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Monitoring Chlorophyll-*a* as a Measure of Algae in Lake Texoma Marinas

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Algae are an important quality component in water bodies. They are photosynthesizing organisms and are the foundation of most aquatic food webs; however, some algae (e.g. blue-green algae) can produce algal toxins (Ueno and Nagata 1994). The presence of algal toxins in water bodies has important implications for humans, as well as aquatic organisms (Duy et al. 2000). Monitoring of chlorophyll-*a* concentrations can serve as a good predictor of algal concentrations. A previous study used measurement of chlorophyll-*a* as an indicator of the viable algae content of water since chlorophyll-*a* reverts to phaeophytin-*a* upon death of the algae (Kampbell et al. 2001).

The seasonal variation of algae was investigated using chlorophyll-*a* as a measure of algae biomass. We monitored chlorophyll-*a* concentrations from March 2000 to October 2001 in five marinas on Lake Texoma, which is located on the Oklahoma and Texas border. It was a measure to predict the viable algal levels during seasons. Their spatial distribution according to water depth and sampling locations was also investigated. Nitrate was also measured from September 1999 to October 2001 for a relationship with chlorophyll-*a* concentrations in the study area.

MATERIALS AND METHODS

Lake water samples were obtained from June 1999 to October 2001 at five marinas in Lake Texoma, as shown in Figure 1. Samples were taken at one-foot depths at locations identified as marinas entrance, gasoline filling station, and boat dock. Bottom samples were also colleted at one-foot from the lake bottom at gasoline filling stations. Samples were collected using ¼ inch diameter polyethylene tubing connected to a peristaltic pump. Polyethylene bottles were rinsed and filled with the lake water for nitrate measurement. For chlorophyll-*a* analysis, 100 mL of lake water was vacuum filtered through glass fiber filters (Whatman, 47mm) on the boat and all filters containing the chlorophyll-*a* were kept in a closed jar with silica gel desiccant and stored in a cooler with blue ice. All samples were delivered the same day to the analytical laboratory.

Chlorophyll-*a* analysis has been previously reported (Kampbell et al. 2001).

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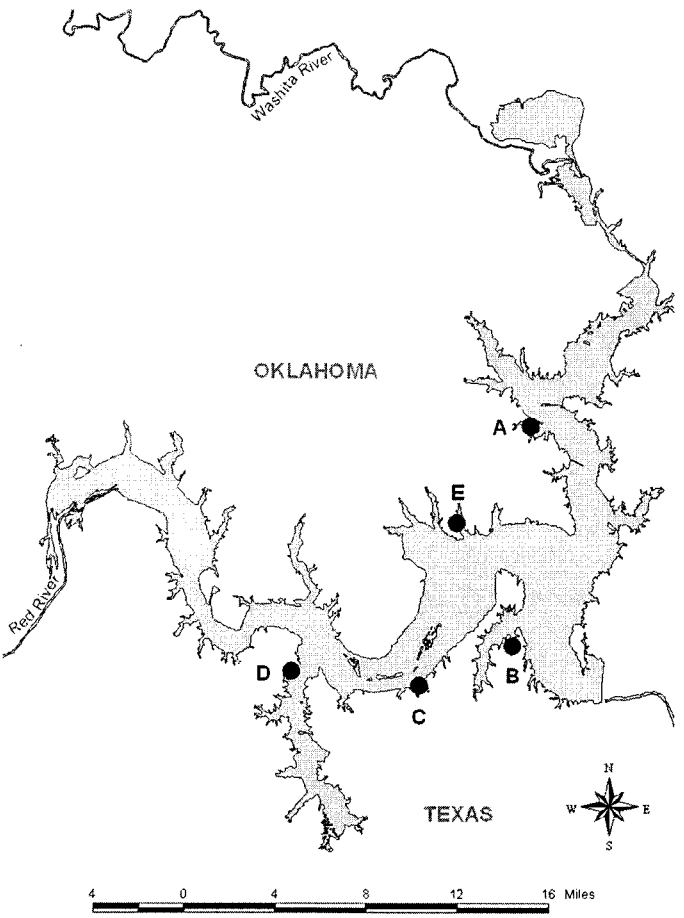

Figure 1. Lake Texoma showing the location of marinas studied.

Chlorophyll-*a* concentration was determined using ethanol extraction, centrifuge and fluorescence measurement. Chlorophyll-*a* was extracted from the filter residue using 90% heated ethanol (HPLC grade). The extract was kept for 24 hours in the dark at room temperature (Sartory and Grobbelaar 1984). All extracts were centrifuged for 30 minutes at 1500 rpm using a Beckman GS-6KR Centrifuge. Fluorescence was measured using a Turner Quantech Digital Field fluorometer (FM 109525) at excitation and emission wavelength for chlorophyll-*a*, which were 440 and 665 nm, respectively. The molar absorptivity of chlorophyll-*a* was 3841 M^{-1} cm^{-1} at 665 nm (Wintermans and De Mots 1965). The limit of detection (LOD) of this method was near 0.2 µg/L.

Water samples for nitrate were filtered before measurement. Nitrate was measured with a Vacu-vials test kit (CHEMetrics, Inc.) following the manufacturer's manual procedure. The test kit measured nitrate concentration from 0 to 1.5 mg/L, which was a cadmium reduction method.

RESULTS AND DISCUSSION

Figure 2A shows the seasonal variation of chlorophyll-*a* concentration in lake water near the surface. Chlorophyll-*a* was detected in all samples over yearly seasons and the mean concentrations of chlorophyll-*a* at each sampling date varied from a minimum of 5.0 μg/L to a maximum of 59.1 μg/L. Chlorophyll-*a* showed a seasonal pattern; chlorophyll-*a* concentrations were lower from winter to early spring. Concentrations of chlorophyll-*a* were lowest in February and March and mean concentrations were less than 10 μg/L. In April, chlorophyll-*a* concentrations greatly increased and mean concentrations reached > 20 μg/L. Chlorophyll-*a* concentrations were at a maximum in fall (47~59 μg/L), and summer chlorophyll-*a* concentrations were lower relative to fall in Lake Texoma.

Figure 2B shows the average temperature variation at the sampling sites from May 2000 to October 2001. Monthly temperatures were compared with monthly chlorophyll-*a* as shown in Figure 2A. Temperature should be an important factor affecting the algae content of water. It appeared that chlorophyll-*a* data were not in seasonal phase or lagged behind by a season in Lake Texoma. Water temperature was coldest in January and reached a maximum during summer. Lowest concentrations of chlorophyll-*a* and peak of chlorophyll-a were in February and fall, respectively.

We expected that chlorophyll-*a* concentration in marinas could be affected by the toxicity of gasoline components including methyl *tert*-butyl ether (MTBE). One previous study on the influence of MTBE on lake water algae demonstrated that MTBE would not be toxic to the lake water algae at concentrations below 3000 mg/L (Kampbell et al. 2001). Thus, typical concentrations of MTBE found in lake water, which are usually less than 10 μg/L (An et al. 2002), will not have an adverse influence on algae biomass.

Nitrate is the most important nutrient for algal growth. Although nutrient has a general relationship with algal biomass, there appeared to be no relationship to nitrate and chlorophyll-*a* concentrations at the study sites. However, no seasonal distribution of nitrate, as well as relation with chlorophyll-*a*, was apparent during the study period. Inter-year variation was observed in nitrate data as shown in Figure 2C. The year 2001 had higher nitrate concentrations compared to the year 2000.

Figure 3 shows the concentrations of chlorophyll-*a* in the surface and bottom water collected from gasoline filling stations. Surface level waters have higher chlorophyll-*a* concentrations than bottom level waters. This is due to the greater light availability in surface water. Depth did not show a trend for nitrate. Chlorophyll-*a* levels were also compared at three sampling locations. They were generally distributed evenly over all marinas in lakes.

It was found that chlorophyll-*a* concentrations were highest in the fall season. This indicated that the algal toxins could occur more frequently in fall. Higher

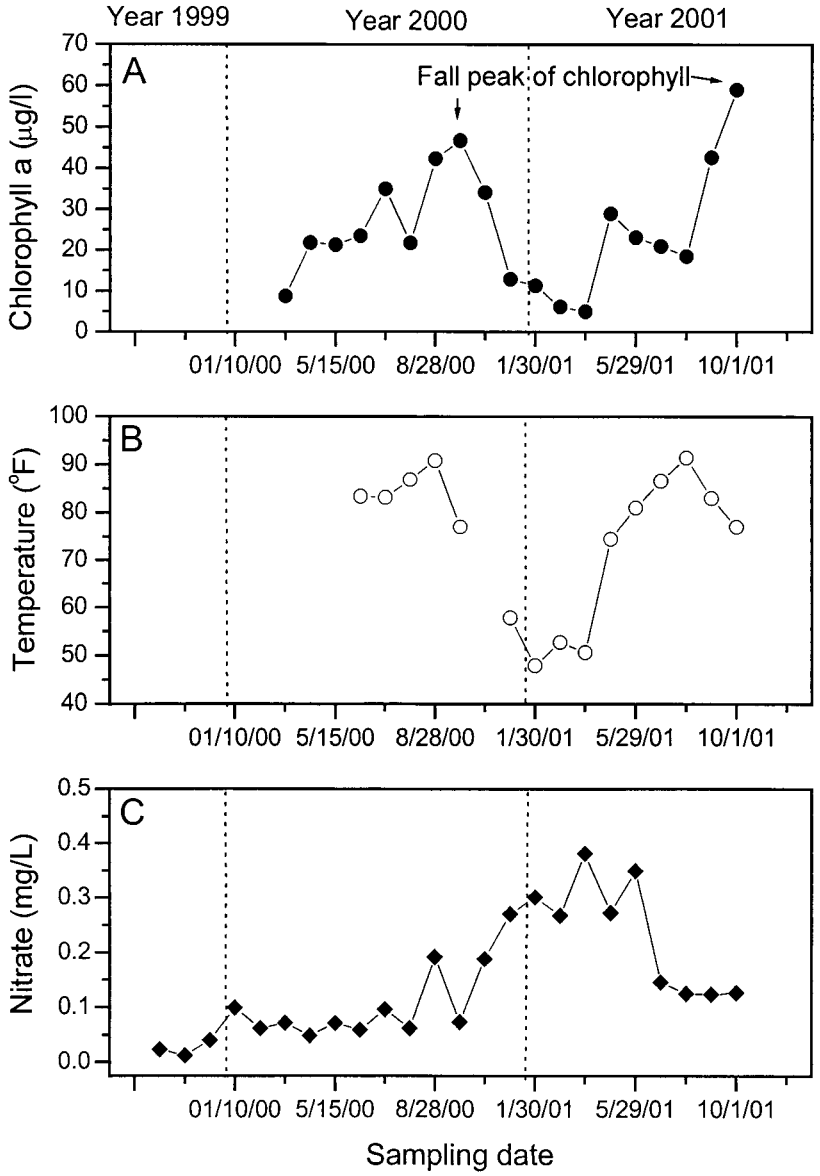

Figure 2. Variation of (A) chlorophyll-*a* concentration, (B) temperature, and (C) nitrate concentration at surface water (one-foot below surface) in Lake Texoma marinas during September 1999 to October 2001. Data represent the mean levels at each sampling date. Discontinuities in the temperature plot are absence of data.

concentrations of chlorophyll-*a* in surface water also indicated a higher health risk by algal toxins in surface water than in lake bottom water.

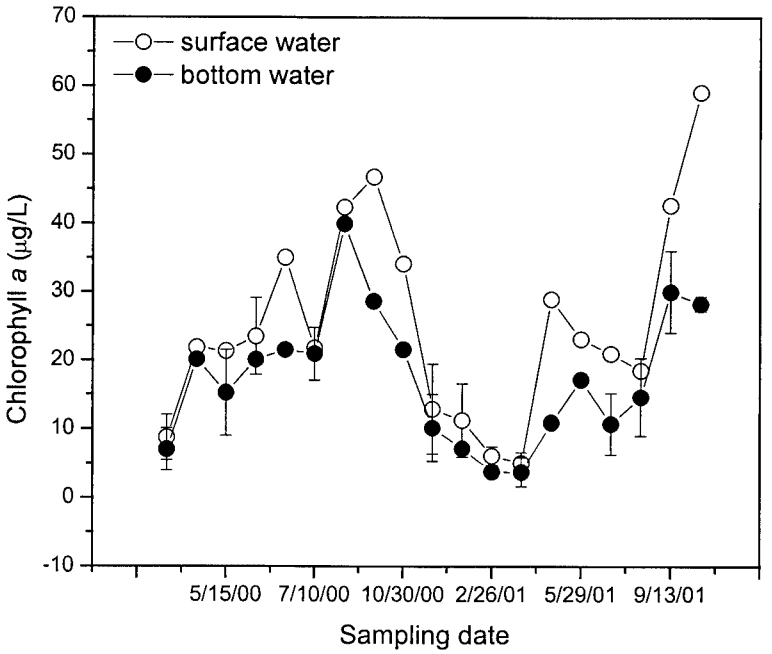

Figure 3. Chlorophyll-*a* concentrations vs. water depth at gasoline filling stations in marinas. Surface and bottom water samples were collected from one-foot from the surface and bottom, respectively. The depth of the water ranged 10-30 ft at the various stations. Data represent the mean levels of chlorophyll-*a* concentrations at each sampling date (n = 3~9).

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