By Randall L. Moore, Utility Service Company, Inc.

A Sustainable Approach To Potable Water Quality Management

As we continue to increase our knowledge about the health risks associated with various contaminants and disinfection by-products, as well as our ability to test for their presence, regulations concerning contaminants and maximum allowable levels will continue to grow ever more stringent. Each new regulation presents new challenges that typically require new sustainable methods and/or technologies in order to meet or surpass the new requirements. The Initial Distribution System Evaluation (IDSE) requirements of the Stage 2 Disinfectants and Disinfection Byproducts Rule will assist in locating areas of high disinfection byproducts within the distribution system that will require corrective action. The impact of the Long Term 2 Enhanced Surface Water Treatment Rule will require more effective disinfection and better disinfectant residual maintenance throughout the distribution system. This increasing regulatory pressure coupled with the drive towards sustainable best practices will require water plant managers/operators to operate their facilities at the highest levels of sustainable performance.

Tightening regulations for potable water quality are causing those responsible for its quality to look for new water quality management tools and methods to meet those requirements in the most sustainable manner possible. While the water quality management tools presented here can be implemented separately, their adoption from the water plant through the distribution tanks provides a synergistic approach to water quality management. It's also important to note that these tools are effective, sustainable and independent of the type of disinfectant used or the raw water source. The sustainable water quality management tools we will examine involve **chemical cleaning, active mixing** and effective water storage **tank asset management.**

> Each new regulation presents new challenges that typically require new sustainable methods and/or technologies in order to meet or surpass the new requirements.

This article will focus on stabilizing disinfectant demand through the distribution tanks by minimizing those things that consume disinfectant, namely, organic and inorganic materials (mainly manganese and iron) through the use of chemical cleaning, a tank asset management program and utilizing active tank mixers to homogenize water stored in tanks. Minimizing those things that consume disinfectant will result in lower disinfectant usage, reduced disinfection by-products, reduced nitrification risk (nitrites and nitrates), increased stability for disinfectant residual and improved consistency and stability of water quality. Beginning at the water plant and ending at the water storage tank we will examine the use of these tools and how they work synergistically to assist with water quality management.

Chemical cleaning at the water plant

The traditional practice for maintaining filters in the water plant has been to backwash as required, either because of head loss, turbidity, or simply by hours of operation; and to then replace the media when the filter performance was no longer acceptable. There is another more sustainable option. Regular chemical cleaning of the media with an NSF 60 certified product will improve filter performance while extending the service life of the media. The sustainable benefits to chemical cleaning are; improved filter performance/efficiency, reduced backwash frequency, reduced backwash times, reduced disinfectant usage (meaning less disinfection by-products), and increased production capacity. Furthermore, rather than following the traditional practice of allowing filter performance decline over time until an unacceptable level of performance is reached, regularly cleaning the media to achieve a higher average level of filter performance throughout the service life of the media is a much more sustainable practice. While media fouled with deposits may "appear" to have lost its angularity, a simple chemical cleaning can return the media to a like new condition significantly improving performance and eliminating the need for a costly replacement (See Figures 1 and 2).

Figure 1: Media before cleaning

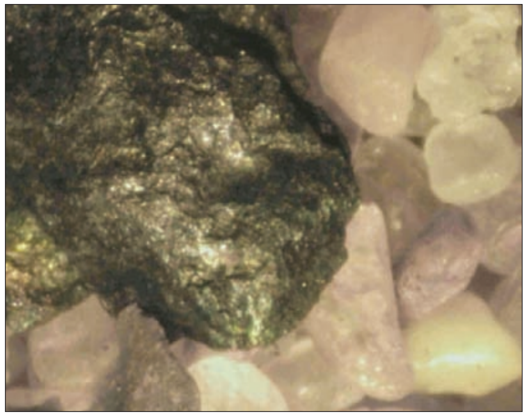


Figure 2: Media after cleaning

Chemically cleaning the filter media is a straightforward process that requires taking the filter out of service for about twenty-four hours compared to several days for a replacement. In addition, any surface at the plant that collects organic or inorganic contaminants can be chemically cleaned to lower disinfectant demand and reduce disinfection by-product formation. All contact vessels, walls, troughs air strippers and aerators can be chemically cleaned to improve performance in a sustainable manner.

Water quality management within storage facilities

When water sits, problems occur; this is why it is important to focus on the distribution tank. There are three water quality management tools recommended to be used in combination for maintaining water quality within potable water storage tanks. From a housekeeping perspective, biennial washouts are recommended in the AWWA M42 "Manual for Steel Water Storage Tanks" to remove sediments and clean the tank. Furthermore the AWWA M56 Manual, "Fundamentals and Control of Nitrification in Chloraminated Drinking Water Distribution Systems", states that removal of deposits and sedimentation is necessary to avoid protecting bacterial growth from the disinfectant and to minimize the risk of nitrification. A tank washout has typically involved sediment removal and pressure washing of tank surfaces followed by disinfection in accordance with AWWA C652 "Disinfection of Water Storage Facilities". However, neither pressure washing nor the disinfection process will kill and remove the bio-film on interior surfaces. Failure to remove the bio-film leaves a major source of disinfectant demand in the tank that simply regenerates during the summer months. A low pressure NSF 60 certified chemical application can remove all biological growth from the tank as well as the mineral staining typically associated with the bio-film. Figure 3 shows a tank that had been pressure washed where the bio-film and staining could not be removed. Figure 4 shows the same tank after receiving a low-pressure chemical cleaning to remove all bio-film and staining. Figure 5 (next page) shows before, during and after low-pressure chemical cleaning of a tank interior to remove the bio-film and Fe/Mn deposits.

From a housekeeping perspective, biennial washouts are recommended in the AWWA M42 "Manual for Steel Water Storage Tanks" to remove sediments and clean the tank.

In addition to the impact on disinfectant demand, bio-film and Fe/Mn stain removal makes inspection and repairs to failures in the coating much easier and more thorough. Maintaining the integrity of the coating is vital and will minimize biological re-growth by eliminating those anchor sites where colonization occurs. Our experience has shown a direct correlation between interior coating surface roughness and bio-film growth.

The second sustainable water quality management tool recommended for water tanks is the installation of an NSF 61 certified "active" mixing system. Active mixing is a full-time mixing system operating twenty-four hours a day, seven days a week, and 365 days a year, as opposed to "passive" mixing systems that mix

Figure 3: Distribution tank after pressure washing

Figure 4: Distribution tank after NSF 60 chemical cleaning to remove bio-film.

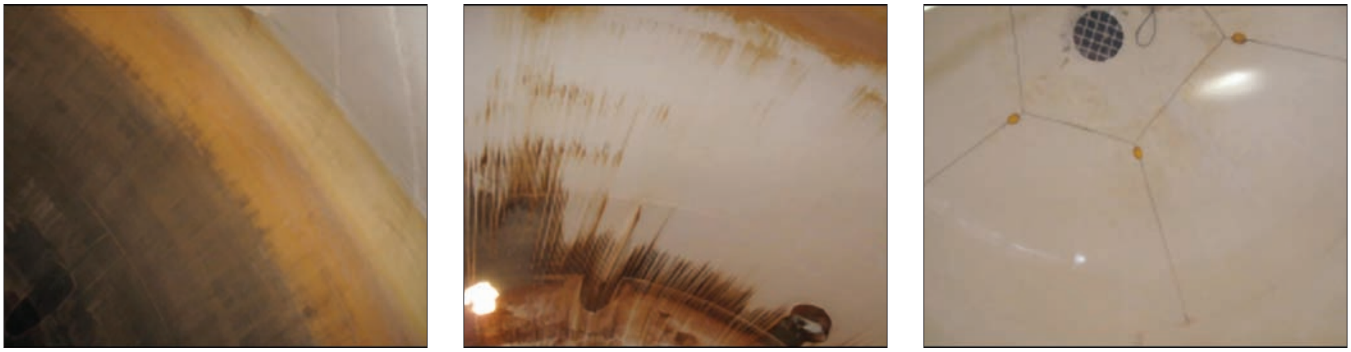


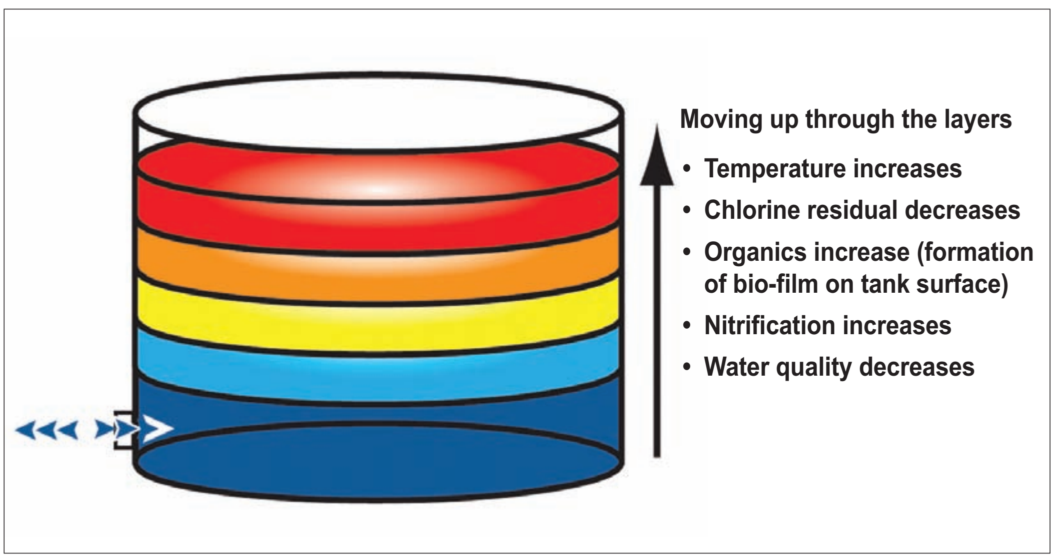
Figure 5: Before, during and after chemical cleaning of a tank interior to remove bio-film and deposits

only when the tank fills. A recent study has shown that passively mixed tanks will re-stratify both thermally and chemically within four hours after pumping water into the tank ceases. Regardless of perceived cycling, or turnover in storage tanks, in warmer weather water will begin to thermally stratify when there is as little as a 0.1 degree Celsius difference in temperature. Therefore, the average age of the water in the distribution tank, simply calculated by capacity and daily flow rate, is only a theoretical average and not a value that actually represents the age of the entire volume of water in the tank. Only when the water in the tank is completely mixed does the actual average age for the water approach the theoretical average age. Without an effective active mixing system, thermal stratification is highly probable. The upper stratified layer has the oldest, warmest water with the lowest (often zero) disinfectant residual. This upper layer is the most likely to have a bacteriological problem and high concentrations of disinfection by-products. The air-water interface on the interior sidewall is often where the most ice damage to the interior coating system occurs and where the Fe/Mn bio-film growth prospers.

Elimination of thermal stratification and achieving homogenous water chemistry within the storage tank is critical to managing water quality in a sustainable manner. Well-mixed tanks are sustainable because they consume less disinfectant, minimize the formation of disinfection by-products, and avoid the need to dump the tank should nitrification occur. The common operational practices of "deep cycling" storage tanks, on-site chlorine boosting, and tank/main flushing used to remedy problems due to poor mixing can be reduced or eliminated with effective active mixing within the storage tank. If disinfectant dosing is required to maintain water quality in tanks with especially low turnover, active mixers provide complete mixing allowing for safe and effective treatment of the tank.

Because homogenous water quality is achieved throughout the tank, an active tank mixing system also minimizes bio-film re-growth by continuously delivering disinfectant to all surfaces of the tank. By continuously moving water along all interior surfaces of the tank bio-film re-growth is minimized or eliminated. This in turn minimizes disinfectant demand, and depending on the disinfectant used, minimizes formation of trihalomethanes (THM's) and haloacetic acids (HAA's) or nitrite and nitrates.

When selecting an active sustainable mixing system a highly energy efficient design is preferred. Recent advances in biomimicry design have resulted in the development of a six inch "Lily" impeller that can mix up to seven (7) million gallons using the



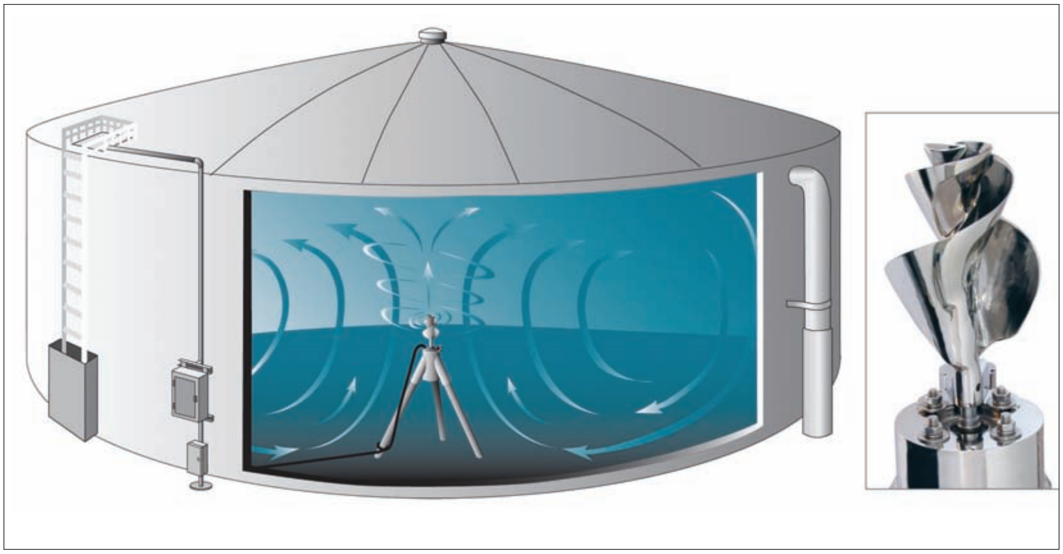


Figure 7: Diagram of a highly energy efficient active mixing system using biomimicry designed impeller (photo on right) to eliminate thermal stratification and achieve homogenous water chemistry.

same amount of power as three (100) watt light bulbs, or roughly at a cost of $1.00 per day. These active mixing systems can be connected directly to the power grid or solar panels can be utilized where grid power is not available. (See Figure 7).

Another advantage to active mixing systems for those tanks in northern climates is the minimization of icing. The continuous active mixing systems will significantly reduce icing in storage tanks as shown in Figure 8. Mixing will reduce ice damage to the tank interior coatings thereby helping to minimize bio-film growth and corrosion by-products. Reducing the formation of ice in storage tanks ultimately improves water quality.

The third water quality management tool recommended for the water tank is a sustainable GASB 34 compliant full service asset management program. A full service asset management program offers benefits directly related to managing water quality in the tank. Maintaining the coatings, sanitary, and security conditions in the tank is critical to water quality management. A well-maintained interior coating system, as previously noted, will help minimize biological re-growth in addition to preserving the steel and the asset itself. Maintaining sanitary conditions through regular washouts to remove sediments and repairs (e.g. vent screens/roof hatches) is a must for minimizing biological activity and, therefore, disinfectant demand. The AWWA M56 Manual repeatedly emphasizes the importance of sediment removal to avoid problems with nitrification for those systems using chloramines as the disinfectant. The benefit to water quality management resulting from maintenance of security conditions through an asset management program, i.e., keeping unauthorized people away from the tank, is obvious. Sustainable tank asset management programs do more than just maintain the physical asset; they assist with water quality management as well.

Summary

Any one of the sustainable water quality management tools described herein; filter media cleaning for consistent efficient performance, bio-film removal in storage tanks, active

Figure 8: Photographs of the interior of the same tank with and without mixing and ice formation.

mixing systems for elimination of thermal stratification, and a full service GASB 34 compliant asset management program can be implemented separately. However, the impact on water quality will generally be limited by the weakest link in the system. The greatest impact on water quality will be attained through adoption of a comprehensive sustainable program utilizing each of the these water quality management tools working synergistically to minimize disinfectant demand resulting in improved stability and consistency of the water quality throughout the system. New regulations are requiring many water systems to search for new sustainable tools to manage water quality. This combination of water quality management tools has delivered a synergistic improvement in water quality for a variety of water systems across the country.

Randy Moore is Vice President of Specialty Products & Technical Services for Utility Service Company, Inc., located in St. Louis, MO. He can be reached at rmoore@utilityservice.com. Utility Service Company, Inc. has been in business since 1963 and is a professional service provider technologies and services that provide water quality management tools to potable water utilities.