ALL'S WELL THAT ENDS WELL - OZONE SUCCESSFULLY TAKES ON HYDROGEN SULFIDE IN A RESIDENTIAL WELL

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Submitted by
Ted K. Rich and Ed Knueve,
ClearWater Tech, LLC

Arguably, there is no such thing as a "typical" well water treatment situation. It's not uncommon for a water analysis from one homeowner's well to differ significantly from that of a neighbor's well located just across the street. Even the water from a single well can vary with changes in groundwater levels or surrounding environmental conditions.

The following example may give some insight into a somewhat typical residential well water treatment application. A family of seven living in a rural northwest Ohio town owns the well, which is 155 feet deep and flows at 10.8 gallons per minute (gpm). The area is known to have hydrogen sulfide contamination in the groundwater and the family has tolerated the quality of the water its well produces. However, shortly after a neighbor drilled a new well and used it to fill a large pond on their property, the family experienced a noticeable deterioration in water quality.

Raw Water Analysis

Not only did the taste and odor problems worsen, but the hydrogen sulfide was believed to be causing corrosion around plumbing fixtures and even on the electronics of their television, stereo and other household appliances. The homeowners were about to purchase a new computer system and, noting the corrosion on existing electronic components, were concerned about the potential damage to the computer. Because of the problems, they decided to seek the assistance of Knueve & Sons, Inc., a local water treatment dealer. An analysis of the raw well water (Figure 1) was ordered and suspicions about the cause were confirmed - hydrogen sulfide was measured at 9 parts per million (ppm).The water also had 769.5 ppm of hardness and 600 ppm of sulfate. The oxidation reduction potential (ORP) was very low at –305 millivolts (mV), reflective of an apparent presence of a high organic load and the relatively high hardness and hydrogen sulfide levels. The water had a pH of 6.97 with low levels of iron and manganese.

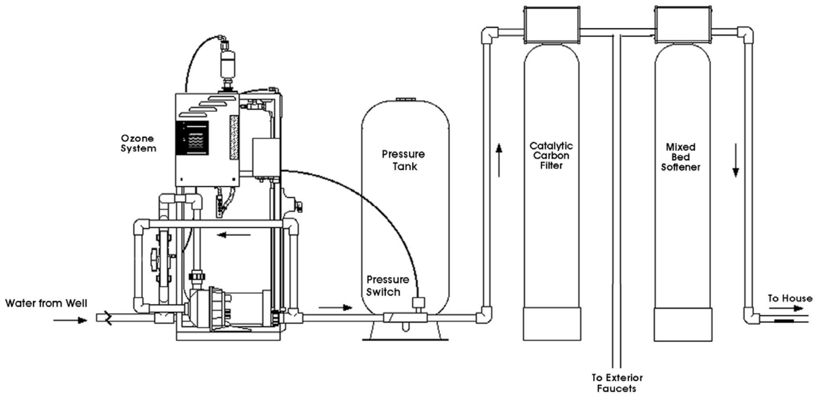
The System

A water treatment professional usually has at least several combinations of treatment technologies available to effectively tackle a problem water situation.

Figure 1: Report of Analytical Results Raw Water

Contaminant	Result	MCL
Hardness	769.5 ppm	-
TDS	1024	500 ppm
PH	6.97	6.5 – 8.5
Hydrogen Sulfide	9.0 ppm	-
Iron	.09 ppm	0.3 ppm
Manganese	.04 ppm	0.05 ppm
ORP	-305 mV	-
Sulfate	600 ppm	250 ppm

Figure 2: Water Treatment System



Naturally, the system that is ultimately used is the one which best accomplishes the water treatment goals at the most favorable price. In this case, minimizing costs was not the primary goal. Rather, the customer wanted to accomplish four objectives – achieve the best possible water quality, use as few chemicals as possible in the treatment process, handle as many of the problems with the fewest possible steps, and minimize the hassles and costs associated with replenishing chemicals. After considering the options presented by the water treatment dealer, the customer chose a system that includes ozone, carbon filtration, a mixed-bed softener and an under-counter reverse osmosis (RO) system. Figure 2 is a diagram of the system selected.

The well head is located some 50 yards from the water treatment system, which was installed in the basement of the customer's home. The water flows from the well head through the one-inch supply line directly to the ozone system, which is a complete skid-mounted unit designed specifically for residential point-of-entry applications. The system includes an ozone generator with built-in air dryer (ozone output is 2.8 grams per hour), a 3/4 horsepower stainless steel circulation pump, a 40-gallon contact vessel, ozone injector manifold and time delay enclosure.

The time delay allows the ozone generator and circulation pump to run for a specified amount of time after the well pump shuts off so ozone-treated water is always available when the well pump restarts. For this installation, the time delay is set at four minutes. From the ozone system, the water flows through 3/4-inch cpvc pipe into a 1.5 cubic foot, automatic backwashing catalytic carbon filter. The water then goes into a 2.5 cubic foot mixed-bed softener and then to the house service lines. Just prior to the softener, a tee was installed to feed two exterior faucets. Finally, an under-counter RO unit was installed for the kitchen faucet to handle the total dissolved solids, which was measured at 1,024 ppm in the treated water.

The Results

Before this system was installed, the customer's water was treated only by a 1.0 cubic foot cation exchange softener. As a result, the hardness, and to a degree, the low levels of iron and manganese were the only contaminants affected.

The new ozone/carbon filtration/mixed-bed softener combination is a different story. The post treatment water analysis (see Figure 3) indicates that the system is meeting the customer's goals. Overall water quality is significantly better; the hardness has been reduced from 769.5 ppm to zero and the sulfate from 600 ppm to zero – thanks to the mixed-bed softener. The original cation exchange softener was handling the hardness but not the sulfate, because sulfate is anion. The ozone system reduced the hydrogen sulfide from 9 ppm to zero and raised the ORP from –305 mV to well into the positive range. And even though the raw water iron and manganese levels were very close to or below U.S. EPA maximum contamination levels (see Figure 1 & 2), the ozone system made sure both were reduced to zero. The U.S. EPA has established primary and secondary drinking water regulations and contaminants like iron, manganese, TDS and sulfate fit into the latter category. Secondary regulations cover contaminants that may only cause cosmetic effects (such as taste, color or odor), so they are deemed non-enforceable. However, some states have chosen to enforce secondary regulations along with the enforceable primary regulations.

Figure 3: Report of Analytical Results
Post Treatment

Contaminant	Result	MCL
Hardness	0 ppm	-
TDS	1024	500 ppm
PH	7.08	6.5 – 8.5
Hydrogen Sulfide	0 ppm	-
Iron	0 ppm	0.3 ppm
Manganese	.04 ppm	0.05 ppm
ORP	+85 mV	-
Sulfate	0 ppm	250 ppm

The customer also wanted a treatment system which was as chemical-free as possible. The use of ozone for oxidation rather than chlorine or hydrogen peroxide accomplished this. It also satisfied their desire to avoid the need and costs associated with replenishing chemicals. While hydrogen peroxide may actually be more efficient at oxidizing sulfide ion (see Figure 3), ozone was employed because the ORP suggested the presence of a high organic load, which ozone is more capable of handling efficiently. Aeration was not used for the same reason; it works well on sulfide ion but would not be nearly as effective as ozone on the organic load.

Summary

This "typical" well water treatment story has a happy ending. The customer's water, once considered "very hard" is now "soft" – according to U.S Department of the Interior and Water Quality Association standards (water is considered "very hard" if it has 180 ppm of hardness or more – the customer's water was over 769 ppm).

The ozone system is completely oxidizing the hydrogen sulfide, iron and manganese, managing the odor and corrosion problems. The ozone system is also handling the organic load in the water as evidenced by the much-improved ORP.

The carbon filter, which is back-washing every other day, is removing any precipitates from the ozone oxidation process. It is also stripping out any residual ozone that may be present.

The mixed-bed softener is busy taking care of the raw water's high hardness and sulfate levels. While the TDS level remains somewhat high, the under-counter RO unit in the customer's kitchen helps produce excellent drinking water and the icemaker is spitting out crystal clear ice cubes.

The family's new computer system is working perfectly.

Figure 4: Theoretical Amounts of Various Agents Required to Oxidize 1mg/L on Sulfide Ion

Oxidizing Agent	Practical Amount Req'd to Oxidize 1mg/LS^2	Theoretical Stoichiometry
Ozone	2.2 to 3.6 mg/L	1.5 mg/L
Chlorine	2.0 to 3.0 mg/L	2.2 mg/L
$KMnO_4$	4.2 to 6.0 mg/L	3.3 mg/L
ClO_2	7.2 to 10.8 mg/L	4.2 mg/L
H_2O_2	1.0 to 1.5 mg/L	1.1 mg/L
Oxygen	2.8 to 3.6 mg/L	0.5 mg/L

References

U.S. Environmental Protection Agency, "Safe Drinking Water Is In Our Hands – Existing Standards and Future Priorities," August 1999.

Water Quality Association – Ozone Task Force, "Ozone for POU, POE, and Small Water System Water Treatment Applications," 1999.