A STUDY OF WATER QUALITY PARAMETERS TO BETTER MANAGE OUR PONDS OR LAKES

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Abstract- Successful pond or lake management requires an understanding of the role of nutrients and other water quality parameters, as well as regular monitoring of environmental conditions within the pond’s or lake’s ecosystem. Water quality is often overlooked in pond or lake management, and poor water quality can lead to common problems, such as excessive algal blooms, overgrowth of plants, noxious smells, or dead and dying fish. In order to prevent these problems, an understanding of basic water chemistry and other physical parameters is necessary. This paper describes the most important water quality factors that influence the health of ponds or lakes. Some factors that are particularly important in recreational fish ponds or lakes to ensure fish health and pond or lake productivity are also discussed.

Keywords: Transparency, DO, PH, chlorophyll

INTRODUCTION

A basic understanding of how these factors interact with one another will help pond or lake owners or local government authorities maintain good water quality and a healthy pond or Lake Ecosystem. Understanding a lake’s or pond’s physical, chemical, and biological properties is essential to determining the lake’s or pond’s condition and in making informed lake or pond management decisions it can help characterize the lake’s or pond’s overall ecology and health. Many companies produce kits and other materials to monitor water quality on your own, or you can send water samples to commercial laboratories for analysis.

Physical parameters
WATER CLARITY (TRANSPARENCY)

Water clarity or transparency is commonly measured using a Secchi disk. 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 or pond 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 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 the water.

Clarity of the water can pose a water quality problem. Lake of clarity or turbidity can have several causes, but the effects are typically the same, cloudy water and decreased aesthetics of the pond. The cloudy water can prevent sunlight from reaching the aquatic plants in the pond, which wouldn't be bad if your pond is overrun with weeds. However, most ponds with turbidity problems do not have much aquatic vegetation to begin with because the cloudiness of the water is caused by bottom sediment mixed up in the water column. The lack of vegetation allows for the sediment to be stirred up and then it blocks the sunlight to prevent further growth. A cloudy pond can also decrease your enjoyment of your pond. Typically, the turbidity is from stirred up sediment, such as clay, or it can be organic, like planktonic algae. If the turbidity is caused by bottom sediment, to fix it is usually a waiting game, however there are some products available which will help remove the cloudiness. If it turbidity is caused by organic growth, the organisms can be treated.

TEMPERATURE

A temperature measurement is used to characterize the presence or absence of thermal stratification. A temperature measurement is an integral part of a basic lake or pond assessment. A lake or pond temperature variations are important in influencing what types and how many fish will live and reproduce in that lake or pond. Temperature problems are caused from uneven warming or cooling of your pond. During the summer, the surface water is warmed and the colder, denser bottom water does not get warmed as much. This causes two distinct layers of water with a
dividing line, called a Thermocline. The problems associated are due to inadequate mixing of the water. Oxygen diffused into the water from the air is not mixed with the cooler bottom water. Therefore, you have a warm, oxygenated layer of water on top of a cool, low oxygen layer at the bottom. When the surface cools in fall, it becomes denser than the bottom and the pond “turns over” call Turnover. This causes a mixing of all water and an overall decrease in dissolved oxygen levels. Turnover can lead to massive fish die off and major problems with your pond.

**DISSOLVED OXYGEN (DO)**

Dissolved oxygen (DO) is probably the single most important water quality factor for pond or lake owners or local government authorities. Oxygen is needed by fish and other aquatic organisms, and levels of DO will determine the ability of ponds or lakes and other water bodies to support aquatic life. Oxygen dissolves in water at very low concentrations measured in parts per million (ppm, which can be used interchangeably with milligrams per liter [mg/L]). Ponds or lakes will rarely have more than 10 ppm DO. Most oxygen in water is produced by algae and green plants through photosynthesis, the process whereby green plants use solar energy to convert water and carbon dioxide (CO2) to oxygen and carbohydrates. Oxygen is also naturally incorporated into water from the atmosphere through surface diffusion and turbulence caused by wind.

**Daily fluctuations and seasonal changes in DO**

Dissolved oxygen levels can vary dramatically in a 24-hour period. During the day, DO concentrations generated by photosynthesis will increase. During the night, DO levels will decline as oxygen is removed from water through respiration, the process whereby plants and animals consume oxygen and release carbon dioxide as they convert organic material to energy. For this reason, DO levels are typically highest at dusk and lowest just before dawn. There is also a strong relationship between temperature and DO: the warmer the water, the less oxygen it can hold. For example, water at 52°F (11°C) can hold 40% more oxygen than water at 80°F (27°C). Warm water increases the metabolism of fish and therefore increases their consumption of oxygen. Bacteria also consume oxygen as they decompose organic matter. Therefore, during the summer months, DO levels will be lower because of increased oxygen demands of fish, warmer water that holds less oxygen, and increased bacterial decomposition of dead plant and algal material toward the end of the growing season.

**Effects of low DO**

Oxygen depletion occurs when the demands for oxygen are greater than what is being produced. Oxygen depletion can occur for different reasons. Situations typically associated with oxygen depletion are

- Hot, cloudy, and still (windless) days;
- Pond or lake stratification followed by turnovers (the mixing of stratified layers, which develop during the summer in ponds or lakes or lakes 8 ft deep or greater);
- After a sudden algal bloom die-off (from natural causes or after a chemical application); and
- Organic waste decomposition (oxygen depletion will occur in the presence of excessive organic matter from waste products, such as uneaten feed).

Whenever DO levels fall below 3 to 4 ppm, oxygen stress will occur. Lack of adequate dissolved oxygen is the leading cause of fish kills. Normal oxygen content in a healthy pond or lake or lake will range from 5 to 10 ppm. Warm water fish (e.g., bass, bluegill, and catfish) require about 5 ppm and coldwater fish (e.g., trout, salmon) require about 6.5 ppm to maintain good health. Dissolved oxygen levels of less than 3 ppm will kill warm water fish and levels less than 5 ppm will kill coldwater fish. Fish exposed to low, nonlethal levels of DO over prolonged periods will be chronically stressed, stop eating, and be more susceptible to disease. Low oxygen concentrations also increase the activity of anaerobic bacteria, which create methane and hydrogen sulfide gases during anaerobic decomposition. Ponds or lakes or lakes with oxygen-poor bottoms and accumulated organic matter can release these gases when the bottom sediment is disturbed. Hydrogen sulfide has a rotten egg smell and is very toxic to fish.

**Preventing low DO conditions**

To help maintain safe DO levels in ponds or lakes, particularly in deeper ponds or lakes in which fish are intensively cultured, mechanical aeration is often needed. Aerators help keep pond or lake water mixed so that layering is minimized and the surface water is well-oxygenated. However, aeration should only be thought of as one of many management tools to help maintain healthy oxygen levels. External nutrient loading is still the critical issue that must be addressed because excessive nutrients can lead to an over-abundance of aquatic weeds and algae, which can result in oxygen depletions when they die and decompose.

**Chemical parameters**

**Phosphorus or Nitrogen (Nutrients)**

It is important to understand the sources and basic pathways of nutrients because there is a direct correlation between available nutrients and populations of algae and aquatic weeds. The most important nutrients in aquatic systems are phosphorus (P) and nitrogen (N) in the forms of phosphates (PO3) and nitrates (NO3). These nutrients are critical to the growth of plants and animals in aquatic systems. Phosphorus has been identified as the limiting factor for algal growth in most lakes and, as such, is the largest contributor to aquatic plant growth. One gram of phosphorus will produce 100 grams of algal biomass. Excessive amounts of nutrients will lead to over-fertilization, or eutrophic conditions, which can result in an over-abundance of aquatic plants and algal blooms. When the excess plants and/or algae die, they decompose, which leads to a depletion of oxygen that can affect water clarity and smell and can lead to fish kills.

**Sources of nutrients**

The main sources of nutrients in ponds or lakes or lakes are bottom silt, dead vegetation, landscape debris, runoff from the surrounding area, poorly functioning septic systems, and wastes from livestock and waterfowl. As aquatic plants and algae grow and die, they sink to the bottom of the pond or lake or lake and provide a source of nutrients for future
aquatic growth, a phenomenon known as nutrient cycling. This, along with landscape debris such as grass clippings, leaves, and pine needles, contributes nutrients to ponds or lakes or lakes, and these nutrients must be managed to prevent eutrophic conditions from developing. Runoff from fertilized fields and lawns in immediate surrounding areas as well as roads, farms, and outlying areas can also be major sources of nutrient enrichment.

**Dissolved and particulate phosphorus**
Phosphorus in water comes in two forms: dissolved and particulate. Dissolved phosphorus enters the aquatic environment from fertilizers, crop residues, or human or animal wastes, and is the form that is readily available to aquatic plants and algae. Particulate phosphorus is bound to soil particles and minerals that contain aluminum, iron, or calcium, as well as to organic matter, and enters aquatic systems primarily through soil erosion and surface runoff. While it may not be as readily available to aquatic plants, particulate phosphorus can accumulate in sediments and can be a source of slow release of phosphorus into the water for years.

**Nitrogenous waste (Ammonia)**
Ammonia is another compound that can affect the health and performance of your pond.

**Sources of ammonia**
Ammonia is a form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays and is the main nitrogenous waste excreted by most fish and freshwater invertebrates. It is very unlikely that ammonia levels in your pond or lake will reach levels that are lethal to fish. However, under conditions where fish are cultured intensively and fed protein-rich diets, they can produce high concentrations of ammonia, and fish may be exposed to sub-lethal levels (greater than 0.02 ppm) for extended periods of time. This can lead to reduced growth and increased susceptibility to disease.

**Forms of ammonia**
Ammonia can exist in two forms: un-ionized ammonia (NH3) and ionized ammonia, also known as ammonium ion (NH4+). The ratio of un-ionized to ionized ammonia depends on pH and water temperature. Un-ionized ammonia (NH3) is extremely toxic to fish and is the predominant form of ammonia when pH is high. Ionized ammonia (NH4+) is nontoxic except at extremely high levels and is the predominant form in water when pH is low. As a general rule, less than 10% of the ammonia will be the toxic un-ionized form when water pH values are lower than 8; however, this proportion increases greatly as pH increases. Water temperature will also affect the equilibrium between NH3 and NH4+. At any given pH, more toxic NH3 will be present in warmer water than in cooler water.

**Ammonia removal and transformation processes**
There are two processes that remove or transform ammonia released into the water. The first is uptake of ammonia by plants and algae, which readily use the nitrogen in ammonia as a nutrient for growth. For this reason, ammonia levels are usually low in ponds or lakes or lakes during summer months when algae are most productive, but can increase rapidly after the crash of an algal bloom. This is also one of the reasons why ammonia levels tend to be higher in ponds or lakes or lakes during the winter months when algal production is low.

The second process, which transforms ammonia, is a step in the nitrogen cycle known as nitrification, the biological conversion of ammonia and ammonium to nitrate nitrogen. Nitrification is a two-step process. First, Nitrosomonas bacteria convert ammonia and ammonium to nitrite (NO2). Nitrite, which is also highly toxic to fish, is then converted to nitrate (NO3) by Nitrobacter bacteria. These reactions are usually coupled, and nitrite is rapidly converted to nitrate, so nitrite levels are usually low. The rate of nitrification is affected by water temperature. Maximum rates of nitrification occur at water temperatures between 86 and 95°F (30–35°C). At temperatures of 104°F (40°C) and higher, nitrification rates fall to near zero. At temperatures below 68°F (20°C), nitrification proceeds at a slower rate, but will continue at temperatures of 50°F (10°C) or less. For this reason, ammonia levels tend to be higher in fall and early spring before nitrification rates have increased as a result of increasing temperatures.

**PH**
The term pH refers to the concentration of hydrogen ions, and is a measure of whether a substance is an acid, a base, or neutral. The “p” in pH stands for “power” and the “H” for hydrogen ions. The scale of pH values ranges ranges from 0 to 14; 7 represents neutral conditions, values less than 7 indicate more acidic conditions, and values above 7 indicate more alkaline or basic conditions.

**Daily fluctuations in pH**
The pH of freshwater ponds or lakes or lakes can fluctuate considerably both daily and seasonally; the magnitude of this fluctuation will depend on how well-buffered the freshwater system is. These fluctuations are due to photosynthesis and respiration by plants and animals, which results in the highest pH typically occurring at dusk and the lowest at dawn. This is because during the night respiration increases concentrations of carbon, which interacts with water to produce carbonic acid (H2CO3), lowering the pH. During the day, carbon dioxide concentrations decrease because of photosynthesis, driving pH values up.

**How pH affects animals and other water quality variables**
Optimum pH for fish growth and health is between 6 and 9. If pH is outside this range, fish growth will be reduced. Mortalities will occur when pH values are less than 4.5 or greater than 10. In addition to the direct effects pH can have on fish and other aquatic animals, pH interacts with other water quality variables such as ammonia, hydrogen sulfide, and dissolved metals, affecting their aqueous equilibria and toxicity as well. For example, as previously mentioned, high pH increases the toxicity of ammonia to fish, whereas low pH increases toxicity of aluminum and copper. Hydrogen sulfide (H2S) is a toxic, colorless gas that can form in pond or lake sediments when bacteria feed on organic debris in areas that are low or depleted of oxygen, giving off a rotten egg smell when the sediments are stirred up. When dissolved in water, H2S can undergo two chemical steps, which go back and
forth depending on the pH. At pH less than 6, most of the hydrogen sulfide will be in the toxic H2S form, whereas at higher pH (8-12), most of the hydrogen sulfide will be in the less toxic H2S⁻ form.

**ALKALINITY**

Alkalinity refers to the water’s buffering capacity, or its ability to withstand changes in pH. It is a measure of the total concentration of bases in pond or lake water, including carbonates, bicarbonates, hydroxides, phosphates, and borates, and is expressed in ppm calcium carbonate. All these bases react with and neutralize acids, which in turn buffers changes in pH. The pH of well-buffered water will normally fluctuate between 6.5 and 9. Carbonates and bicarbonates are the most common and important components of alkalinity. In an established pond, the ideal alkalinity measurement should be around 100 ppm, but readings from 50 to 200 ppm are acceptable. If the alkalinity is low, even a small amount of acid can cause a large change in pH. Alkalinity values greater than 300 ppm will not adversely affect fish, but such high values will render some commonly used chemicals, such as copper sulfate, ineffective. Alkalinity can be increased by adding agricultural limestone [CaCO₃ and CaMg (CO₃)₂] to ponds or lakes.

**HARDNESS**

Hardness is a measure of divalent salts, or positively charged ions, particularly calcium (Ca²⁺) and magnesium (Mg²⁺), in water. Total hardness is the sum of the concentrations of Ca²⁺ and Mg²⁺, expressed in ppm calcium carbonate. Calcium carbonate hardness is a general term that indicates the total amount of divalent salts present, but it does not specify which salts are causing water hardness. Hardness and alkalinity are often confused because both are expressed using the same term (ppm calcium carbonate), and sometimes both parameters have similar values in a given water body. However, alkalinity measures negative ions (carbonate and bicarbonate) and hardness measures positive ions (calcium and magnesium), and sometimes these values can differ greatly. If limestone (calcium carbonate) is the cause of hardness and alkalinity, these values will be similar or identical. However, if sodium bicarbonate (NaHCO₃) is responsible for high alkalinity, it is possible for water to have high alkalinity and low hardness and calcium. Calcium and magnesium are essential to fish for biological processes such as bone and scale formation. If your pond or lake is used to culture fish, water hardness should be above 50 ppm and can be adjusted by adding agricultural limestone.

**CONDUCTIVITY**

Conductivity 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. Because the measurement is made using electrodes placed one centimeter apart, conductivity is generally reported as micromhos per centimeter (µmhos/cm).

**SUSPENDED SOLIDS**

Suspended materials influence a lake or pond’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 and organic forms. 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. Turbidity is reported in nephelometric turbidity units. TSS can be subdivided into volatile suspended solids (VSS), which include organic materials such as algae and decomposing organic matter and nonvolatile suspended solids, which includes non organic “mineral” substances (e.g., sediment particles).

**Biological parameters**

**CHLOROPHYLL**

Chlorophyll is the pigment in the 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 plankton (suspended) algae in a lake is commonly estimated using the chlorophyll a concentration. Chlorophyll a should be “corrected” for phaeophtin 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.). Chlorophyll a levels greater than about 55µg/L (micrograms per liter) could highly impair recreational lake use, while concentrations of 7 to 20 µg/L could cause slight impairment.

**Aquatic Plant and Algae**

Aquatic plant and algae problems, as stated, are typically caused by increased nutrients in the pond. Plants produce energy through photosynthesis. During this process, they use sunlight and carbon dioxide to produce energy and oxygen as a byproduct. However, during the night when there is no sunlight, the plants use up oxygen and give off carbon dioxide. Therefore, oxygen levels drop all during the night in your pond and could harm your fish and overall water quality. Also, when the plants die off, especially a massive algae bloom die off, the oxygen levels drop drastically over a short period of time. When the plants die, bacteria begin to decompose the organic material and use up oxygen quickly and causing the overall dissolved oxygen in the pond to drop.

**Fecal coli form bacteria**

Analysis of bacteria levels at swimming areas is a good public health practice and it may be required by state, country, or local health department regulations. Analyses typically are made for fecal coli form Escherichia coli (E.coli). Fecal coli form are microscopic organisms that live in the intestines of warm blooded animals and are excreted in the their waste. Coli form 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.

**Living Organism**

Other living organisms can also cause problems in your pond. Wildlife that uses your pond is adding nutrients with their waste and can create an unbalanced pond ecosystem. Too many or too few fish and of the wrong species can also have a negative effect on your pond and the overall water quality. Also, as stated earlier, bacteria are a major player in water quality of your pond. They breakdown the organic
material during decomposition. The two ways of decomposition are aerobic and anaerobic. Anaerobic occurs without oxygen present and is a slow process that has byproducts of sulfur dioxide and other sulfur compounds which give you the rotten egg smell in your pond sediment. It is also not the greatest for your fish. Aerobic decomposition occurs in the presence of oxygen and is much quick with a byproduct of carbon dioxide.

CONCLUSION

The chemical components of aquatic ecosystems are important to successfully manage any pond or lake. The interaction between temperature, nutrients, and oxygen plays a critical role in many common problems encountered by pond or lake owners, local government authorities, such as excessive algal growth, oxygen depletion, and fish kills. A healthy pond or lake ecosystem is easier to achieve by understanding this interaction and managing excessive nutrient loading to the pond or lake system. Other parameters, such as pH, alkalinity, and hardness, can also affect fish growth and survival and can influence toxicity of other A basic understanding of the chemical components of aquatic ecosystems is important to successfully manage any pond or lake.

The interaction between temperature, nutrients, and oxygen plays a critical role in many common problems encountered by pond or lake owners or local government authorities, such as excessive algal growth, oxygen depletion, and fish kills. A healthy pond or lake ecosystem is easier to achieve by understanding this interaction and managing excessive nutrient loading to the pond or lake system. Other parameters, such as pH, alkalinity, and hardness, can also affect fish growth and survival and can influence toxicity of other compounds, such as ammonia and metals. Water quality testing should be considered if pond or lake is to be used for intensive fish culture. A variety of methods are available to monitor water quality. Several companies produce kits and materials to monitor water quality, or water samples can be sent off to commercial laboratories for testing.

REFERENCES