Taste and Odor Issues Resulting from Chloramination and Nitrification

By Tobin Synatschk, PE

With a change to surface water many municipalities have had episodes of poor water quality that are the result of several factors. This memo is intended to give a little background on why conversion was necessary in the Houston area, a discussion of what those factors are, and recommendations on what to do as we move forward.

Our conversion to surface water in the Houston area is the result of subsidence, but many areas of Texas use surface water because of a lack of ground water. Surface water differs from ground water in many ways but of particular importance is that it has naturally occurring organic material in it. This is important because when disinfected with chlorine, this material forms byproducts that are shown to be carcinogenic. The byproducts are many and generally classified as either haloacetic acids or as trihalomethanes. Collectively they are called disinfection byproducts (DBPs) and are now regulated by the EPA. To avoid the formation of DBPs, many entities supplying surface water changed from using straight chlorine to chloramines, chlorine dioxide, or other disinfectants. Chloramines were the disinfectant of choice in Houston. Making chloramines is a tricky process, and the addition of too much chlorine can form Di- and Trichloramines that have a bad taste and odor. If chlorinated water were blended with chloraminated water the free chlorine residual would combine with the chloramines and form Di- and Trichloramines. This would be undesirable and thus the reason that all the regional water suppliers asked their customers to match their form of disinfection.

Formation of Di-and Trichloramines is the first factor that can result in poor water quality and they can be made inadvertently by blending, as mentioned above, or through using the wrong recipe. To form the chloramines we add ammonia in the form of Liquid Ammonium Sulfate (LAS) to bind with the free chlorine before it can form any DBPs. The ratio of chlorine to ammonia for monochloramine formation is theoretically 4.2:1, but we do not use pure ammonia. On a molar ratio the chlorine to LAS ratio is 1.08:1. Any less ammonia and we form Di-and Trichloramines. Too much ammonia and we end up with a free ammonia residual. Free ammonia residuals greater than 0.5 mg/L can start to become noticeable, and with some people objectionable; therefore, it is important to limit this residual concentration. **Too much ammonia is the second factor for poor water quality.**

To understand chloramines a little better one has to understand that we disinfect our water but do not sterilize it. We apply oxidants that kill the most common pathogens, viruses and other organisms that cause illness in humans but not all bacteria. Chloramines do not do this as well as free chlorine and as chloramines age, they start to decompose. This is known as autodecomposition and results in the ammonia disassociating from the chlorine fraction. One can tell when this happens because the monochloramine residual will start to drop and the free ammonia residual will start to rise. This is a problem for water systems because it creates conditions where nitrification can occur.

Nitrification is a biological process where two specific families of bacteria convert ammonia to nitrite and then to nitrate. The free ammonia is basically food for the bacteria. **During the conversion process byproducts are formed**

that taste and smell bad and these are yet another factor that contribute to poor water quality. Once the nitrification process has started it is very difficult to stop. Debris, tuberculation (rust nodules) and scale on the distribution pipes harbor the bacteria and shield it from the disinfectants. For systems with substantial amounts of sand production or cast iron pipes, an initial cleaning can be beneficial to help prevent nitrification. To make matters worse, these bacteria can be fairly resistant to chloramines and often seems to only slow them down rather than killing them. The best defense against nitrification is to make sure that the free ammonia residual is very low thus reducing the food source. The best free ammonia residual is one that is close to zero but still measureable. For most test kits and analyzers this is less than 0.1 mg/L or better yet 0.05 mg/L. Another strategy that can be employed is to maintain the total chlorine residual around 3.5 mg/L, which keeps their growth rate in check.

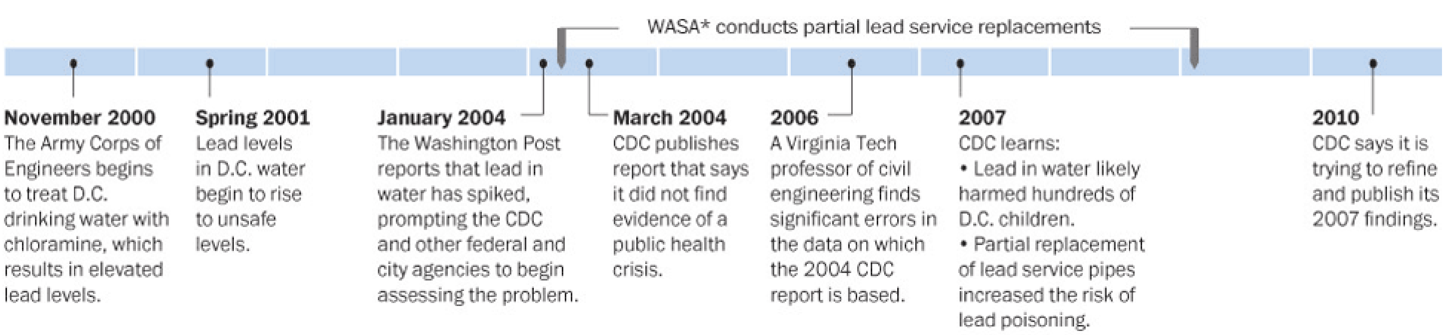
A side effect of nitrification is that it consumes alkalinity and reduces the pH of the water. It is accelerated with increasing temperatures and tends to occur in lines that have long water ages. It can however occur in all portions of a system including the ground storage tanks. It can even occur in the transmission pipes owned by a regional water authority. When alkalinity is reduced along with the pH, conditions can occur where the corrosivity of the water is increased. This can strip the pipes of any scale they may have and even cause pinhole leaks in copper, lead or galvanized steel pipes. In unused bathrooms of homes where the water sits for long durations this can cause the water to look, smell and taste bad. It can also cause the municipality to exceed the concentrations for lead and copper that are set by the EPA in its Lead and Copper Rule. This problem made national headlines when Washington DC converted to chloramines in 2000.

A proactive flushing program can help alleviate nitrification particularly in areas with long water ages or poor water movement. Directional flushing is a must and field crews should follow a well thought-out flushing plan. This is a controversial tool since customers see this as wasting water and municipalities should encourage their operators to quantify the volumes of water flushed with flow meters to aid in accountability and mandated water audits. Small systems can fashion flushing plans by hand, but larger systems will likely need the help of a water model to correctly locate the valves to close and durations to flush. With the price of water increasing all the time, a model-based flushing plan can pay for itself in short order.

A common problem that occurs when converting to surface water is that the overall water chemistry is different than groundwater systems. Surface water is generally softer than groundwater and the change can cause reductions in the scale layers that coat the pipes. **This can cause color issues but generally do not cause taste and odor problems.** A very prominent case where this occurred was in Tucson Arizona when they commissioned their new 150 MGD surface water plant to treat Central Arizona Project water. An excerpt from an article is below:

> *"Unfortunately circumstances beyond the design of the plant complicated Tucson's plans. CAP water with its high mineral content was being delivered through old steel pipes previously used only for groundwater. The situation was further aggravated when the pH level of the released water was not properly adjusted. Experts say releasing water with a pH level below 7 was asking for trouble, and trouble occurred. Discolored water and damaged pipes resulted, and a political debacle arose. Politics drove water policy, and the treatment plant was shut down in 1994."*

The plant was only two years old. There will be a period of time in all systems where this will occur but should stabilize with time. Fortunately, water received in the Houston area generally has a high pH which decreases



it corrosivity. It is important that water systems new to surface water or chloramines flush their lines frequently until things stabilize.

When considering a change to chloramines or surface water plan on problems. One of the challenges faced by system operators is getting good data on residuals. Without good data, it is very difficult to determine what the problem is and how to fix it. The installation of residual analyzers can provide this detail if maintenance is routinely provided. Create and follow a water quality monitoring plan that outlines the steps to take if problems arise. The plan should outline what tests to run, where to take the samples and how often to collect them. It should also include triggers for when to make process changes or initiate flushing. This is a vital part to minimizing water quality complaints.

SUMMARY

In summary, the following can cause taste and odor problems in water:

1. Formation of Di- and Trichloramines by blending chlorinated water with chloraminated water or by dosing too much chlorine.
2. High free ammonia residuals.
3. Nitrification byproducts.
4. Color problems that result from the change in water chemistry.

The following steps can be taken to reduce the chances of taste, odor and color problems in your system:

1. Develop a directional flushing plan and implement it.
2. Develop a water quality monitoring plan.
3. Review handheld test results daily.
4. Monitor water age in the water plants and distribution system.
5. Consider air scouring or pigging of waterlines if poor water quality conditions persist.
6. Consider adjusting the pH to control corrosivity and chloramine formation.
7. Consider a free chlorine burn if nitrification flourishes and all other measures fail.

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