Pre-settlement water quality and algal change in Spring Lake, Scott Co., MN

St. Croix Watershed Research Station

Science Museum of Minnesota

Study Objectives

The goals of this study were to establish the site-specific historical (pre-settlement) total phosphorus (TP) concentrations of Spring Lake, Scott Co. In addition, our aim was to determine if there was any evidence of cyanobacteria blooms prior to settlement in the watershed. To achieve these goals we analyzed sediment deposits at the bottom of Spring Lake for algal fossils (physical and biochemical).

Key Findings

Lake sediments accumulate annually and undisturbed at the bottom of lakes. Using radioisotopic techniques we can date these deposits and uncover the history of the lake. We were able to establish reliable dates for the sediments we collected from Spring Lake. At our sample location 58 cm of sediment has accumulated since 1900, and 10cm since 2000 (Figure 1). Sampling the sediment core at different depths (representing time), we inspected the sediments using a microscope for the remains of algae known as diatoms. This type of algae is responsive to changes in water quality (e.g. TP) and the community structure will change over time favoring different species at different nutrient concentrations. We found that species that do well under nutrient-rich conditions have dominated the diatom

Highlights

- Two hundred years ago Spring Lake was nutrient rich and cyanobacteria algae were common.
- The current total phosphorus (TP) standard under the 2011 TMDL Plan (40 ppb) is lower than historical TP concentrations.
- A more appropriate historical TP concentration is 60 ± 5 ppb.
- Spring Lake experienced significant algal blooms during the Dust Bowl era.

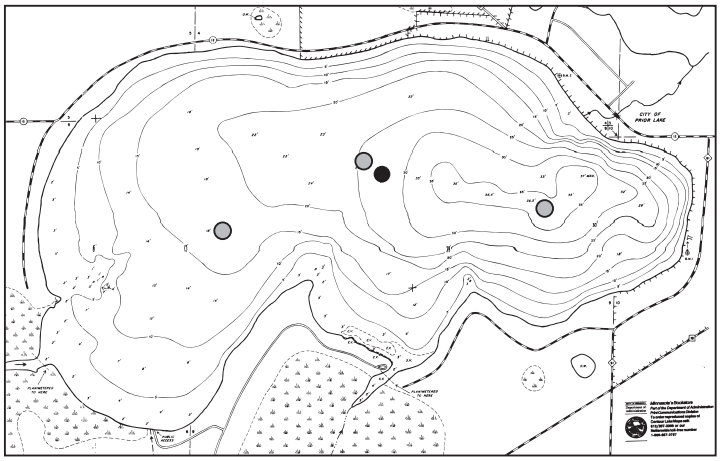

Figure 1: Spring Lake bathymetry map showing sediment core location from this study (black circle) and previous sediment cores (grey circles). The age-depth model from the 2009 sediment core nearest to the 2012 one was used to infer sediment dates.

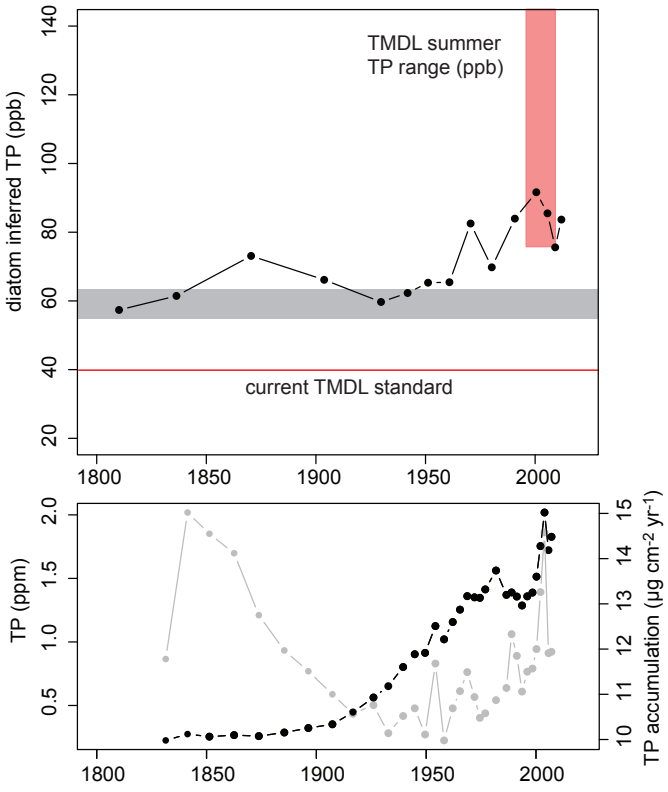

Figure 2: (upper) diatom modeled TP concentrations for Spring Lake over the last ~ 200 years. The current TMDL standard is shown by the red line and the range of measured modern summer TP concentrations in Spring Lake from 1996-2006 is shown as the red shaded area. The suggested pre-settlement TP levels shown as the grey shaded area. (lower) TP concentrations measured in the sediments (grey, left axis) and TP accumulation (black, right axis) in Spring Lake sediments near the deepest part of the lake.

communities over the last 200 years. In addition to these observations, we are able to model historical TP based on our extensive knowledge of the modern environments these algae inhabit (Ramstack et al., 2003). When we modeled the diatom communities over the last 200 years from Spring Lake (Figure 2), we found that the modern estimates fell well within the range of observed summer TP concentrations collected from 1996-2006 (TMDL, 2011). Prior to settlement in the area (~ pre-1850) the lake water TP concentration was ~ 60 (± 5) ppb (Figure 2). While this is considerably less than today it does suggest that the lake was historically nutrient-rich. This finding is similar to previous results of a different sediment core from the same location suggesting that the accumulation of TP directly bound to the sediments has been increasing steadily since ~1920 (Figure 2).

An additional method to detect changes in algae over time from lake sediments is to use the biochemical remains of the pigments (chlorophylls and carotenoids) that algae use during photosynthesis. In Spring Lake we were particularly interested whether the nuisance and potentially toxic types of algae known as cyanobacteria were present historically. When we looked at the pigment remains in the lake sediment record we found that cyanobacteria have been common in Spring Lake over the last 200 years (Figure 3). Cyanobacteria generally grow well in very nutrient-rich water, particularly phosphorus-rich waters. Therefore, this finding complements our earlier result that Spring Lake has long been a nutrient-rich lake. The pigment data also show that there were some significant algae blooms during the 1920s through the 1930s (Figure 3). It is possible that these blooms were encouraged by both the development activities of Prior Lake and the drier climate during this 'Dust Bowl' era.

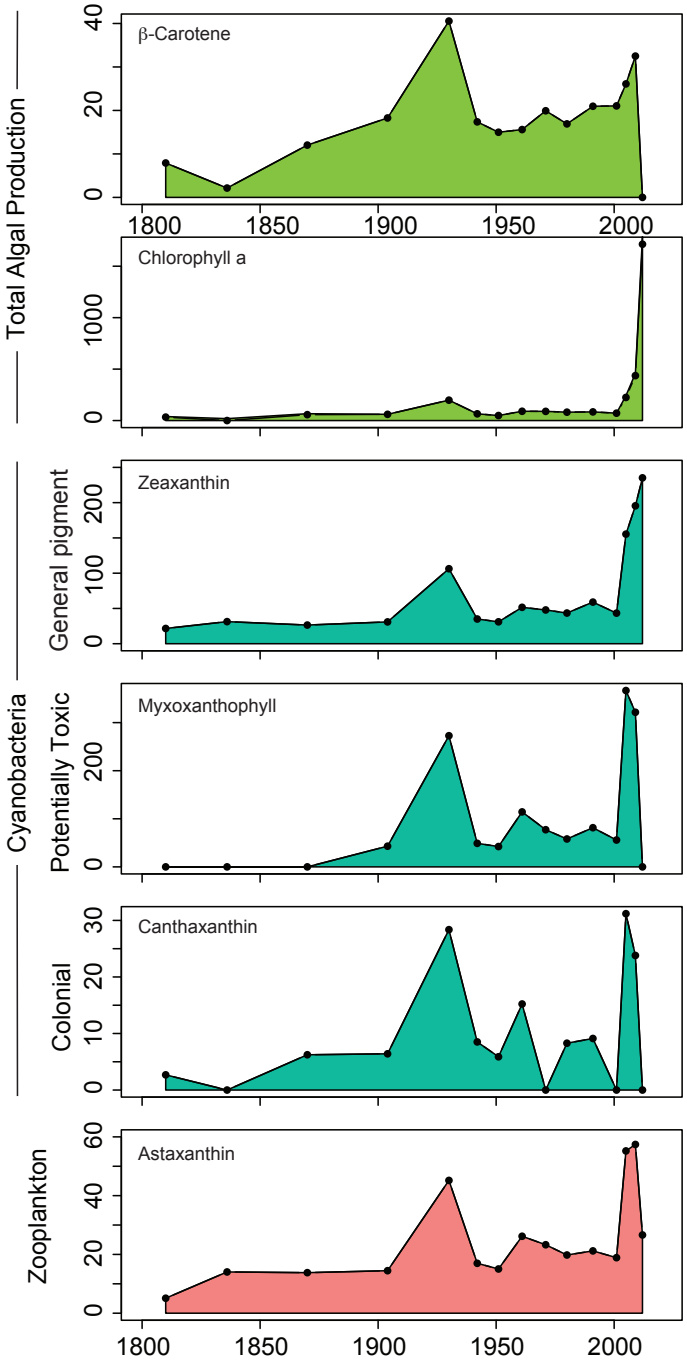

Figure 3: Pigment (chlorophylls and carotenoids) concentrations (μg g^{-1}organic matter) in the sediments of Spring Lake over the last ~ 200 years. Total algal production (green), cyanobacteria production (blue-green), and zooplankton biomass (red) are recorded. Time is on the x-axis.

References

Ramstack JM, Fritz SC, Engstrom DR, Heiskary SA. 2003. The application of a diatom-based transfer function to evaluate regional water-quality trends in Minnesota since 1970. Journal of Paleolimnology 29:79–94.

TMDL – Spring Lake and Upper Prior Lake. 2011. Wenck Associates, MN Pollution Control Agency, and Prior Lake-Spring Lake Watershed District. Wenck report: 1242-53.

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