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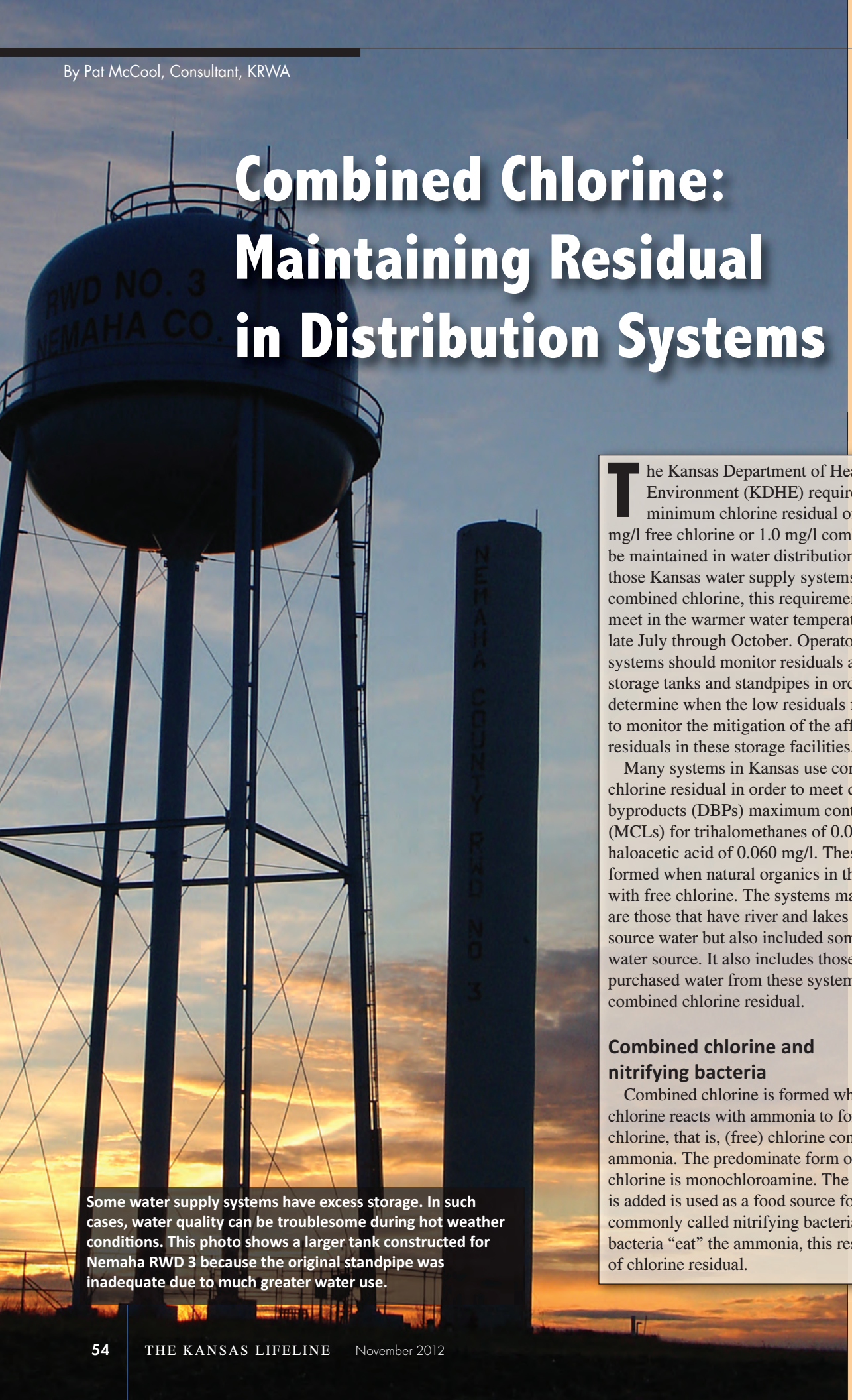
Combined Chlorine: Maintaining Residual in Distribution Systems



Some water supply systems have excess storage. In such cases, water quality can be troublesome during hot weather conditions. This photo shows a larger tank constructed for Nemaha RWD 3 because the original standpipe was inadequate due to much greater water use.

The Kansas Department of Health and Environment (KDHE) requires that a minimum chlorine residual of either 0.2 mg/l free chlorine or 1.0 mg/l combined chlorine be maintained in water distribution systems. For those Kansas water supply systems that have combined chlorine, this requirement is difficult to meet in the warmer water temperature months of late July through October. Operators of those systems should monitor residuals at the water storage tanks and standpipes in order to determine when the low residuals first occur and to monitor the mitigation of the affects of the low residuals in these storage facilities.

Many systems in Kansas use combined chlorine residual in order to meet disinfection byproducts (DBPs) maximum contaminant levels (MCLs) for trihalomethanes of 0.080 mg/l and haloacetic acid of 0.060 mg/l. These DBPs are formed when natural organics in the water react with free chlorine. The systems mainly included are those that have river and lakes as the water source water but also included some with well water source. It also includes those systems that purchased water from these systems using combined chlorine residual.

Combined chlorine and nitrifying bacteria

Combined chlorine is formed when free chlorine reacts with ammonia to form combined chlorine, that is, (free) chlorine combined with ammonia. The predominate form of combined chlorine is monochloroamine. The ammonia that is added is used as a food source for bacteria commonly called nitrifying bacteria. When the bacteria “eat” the ammonia, this results in the loss of chlorine residual.

The nitrifying bacteria grow and form biofilm growth on the wetted surfaces of storage tanks and water lines. These bacteria do not show up as coliform bacteria in required bacteriological sampling and analyses. These bacteria need warm water temperatures and are only a problem during the warmer water temperature months.

In the late spring and early summer, water warms up considerably in the water storage tanks. The water temperature rise is due to the warm air and sunlight on the tank while the ground is still relatively colder. This temperature rise causes biofilm growths in the tanks and a resultant decrease in the combined chlorine residual.

Taking chlorine residual

Chlorine residual at the storage tanks should be regularly taken and recorded in order to monitor the possible problem of chlorine loss and to monitor corrective measures that might mitigate the problem. If and when chlorine loss occurs in these tanks, the low chlorine water then enters water lines thus spreading the low chlorine residual throughout the distribution system.

When monitoring the residuals at the tanks, the residual should be taken at or near the tank when the tank is at its lowest level. Thus, the residual would probably represent the lowest residual leaving the tank. If such a residual was taken when the tank was filling or when the tank is say 60 percent to 100 percent full, then the residual would probably represent the residual of the water filling the tank.

If possible, residual should also be taken of the overflow. This residual would probably be the lowest residual in the tank as the residual sometimes stratifies from higher at the bottom to much lower at the top. Of course, this does not apply to a tank that is designed to fill at the top and draw off at the bottom.

It is important to monitor tanks in the December through maybe mid-May colder period to determine if any and how much chlorine loss occurs before the water temperature rises and nitrifying bacterial occur. This background data should be taken on a two-week or monthly basis.

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Once the warmer water temperature months arrive, then residuals should be taken on a weekly or more frequent basis as needed to determine when the chlorine loss problem starts and its severity. Many systems monitor the residual at the tank with continuous chlorine residual analyzers tied-in to the systems SCADA system. The continuous readings are sometimes shut down during colder months to save money and avoid freezing problems.

Storage tank operation

The reason for monitoring the residual at the tanks is that is where the chlorine loss first occurs and may be the sole source of the chlorine loss later in the water lines. If the residual loss at the tank can be lessened or "controlled", then a system wide residual loss can be delayed or possibly avoided in all or some years.

With respect to residual loss, all tanks are somewhat similar but also have different design and operational characteristics. The differences are due to several factors. For instance, the storage capacity in relation to the number of customers served, quantity of flow, and service area all impact operations. These factors determine, among other things, the number of fill-and-draw cycles in a day. The lower the storage capacity in reference to the aforementioned variables, the more likely the residual loss will be low or will be for possibly a fewer number of days. Unfortunately in Kansas, many tanks are quite large and, thus, maintaining residual is a challenge.

Once the residual loss begins at the tanks, the operator has several choices as to how to address the matter. First, varying the water levels more (by increasing the vertical distance between the pump turn-on and pump-turn off water levels) might help; that is, putting more "fresh", high residual water in the tank when it is filled. Unfortunately, this will result in less fillings of the tank also.

An operator might choose to use a tank to much less than its capacity. In Kansas where some tanks are too large, this is a possible choice. For instance, if a tank was filled to only 35 percent to 65 percent of its capacity, the filling cycles per day would be increased and possibly the residual loss would be less. The method has been performed to much success in some systems in Kansas.

The operator might overflow the tank in order to get rid of the lowest residual water and to put more high residual water in the tank. Periodically overflowing on say a bi-weekly basis might keep the problem of low residual water in the top of the tank and not let it spread to the distribution system. Of course, this does not apply to a tank that is designed to fill at the top and draw off at the bottom.

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Also, the contents of the tank could be discharged onto the ground and then filled with high residual water. The tank piping would have to have the necessary discharge hydrant and valves to accomplish such. This "flushing" method is much better for getting rid of low residual water early than to wait and try flushing low residual water from the water lines especially considering that the low residual water in the line probably came from the storage tank. "Flushing" at the tank by dumping the contents or overflowing the tank will probably be more beneficial and take much less time than "flushing" water lines once the problem spreads to the distribution system. Sometimes, flushing of water lines just spreads the problems and accomplishes little.

Free chlorine "burnout"

When systems cannot maintain residual in the water lines, then systems perform free chlorine "burnout"; that is, the systems go back to a free residual for a period of approximately four weeks. The free chlorine kills the nitrifying bacteria. It is most important that the "burnout" include a complete "burnout" of the storage tanks.

One past summer a city had to do a second "burnout" a few weeks after it went back to combined chlorine after the first "burnout" because the elevated storage tank was not "burnout" completely with free chlorine. It is most important that the storage tanks are "burned out"; otherwise the chlorine loss will soon reoccur. During a "burnout" be sure to dump the tank and fill with free chlorine water or overflow the tank until a free residual is obtained.

In conclusion, it is important for operators using combined chlorine to monitor and record residuals at the storage tanks. Then operators can try different tank operations to hopefully maintain residuals at the tanks and not let the loss of residual spread throughout the distribution system.

Kansas Rural Water Association can provide assistance in helping water system operators know how to operate storage tanks or what response to make when chlorine loss is anticipated or realized. I encourage system representatives to contact KRWA. Many systems address this challenge each summer.

Pat McCool has worked as a consultant to KRWA since January 2004. He previously worked for KDHE for 30 years. Pat has a bachelor degree in Chemical Engineering and a masters degree in Environmental Engineering from the University of Kansas.