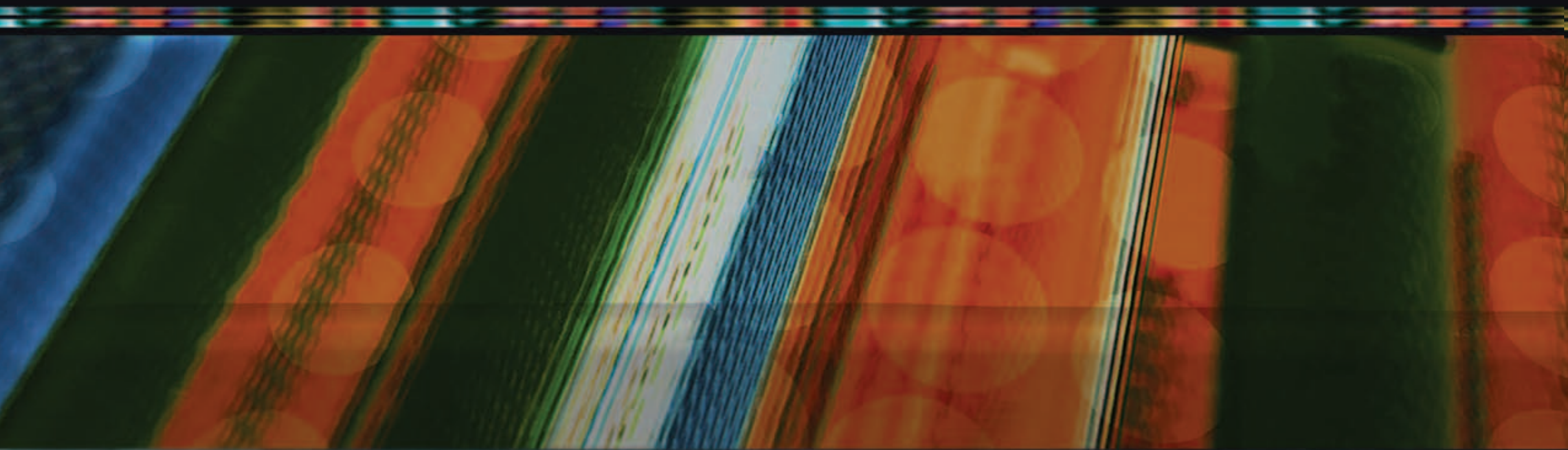

Understanding LAB DATA

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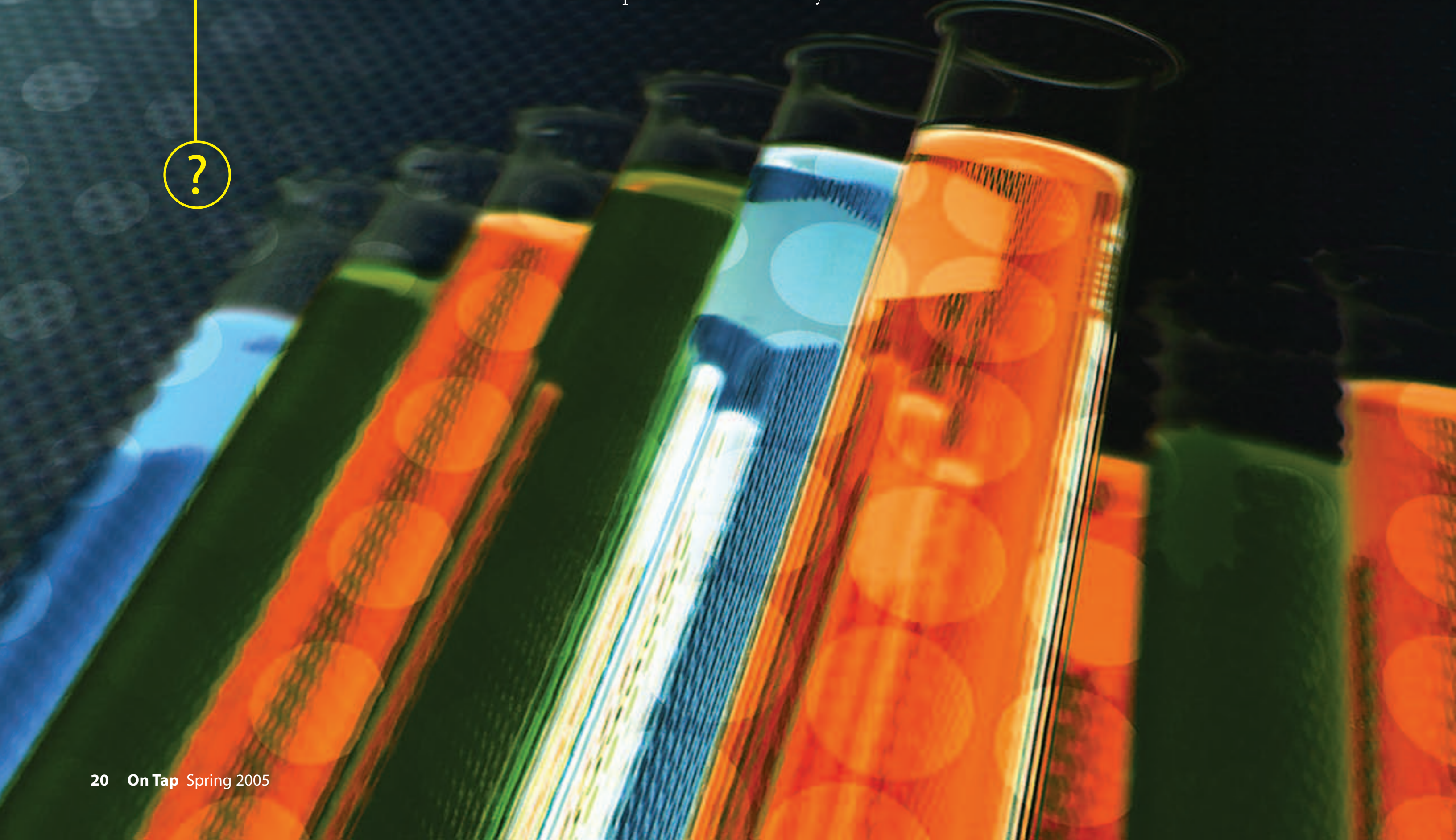
Operating a small drinking water system requires many skills, including how to test the water and understand what the results mean. Most small water systems must perform basic laboratory processes, including measuring pH, collecting coliform bacteria samples, and evaluating turbidity, alkalinity, and chlorine residual. Understanding how the tests are performed, what equipment is required, and what the results mean can make the job easier. While most operators learn lab techniques from other operators, a hands-on training class is the best way to learn how to perform laboratory tests.



What does pH mean?

The term pH can be defined as "the negative log of the hydrogen ion concentration." But what does that mean? An easier definition is that pH is a measure of how acidic or basic the water sample is. If the sample has a pH of 7.0, the water is said to be neutral—neither acidic nor basic. If the pH is below 7.0, then the water is acidic. If the pH is above 7.0, then the water is basic. The pH scale is logarithmic so each pH unit represents a power of 10. The pH scale goes from zero to 14, but the difference between a pH of 6.0 and 7.0 is really tenfold.

If the pH in a community water supply is acidic, it is called aggressive or corrosive, and may cause the pipes within the water distribution system to corrode. Most water utilities try to keep the pH above 7.0, adding chemicals to the water, such as lime or alum, to cause the pH of the water to rise.

On the flipside, however, water that has a pH above 7.0 may contribute to plating or scaling, meaning that water deposits a layer of calcium carbonate in the distribution lines. While scaling may help protect against corrosion, the deposits may become too thick. When this happens, the pipe's diameter may become much more narrow, restricting the water's flow. Controlling the pH of the water in the distribution system can have a significant impact on how well a utility can deliver a high volume of safe water to consumers.

The pH is measured using a meter that must be calibrated each time it is used with at least two buffer solutions that will bracket the expected pH. A buffer solution is a standard solution with a known pH. Most labs have buffer solutions with a pH of 4.0, 7.0, and 9.0 but solutions are available from 1 to 14. Buffer solutions, like other laboratory chemicals, have an expiration date. Always use fresh buffer solutions to calibrate the pH meter.

Many of the meters used today employ automatic temperature compensation (ATC) probes that may be filled with a liquid or gel electrolyte solution. The gel-filled probes have become more popular and do not need to be refilled, but they are usually more expensive than liquid-filled probes. The sample should be swirled or stirred during calibration and measurement to obtain an accurate pH measurement. The results should be reported to the nearest tenth, for example 7.2, because that is the practical limit of most meters. Samples should be analyzed immediately because pH will change due to microbial, chemical, or temperature changes.

How to Measure Alkalinity

Alkalinity is a measure of the buffering capacity of water or the ability of the water to neutralize acidity. Alkalinity is usually expressed as milligrams per liter (mg/L) of calcium carbonate, although bicarbonates, carbonates, hydroxides of calcium, magnesium, or sodium may be present. The alkalinity of surface water may vary from 20 mg/L up to 300 mg/L. Groundwater may contain from 80 up to 500 mg/L of alkalinity, depending upon the geology of the area. The alkalinity of the water affects the chemical dose needed to treat the water and is an important operational tool.

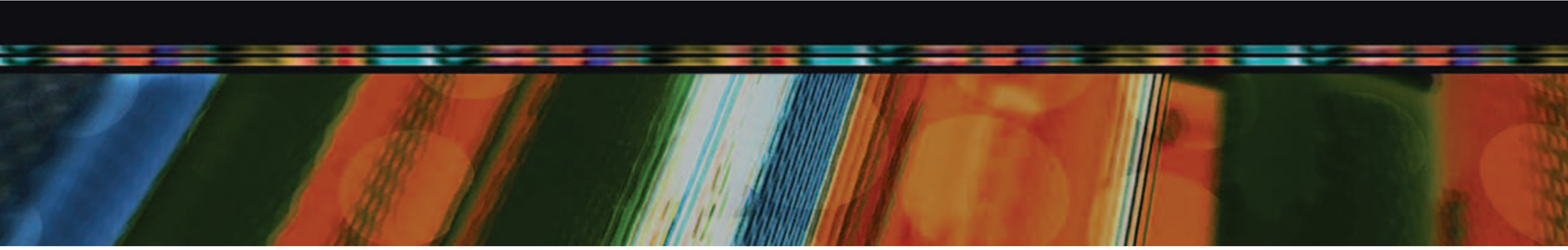
Alkalinity is measured in the laboratory using a technique called titration, whereby several pH color indicators are added to the sample followed by sulfuric acid using a buret. The buret is a piece of laboratory glassware that very precisely measures the volume of a liquid and has a stopcock at the bottom to allow only a very small volume of flow into the sample. The total alkalinity is determined by the volume of sulfuric acid needed to produce a pH of 4.5 in the water sample. The concentration of the sulfuric acid used must be exactly 0.2 N [normality] sulfuric acid. (Normality is a measure of the strength of the solution.)

Most laboratories buy the sulfuric acid as a standard solution because the concentration is so critical. Once again, check the chemical's expiration date before beginning the test. This procedure is easier if the sample is gently stirred using a magnetic stirrer during the test with a pH probe in the sample, if possible, to check that proper pH has been reached. Samples should be processed as quickly as possible because the alkalinity may change due to biological activity in the sample.

This laboratory technician is testing for alkalinity from a local water source. There are a variety of tests and filtering processes before water is pumped to holding tanks for consumption.

Photo courtesy of Kentucky Division of Water

Photo by Cindy Schafer



Chlorine Residual

Chlorine residual must be determined in the finished water and the distribution system to make sure the water meets the minimum requirements of the Safe Drinking Water Act (SDWA). A minimum of 0.2 mg/L of total chlorine residual must be maintained throughout the distribution system. Samples must be analyzed immediately since chlorine may be lost if samples are mixed or exposed to sunlight.

Several methods are acceptable for determining the chlorine residual, but most small treatment plants use the portable colorimeter. For this method, N,N-diethyl-p-phenylenediamine (DPD) is added to the sample, and the resulting color is measured using a colorimeter. The DPD reacts with chlorine residual present in the sample to produce a pink or reddish color. The amount of chlorine in the sample determines the intensity of the color produced. The intensity of color is then calculated using a colorimeter that measures the amount of light transmitted at a certain wavelength of light.

The colorimeter is an expensive but highly accurate meter for measuring light intensity. Most small utilities have a portable chlorine meter that can be taken into the field to determine chlorine residuals in the distribution system. The portable meters are preset to a certain wavelength of light and cannot be adjusted, so separate meters must be purchased for chlorine and fluoride testing. These meters produce consistent and accurate results but should be checked with calibration standards quarterly. The calibration standards can be purchased from the manufacturer of the colorimeter.

Portable Colimeter

Photo coutesy of Koehler Instument Company

Most small treatment plants use portable colorimeters. There are many different types and brands that vary in price, versatility. Manufacturers strive to produce colorimeters that are easy to operate.

Coliform Testing Reveals

Coliform testing is done to assess the microbiological quality of drinking water. The coliform bacteria are actually a group of 16 different species of bacteria that include *E. coli* the bacteria. *E. coli* is found in the intestinal tract of all warm-blooded animals and has been used as an indicator of recent fecal pollution.

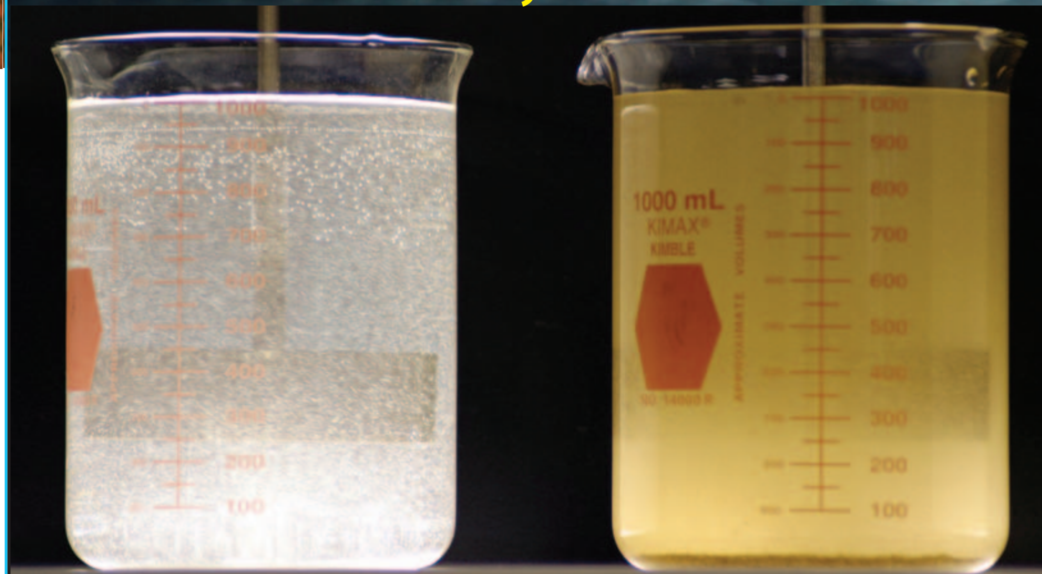
For many years, the total coliform test was used to determine if drinking water was microbiologically safe. The total coliform test would produce positive results if *E. coli* or one of the other so-called coliform bacteria were present in the sample. Public drinking water had to have less than one total coliform per 100 millilters (mL) of sample to be considered safe. In recent years, most laboratories have switched from the total coliform test to the presence-absence test. This test is specific for *E. coli* and produces reliable results in 24 hours, which may be positive for total coliform or positive for *E. coli*. One advantage of this test procedure is that it produces a positive identification of *E. coli* without requiring the additional confirmation-testing step that was part of the total coliform test procedure.

If the test results are positive, the water must be retested immediately. If the results are positive for *E. coli*, a boil water order must be issued. To retest the water, a repeat sample must be collected from the original positive coliform test point as well as points in the distribution system above and below the original sample. The specific number of samples required depends on the volume of gallons produced per day by the drinking water system. You should consult the Total Coliform Rule to be certain of the requirements for your particular system as well as the specific notification requirements.

The presence-absence coliform test uses a special form of lactose that is tagged with a fluorescent dye. The sample is mixed with this special media containing the tagged lactose. If total coliform bacteria are present in the sample, it will turn from clear to yellow after 24 hours of incubation at 35° Centigrade. If *E. coli* is present in the sample, it will turn yellow and show fluourescence when examined with a UV lamp. The test procedure is simple to perform and produces very accurate results, but the testing does require some detailed quality control to document that the results are accurate. The quality control procedures are described in *Standard Methods* and can be too expensive for a small utility that tests very few samples per month. For this reason, many small drinking water systems collect the coliform samples and send them to larger laboratories for analysis.

Collecting samples for coliform analysis can be difficult and must be carefully planned to prevent contamination of the sample. The sample bottle to be used must be sterile and contain a small amount of sodium thiosulfate to dechlorinate the sample as the water is collected. The laboratory should provide ready-to-use sterilized bottles, but the person collecting the samples should always have extra bottles. If any type of trouble occurs during the sample collection process, such as dropping the open bottle or lid on the ground, a new bottle should be used. Contamination of a sample can happen easily but the regula-

What is turbidity?



Turbidity photos by Julie Black, provided by the Morgantown Utility Board

Turbidity is a measure of the cloudiness of the water. It is caused by the presence of extremely fine, suspended particles that cannot be trapped in a filter because they are too small. Adding a coagulant, such as an organic polymer or alum, will cause the particles to clump and make the filter more efficient.

tory consequences of a positive coliform sample are high, so be very careful. (See article on page 26 about proper sample collection procedures.)

What is turbidity?

Suspended particles, such as silt and algae, produce turbidity, a measure of the cloudiness of the water. Turbidity is a good indication of water quality and may change rapidly in surface water sources. High levels of turbidity interfere with water treatment processes, especially chlorine. The SDWA has set very strict standards for turbidity levels in finished water to ensure that the drinking water is safe. Continuous turbidity monitoring equipment may be required for some drinking water systems. Turbidity measurements are also an important process control test to monitor the treatment process, anticipate operational changes due to changing raw water quality, and as an indication of the treatment efficiency of various plant components.

Turbidity is expressed as nephelometric turbidity units (NTU). The NTU is based upon the light scattering produced by a standard solution of formazin. Formazin standard solutions may be ordered or supplied with the turbidity meter called a nephelometer. The nephelometer measures the amount of light scattered at a 90-degree angle from the light source. Suspended particles that cause turbidity will scatter light particles and the nephelometer is designed to measure this scattered light. The nephelometer must be calibrated for each use with the formazin standards mentioned above. The laboratory should maintain a range of formazin standards so the meter can be calibrated across a array of turbidity levels from zero NTU up to 100 NTU.

The turbidity meter should use a high intensity tungsten filament and have a light path of five centimeters. The meter should have a range of zero to 100 NTU with sensitivity to the nearest 0.01 NTU. The nephelometer, sample cells, and standard solutions should be kept in a clean area. Refer to the manufacturer's manual for cleaning and maintenance instructions.

Samples should be analyzed as soon as possible after collection because the turbidity may change. The equipment used for testing turbidity must be kept clean and free of scratches. Scratches or dirt on the sample cells will produce poor results. The sample cells should be carefully handled using a lab towel and touched only around the top rim, if at all. The oils and dirt from your fingers can damage the sample cells.

The sample procedure is fairly simple. Calibrate the meter using the standard solutions mentioned above. Shake up the sample, fill the sample cell, wipe off any excess moisture using a lab towel, insert it into the meter, close the cap over the sample cell, and read the turbidity in NTU.

What does it all mean?

Understanding how to collect and use lab data is an important task for the water treatment plant operator. Laboratory processes and techniques are demanding, but remember that each step has a purpose and must be done exactly as described to produce accurate and consistent results.

Most small drinking water systems will use a larger laboratory for at least part of their required laboratory testing, but the operator must still understand how to properly collect, preserve, and transport the samples. Even small drinking water systems must be equipped to test the water for pH, turbidity, alkalinity, and chlorine residual. The laboratory equipment and chemicals used for this testing must be properly maintained, and records should be available that show samples were properly collected, managed, and tested. Laboratory testing is one of the many duties that the operator of a small drinking water system must understand, and laboratory training is important to maintain those job skills.

For more information about laboratory procedures, see Standard Methods for Examination of Water and Wastewater 20th Edition. *American Public Health Association, Washington, D.C. You also may call the National Environmental Services Center at (800) 624-8301 for more information.*