Causes of Water Quality Problems

From maintaining good water quality to being able to identify, diagnose and find a cure to what may be causing aquatic problems; managing the water quality of your pond or lake can be challenging. Excessive aquatic vegetation, fish kills and foul odors are all common ailments that pond owners face, and with the array of contributing factors that can create these aquatic problems, it makes finding a solution that much more difficult.

The best way to find a solution is to obtain a better understanding of the components that impact the delicate balance of a pond's ecosystem. From a lake manager's perspective the most significant factors are: light and temperature, nutrients, and oxygen. Let's explore them further.

Light & Temperature

Sunlight is of major significance to lake dynamics as it's the primary source of energy. Most of the energy that controls the metabolism of a lake comes directly from the solar energy utilized in photosynthesis. Photosynthesis will occur only in the upper layer of the pond, or euphotic zone, this is the area in the water column that sunlight is able to penetrate. Shallow bodies of water less than 9ft/3m in depth more commonly experience problems such as bottom-rooted weeds or benthic algae.

Thermal Stratification is a term meaning temperature layering. As the sun shines on a pond it warms the surface water, this water becomes lighter than the cooler, denser waters which are trapped at the pond's bottom. As the hot summer season progresses the difference in temperature between the warm surface waters and the colder bottom waters increase. As a result the water becomes stratified or separated into layers and the top and bottom layers of the lake do not mix with each other. The area created between the warm and cold layers, called the thermocline or metalimnion, can act as a physical barrier preventing any

vertical mixing in the lake, and encourage algae growth throughout the warm surface waters.

Thermal stratification impacts the water quality in a lake primarily because of its effect on dissolved oxygen levels, the way we measure how water holds oxygen. Compared to cooler water, Warm water has a diminished capacity to hold oxygen, in fact water at 52≡ Fahrenheit (11≡ Celsius) can hold over 40% more oxygen than water at 80≡ Fahrenheit (27≡ Celsius.) As water temperature increases, the water's capacity to hold oxygen decreases.

Dissolved oxygen in a lake comes primarily from photosynthesis and wave/wind action. During stratification, bottom waters are removed from both of these sources and an anoxic or no oxygen condition occurs. Aquatic organisms require oxygen to survive, in its absence organisms must move from the anoxic area or die. Anoxic bottom waters lose most if not all of the zooplankton and aerobic bacteria necessary for efficient and effective digestion, while less effective more pollutant tolerant forms of anaerobic bacteria will develop.

The lack of dissolved oxygen sets in motion a series of chemical reactions that further reduce water quality: sulfide is converted to hydrogen sulfide, insoluble iron is converted to soluble forms, suspended solids increase and a severe decrease in the decomposition of waste materials on the pond bottom will occur.

Thermal stratification occurs in a seasonal cycle with the thermocline becoming more severe in late summer and late winter. Lakes and ponds in warmer weather regions experience a shorter annual cycle spending more time in late summer and early fall conditions.

Shallow lakes offer the water manager an even greater challenge. Shallow ponds less than 6ft/2m in depth tend to be very warm allowing for the entire water column to be productive with weed and algae growth. These types of lakes need extra consideration when determining the correct water management solution.

Nutrients

The second essential factor in our lake management discussion is the impact of nutrients on the aquatic ecosystem. There is a direct correlation in the level of available nutrients and the populations of algae and aquatic weeds.

To gain a deeper knowledge it is important to understand the sources of nutrients, how the nutrients are absorbed and broken down, and the impact nutrients can have on water chemistry. A diagnosis of a lake's chemical make up can help you design a preventative program for a problem lake.

Consider the way that organic nutrients are accumulated and digested in the lake. An organic nutrient is a carbon based compound essential to the life of a plant. In lake ecology the macro nutrients we specifically talk of are phosphorus and nitrogen. In fact, phosphorus has been identified as the single greatest contributor to aquatic plant growth; one gram of phosphorous will produce one hundred grams of algal biomass. As the nutrient level in the water increases so does aquatic plant and weed growth, this leads to severe problems from an environmental and aesthetic viewpoint.

It is beneficial to try to identify the sources of nutrient coming into the pond. The three most common sources are bottom silt and dead vegetation in the lake, runoff water from surrounding turf areas, and the sources of incoming water.

Bottom Silt and Vegetation in the Lake. Vegetative life in the lake and sediment at the lake bottom are the primary sources of nutrient. Although they only have a two-week life cycle, blue-green algae can experience cell division and double their population as often as every 20 minutes. At the end of the cycle, the plants simply die and begin to sink to the lake's bottom, adding to the biomass, or total amount of biological material in the pond. This adds to the "aquatic compost pile" at the bottom, or benthic zone. The layer of dead plant material acts as nutrient for future algae and aquatic weed blooms, a phenomenon called nutrient cycling.

Nutrient cycling creates additional demands on the available oxygen in the bottom waters, or hypolimnion, and creates a stress situation.

Studies at the University of Florida indicate that sediment, or sludge build up, can accumulate at a rate of 1 to 5 inches (2.5 to 12cm) per year in temperate climates. While in tropical climates the rate increases to 3 to 8 inches (6 to 16 cm) per year all depending on the level of nutrient loading.

At a mid point accumulation rate of 3 inches (7cm) per year, a one surface acre (4000 m2) lake will lose 80,000 gallons (300 m3) of water storage capacity in a single year. Imagine the impact on an irrigation storage basin over the course of ten, twenty or fifty years. Sludge build up can gradually occur, robbing any lake or irrigation basin of its capacity to store water.

Run Off. The second most common source of nutrients is runoff from surrounding turf areas as well as roads, farms and other outlying areas. The USGA reports that up to 4% of the fertilizers applied to areas adjacent to ponds and lakes may eventually runoff into the lakes, this runoff of fertilizers into lakes is known as nutrient loading. Consider that a golf course may apply up to sixteen tons of fertilizer in a year the possibility for a half ton of fertilizer to runoff into the lakes or drainage basins exists. Leaves, grass clippings, and other materials will also runoff into the lakes, placing additional burdens on the lake's natural clean up processes. Ponds and lakes often act as Mother Nature's "garbage cans."

Nutrient loading can be very high in waters adjacent to green areas or turf grass. As the nutrient levels in the pond increase, the rate of plant growth will increase as well. The following chart shows the impact that nutrient levels can have on aquatic plants and algae.

A case study presented by the North American Lake Management Society (NALMS) suggests that algae can absorb over 1mg\L of phosphorus and over 2.5mg\L of nitrogen (Figure 8). Nutrients do have a significant impact on algae

and aquatic weed growth; increased nutrient levels usually mean increased plant levels.

Incoming Water Sources. Nutrient is also added to lakes and ponds through inlet waters. This inlet water can come from effluent sewage, wastewater treatment plants and leeching from septic systems. Often inlet waters have minimal oxygen and are loaded with phosphorus, an indication of excess phosphorus is foaming water.

Oxygen

The third essential factor in lake and pond ecology is the role oxygen plays. Oxygen is important to all forms of life in the lake, and supports the food chain. A healthy ecosystem in a lake contains a wide variety of plants and animals including a natural mechanism to biodegrade organic nutrients. The bottom of the food chain consists of microscopic algae which are consumed by slightly larger zooplankton. Each level of consumer transfers a small fraction of the energy the lake receives up the food chain to the next level of consumer. This means that a few sport fish depend on a much larger supply of smaller fish, and in turn the smaller fish depend on a large base of plants and algae, and the large mass of plants and algae require an even larger amount of nutrient to grow. As you can see a healthy food chain can pull a tremendous amount of nutrient out of the water, and oxygen supports this entire system.

Natural decomposition processes in the aquatic ecosystem are oxygen dependent. Aerobic digestion is a fast and efficient way of breaking down nutrients. Moreover, an abundant supply of dissolved oxygen supports the oxidation and other chemical processes that help keep the lake in ecological balance.

How is a lake supplied with oxygen? From several sources but primarily through photosynthesis, wave and wind action. Aquatic plants and algae produce large

amounts of oxygen through the light process of photosynthesis. This is an important source of oxygen in most lakes especially older, or eutrophic lakes. At night plants become oxygen consumers in the dark process of photosynthesis and produce carbon dioxide. The other significant oxygen producer is the oxygen transfer created by wave and wind action. The surface area of the lake is increased by surface waves or ripples caused by wind or other means, the wave action created by the wind creates additional circulation and partially breaks down thermal stratification. Surface waters that have direct contact with the air will be oxygenated through diffusion. And finally, as the rain passes through the atmosphere it picks up free oxygen and deposits it in a dissolved state when it strikes the surface waters of the lake.

Oxygen depletion or stress situations occur for different reasons. Whenever oxygen levels fall below 3 to 4 parts per million (PPM) an oxygen stress will occur. Typical situations when this will happen are:

--Late at night and just before dawn

--Cloudy and still days

--Hot and humid days

--When the lakes nutrient content is high

--After a chemical application

The most immediate reactions to oxygen depletion would be fish kills or odors. Long term issues include nutrient build up, sludge accumulation, and a chemical imbalance in the lake.

Nature has provided a clean up process that will metabolize or decompose excess nutrients. This process is called organic digestion. Two types of naturally occurring bacteria are present in all lakes and ponds, aerobic and anaerobic. The

bacteria in the water will work to break down the nutrient load by feeding on the organic nutrients and digesting it into non-organic compounds that algae and aquatic plants can not readily use for food.

The most effective of these bacteria are aerobic bacteria. Aerobic bacteria only live in the presence of oxygen and they metabolize or break down nutrients respiring or consuming oxygen in the process. They are very efficient, breaking down organic nutrients, carbon dioxide and other materials and are roughly seven times faster in organic digestion than anaerobic bacteria.

Anaerobic bacteria also break down organic nutrient and exist in pond water and soils that are oxygen deficient. They are not as effective as aerobic bacteria in the digestion of organic wastes and allow soluble organic nutrients to recycle into the water column. Noxious by-products such as methane, ammonia and hydrogen sulfide are created by anaerobic decomposition. In general, any foul smelling waters can be assumed to be anoxic or oxygen deficient.

Oxidation is a chemical process that is dependent on oxygen. Oxygen has a positive molecular charge, as an oxygen molecule affixes itself to a particle in the water it then starts to oxidize or break down the molecular bonds which hold the particle together. In addition, the positive molecular charge of the oxygen molecule will create an attraction and pull several small particles together, a process known as coagulation. These heavier, coagulated particles now precipitate, or fall out of suspension. In this process soluble substances like phosphorus and iron become insoluble and unavailable for use by aquatic vegetation. A balanced aquatic ecosystem contains a fairly low population of algae and aquatic weeds as well as other forms of nutrient. Aerobic bacteria feed on the organic nutrients and digest it into non-organic compounds that algae and aquatic plants can not use as readily for food.

Simple water quality tests will indicate the nutrient levels and other valuable information in regards to lakes and ponds. These tests typically monitor dissolved

oxygen, biological oxygen demand, alkalinity, pH, phosphorus, nitrogen, and fecal coliform in some situations. Dissolved oxygen is described in either parts per million or milligrams per liter. Biological Oxygen Demand is referred to as BOD. This testing can be completed by most water testing laboratories and water testing is important for a complete understanding of the water you are trying to manage.

Let's put it all together...

Let's take a look at how all of these mechanisms interact to make the lake behave the way it does. As a lake ages the level of nutrient rises, this is due to an increase in runoff, organic bottom sediment, or fertilizer used in the surrounding area, and in the amount of algae and aquatic weed growth. As these weeds grow and die they sink to the bottom of the pond to decompose, this will result in a sudden increase in the activity and population of aerobic bacteria due to the large food supply. The depth of the lake will decrease as the biomass at the lake bottom accumulates. Aerobic bacteria will use a large amount of oxygen as they digest organic waste, with primary source of oxygen in the pond coming through surface contact, rainfall and plant photosynthesis.

Due to thermal stratification the top and bottom layers of the pond will not mix and the needed oxygen can not get down to the lake bottom to support aerobic digestion. This will cause an oxygen depletion problem in the lower layers of the lake and may result in nutrient cycling, fish kills and foul odors caused by anaerobic digestion. The problem is caused by poor water quality, that has excessive nutrient levels, poor circulation and low oxygen levels.

Balance is critical to the aquatic ecosystem, without it your pond or lake will suffer. There are many steps that can prevent an imbalance from occurring, and knowing the causes will assist in determining the best solution for your application. Some methods include proper pond construction, including the placement of aquatic plants on the shores of a pond to assist with the filtering of

excessive nutrient, chemical applications, and the addition of oxygen through aeration systems and devices.