Sea Grant
ILLINOIS - INDIANA

Water Issues And Concerns Fact Sheet Series

Water Clarity

by Leslie Dorworth

Water clarity can be determined by simply looking into a lake or river and being able to see the bottom or not see the bottom. As light penetrates water, it becomes attenuated and altered in its spectral composition. The change that occurs in the spectral composition is from predominantly yellow light at the surface to blue green at depth in clear water or yellow-green in waters containing high concentrations of dissolved organic material.

Changes in light as it passes the air-water interface

In fact the initial reduction in solar intensity happens before the light passes through the upper surface of the water. On a clear day, the intensity of the solar beam is significantly reduced during its passage through the atmosphere. The reduction in intensity is partially due to the scattering by air molecules and dust particles, and partly due to water vapor, oxygen, ozone, and carbon dioxide in the atmosphere.

Now that the solar radiation has passed through the atmosphere, it must penetrate the air-water interface. Some of it will be reflected into the atmosphere, and this is dependent on how flat the surface of the water is as well as the angle of the sun in the sky. Once the energy has penetrated the water's surface, all of the absorption which takes place in natural waters is attributable to four components of the aquatic ecosystem: the water itself, dissolved yellow pigments, the photosynthetic biota (phytoplankton and macrophytes) and inanimate particulate matter.

Most of the solar photons which enter the water are absorbed. However, many of these photons also undergo scattering before they are absorbed. The effect of scattering is to impede the vertical penetration of light thereby increasing the total pathlength which the photons follow in traversing a certain depth and so increases the probability of their capture by one or more of the absorbing components of the medium.

Turbidity

Turbidity is a unit of measurement quantifying the degree to which light traveling through the water column is scattered by the suspended organic (including algae) and inorganic particles. The scattering of light increases with a greater suspended load. Turbidity is commonly measured in Nephelometric Turbidity Units (NTU) which replaces the Jackson Turbidity Unit (JTU). The nephelometric method compares the scattered light by the sample and the light scattered by a reference solution.

The composition of the suspended load is largely dependent on the velocity of the moving water. Suspended materials in an aquatic environment are varied, ranging from clay, silt, and plankton to industrial wastes and sewage. Obviously, the less turbid the water, the better.

The sediments involved may contain organic and or inorganic constituents. Organic particles may contain microorganisms, thereby increasing the possibility of waterborne diseases in extremely turbid waters. Industry should be wary since an over abundance of suspended materials could clog pipes and machinery and increase the treatment of water. Potentially hazardous obstructions in the water for swimmers and boaters could be obscured in highly turbid waters.

The environmental effects of a highly turbid body of water are seen often in the altering of the community structure. The turbidity of the water will reduce the penetration of light thereby suppressing the photosynthetic activity of the phytoplankton, algae, and macrophytes. If the algae are the primary contributors to the turbid

water column, then the light will penetrate only through the surface waters. Primary production is then limited to the upper most layers of the water. When this situation occurs, then cyanobacteria are selectively favored since they have mechanisms that enable them to float.

Excess turbidity leads to fewer photosynthetic organisms available to serve as food sources for many of the invertebrates. As a result, the invertebrate numbers will decrease, which may lead to declines in the fish populations.. Excess nutrients will encourage the micro-organisms to grow and breakdown material. This process requires dissolved oxygen. Algae, besides being photosynthetic during the day, will continue to respire at night using oxygen. The resultant oxygen depletion may lead to fish kills.

Measuring turbidity

A common device used to measure water transparency or visibility is a Secchi Disk. The disk is a 20 cm circular black and white plate. The Secchi disk is attached to a calibrated line and lowered into the water to the depth at which it disappears (Figure 1). The disk is then lifted

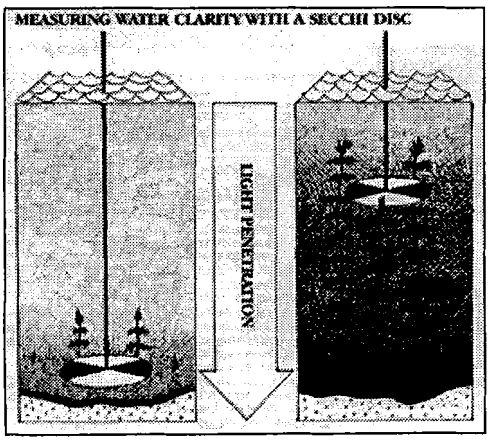

Figure 1. Measuring water clarity with a Secchi disc.

until it reappears. The arithmetic mean of the two depths is considered the Secchi disk transparency or limit of visibility. Calculation of the Secchi depth is based on the vertical attenuation coefficient of Photosynthetically Active Radiation (PAR) (400-700nm wavelength).

$$\text{Secchi Depth} = \left(\frac{1.44}{Kd}\right)$$

Kd is the vertical attenuation coefficient.

$$Kd = 0.033 \ln E(z) = -Kd + \ln E(o)$$

Ez and Eo are the light measurements at depth and at the surface, respectively. The equation says that the log of the downwelling irradiance at depth z is equal to the vertical attenuation of the light plus the log of the downwelling irradiance.

The nephelometric method is based on a comparison of light scattered by the sample and the light scattered by a reference solution. A nephelometer is an instrument for measuring turbidity in the water using a photometric technique. It measures the light scattered by finely divided turbidity or colloidally dispersed particles suspended in the water column. The detection limits of the instrument are differences in turbidity from 0.02 NTU with a range of 0 to 40 NTU.

A light meter is another method to measure light penetration through the water. A light meter is suspended in the water column. Based on the Beer-Lambert Law, the vertical attenuation of light can be measured. The Law assumes that light passing through a uniform body of water will change exponentially with depth.

$$I_z = I_o \exp(-K_p z)$$

Where Io and Iz are values of irradiance on the surface of the water and at depth, z. Kp is the attenuation coefficient for PAR and z refers to the sampling depth. A semi-logarithmic plot is used to obtain Io.

Effects of turbidity on drinking water quality

The American Water Works Association recommends an operating level of no more than 0.5 NTU of turbidity in the filter effluent of water treatment plants and a goal of no more than 0.2 NTU. Turbidity in drinking water may interfere with the overall disinfection process. To ensure removal of the pathogens from the water and produce effective disinfection as well, turbidity levels should be consistently maintained at low levels. The turbid content of the water can be effectively removed by the application of a complete treatment facilities. A complete treatment facility includes, for example, chemical addition, coagulation, flocculation, sedimentation, and filtration. Direct filtration may be substituted.

Recommended Resources

Field Manual for Water Quality Monitoring. An Environmental Education program for Schools. M.K. Mitchell and W.B. Stapp. 10th edition. Kendall/Hunt Publishing Company, 304p.

Light and Photosynthesis in Aquatic Ecosystems. J.T.O. Kirk. 2nd edition. Cambridge Press, 509p.

Water Quality Issues and Concerns is an ongoing series addressing relevant water quality issues. For water quality information, contact Leslie Dorworth, Sea Grant aquatic ecology specialist, at 219 989-2726; dorworth@calumet.purdue

Produced by the Illinois-Indiana Sea Grant College Program, one of 29 National Sea Grant College Programs. Created by Congress in 1966, Sea Grant combines university, government, business and industry expertise to address coastal and Great Lakes needs. Funding is provided by the National Oceanic Atmospheric Administration (NOAA), U. S. Department of Commerce, Purdue University, West Lafayette, Indiana, and the University of Illinois at Urbana-Champaign.

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IISG-98-12