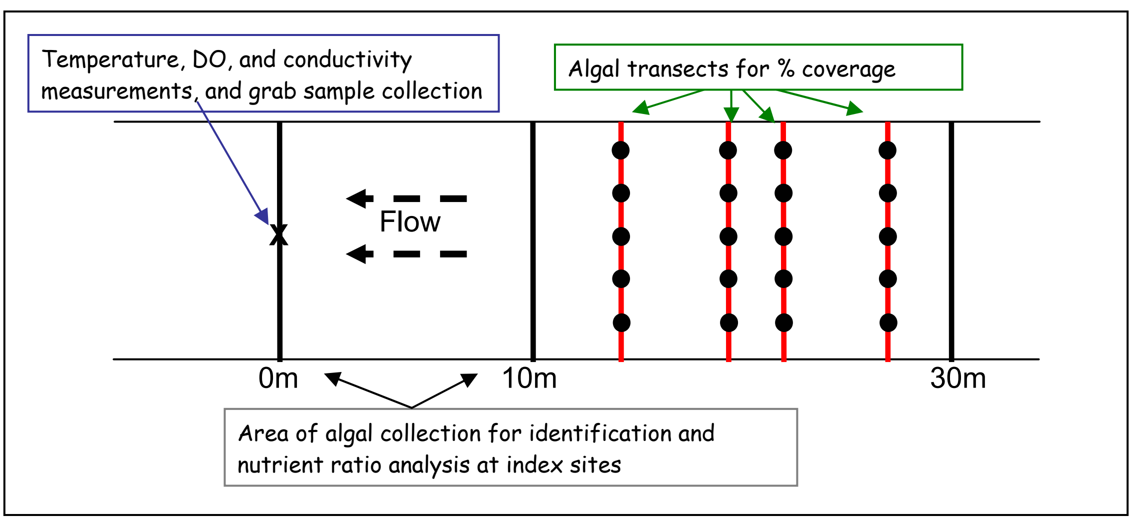

Fig 2. Conceptual diagram of the water chemistry sampling plan and the algal assessment transects.

PRINCIPLE FINDINGS TO DATE

Water chemistry

Soluble reactive phosphorus, that P which is most available for plant and microbial uptake, was often not differentiable from the detection limits of our method, therefore we report the season average of Total P which includes soluble and particulate P in unfiltered samples (Fig. 3). Season averages for the individual sites necessarily have a considerable amount of error associated with them and this is owing to processes in the watershed that mobilize P as well as the water flow regime. However, we do see a trend in increasing P loading as one goes from headwaters to the furthest point downstream in our study (Fig. 3). Total P levels appear to have a high value just downstream of the waste water treatment plant and the large error is consistent with a discreet treated water release pattern.

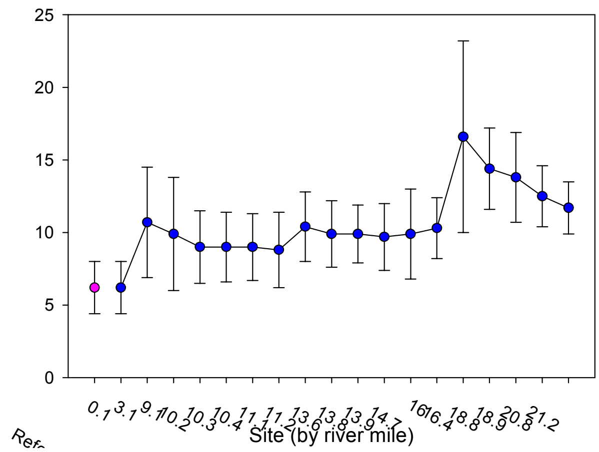

Fig. 3. Total P concentrations averaged from May to September; reported by River Mile.

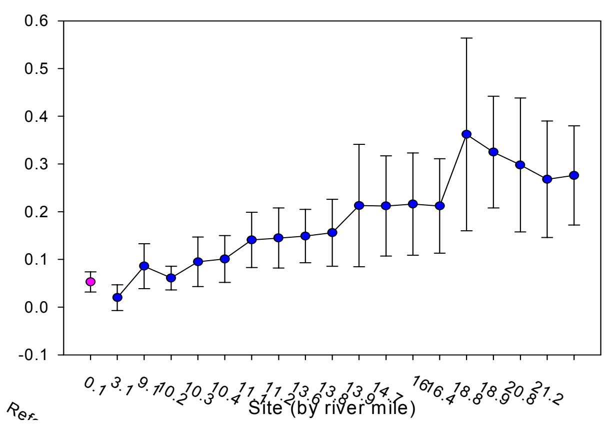

Fig. 4. NO_3 N concentrations averaged from May to September; reported by River Mile.

We measured dissolved inorganic N as NH_4^+ and NO_3^-, however since NH_4^+ concentrations were almost always at the detection limit, we report NO_3^- only, below (Fig 4). Trends in the concentrations were similar to those for total P; there was a general increase in the concentration of NO_3^-N despite concomitant increases in water volume in the river as one heads downstream. NO_3^- concentrations peaked below the waste water treatment facility and then declined somewhat, probably owing to dilution by other stream confluences and biological N consumption. Samples for 2004 were frozen and the DIN data are currently being utilized to prepare stream waters for natural abundance isotope analysis. This analysis will take place spring 2005 and will be compared to the isotopic signature of algae collected from the stream over the same period. We will use a simple mixing model to assess the source of N supporting algal growth in the watershed, but this methodology alone does not allow one to assess nutrient limitations on the algal growth and thus "causation" rather, it will give us a sense of where nutrient inputs occur and if they might be associated with point source and non-point source inputs to this river.

Algal Assessments

In 2004, a cool spring with higher than average precipitation delayed onset of algal growth until late August and early September. Algal cover was less than 5% of the substrate in greater than 60% of the sampling sites. Community analyses revealed three dominant filamentous genera: *Spirogyra*, *Mougeotia*, and *Zygnema*. They are all unbranched green algae belonging to the Class Charophyceae and are not indicative of a particular trophic environment.

Implications and Expected Outcomes:

The HBMI and USGS are investing much into the Meduxnekeag River watershed, and this project will add to the effort by defining the nutrient status of the river and studying the dynamics of the algal bloom. It will help the HBMI to determine the necessity for a nutrient monitoring program in the future and to find areas of the watershed to focus nutrient reductions efforts. The Maine DEP is currently developing nutrient and biological criteria (including algae) for the state's rivers. The results from this project will be made available to the DEP to add to their database. The historical algal growth in the Meduxnekeag River is rare for the state, and therefore, nutrient and algal growth data for the river will be valuable in helping to define the range of conditions found in Maine.

Deliverables:

To date, no publications have arisen from this investigation:

Other Activities

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