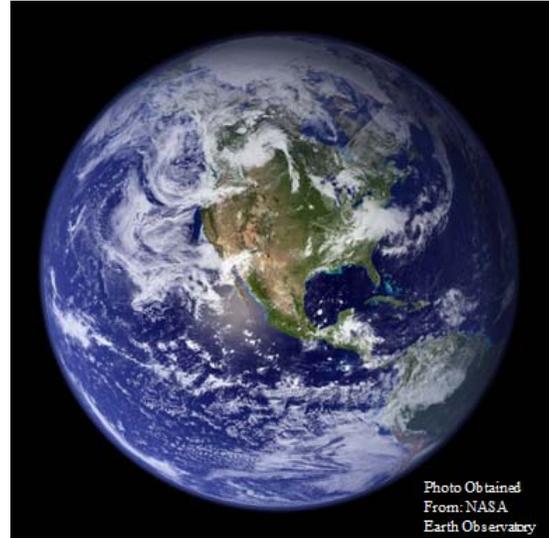


Tennessee Aquarium – River Gorge Explorer

Water Quality Monitoring

Daniel Lawrence, Feb. 2014

When you see a picture of the earth, one of the first things you'll notice is all the water! Approximately 70% of the surface of the earth is covered by water. Every living thing on earth needs water to survive. As humans, we require fresh water, and for many of us that water comes from rivers and lakes. It may surprise you that although 70% of the earth's surface is water, 97% of that water is salt water, and the majority of the fresh water is either frozen or deep underground! In total, less than 1/100th of 1% of the water on earth is fresh water that is readily available for our use. This water may be underground in shallow aquifers or on the surface as lakes, streams, and reservoirs. Because water is such a precious resource, it is important that we keep it clean. We can do this by monitoring our water, and measuring many different physical, biological and chemical characteristics.



The Tennessee Aquarium monitors the health of the Tennessee River with the help of a sonde – a device that records characteristics of the water at regular intervals. The sonde is installed on the Aquarium's tour boat (the River Gorge Explorer), and measures the Temperature, pH, Nitrate concentration and Dissolved Oxygen content of the river once every 6 hours. This measurement normally occurs in Chattanooga, Tennessee at River Mile 464. The River Gorge Explorer operates on Nickajack Reservoir of the Tennessee River, and readings may be recorded as far downstream as River Mile 451 during a cruise. The sonde is installed inside an engine room, and samples river water as it is pumped through a chamber called a Flow Cell. This protects the monitoring equipment while providing a constant supply of fresh river water.



The Tennessee River

The Tennessee River carves a 652-mile long journey from its beginning in Knoxville Tennessee, south to Alabama, and then north to Kentucky before joining the Ohio River at Paducah. The Tennessee River is considered to be one of the most biologically diverse river systems in the United States for aquatic organisms, particularly for fish and mussel diversity. In addition to many fish and mollusks, The Tennessee River also provides habitat and food for many other species, such as Great Blue Herons, Osprey, Bald Eagles, Basking Turtles, Ducks and River Otters.



Today, approximately 9 million people rely on the Tennessee River as a source of drinking water, irrigation water for farmland, and electrical power. The river is equally essential to many recreational activities, industrial operations and commercial transportation. The Tennessee River has been modified heavily to allow for safer and easier use of the river, power generation, and flood control. Nine dams currently exist along the Tennessee, causing the river to be much wider and deeper than it originally would have been. With so many varied uses for the river both by humans and by wildlife, as well as many man-made changes to the river, it is imperative that we monitor and ensure the health of our water resources.

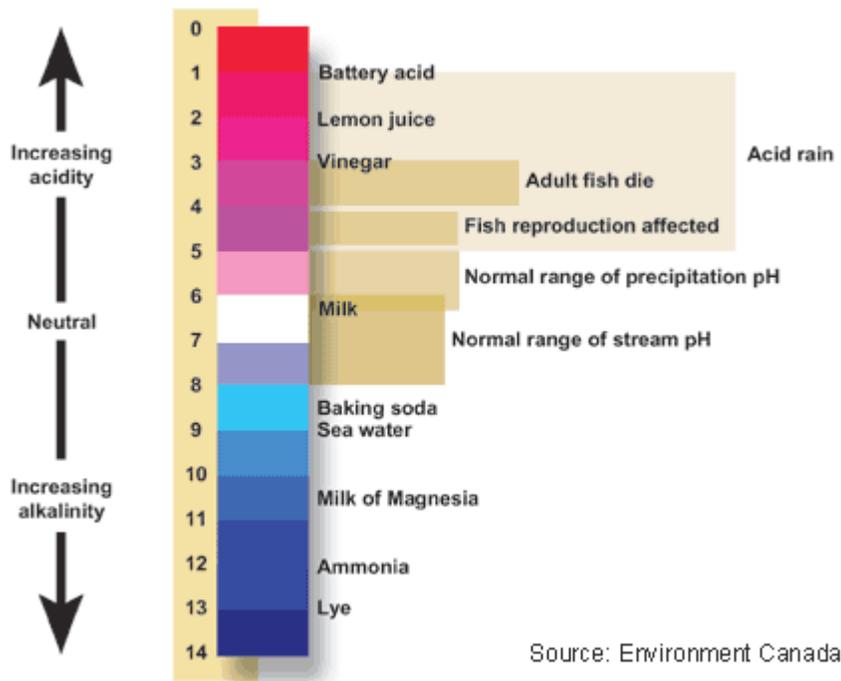
Why Measure Temperature?

The temperature of the river is important because it affects what organisms can live there. Many organisms use the temperature of the water as a calendar that tells them when to lay eggs, mate, or migrate. Water temperature also affects the chemistry of the water. Cooler water is able to hold more dissolved oxygen than warm water, and cooler water also results in a slower rate of photosynthesis in algae and aquatic plants. The temperature of the river varies naturally

throughout the year, but it is important to check on the temperature to make sure we aren't influencing it. Constructing dams along the river, using river water to cool industrial processes and power plants, and cutting down trees that provide shade to creeks and streams are just a couple of ways that humans may accidentally change the temperature of the river.

Why measure pH?

You may have heard that the formula for water is H₂O, but there are actually lots of things in our water! pH is a measurement of free hydrogen ions (H⁺), relative to the number of hydroxyl ions (OH⁻) present in a sample. The pH scale ranges from 0 to 14. At a pH of 7, there are an equal number of H⁺ and OH⁻ ions, so this solution would be considered neutral because the two ions cancel each other out. If there is more H⁺ than OH⁻, a sample is said to be acidic (pH of less than 7). If a sample contains more OH⁻ than H⁺, it is said to be alkaline or basic (pH greater than 7). The pH scale is logarithmic, so a pH of 5 contains 10 times as many H⁺ ions as a pH of 6, and 100 times as many H⁺ ions as a pH of 7. In lakes and rivers, pH typically ranges from 6.5-8.5. The pH of the water affects how well chemicals dissolve in water, and the effect these chemicals will have on organisms living in the water. A pH that is too low or too high can be dangerous to aquatic life.



Why Measure Dissolved Oxygen?

Just like humans, aquatic organisms need oxygen to breathe. Measuring for dissolved oxygen (DO) tells us the amount of oxygen that is in the water and available to aquatic life. Oxygen is added to the river in several ways. At the surface, the amount of oxygen in the air and the

amount in the water will reach a natural equilibrium. This equilibrium can be sped up by aeration of the water – which is common around man-made dams, fast moving mountainous streams, and waterfalls. In addition, aquatic plants add oxygen to the water during photosynthesis. The amount of dissolved oxygen in the river changes during the year, as warmer water is capable of holding less than colder water, and processes such as photosynthesis increase and decrease seasonally. Humans may negatively impact the amount of dissolved oxygen in many ways, such as increasing river depth with dams, changing the route of creeks and rivers by channelization, or by the accidental addition of pollutants to the river that affect aquatic plants and animals. Dissolved oxygen is measured in milligrams per liter (mg/L). Although the amount of oxygen varies throughout the year, a reading of 4–10 mg/L is generally considered to be healthy, although the amount can be even higher in the winter months.

Why Measure Nitrates?

Nitrate (NO_3^-) is a nutrient. Just like nutrients in our food, a healthy amount of nitrate is essential to plants and animals. Too much nitrate, however, can actually be harmful to organisms that live in the water. Because nitrate is a nutrient used in plant growth, too much nitrate can result in an over-abundance of aquatic plants and algae, which may block light from entering the water, deprive areas of dissolved oxygen through the decomposition of plant matter, and decrease the abundance and diversity of aquatic species. Humans can affect the amount of nitrate in our water in several ways. Nitrate is found in fertilizers, and runoff from agricultural areas frequently carries nitrates and other nutrients into lakes, rivers, and streams. Faulty septic tank systems and effluent from wastewater treatment plants are other potential source of nitrates. Nitrate is measured in mg/L, and a value of less than 1 mg/L is usually considered to be healthy.

Additional Notes on Sampling Method

The River Gorge Explorer normally operates between River Mile 464 and River Mile 451, on Nickajack Reservoir of the Tennessee River. The majority of water samples were obtained while the boat was docked at River Mile 464, however samples may be from any point between the two locations – roughly a 14-mile portion of Nickajack Reservoir.

Due to its unique application, there are many external factors that may affect results from this water quality monitor. Monitoring location may vary from sample to sample, the ambient temperature around the sonde and flow-cell may change significantly due to nearby machinery, and sampling depth will change when the boat is at speed due to hydrodynamic lift of the boat. In addition, water parameters can be expected to change along the trip route due to factors such as change in river depth, velocity, surface area, addition of water from entering creeks, as well as industrial and residential sites.

As with any monitoring equipment, data collected will be relative to the equipment itself. Differences between equipment, calibrations, and sampling conditions mean that no two instruments will ever report the exact same value for a given sample. A far more important tool

is the observation of trends. By sampling for extended periods of time, it is possible to identify trends in water quality that can be tied to other conditions in the environment. Changing temperatures, precipitation, changes in river flow, etc. all contribute to the data recorded by the river monitor. By hypothesizing on possible reasons for changes in our data, we may be able to better understand the ecology of the river, and improve our ability to be good stewards of our natural resources.

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