Lake Notes

Common Lake Water Quality Parameters

Understanding a lake's physical, chemical, and biological properties is essential to determining the lake's condition and in making informed lake management decisions. The water quality measurements or "parameters" most frequently tested in lakes are reviewed in this edition of *Lake Notes*. These include:

- physical measurements such as water clarity, dissolved oxygen, and temperature;
- chemical measurements such as nutrients, suspended solids, pH, and conductivity; and
- biological measurements such as chlorophyll and bacteria.

By including these parameters in a lake monitoring program, you can help characterize the lake's overall ecology and health.

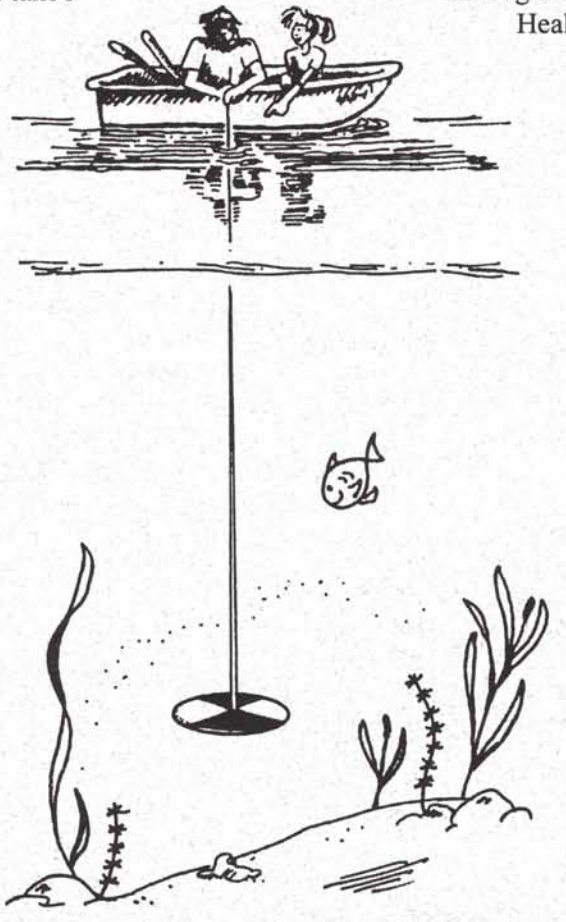
Physical Parameters

Water Clarity

Water clarity—or *transparency*—is commonly measured using a **Secchi disk**, an eight-inch diameter, weighted disk that is painted black and white in alternate quadrants and attached to a calibrated rope (see illustration). The disk is lowered into the water and the depth at which it is no longer visible is recorded. Measurements are typically taken twice per month from May through October.

Secchi disk measurements reveal how deep sunlight can reach into the water and thereby indicate general water quality conditions. This region of a lake where there is enough sunlight to allow the growth of algae and rooted aquatic plants is called the "euphotic zone." It typically extends from the lake surface down to about two to three times the Secchi disk depth. Because plants produce oxygen during photosynthesis, Secchi measurements also may indicate the depth to which the lake contains enough oxygen to support fish and other aquatic life.

Algae, microscopic aquatic animals, water color, and suspended sediment interfere with light penetration and reduce water clarity. Hence, Secchi transparency is considered an indirect measurement of how much algae and sediment is in the water. In Illinois, there are no water quality standards for Secchi transparency, although the Illinois Department of Public Health suggests at least 48 inches of clarity for swimming safety.



Secchi transparency is a fundamental part of any lake monitoring program. It is the least expensive of the three measurements used to calculate a lake's "trophic status"—or how nutrient-rich the lake is (the other two parameters used are phosphorus and chlorophyll *a*, which are discussed later).

A good way to get started in lake monitoring is through Illinois' Volunteer Lake Monitoring Program (VLMP). Volunteers are provided with a Secchi disk and monitoring forms, and are instructed in proper data collection techniques. Call Illinois EPA's Lake and Watershed Unit at 217/782-3362 for details.

Dissolved Oxygen and Temperature

Dissolved oxygen measurements determine the amount of oxygen in the water available for fish and other aquatic life. Temperature measurements are used to characterize the presence or absence of thermal stratification (the forming of "layers" of water with distinct temperature differences—see the *Lake Notes* fact sheet "Lake Stratification and Mixing"). Both dissolved oxygen and temperature measurements are an integral part of a basic lake assessment.

A lake's temperature variations are important in influencing what types and how many fish will live and reproduce in that lake. Low oxygen levels may restrict where fish can go within a lake and limit the types and numbers of fish in the lake's bottom waters. Generally, warmwater fish (e.g., bass, bluegill, catfish) need at least 5 milligrams per liter (mg/L) of dissolved oxygen to survive, while coldwater fish (e.g., trout and salmon) require 6-7 mg/L. For the protection of aquatic life, Illinois' water quality standards specify that dissolved oxygen "shall not be less than 6.0 mg/L during at least 16 hours of any 24 hour period, nor less than 5.0 mg/L at any time."

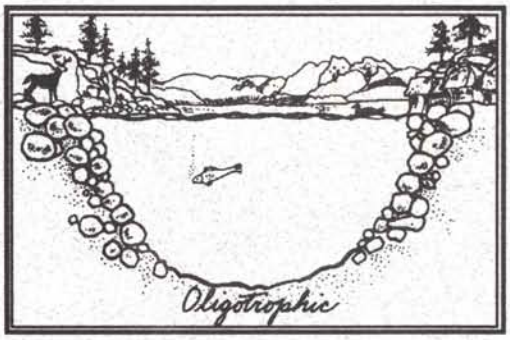
Chemical Parameters

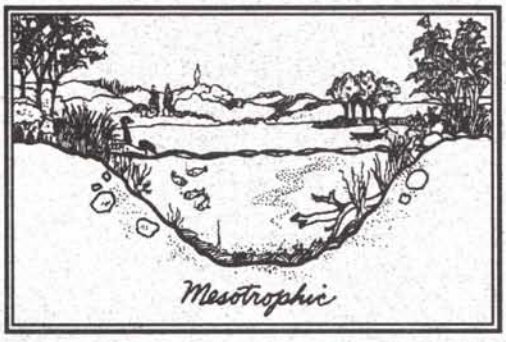
Nutrients

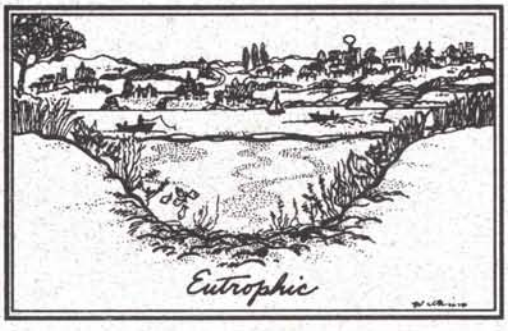
Nutrients in lakes serve the same basic function as nutrients in your garden: they help plants grow. In a garden, lush growth and high productivity are considered beneficial, but this is not necessarily so in a lake. While some algae and other aquatic plants are essential parts of a healthy lake ecosystem, elevated nutrient levels can stimulate nuisance plant growth and lead to an out-of-balance ecosystem and impaired recreation.

Phosphorus and **nitrogen** are the two nutrients of primary concern in lakes. Of these two, phosphorus is usually the nutrient that regulates algae growth the most. For many lakes, additional phosphorus loadings will stimulate additional algae growth. Because phosphorus is so important to the growth of algae and aquatic plants, many lake and watershed management activities focus on reducing phosphorus availability in the lake water.

Measuring phosphorus provides an indication of the fertility or "nutrient enrichment" of a lake. Lakes with low nutrient concentrations are termed "oligotrophic." Those with intermediate nutrient levels are called "mesotrophic." Lakes with high nutrient concentrations are termed "eutrophic." Lakes with extremely high nutrient levels are labeled "hyper-eutrophic."







Both phosphorus and nitrogen can be measured in different forms. Phosphorus is measured as **total phosphorus** (TP) and in various dissolved forms. TP is a measure of all forms of phosphorus in the water sample including that attached to soil particles or contained in algae cells. The dissolved forms, such as **total dissolved phosphorus** (DP), represent the portion of TP that is immediately available for plant and algae growth. TP concentrations above 0.030 mg/L are enough to stimulate nuisance algae growth. While Illinois' water quality standard for lakes is 0.050 mg/L TP, levels above this standard are not uncommon among the state's many eutrophic lakes.

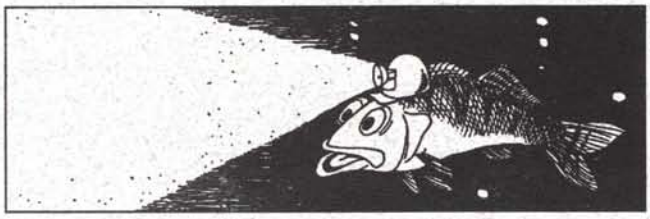
The nitrogen forms of greatest interest to lake studies are **nitrate+nitrite nitrogen** ($NO_3^- + NO_2^-$), **total ammonia nitrogen**, and **total Kjeldahl nitrogen** (total ammonia plus organic nitrogen). The inorganic nitrogen forms (nitrate and ammonia) are readily utilized by algae for growth. Researchers have found that inorganic nitrogen concentrations above 0.30 mg/L are able to stimulate algae growth. Additionally, high ammonia concentrations are toxic to fish and other aquatic organisms.

Total ammonia nitrogen is comprised of un-ionized ammonia (NH_3) plus ionized ammonium (NH_4^+). Illinois' water quality standards for ammonia are based on the un-ionized ammonia component (NH_3) since that is the form most toxic to aquatic life. The standards are rather complicated and vary depending on water temperature, pH, and the time of year. The un-ionized ammonia standards are more stringent in the winter than in the summer. And in all cases at any time of year, no sample may exceed 15 mg/L total ammonia.

Illinois' nitrate nitrogen standard of 10 mg/L applies only in public drinking water reservoirs because of potential adverse physiological effects on infants (though nitrates are not toxic to aquatic life at this concentration).

Suspended Solids

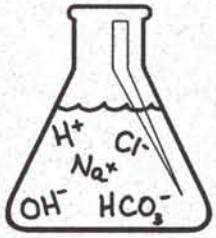
Suspended materials influence a lake's transparency, color, habitat quality, recreational values, and overall ecosystem health. **Total suspended solids** (TSS) and **turbidity** reveal the amount of solids suspended in the water, and include both inorganic forms (such as soil particles) and organic forms (such as algae). TSS measures the actual weight of material per volume of water. Turbidity measurements depend on how much light is scattered or absorbed by a water sample (more suspended particles cause greater scattering; tinted water absorbs more light). Turbidity is reported in nephelometric turbidity units (NTU).



TSS can be subdivided into **volatile suspended solids** (VSS), which include organic materials such as algae and decomposing organic matter, and **nonvolatile suspended solids** (NVSS), which includes non-organic "mineral" substances (e.g., sediment particles).

There are no state standards for TSS, VSS, NVSS, or turbidity. However, Illinois EPA's general lake assessment criteria suggest that NVSS above 15 mg/L could "highly impair recreational lake use," while NVSS of 3 to 7 mg/L might cause slight impairment.

Ions

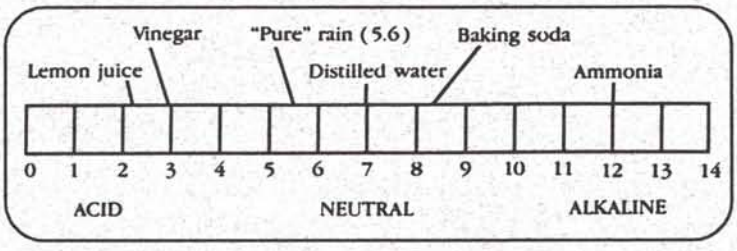


The amount and types of ions (positively or negatively charged dissolved minerals) in the water provide general information on the lake's overall ionic chemistry. Parameters that describe the ionic makeup of lake water include alkalinity, conductivity, and pH. They also generally reflect the lake's watershed geology and soil characteristics.

Alkalinity is a measure of the acid-neutralizing or "buffering" capacity of water. The higher a lake's alkalinity, the greater its resistance to a decline in pH. Alkalinity is commonly influenced by bicarbonates and thus is reported as the concentration of calcium carbonate ($CaCO_3$) in the water. Natural alkalinities fall within a general range of 20 to 200 mg/L $CaCO_3$. Illinois lakes typically have high alkalinities and therefore are well-buffered from the effects of acid rain.

Conductivity (specific conductance) is a measure of the water's ability to conduct an electric current. It is useful for estimating the concentration of total dissolved solids (TDS) in the water (TDS equals about 60 percent of conductivity). Because the measurement is made using two electrodes placed one centimeter apart, conductivity is generally reported as micromhos per centimeter (μmhos/cm). Lakes with high alkalinity often have high conductivity and vice versa. Illinois' standard of 1000 mg/L TDS equates to about 1,700 μmhos/cm conductivity. The conductivity of most Illinois lakes is well below this level.

The water's **pH** is a measure of its hydrogen ion (H^+) concentration and reflects the water's acidity. The lower (more acidic) the pH, the more "free" or "unattached" hydrogen ions in the water. The pH scale ranges from 0 to 14. A pH of 7 is neutral, less than 7 is acidic, and greater than 7 is basic or alkaline.



A lake's pH will fluctuate somewhat each day and from season to season in response to photosynthesis by algae and other aquatic plants, watershed runoff, and other factors. Like dissolved oxygen concentrations, pH may change with depth, primarily due to various chemical reactions and a decrease in photosynthesis. In Illinois lakes, pH values typically remain within the range that is the state standard: 6.5 to 9.0.

Biological Parameters

Chlorophyll

Chlorophyll is the pigment in plants that allows them to create energy from light—a process called photosynthesis. There are several forms of chlorophyll and each absorbs a different wavelength of light. Chlorophyll *a* is found in all photosynthesizing plants. For this reason, the amount of planktonic (suspended) algae in a lake is commonly estimated using the chlorophyll *a* concentration. Chlorophyll *a* should be "corrected" for phaeophytin *a*, a common breakdown product of chlorophyll *a* that can interfere with its measurement. Analysis for chlorophyll *b* and *c* provides information on the various types of algae present (blue-greens, green algae, diatoms, etc.).

Illinois' general lake assessment criteria suggest that chlorophyll *a* levels greater than about 55 μg/L (micrograms per liter) could "highly impair recreational lake use," while concentrations of 7 to 20 μg/L could cause slight impairment.

Fecal Coliform Bacteria

Analysis of bacteria levels at swimming areas is a good public health practice—and it may be required by state, county, or local health department regulations. Analyses typically are made for fecal coliform bacteria, or for the particular fecal coliform *Escherichia coli* (*E. coli*). Fecal coliforms are microscopic organisms that live in the intestines of warm-blooded animals and are excreted in their waste. Coliform bacteria themselves usually are not disease-causing. However, they are good indicators for the presence of sewage and animal wastes that may contain disease-causing organisms and pathogens.

Unlike the other water quality parameters discussed already, bacteria counts are not easy to predict. This is because, under certain conditions, bacteria can grow quite rapidly. Hence, weekly testing during the swimming season is commonly recommended.

For public beaches, the Illinois Department of Health has set stringent beach licensing requirements and bacteria standards. Their bathing beach code states that during the initial licensing survey, a fecal coliform count of 200 colonies/100 mL or an *E. coli* density of 126 colonies/100 mL in one or more water samples requires additional investigation. Once licensed, testing every other week is required. Beaches are closed if a fecal coliform count of 500 colonies/100 mL or an *E. coli* count of 235 colonies/100 mL in each of two samples collected on the same day occurs. The beach can't be reopened until two additional samples collected on the same day are both less than the above criteria.

Keep in mind that because stormwater runoff from agricultural and urban areas often carries with it livestock, pet, and/or waterfowl waste, some lakes experience an increase in bacteria levels soon after rainfall events.

Note to the Reader:
To learn more about setting up a lake monitoring program and which parameters to include, see the *Lake Notes* publication "Monitoring Lake Quality."

Lake Notes . . is a series of publications produced by the Illinois Environmental Protection Agency about issues confronting Illinois' lake resources. The objective of these publications is to provide lake and watershed residents with a greater understanding of environmental cause-and-effect relationships, and actions we all can take to protect our lakes.

Appreciation is extended to the University of Wisconsin-Extension and the Wisconsin Department of Natural Resources for illustrations from their "Water Quality Digitized Clip Art Collection." Other illustrations by Lynda Wallis, Holly Hudson, and Jim Lillygren.

This *Lake Notes* publication was prepared by Holly Hudson of the Northeastern Illinois Planning Commission, Chicago, Illinois. Thanks are extended to Bob Kirschner, Bob Mosher, and Mark Pfister for their review and comments.

For more information about other publications in this series and to request copies, please contact: Illinois Environmental Protection Agency, DWPC-Lake and Watershed Unit, P.O. Box 19276, Springfield, Illinois, 62794-9276; 217/782-3362.