

research management

findings

Number 11 • April 1988

PHOSPHORUS TRENDS IN THE YAHARA LAKES SINCE THE MID-1960s

by Richard C. Lathrop

The 4 Yahara River lakes (Mendota, Monona, Waubesa, and Kegonsa) are among the most important water resources of southern Wisconsin (Fig. 1). Their water quality has deteriorated since the late 1800s because of phosphorus (P) loadings from sewage effluent discharges and urban and rural nonpoint pollution. These loadings have enriched the lake sediments resulting in high levels of internal P recycling that worsen algal and weed problems.

This article presents information on phosphorus concentrations in the Yahara lakes since the mid-1960s. It draws on new, unreported P information collected by the Wisconsin Department of Natural Resources (WDNR) Bureau of Research as part of our continuing long-term research study begun in 1976 on water quality of the Yahara lakes. Bureau of Research monitoring data on the Yahara lakes (particularly Monona) for 1967-75 also are used. Other data sources for Lake Mendota are Univ. of Wisconsin Water Chemistry Program unpublished student data for 1965-67 and thesis data from Torrey for 1970-71, Sonzogni for 1971-73, and Vigon for 1974-75. Bureau of Research lab analyses

were performed at the WDNR Fish Management Water Analysis Lab in 1967-68, the State Lab of Hygiene in January 1969 and after March 1980, and the WDNR Delafield Research Lab from April 1969 to January 1980.

Sources of Phosphorus

Lake Mendota has received most of its P via rural and urban runoff from the watershed. Mendota also received P from the sewage effluents of upstream communities until their systems were connected to the Madison Metropolitan Sewerage District (MMSD) in 1971.

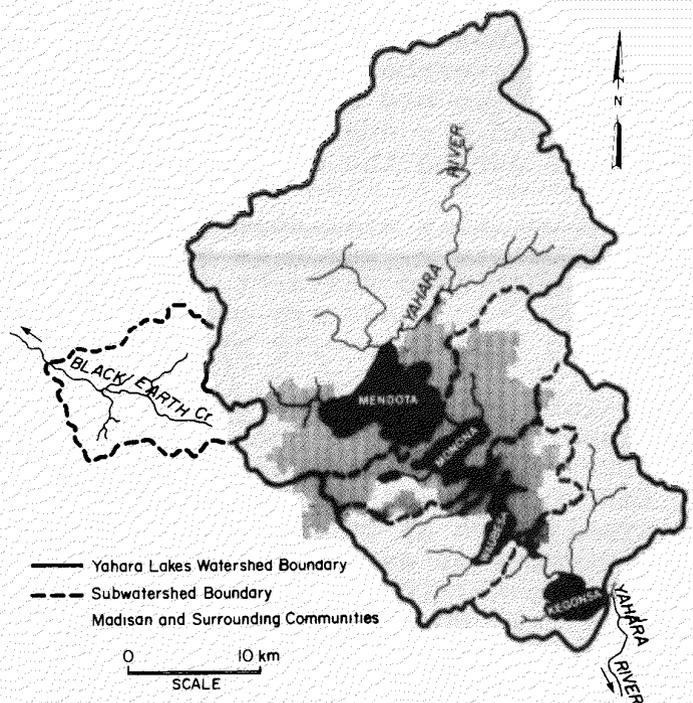


FIGURE 1. Yahara lakes watershed.

The lower 3 lakes, particularly Waubesa and Kegonsa, were heavily enriched from MMSD's effluent until it was diverted in 1958. Today, the lower lakes receive most of their P from the Yahara River, which carries P from each upstream lake in the chain. Urban runoff is also an important source of P to Lake Monona, and rural runoff contributes P to Lakes Waubesa and Kegonsa. Nonpoint pollution of the Yahara lakes was addressed in the Dane County Water Quality Plan prepared by the Dane County Regional Planning Commission in 1979.

Indices of Phosphorus Trends

I used spring (January-March) runoff volumes for Black Earth Creek (Fig. 1) as an indicator of long-term trends in nutrient loadings to the Yahara lakes, particularly Mendota. Runoff volumes (surface runoff separated from baseflow) were determined from U.S. Geological Survey discharge data collected since 1954. Spring runoff occurs over a large region, while summer runoff can occur from localized storms that do not affect Mendota's entire watershed. Early spring runoff also has much higher dissolved P concentrations than runoff during the growing season. Dissolved P is also more "biologically available" than particulate P, which is associated with suspended sediment (SS) in runoff. SS loads are greatest during high-intensity storms.

In-lake P trends were assessed by dissolved reactive phosphorus (DRP) concentration data. For Lake Mendota, I used DRP in the hypolimnion at 20 m of depth on 1 September of each year as an index of long-term changes in sediment P release. Concentrations were interpolated from samples taken at different depths and different dates, except for 1987 when the standardized date and depth were

adopted into our sampling program. I also compared Lake Mendota DRP concentrations in surface water during fall (mid-October through November), winter, and spring (April). Sonzogni (1974) found that the mass of DRP that accumulated in Mendota's bottom waters in summer was transferred to the entire water column during fall turnover. DRP remained high through the winter and was not depleted by the algae until later in the spring or early summer. (Undetectable DRP usually signifies P limitation to the algae, but not the degree of P limitation.) Thus, spring concentrations are an index of how rapidly the DRP is being depleted prior to the summer algal blooms.

For the lower three lakes, I used surface DRP in April as an index of long-term P changes. Only April data were used because the shallowness of Waubesa and Kegonsa precludes thermal stratification throughout the whole summer and hence no build-up of hypolimnetic P. An analysis of hypolimnetic P concentrations in Lake Monona will be presented in a more detailed technical report.

Lake Mendota Phosphorus Trends

The amount of spring runoff from Black Earth Creek has been highly variable since 1954 (Fig. 2). Very high volumes occurred from 1973-76 followed by less than average runoff in most years from 1977-87. The P loadings from runoff to Lake Mendota during 1973-76 probably offset any decrease in P loading from the sewage diversion in 1971. Reduced loadings during low-runoff years (1977-87) may have decreased the amount of labile (easily remineralized) P available for recycling from lake sediments.

Beginning in 1978, Lake Mendota's hypolimnetic P concentrations

have been about 20% lower than in 1965-77 (Fig. 3). Surface DRP also decreased in recent years (Fig. 4). Fall DRP began a gradual decrease in the late 1970s except for high levels in 1982 and 1985. Winter DRP began to gradually decrease beginning in 1982, with high concentrations found only in 1986. Spring DRP was much lower after 1978 than in 1972-78. Aberrations in these

long-term trends reflect unusual conditions in a given year. For example, the high DRP in fall 1985 and winter 1986 may have been caused by a longer period of mixing, which delayed thermal stratification in summer 1985. Algal blooms in all the Yahara lakes were very severe that summer and early fall. The low DRP in April 1971 was attributed to a massive diatom bloom (Sonzogni 1974).

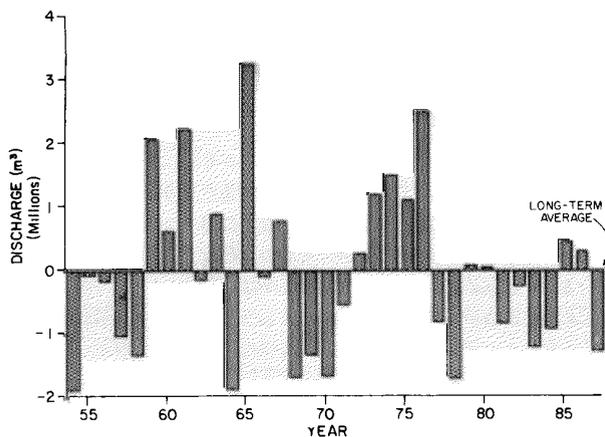


FIGURE 2. Spring runoff to Black Earth Creek, 1954-87, portrayed as deviation from long-term average.

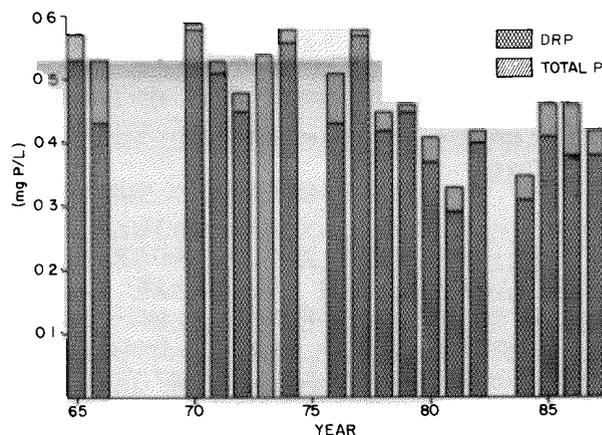


FIGURE 3. Hypolimnetic DRP and total P for Lake Mendota on 1 September, 1965-87.

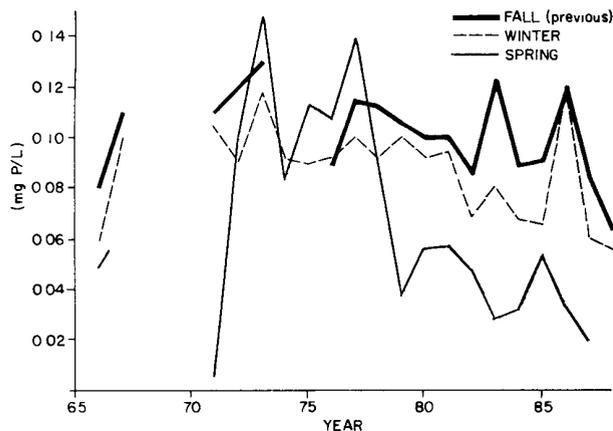


FIGURE 4. Surface water DRP for Lake Mendota during fall, winter, and spring 1965-88.

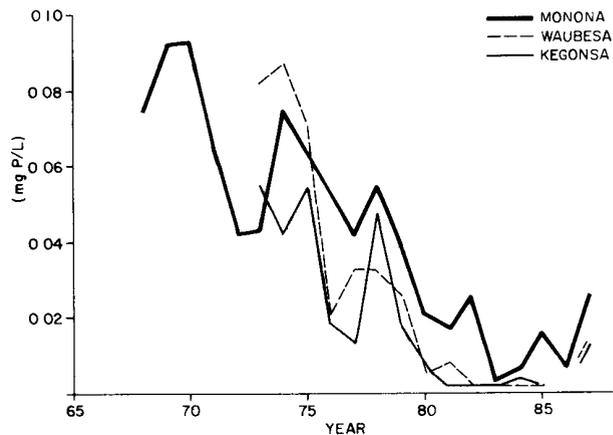


FIGURE 5. Surface water DRP for Lakes Monona, Waubesa, and Kegonsa during spring 1965-87.

**Phosphorus Trends in Lakes
Monona, Waubesa, and Kegonsa**

Spring DRP concentrations also have decreased in the lower Yahara lakes since the late 1970s (Fig. 5). DRP has been below analytical detection in Lakes Waubesa and Kegonsa for most of 1981-85. This P decrease can be attributed to reduced P loadings to the lakes because of lower DRP in the outlet discharges from each upstream lake and because of less spring runoff since 1977. River discharge volumes as well as direct P loadings to each lake were reduced.

**Significance of the Phosphorus
Trend Data**

The decreased P concentrations in the Yahara lakes in recent years are an encouraging sign that water quality improvements can be achieved. However, because part of this P reduction may be due to less than normal spring runoff in 1977-87, the decrease may be temporary. Greater runoff volumes in future years could increase the P loadings to Mendota unless P concentrations in the runoff were reduced by nonpoint source management. (Cost-sharing monies for improving land management in the western part of Mendota's watershed have recently been available through the Wisconsin

Fund administered by the WDNR.) Interestingly, Lake Mendota's water quality deteriorated during the early 1960s when spring runoff volumes were high. Summer algae and weed problems in 1965 were so severe that the Lake Mendota Problems Committee was formed.

If runoff volumes in future years continue to be low, further P reductions in all the Yahara lakes may be possible by reducing runoff P concentrations. These P loading reductions could extend the seasonal period of P limitation in the lakes and thereby restrict algal growth.

Reference

Sonzogni, W. C. 1974. Effect of nutrient input reduction on the eutrophication of the Madison lakes. Ph.D. Thesis. Univ. Wisconsin, Madison. 352 pp. + App.

Dick Lathrop is a limnologist with the Wisconsin Department of Natural Resources, Bureau of Research. Dick has conducted research on the Yahara lakes since 1976. Address: 3911 Fish Hatchery Road, Madison Wisconsin 53711. Telephone: (608)275-3221.

Edited by Betty Les

*Bureau of Research
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707*

B L K R T	U S POSTAGE PAID MADISON, WI PERMIT 906
-----------------------	--