Tishomingo Lake - Water Quality Report

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Introduction

As part of the Statewide Lake Assessment Program (SLAP), the University of Missouri sampled Tishomingo Lake four times during the summer of 2022. Sampling occurred in deep water near the dam. Surface water grab sample parameters included phosphorus, nitrogen, phytoplankton chlorophyll, inorganic suspended solids, Secchi transparency, and algal toxins. Additionally, during each visit, a continuous data sonde was lowered through the water column to measure temperature, dissolved oxygen, conductivity, turbidity, and phytoplankton chlorophyll, along with corresponding depth. From these measurements, it is possible to visualize the chemical make-up of the lake from its surface to its bottom in a vertical water column profile.

Phosphorus and nitrogen are naturally occurring nutrients that can act as fertilizer within a lake. These nutrients, found in soil, often enter a lake as erosional runoff following a rain event. Human influences can increase the nutrient inputs to a lake. Human impacts might include, but are not limited to, improperly operating septic systems; excess fertilizer application on crop fields, lawns, and golf courses; and land disturbances associated with urbanization and development.

Nutrients fertilizing a lake may lead to increased growth of phytoplankton (commonly referred to, simply, as algae). These small aquatic plants, serving as the base of the aquatic food chain, are very important to a lake's overall health. While phytoplankton are important for a lake in limited and balanced quantities, too much can be a bad thing. Some potential negative impacts associated with excess phytoplankton are loss of aesthetic value; reduced recreational use; taste and odor problems; elevated risk of cyanotoxin exposure; decreased dissolved oxygen levels; as well as harm to aquatic life. The amount of phytoplankton within a lake is gauged by measuring the photosynthetic pigment, chlorophyll.

Inorganic suspended solids are the soil and sediment particles suspended in the water column. These materials can enter the lake in erosional runoff or be stirred up from the lake bottom or shoreline. Inorganic suspended solids, along with phytoplankton, influence water clarity. Water clarity can be reported as water transparency or as turbidity. Water transparency is measured using a Secchi disk, an eight inch diameter black and white disk lowered through the water column until it disappears from sight. A higher Secchi transparency depth indicates deeper vertical water clarity. Turbidity, which is measured throughout the water column using an optical sensor, quantifies the murkiness of the water. Higher turbidity indicates poorer water clarity and increased murkiness. Water clarity is important because it is how the average lake user perceives water quality.

Microcystin, cylindrospermopsin, anatoxin and saxitoxin are four types of algal toxins, or cyanotoxins, which are sometimes produced by cyanobacteria in Missouri lakes. If present in high enough concentrations, these algal toxins can be toxic to humans and animals. The Environmental Protection Agency (EPA) guidelines for microcystin and cylindrospermopsin are listed in Table 1. Due to data limitations, the EPA does not presently have action level guidelines for anatoxin or saxitoxin. SLAP analyzes all four algal toxins.

Table 1. EPA recommended values for recreational criteria and drinking water advisories. There are no criteria for anatoxin or saxitoxin at present.

Cyanotoxin	Recommended maximum total magnitude for recreational water*	Drinking water health advisory (10 day)**
Microcystin	8 µg/L	1.6 µg/L
Cylindrospermopsin	15 µg/L	3.0 µg/L

* https://www.epa.gov/sites/default/files/2019-09/documents/recommend-cyano-rec-water-2019-update.pdf, https://www.epa.gov/sites/default/files/2019-05/documents/hh-rec-criteria-habs-factsheet-2019.pdf

** https://www.epa.gov/cyanohabs/epa-drinking-water-health-advisories-cyanotoxins

Results

Surface water quality parameters

Here, surface water quality results are summarized for the four sampling events at Tishomingo Lake in the summer of 2022 (Figure 1). Summer nitrogen concentrations ranged from 0.58–0.97 mg/L; averaging 0.79 mg/L, this is below the summer 2022 statewide average of 0.95 mg/L. Phosphorus concentrations ranged from 0.022–0.043 mg/L; averaging 0.032 mg/L, this is also below the statewide average of 0.06 mg/L. Chlorophyll, corrected for photosynthetic pigment degradation, was below the statewide average of 23.1 µg/L, ranging from 9.0–17.3 µg/L, with an average of 12.8 µg/L. Secchi depth ranged from 0.85–1.48 m; averaging 1.19 m, this is shallower than the statewide average of 1.3 m. Overall, there was a trend of increasing nutrient concentrations, increasing chlorophyll levels, and decreasing water transparency throughout the summer (Figure 1).

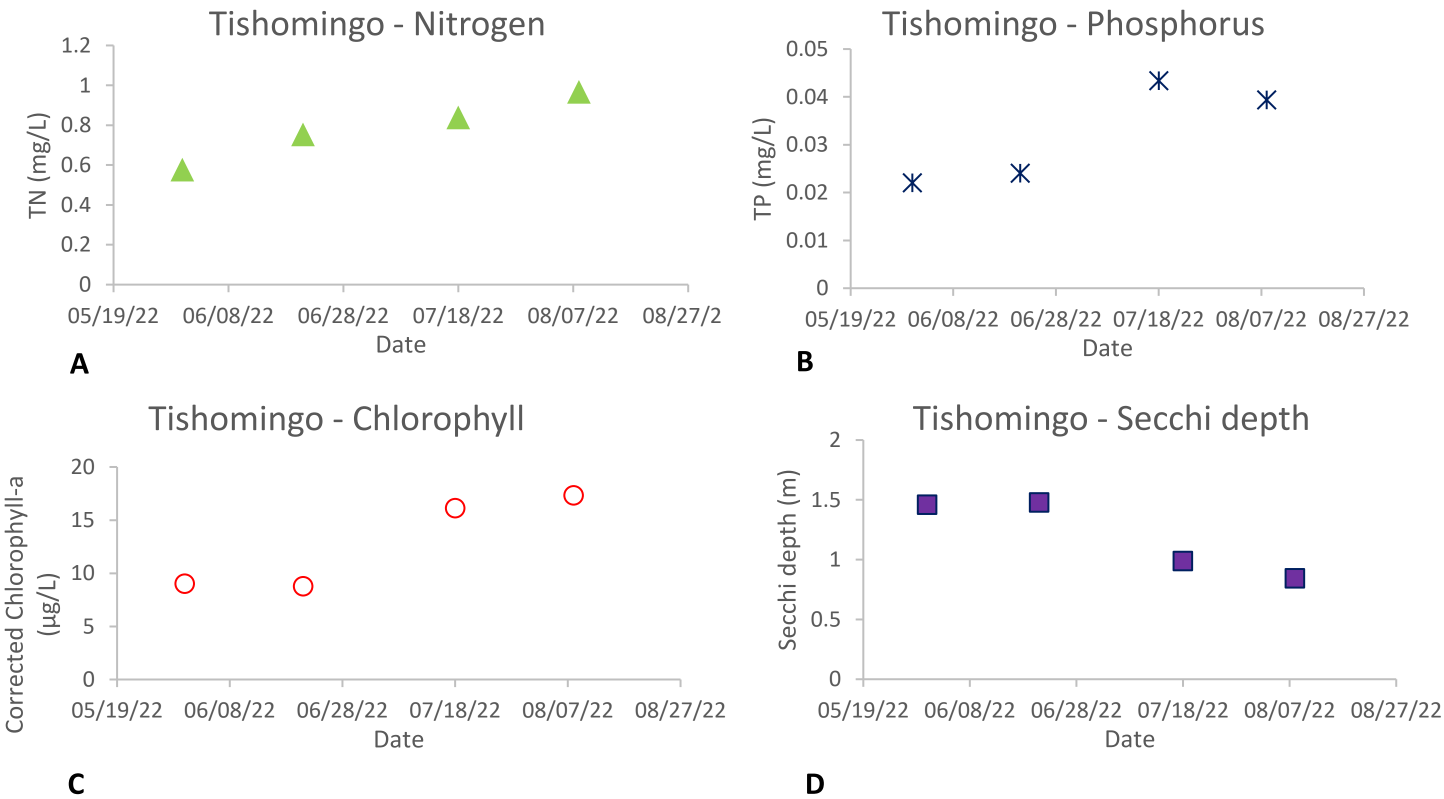

Figure 1. Surface water quality parameters in Tishomingo Lake measured in summer 2022. A) nitrogen, B) phosphorus, C) corrected chlorophyll, D) Secchi depth

Cyanotoxins in surface water

Here, algal toxin results are summarized for the four sampling events at Tishomingo Lake in the summer of 2022 (Figure 2). All four cyanotoxins had detectable concentrations during each lake visit, except for saxitoxin which was below detection on May 31. Both microcystin and cylindrospermopsin (averaging 0.13 and 0.15 µg/L, respectively) were well below the EPA's recommended maximum values for recreational water use of 8 and 15 µg/L, respectively (Table 1). Anatoxin and saxitoxin were relatively low throughout the summer, except on June 21 when anatoxin concentrations increased to 1.08 µg/L.

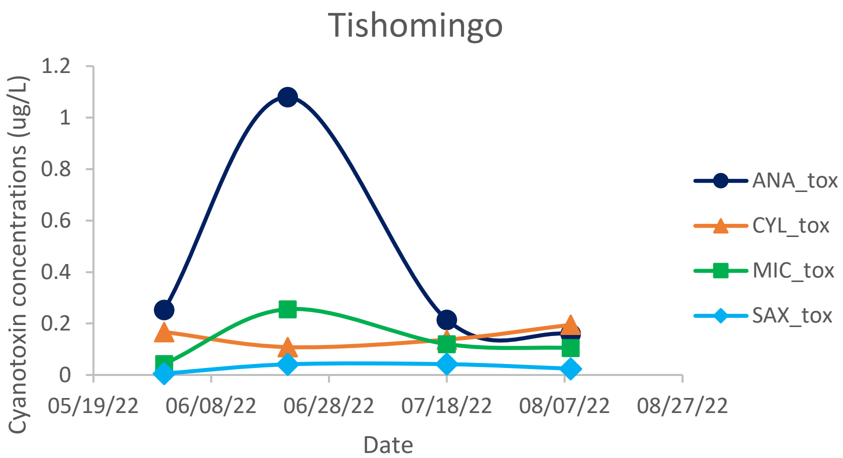

Figure 2. Concentrations of microcystin (MIC_tox), cylindrospermopsin (CYL_tox), anatoxin (ANA_tox), and saxitoxin (SAX_tox) in Tishomingo Lake during summer 2022. Detection limits: microcystin and anatoxin = 0.10 µg L^{-1}, cylindrospermopsin = 0.04 µg L^{-1}, saxitoxin = 0.015 µg L^{-1}

Vertical profiles

The continuous vertical water column profiles of temperature, dissolved oxygen, chlorophyll, and turbidity are shown in Figure 3 for each of the lake visits in 2022.

The temperature profiles for Tishomingo Lake demonstrate a typical summer temperature profile for a stratified lake, with warm surface water and cooler water at depth. In Tishomingo Lake, water temperature remained relatively stable at 26–33 °C in the upper 3–4 m. This uppermost thermally stable layer is called the surface mixed layer. Below the surface mixed layer, temperatures in Tishomingo Lake decreased to approximately 10 °C with depth.

Dissolved oxygen is generally highest in the surface water due to atmospheric mixing. In Tishomingo Lake, dissolved oxygen remained relatively constant in the surface mixed layer and then sharply declined around a depth of 3 m. Chlorophyll concentrations were also higher in this layer. Phytoplankton photosynthesize, which produces oxygen, thus it is common for chlorophyll and dissolved oxygen to peak simultaneously at the surface. As phytoplankton die, they sink below the mixing zone where they decompose. Decomposition consumes oxygen, reducing dissolved oxygen levels at depth. We see this in Lake Tishomingo, where water in June, July, and August had very little dissolved oxygen in the bottom layer (Figure 3B).

Turbidity, an indicator of how much sediment and/or phytoplankton are in the water, also show sub-surface peaks that roughly corresponded to sub-surface peaks in chlorophyll (Figure 3D).

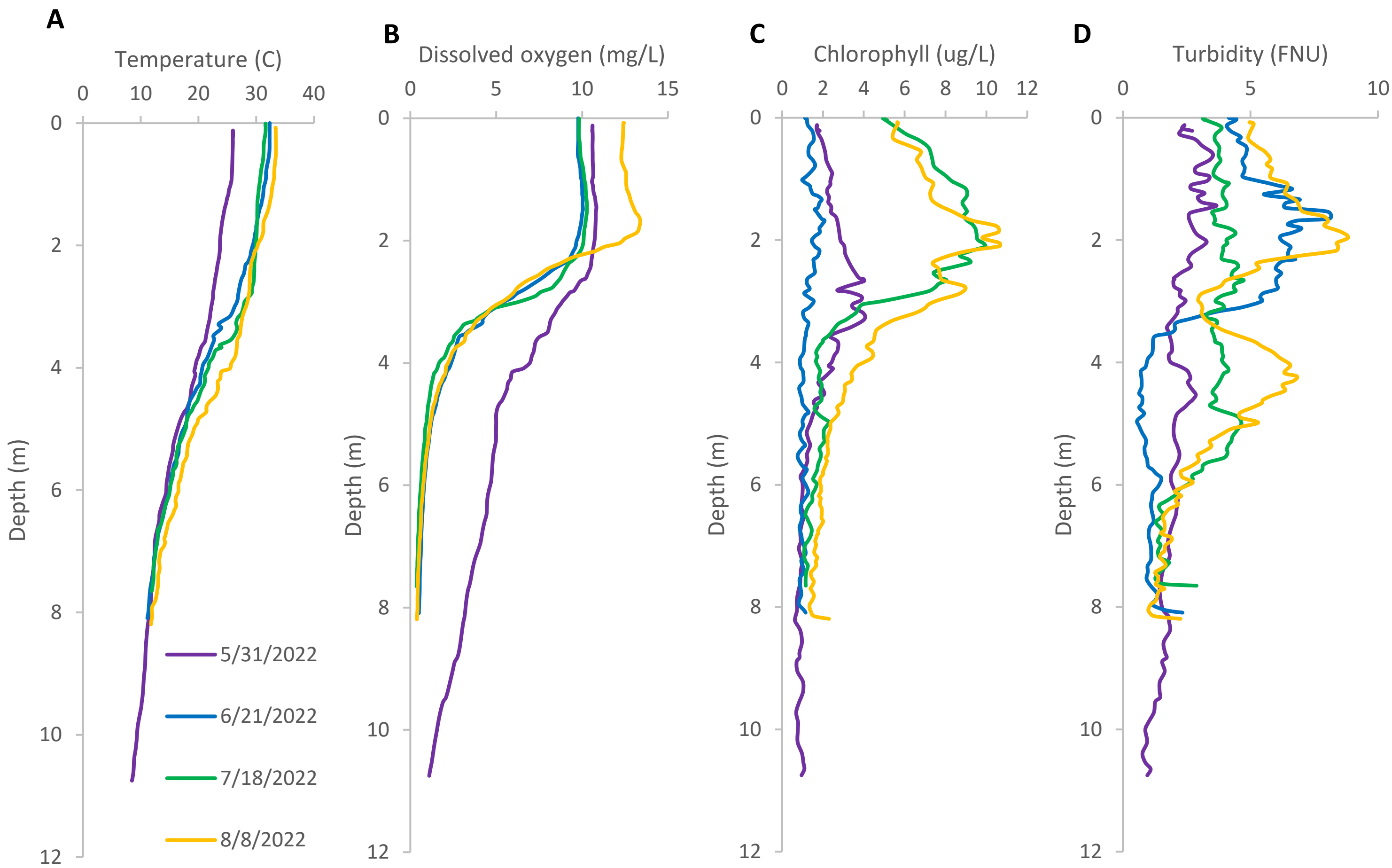

Figure 3. Vertical water profiles collected on May 31 (purple), June 21 (blue), July 18 (green), and August 8 (yellow). Note that the y-axis (depth) is reversed. Lake surface has a depth of 0 m. A) temperature, B) dissolved oxygen, C) chlorophyll, D) turbidity

Trophic state

Lake trophic state criteria can be used to indicate the overall water quality of a lake and relates to the amount of biological productivity. The criteria range from oligotrophic (good water quality) to hypereutrophic (poor water quality; Table 2). Based on the average observed phosphorus, nitrogen, and chlorophyll concentrations, as well as Secchi depth, Tishomingo Lake is classified as eutrophic for the summer of 2022.

Table 2. Trophic state criteria for Missouri reservoirs from Jones et al. (2008).

Trophic State	Phosphorus (mg P L^{-1})	Nitrogen (mg N L^{-1})	Chlorophyll* (µg L^{-1})	Secchi (m)
Oligotrophic	<0.01	<0.35	<3.0	>2.60
Mesotrophic	≥ 0.01 – 0.025	≥ 0.35 – 0.55	≥ 3.0 –9.0	≥ 1.30 – < 2.60
Eutrophic	≥ 0.025 – 0.100	≥ 0.55 – 1.20	≥9.0 – 40.0	≥ 0.45 – < 1.30
Hypereutrophic	>0.100	>1.20	>40.0	<0.45

*Corrected chlorophyll-a.

Summary

Overall, water quality in Tishomingo Lake during the summer of 2022 was better than the statewide average, with lower chlorophyll and nutrient levels. However, water transparency (Secchi depth) was slightly worse than the statewide average. It appears that water quality was better in May and June, and decreased in July and August (increasing nutrients and chlorophyll, decreasing water transparency). Cyanotoxins were mostly low throughout the summer, with the exception of anatoxin on June 21. Vertical water column profiles showed a typical stratified summer water column. Sub-surface peaks in chlorophyll were observed, likely contributing to the observed sub-surface peaks in turbidity.

Reference

Jones, J. R., Obrecht, D. V., Perkins, B. D., Knowlton, M. F., Thorpe, A. P., Watanabe, S., & Bacon, R. R. (2008). Nutrients, seston, and transparency of Missouri reservoirs and oxbow lakes: An analysis of regional limnology. *Lake and Reservoir Management, 24*(2), 155–180. https://doi.org/10.1080/07438140809354058