Leesville Lake Water Quality Newsletter

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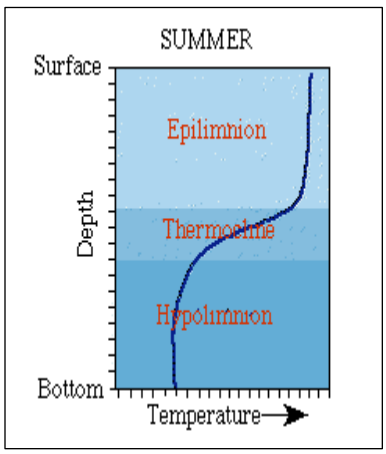


Figure 1 – Lake Stratification and Temperature (Courtesy of California State University)

How Hydrology and Stratification Impact Nutrients in Reservoirs

The following is a summary of the article Effects of reservoir stratification and watershed hydrology on manganese and iron in a dam regulated river by Zackary W. Munger, Thomas D. Shahady, and Madeline E. Shreiber that was published in the March 2017 issue of "Hydrological Processes".

Leesville Lake is a stratified, eutrophic reservoir with unique hydrology due to the Appalachian Power pump-back operation, which pumps water between Leesville Lake and Smith Mountain Lake to generate power. A stratified water body is one that has distinct thermal boundaries along the water column, including the epilimnion, thermocline, and hypolimnion (*See Figure 1 – left*). The term "eutrophic" refers to a body of water that has high amounts of nutrients available for biological uptake, while hydrology describes how much water moves in and out of a given area, and the way in which it does it.

So why is all of that important? Well, the Smith Mountain Lake Dam has altered the hydrology of Leesville Lake in a way that changes the way that nutrients and chemicals are transferred between living systems and the environment causing a potential increase of iron (Fe) and manganese (Mn) concentrations in Leesville Lake. The impacts of which were studied over a two-year period from 2012-2014 and published in the March 2017 issue of *Hydrological Processes.*

(***Continued on page 2)***

Stratification, cont.

Iron and manganese are metals that can make their way into the water from geologic sources. Elevated concentrations of iron and manganese can cause discoloration, staining, and issues with taste and odor in drinking water. In addition to associated problems with drinking water, prolonged exposure to high levels of Mn may lead to learning impairments in humans, fish gill damage, and other stresses to human and fish populations. Concentrations of Fe and Mn vary both seasonally and throughout the water column, but tend to be highest in July in the deepest layers of the lake.

Pump back operations increase the degree of stratification of Leesville Lake in a way that causes dissolved oxygen in to deplete. This depletion (or reduction) of oxygen creates hypoxic conditions, which lead to an increase in iron, manganese, and phosphorous concentrations. The most dramatic effects occur in the deepest part of the lake, the hypolimnion, because this layer has the least amount of oxygen.

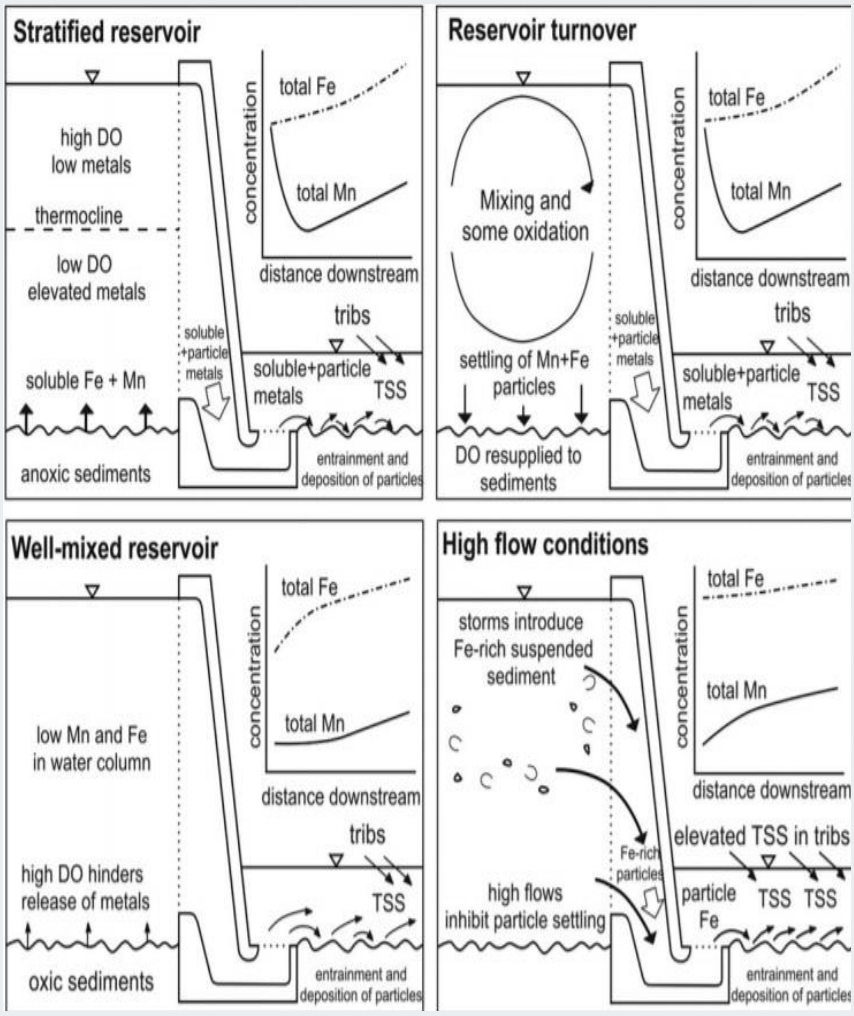


Figure 2 - *Metal cycles in a hydropower dam watershed in response to seasonal reservoir conditions and flow downgradient of the dam. DO = dissolved oxygen; FE = iron; MN = manganese; TSS = total suspended sediment (Image courtesy of Dr. Thomas Shahady)*

In September, as the Fall air cools the warm surface water, it causes the surface waters to become denser, which then sink and cause the water in the deep areas to rise. This process is called lake "turnover", and as the layers switch places, so do all of the chemicals, nutrients, and sediments that are contained within those layers. During the study period, metals such as iron and manganese were present in the water column for 1-2 months after lake turnover. The effects of turnover on iron and manganese are demonstrated by Figure 2 (*left*).

The study shows that understanding the seasonal and hydrological drivers of iron and manganese concentrations is necessary to identify the sources of those metals. A conceptual model was created that can be modified to forecast under which seasonal or hydrological conditions iron and manganese levels may be elevated.

Removing the Pigg River Dam

The removal of dams from rivers, especially from those that feed into reservoirs, is a complex and controversial subject, and is an issue that generally needs to be evaluated on a case-by-case basis. On one hand, removal of a dam can positively impact fish populations by improving migratory fish passages through the stream.

A line of debris that formed along the top of the water where the Pigg River enters Leesville Lake. This was taken during pumpback operation, and the water is noticeably less muddy on the Leesville Lake side(left) than on the Pigg side(right).

On the other hand, removing a dam may release the sediment which has become deposited behind the dam over the course of the structure's lifetime, potentially causing sharp spikes in nutrient, sediment, and bacteria levels downstream. Dam removal may also lower a stream's capacity to remove nitrogen from the water, however, this is typically only an issue with dam removal on high-order streams. Overall, the removal of the dam from the Pigg River should improve water quality and fish populations in both Leesville Lake and the Pigg River, and the nutrient spikes associated with dam removal typically return to normal levels after only a few months. Dr. Shahady will continue to monitor water quality of the Pigg River and its impact on Leesville Lake. He plans on beginning bacteria source tracking this Summer in an effort to determine the cause of consistently elevated bacteria and turbidity levels in the Pigg. Updates on the bacteria source tracking will be included in future issues of this newsletter.

Parameter of the Month

pH

For June's parameter of the month, we will be discussing percent hydrogen, often simply abbreviated as pH. Percent hydrogen is a measure of the concentration of hydrogen ions (H+) present in a sample, and is used to measure how acidic or basic a substance is. In general, an even concentration of hydrogen ions and hydroxide ions ($H^+ = OH^-$) result in a neutral pH of 7, while below 7 is acidic ($H^+ > OH^-$), and above 7 is considered basic ($H^+ < OH^-$). The pH scale is logarithmic, so a pH of 6 is 10 times more acidic than a pH of 7, and a pH of 5 would be 100 times more acidic. For reference, Leesville Lake tends to have a pH between 7.2-8.0, while the largest variety of animals prefer a pH range of 6.5-8.0. Values outside of this range will stress both the populations of these animals and the aquatic systems in which they reside.

There are many things that may influence pH of a lake or stream. For example, the amount of debris present in a water system can lower the pH of a stream because as it breaks down, it releases CO_2, which takes form as carbonic acid in water. Local soils, rocks, and contaminants that come into contact with water may also affect its pH. The pH of the water also influences the type and rate at which various chemical reactions may occur.

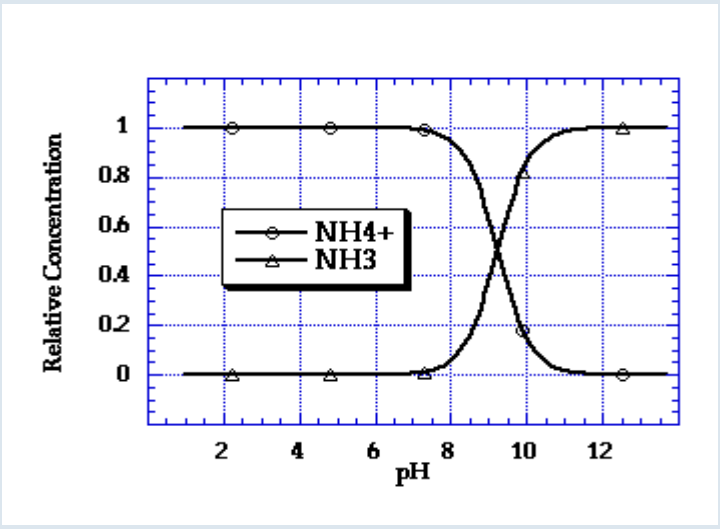
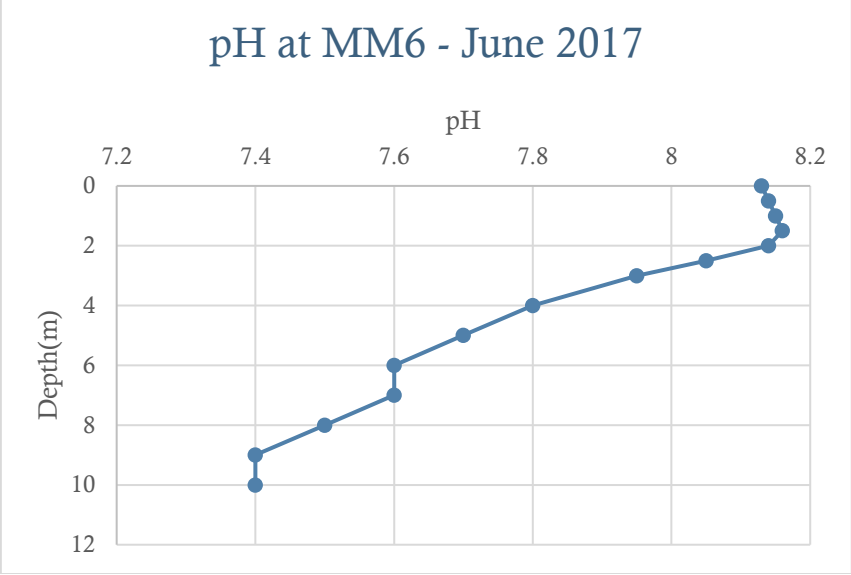


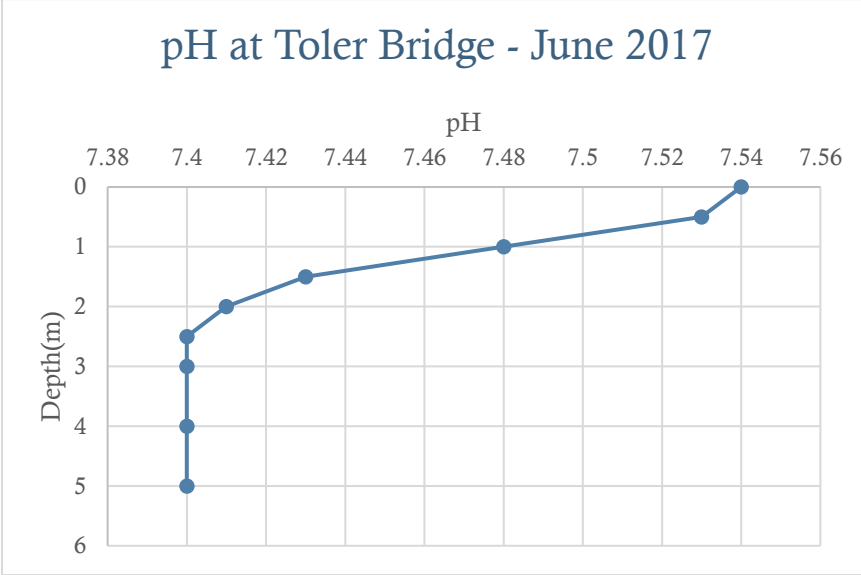
Figure 2 (*above)* displays the relationship between pH, ammonia (NH3), and ammonium ($NH4^+$). If the pH remains low, relatively non-toxic ammonium will dominate the reaction. However, if the pH exceeds 9.25, toxic ammonia will dominate the reaction, potentially harming important ecological cycles within the lake. (Graph courtesy of Cornell University)

The pH of Leesville Lake tends to fluctuate throughout the year, with the highest average pH occurring during July, and the lowest average pH occurring during October. Although there is not a large difference between them, Mile Marker 6 tends to have the highest pH, while the tail waters near the SML dam have the lowest average pH of the sampled locations.

Monthly Water Quality Report



Above: The pH at MM6 ranged from 7.4 at 10m up to 8.16 at 1.5m deep. The pH gradually declines as the depth increases.



Above: Even though it looks like there is a large difference, the pH at the Toler Bridge sampling site only ranged from 7.4-7.54. The pH is more stable here than at the MM6 site.

As mentioned in the parameter of the month, pH tends to fluctuate spatially and temporally. The two graphs to the left illustrate how pH at two sites in Leesville Lake decreases as depth increases. This change is due to changes in photosynthesis and other chemical reactions as depth increases, in part because less light reaches lower layers of the water.

Changes in pH are also due to stratification, with deeper areas having lower pH because CO_2 (which acts as an acid in water) tends to accumulate there, because no plants are present to fix the CO_2. Decomposition also releases CO_2, but there are plenty of other chemical buffers that act as "shock absorbers" and prevent sudden changes from occurring. Throughout the year, the pH of Leesville Lake tends to remain well within the bounds of a healthy reservoir.

Water Quality Research Members

Dr. Thomas Shahady has been conducting water quality research at Leesville Lake since 2006. He is an Environmental Science professor at Lynchburg College, and teaches a variety of freshwater ecology courses. He received his BS in Biology at Guilford College, MSP.H. in Environmental Biology at UNC School of Public Health, and PhD in Zoology at North Carolina State University. He has had experience with the EPA and North Carolina Departments of Environmental and Natural Resources. His research interests are in aquatic ecology, lake management, and environmental compliance.

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C.T. Boaz is a new member to the Water Quality Project. He is a senior at Lynchburg College, studying Environmental Science with a focus on water quality. Some of his interests include hiking, fishing, gardening, and woodworking. His plan is to intern for Dr. Shahady during the Summer and continue water quality research with him throughout the 2017-2018 school year. He will be managing the water quality newsletter for the Summer, hoping to bring some basic understanding of what the research purpose is, and discussing the monthly findings. Please feel free to email him with any questions, concerns, or suggestions!

Email: Boaz_c@lynchburg.edu

Anthony Capuco, aka Tony, has lived at Leesville Lake for 3 years. After receiving his BA in Biology from Hobart College, he went forward to pursue a PhD in Mammalian Physiology from Cornell University. He then had a 30-year career as a research scientist with the USDA- Agricultural Research Service as a lactation and cell biologist. He has been a member of the water quality committee for 3 years. Tony likes spending time woodworking, swimming, golfing, and time with family and friends.

Dave Waterman is a new member to both Leesville Lake, moving here a little over a year ago, and the water quality project. Before joining the Leesville Lake community Dave received his BS in Economics at Northeastern University, which led to his career working for an electric company called National Grid. He recently began engaging in the water quality project volunteering with the TLAC Environmental Committee. During his off time he is a voracious reader, enjoys swimming and boating, and daily walks and hikes.

Mike Gooden is a new member of the Leesville Lake Water Quality Committee. Before settling into the cabin his wife, Margy, and himself built in 2010, he received his Bachelor's degree in Chemistry of the University of Maryland at Baltimore County. He then worked at the National Institute of Standards and Technology from July 2007 to June 2016, acting as a liaison between the technical staff and the contracting office to generate contacts that met mission requirements. During his time off he enjoys hiking, running, kayaking, photography, reading, and helping others.