Cooperative Extension Program
University of Arkansas at Pine Bluff

Aquaculture/Fisheries

Understanding Your Fish Pond Water Analysis Report

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Some sportfish and aquaculture pond owners choose to submit water samples to the University of Arkansas Cooperative Extension Service for analysis. The water samples are mailed to the Water Quality Laboratory, Arkansas Water Resources Center, University of Arkansas at Fayetteville. The laboratory tests the water and sends the results back. Below are some guidelines for interpreting those results. These guidelines describe how to interpret results for both surface waters and ground waters. Surface waters are those exposed to the air and sunlight, such as streams, ponds, reservoirs and lakes. Ground waters are waters from wells or springs tapping underground aquifers and are often devoid of dissolved oxygen. These waters may also contain high levels of dissolved gasses or iron. It is important to know the source of the water sample (surface water or ground water) in order to interpret the results correctly.

Figure 1
Water Analysis Report: Fish
(Example)

pH	7.24
Electrical Conductivity	205 µSiemens/cm
Alkalinity, Total	100.00 mg/l as $CaCO_3$
Hardness, Total	103.80 mg/l as $CaCO_3$
CO_3 (Carbonate)	0.09 mg/l as $CaCO_3$
HCO_3 (Bicarbonate)	99.90 mg/l as $CaCO_3$
Fe (Iron)	0.05 mg/l
Mn (Manganese)	0.01 mg/l
F (Fluoride)	0.15 mg/l
Cl (Chloride)	3.13 mg/l
SO_4 (Sulfate)	3.21 mg/l
NO_3 (Nitrate)	0.04 mg/l
NO_3-N (Nitrate-Nitrogen)	0.01 mg/l
NH_3-N (Ammonia-Nitrogen)	0.11 mg/l
NO_2-N (Nitrite-Nitrogen)	0.00 mg/l
PO_4 (Phosphate)	0.06 mg/l

Interpreting Results

Figure 1 is an example of a pond water analysis. An explanation of each parameter listed in the report follows. While most of these parameters are important in fish culture, others are measured incidentally in the process of water analysis and are ordinarily of little concern.

pH

Desirable Range	Acceptable Range
6.5-9.5	5.5-10.0

The pH of water is a measure of how acid or basic it is, on a scale of 0 to 14 with 7 being neutral. In fish ponds, the time of day that a sample is taken often will influence the pH because of variations in the carbon dioxide (CO_2) concentration. As plants in the water remove carbon dioxide for photosynthesis, the pH will increase. At night, the pH will decrease as carbon dioxide accumulates. Increasing the total alkalinity concentration in water helps buffer against pH changes. Most fish species do well within the pH range of 6.5 to 9.5. Chronic pH levels below 6.5 may reduce fish reproduction and are associated with fish die-offs that sometimes occur in the late winter. Newly hatched fish (fry) are often sensitive to pH levels above 9.0 t o 9.5.

The pH of water sent to the testing laboratory will change during shipment, especially for waters that have significant amounts of organic matter (e.g., algae and bacteria) or elevated carbon dioxide concentrations. Nevertheless, pH testing is useful to detect possible mineral acidity. A pH reading below 4.5 indicates that there is strong mineral acidity, which is harmful to fish and difficult (expensive) to neutralize. Low pH between 4.5 and 6.5 can often be corrected by the addition of crushed limestone (see SRAC Fact Sheet No. 464).

Electrical Conductivity

Desirable Range	Acceptable Range
100-2,000 µSiemens/cm	30-5,000 µSiemens/cm

Electrical conductivity (EC) is a measure of how well a solution conducts electricity and is correlated with salt content. Conductivity is typically reported in units of µSiemens/cm (microsiemens per centimeter). Freshwater fish generally thrive over a wide range of electrical conductivity. Some minimum salt content is desirable to help fish maintain their osmotic balance. The upper range varies with fish species. Channel catfish, for example, can withstand salinities up to 1/2-strength seawater. Seawater has a conductivity of around 50,000 to 60,000 µSiemens/cm. Electrical conductivity (EC) also can be used to give a rough estimate of the total amount of dissolved solids (TDS) in water. Typically, the TDS value in mg/l is about half of the EC (µSiemens/cm). Conductivity should change little during shipment to the laboratory.

Alkalinity, Total

Desirable Range	Acceptable Range
50-150 mg/l as $CaCO_3$	Above 20 mg/l and less than 400 mg/l for ponds Above 10 mg/l for hatchery water (measured as $CaCO_3$)

Total alkalinity (TA) is a measure of the concentration of bases (typically carbonate and bicarbonate) in the water that provide buffering capacity. The units are milligrams per liter (mg/l) as calcium carbonate. TA below 20 mg/l limits primary productivity in water, and ponds with such water benefit from lime. See our publication MP360, *Farm Pond Management for Recreational Fishing*, for information on liming ponds. Application rates of copper sulfate for algae control are based on the TA of the water, and copper sulfate should not be used at all in waters with fish if the TA is less than 50 mg/l.

The total alkalinity of a surface water sample sent to the testing laboratory usually will not change significantly over the 2- to 3-day shipping period.

Hardness, Total

Desirable Range	Acceptable Range
50-150 mg/l as $CaCO_3$	Above 10 mg/l as $CaCO_3$

Total hardness is a measure of the calcium and magnesium concentrations in water. Other divalent ions (those with 2+ charges) contribute to total hardness but are usually present in insignificant amounts. The amount of calcium hardness is important in pond fertilization because higher rates of phosphorus fertilizer are required at higher calcium hardness concentrations. At least 5 mg/l of calcium hardness is needed in fish hatchery water supplies. Like total alkalinity, total hardness will not change very much during shipment.

CO_3 (Carbonate) and HCO_3 (Bicarbonate)

Carbonate and bicarbonate, together with dissolved carbon dioxide, are components of total alkalinity (see “Alkalinity” above). The relative amount of each of these compounds depends upon the pH of the water sample. As such, there are no specific recommendations for levels of these compounds. Instead, see “Total Alkalinity” and “pH.” SRAC Fact Sheet No. 464 (see “Sources of Information”) provides additional information on the relationship among these parameters.

Fe (Iron) and Mn (Manganese)

Desirable Range	Acceptable Range
For hatchery water: Ferrous iron: none Ferric iron: none	For hatchery water: No ferrous iron Ferric iron: Less than 0.1 mg/l for fry, less than 1.0 mg/l for most fish
For pond water: Any level of ferric iron, no ferrous iron.	For pond water: Any level of ferric iron, presence of ferrous iron acceptable if limited to zone around water inlet (see text).
Manganese: 0-0.01 mg/l	Manganese: Up to 1 mg/l

These two elements behave similarly and will be discussed together. Well water may contain elevated levels of iron (ferrous iron) and manganese but still appear clear to the eye. When the well water is exposed to oxygen, the iron is changed into rust (ferric iron), giving the water a rusty brown color. Water high in iron and/or manganese should be treated before use in a fish hatchery. Typically, well water is aerated to oxidize the iron and manganese, and then the water is passed through a sand filter to remove the floc (small clumps). Ordinarily, waters high in these elements can be used “as is” for outdoor culture ponds. If a pond must be stocked immediately after filling, aeration can be supplied to speed the oxidation process and render the water safe for fish. While the relative amounts of the forms of iron or manganese might change during shipment, the total values will be unaffected.

F (Fluoride)

Fluoride is a trace element typically present in water at levels of 0.1 to 1.5 mg/l. It may be added to water as a measure to prevent tooth decay in humans (0.7 to 1.2 mg/l). Levels at or above 3 mg/l are reported to cause losses of some fish species, depending upon complex water conditions.

Cl (Chloride)

Desirable Range	Acceptable Range
Above 60 mg/l (for catfish ponds)	10 times the nitrite concentration (for catfish ponds)

Chloride (Cl^-) together with sodium (Na) forms common salt (sodium chloride). Chloride should not be confused with the gas, chlorine (Cl_2). *Chlorine* is a highly reactive compound and is used as a disinfectant. *Chloride* is the same element in the form of a salt. Chlorine and chloride have dramatically different chemical properties. Chloride is a common component of most waters and is beneficial to fish in maintaining their osmotic balance. In commercial catfish production, chloride (in the form of salt) is often added to waters to obtain a minimum concentration of 60 mg/l. This is done because catfish are susceptible to "brown blood" disease, caused by excess nitrite in the water. A ratio of chloride to nitrite of 10:1 reduces nitrite poisoning. High chloride levels (above 100 mg/l) are a concern only if the water is also used to irrigate sensitive land-based crops.

SO_4 (Sulfate)

Sulfate is a common compound found in water as a result of the dissolution of minerals from soil and rocks. Typical levels are between 0 and 1,000 mg/l. Fish tolerate a wide range of sulfate concentrations, and levels of sulfate above 500 mg/l are a concern only if the water is used for other purposes, such as watering cattle.

NO_3 (Nitrate) and NO_3-N (Nitrate-Nitrogen)

Nitrate levels in drinking water for humans and livestock are a major concern. Typical levels in surface waters range from 0.005 to 0.5 mg/l nitrate. However, nitrate is relatively nontoxic to fish and is not a health hazard except at exceedingly high levels (above 90 mg/l NO_3-N). Nitrate and nitrate-nitrogen are two ways of expressing the same parameter. Nitrate-nitrogen expresses the concentration of nitrate based only on the weight of the nitrogen in the nitrate (to convert nitrate-nitrogen concentrations to nitrate, multiply by 4.43).

NH_3-N (Ammonia-Nitrogen)

Desirable Range	Acceptable Range
Total NH_3-N: 0-2 mg/l	Total NH_3-N: Less than 4 mg/l
Un-ionized NH_3-N: 0 mg/l	Un-ionized NH_3-N: Less than 0.4 mg/l

Ammonia is a dissolved gas present naturally in surface and wastewaters, and in some well waters. It is the major nitrogenous waste product of fish and also results from the decomposition of organic matter. It is quite soluble in water, especially at low pH, and ordinarily is removed by plants or bacteria (as a nutrient or energy source). Ammonia in water is present in two forms – un-ionized ammonia (NH_3) and the ionized form (NH_4^+) – and the relative proportion of each type depends on pH and temperature. As pH increases, there is an increasing proportion of un-ionized ammonia, which is very toxic to fish. In addition to pH, the toxicity of ammonia to fish varies with the fish species and whether the fish has time to adjust to elevated levels. Catfish acclimate to high ammonia levels, and in commercial ponds, 2 to 5 mg/l of total ammonia nitrogen is common in the spring and fall. For more information on ammonia in fish ponds, see SRAC Fact Sheet No. 463. Ammonia values in surface water samples shipped to the laboratory are not reliable, as levels often will increase during shipment due to bacterial decomposition of organic matter, especially during the warmer months.

NO_2 (Nitrite) and NO_2-N (Nitrite-Nitrogen)

Desirable Range	Acceptable Range
0-1 mg/l NO_2	Less than 4 mg/l NO_2

Nitrite is another form of nitrogenous waste product that can be found in pond water. Typical concentrations range from 0.005 to 0.5 mg/l. Ammonia can be transformed into nitrite, and nitrite to nitrate, by certain bacteria. In commercial catfish ponds during the spring or fall, nitrite levels can increase greatly. Salt is added if necessary to prevent "brown blood" disease (see "Chlorides"). The toxicity of nitrite to fish varies greatly with the species of fish. Some species are quite susceptible while others are very resistant. For more information on nitrite in fish ponds, see SRAC Fact Sheet No. 462. As with ammonia, nitrite levels in surface water samples may change during shipment to the laboratory and are not reliable.

PO_4 (Phosphate)

Almost all of the phosphorus (P) in water is in the form of phosphate (PO_4). Much of the phosphorus in surface water is bound to living or dead particulate matter. Phosphorus is an essential plant nutrient, and because it is often in limited supply, adding phosphorus to water will stimulate plant (algae) growth. This growth of algae can be undesirable, as in the case of pristine streams, or desirable, as in ponds for fish culture. The typical range for surface waters is 0.005 to 0.5 mg/l. Groundwater in the Arkansas delta may contain significant concentrations of phosphorus. In the Lonoke area, for example, the average for wells in the alluvial aquifer is 0.33 mg/l. Ponds on watersheds fertilized with chicken litter or with livestock may be fertile (or excessively fertile) due to the influx of phosphorus from animal wastes. Considerable care in sample collection, handling and preservation is required to obtain truly accurate phosphorus values. Results from samples shipped through the mail to the laboratory may differ significantly from the actual values.

Summary

Many of the water quality problems faced by pond owners and fish farmers may not be resolved by the results of the Water Quality Laboratory testing. For example, a common pond problem and the leading cause of fish kills is low dissolved oxygen (see MP360, *Farm Pond Management for Recreational Fishing*, for additional information). Dissolved oxygen must be measured on-site, as it changes dramatically during shipment to the laboratory. Similarly, well water problems such as high carbon dioxide or hydrogen sulfide cannot be detected in samples shipped by mail. Water quality parameters such as pH and ammonia will be influenced and altered by organisms (e.g., bacteria) naturally present in the pond water samples. Results from the water testing service are rarely helpful in determining the cause of a fish kill.

In the event of a fish kill, determination of the cause of the problem may require specialized tests and rapid analysis. For help, contact your county agent or the nearest UAPB Fish Disease Diagnostic Laboratory. If a pesticide is suspected, contact the Arkansas State Plant Board for advice and information regarding sample preservation and specialized testing. The Water Quality laboratory does not test for pesticides or other poisons.

Most waters are suitable for fish production, although tolerances to different water quality parameters do vary among fish species. If the water is also used for other purposes, such as watering livestock or crop irrigation, be sure to check recommended levels of the various compounds for these uses. In all cases, it is important to remember that these tests cannot detect all possible water quality problems. Such testing would be prohibitively expensive. In addition, water supply characteristics can change, so it is important to re-test waters periodically.

Sources of Information

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