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Lake Water Quality

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Progressive AE

Lakes can be classified based on their ability to support plant and animal life. When classifying lakes, scientists use the broad categories “oligotrophic,” “mesotrophic,” or “eutrophic.”

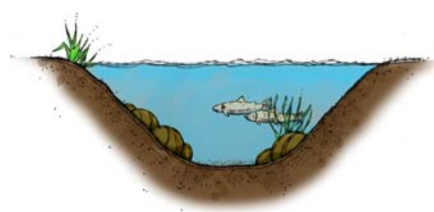
Oligotrophic lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient dissolved oxygen in the cool, deep bottom waters during late summer to support cold-water fish such as trout and whitefish.

Lakes that fall between the two extremes of oligotrophic and eutrophic are called **mesotrophic** lakes.

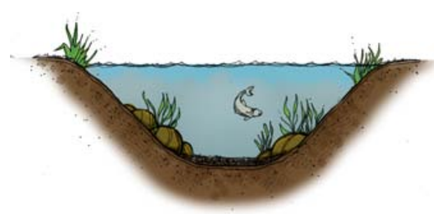
Eutrophic lakes have poor clarity and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm-water fish such as bass and pike.

Under natural conditions, most lakes will ultimately evolve to a eutrophic state as they gradually fill with sediment and organic matter transported to the lake from the surrounding watershed. As the lake becomes shallower, the process accelerates. When aquatic plants become abundant, the lake slowly begins to fill in as sediment and decaying plant matter accumulate on the lake bottom. Eventually, terrestrial plants become established and the lake is transformed to a marshland. The natural lake aging process can be greatly accelerated if excessive amounts of sediment and nutrients (which stimulate aquatic plant growth) enter the lake from the surrounding watershed. Because these added inputs are usually associated with human activity, this accelerated lake aging process is often referred to as *cultural eutrophication*.

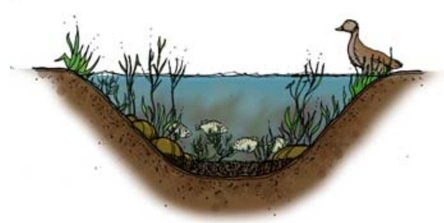
There are many ways to measure lake water quality, but there are a few important physical, chemical, and biological parameters that indicate the overall condition of a lake. These measurements include temperature, dissolved oxygen, total phosphorus, chlorophyll-*a*, and Secchi transparency.



Oligotrophic



Mesotrophic

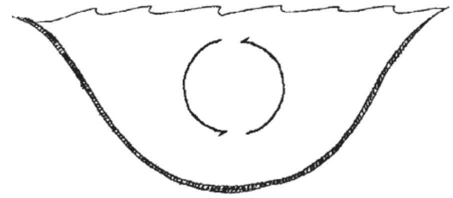


Eutrophic

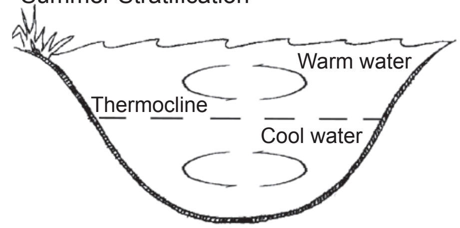
Temperature

Temperature is important in determining the type of organisms that may live in a lake. For example, trout prefer temperatures below 68°F. Temperature also determines how water mixes in a lake. As the ice cover breaks up on a lake in the spring, the water temperature becomes uniform from the surface to the bottom. This period is referred to as “spring turnover” because water mixes throughout the entire water column. As the surface waters warm, they are underlain by a colder, more dense strata of water. This process is called “thermal stratification.” Once thermal stratification occurs, there is little mixing of the warm surface waters with the cooler bottom waters. The transition layer that separates these layers is referred to as the “thermocline.” The thermocline is characterized as the zone where temperature drops rapidly with depth. As fall approaches, the warm surface waters begin to cool and become more dense. Eventually, the surface temperature drops to a point that allows the lake to undergo complete mixing. This period is referred to as “fall turnover.” As the season progresses and ice begins to form on the lake, the lake may stratify again. However, during winter stratification, the surface waters (at or near 32°F) are underlain by slightly warmer water (about 39°F). This is sometimes referred to as “inverse stratification” and occurs because water is most dense at a temperature of about 39°F. As the lake ice melts in the spring, these stratification cycles are repeated. Shallow lakes do not stratify. Lakes that are about 15 to 30 feet deep may stratify and destratify with storm events several times during the year.

Spring Turnover

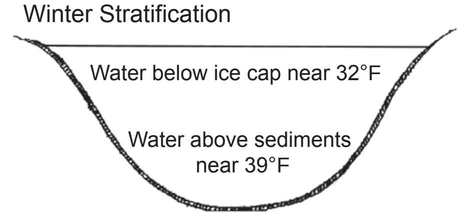


Summer Stratification



Fall Turnover

Winter Stratification

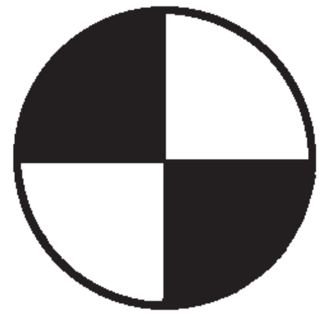


Dissolved Oxygen

An important factor influencing lake water quality is the quantity of dissolved oxygen in the water column. The major inputs of dissolved oxygen to lakes are the atmosphere and photosynthetic activity by aquatic plants. An oxygen level of about 5 mg/L (milligrams per liter, or parts per million) is required to support warm-water fish. In lakes deep enough to exhibit thermal stratification, oxygen levels are often reduced or depleted below the thermocline once the lake has stratified. This is because deep water is cut off from plant photosynthesis and the atmosphere, and oxygen is consumed by bacteria that use oxygen as they decompose organic matter (plant and animal remains) at the bottom of the lake. Bottom-water oxygen depletion is a common occurrence in eutrophic and some mesotrophic lakes. Thus, eutrophic and most mesotrophic lakes cannot support cold-water fish because the cool, deep water (that the fish require to live) does not contain sufficient oxygen.

Phosphorus

The quantity of phosphorus present in the water column is especially important since phosphorus is the nutrient that most often controls aquatic plant growth and the rate at which a lake ages and becomes more eutrophic. In the presence of oxygen, phosphorus settles to the lake bottom and is unavailable for aquatic plant growth. However, if bottom-water oxygen is depleted, phosphorus is released from the sediments and may be available to promote aquatic plant growth. In some lakes, the release of phosphorus from the bottom sediments is the primary source of phosphorus loading (or input) to the lake. By reducing the amount of phosphorus in a lake, it may be possible to control the amount of aquatic plant growth. In general, lakes with a phosphorus concentration greater than 20 parts per billion are able to support abundant plant growth and are classified as nutrient-enriched or eutrophic.



Secchi disk

Chlorophyll-*a*

Chlorophyll-*a* is a pigment that imparts the green color to plants and algae. A rough estimate of the quantity of algae present in lake water can be made by measuring the amount of chlorophyll-*a* in the water column. A chlorophyll-*a* concentration greater than 6 parts per billion is considered characteristic of a eutrophic condition.

Secchi Transparency

A Secchi disk is often used to estimate water clarity. The measurement is made by fastening a round, black and white, 8-inch disk to a calibrated line. The disk is lowered over the deepest point of the lake until it is no longer visible, and the depth is noted. The disk is then raised until it reappears. The average between these two depths is the Secchi transparency. Generally, it has been found that aquatic plants can grow at a depth of approximately twice the Secchi transparency measurement. In eutrophic lakes, water clarity is often reduced by algae growth in the water column, and Secchi disk readings of 7.5 feet or less are common.

Lake Classification Criteria

Ordinarily, as phosphorus inputs to a lake increase, the amount of algae will also increase. Thus, chlorophyll-*a* levels will increase and transparency decreases. A summary of lake classification criteria developed by the Michigan Department of Natural Resources is shown in the table below.

LAKE CLASSIFICATION CRITERIA

Lake Classification	Total Phosphorus (µg/L)[1]	Chlorophyll-*a* (µg/L)[1]	Secchi Transparency (feet)
Oligotrophic	Less than 10	Less than 2.2	Greater than 15.0
Mesotrophic	10 to 20	2.2 to 6.0	7.5 to 15.0
Eutrophic	Greater than 20	Greater than 6.0	Less than 7.5

Recent sampling of 364 lakes across Michigan indicates that, of the lakes sampled, less than about 20% of lakes are oligotrophic, more than 50% are mesotrophic, and about 30% are eutrophic.[2]

Variability and Trends

Often there is a desire to evaluate trends in water quality. However, this can be a difficult task. It is important to realize that there are a number of factors that influence water quality. Weather, for example, can have a strong influence on water quality conditions. A lake sampled immediately after several days of strong winds and rain may appear much different than if sampled after several days of calm, sunny weather. There can be significant natural variability in lake water quality daily, seasonally and year-to-year. Because of this natural variability, it can be very difficult to detect subtle changes or trends that may occur in water quality over time. In fact, it may take many years of regular sampling to detect a statistically significant trend in water quality.

References

[1] μg/L = micrograms per liter = parts ber billion

[2]Fuller L.M. and R.J. Minnerick. 2008. State and regional water-quality characteristics and trophic conditions of Michigan's inland lakes, 2001-2005. U.S. Department of the Interior, U.S. Geological Survey. Scientific Investigations Report 2008-5188.

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Tony Groves, Pam Tyning, and Paul Hausler have nearly 70 years of combined experience working as lake management consultants with Progressive AE in Grand Rapids, Michigan. Tony, Pam, and Paul created MichiganLakeInfo.com, a website for those interested in Michigan's inland lakes. On the site you can find this article and information on topics such as lake water quality, watershed management, aquatic plants, lake levels, lake improvement boards and more.