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Use of Chlorine to Disinfect Water Wells

There are several things to consider the next time you disinfect.

By John H. Schnieders, Ph.D.

What contractor hasn't used or consultant recommended a hypochlorite solution for water well disinfection? Sodium and calcium hypochlorite are by far the disinfectants of choice in wells.

Chlorine as a gas is a powerful disinfectant and because of the ease of use and the relative safety of hypochlorite products, they are overwhelmingly the chemistries of choice.

Of the two, the sodium hypochlorite has some clear advantages. It's very soluble and doesn't add calcium to the well. Calcium hypochlorite adds considerable calcium, and in a hard water area this can push the saturation index to a positive state. This results in the formation of deposits of calcium carbonate (calcite) and sometimes even calcium sulfate or gypsum, both of which are capable of blocking water flow.

Another poor practice is adding calcium hypochlorite powder or granular directly to the well without first dissolving it. This usually results in a lot of the material ending up in the well bottom. The material then takes considerable time to dissolve, remaining long after the disinfection process has been completed.

Setting aside the discussion of the two hypochlorites, let's take a look at all of the conditions that should be considered before chlorinating or disinfecting a well. Here are the more important parameters:

- What concentration of chlorine should be used?
- Should we consider pH control during chlorination?
- How should we add the chlorine to the well?
- What is the proper contact time for the chlorine to do the job?

What concentration of chlorine should be used?

There are several factors that usually determine the concentration to be used. First, we tend to theorize that the more we put in at the top, the more that will spread through the well. Secondly, we usually assume the well has a high chlorine demand (we learned that from the surface water people who deal with much lower levels of chlorine than we use). Lastly, we don't often take the time to calculate a proper dose and end up treating the well at excessive concentrations.

But let's take a little more scientific approach, and maybe we can improve the chlorination process. We all know it takes very little chlorine to kill one bacterium. In fact, if we have clean water it actually takes less than 1 mg/L to kill the free swimming bacteria. So there has to be some other reason we need to use more. The answer of course is the particulates, the clay and mineral particles, and the biofilm, the slimy formation the bacteria reside in within the well structure and aquifer around the well. While the particulates physically block the lower chlorine levels, the polysaccharide covering prevents the penetration of the chlorine, keeping it from destroying the bacteria. Several researchers have shown that it often takes as much as 1500 times more chlorine to penetrate biofilm. While this information is useful in understanding the effects of chlorine as a disinfectant, it has also led to excessive use of chlorine.

One reason this phenomenon exists is that chlorine (or any oxidizing chemistry) causes an effect on the polysaccharide, which converts it to a dense, far less penetrable covering. Some work in our laboratory several years ago (*Water Well Journal*, October 2001) showed the most effective levels of chlorination for wells lie somewhere between 50 and 200 mg/L. Concentrations higher than those often resulted in an incomplete kill of coliforms present. So what we are looking for is a level of chlorine that will overcome the excess organic debris ("chlorine demand" if you must) and yet not so high as to condense or thicken the organic mass we call biofilms.

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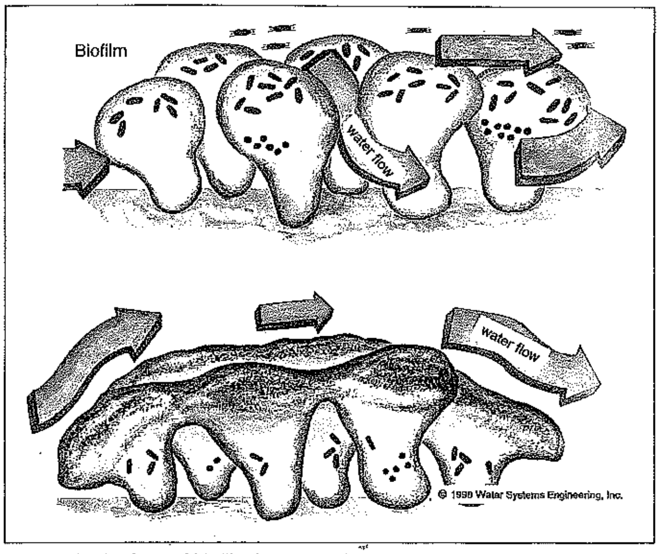

Biomass in the form of biofilm is attacked by oxidizing chemical such as chlorine.

Should we consider pH control during chlorination?

It's true, if you control the pH of the chlorinating solution to around 6.5, you have increased the biocidal effect by at least a hundredfold. See articles in *Water Well Journal*, February 1998 and October 2001, for the complete method. However, use of pH control is not easy. The hypochlorite solution will raise the water pH by almost two points for every 200 mg/L used, thus requiring in most cases the use of some type of acid to lower the pH to the 6.5 level. There are a number of good products on the market to help you with this control. Products like Johnson Screen's NW-410, Layne Christensen's Oximate®, AmeriWest Water Services' KlearWell 440 ChlorHelp, and Design Water's Chlor-Pal all take into consideration the quantity of hypochlorite used and the natural alkalinity of the water. Products that don't include these considerations or calculations are of little help. But remember that this type of buffering chemistry does require better methods of chlorine addition than just pouring hypochlorite into the well.

How should we add the chlorine solution to the well?

I mentioned in an earlier article that it took three hours for a chlorine solution to reach the well bottom when added directly at the static water level. I also added that it took another three hours to disperse out around the well or throughout the gravel pack. However, the results weren't uniform. Lower levels of hypochlorite were recorded outside the casing and screen and a lower concentration was recorded in the well bottom. Obviously, waiting a little longer (10 to 12 hours) before pumping out the chlorine will help, but there should be a better way of placing the chemistry closer to the area of need.

One of the methods we used in the laboratory and later in some field trials was to mix the hypochlorite into 50 gallons of water. Then, with the use of a hose, we easily pumped to it almost everywhere in the well. The 50-gallon volume was chosen because of the almost universal presence of 55-gallon plastic drums and the appropriateness of the 50-gallon amount to most small-diameter wells. This volume will allow the chlorine solution to displace a lot of the well water and allow dispersal throughout the well much quicker and more uniform in concentration. The use of 55 gallons should be increased for larger wells. Blending the hypochlorite into a specific volume of water also allows you to more easily use the pH control method as the buffered hypochlorite solution is easily prepared in a separate tank or drum.

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What is the proper contact time for the chlorine to do the job?

Now that we have the hypochlorite in the well and properly placed, we need to determine how long we should leave it in the well to do the job. If we have tremied it near the intake areas and the well bottom, it will take only three more hours to disperse throughout the well and surrounding area. Of course, any surging or swabbing would help. The actual contact time — the time for the chlorine to penetrate the biofilm or incrustations protecting the bacteria — is usually measured by a formula based on contact units. A thousand units are required for adequate penetration. Thus, five hours of contact time are required for a 200 mg/L treatment rate.

So add them up. Three to six hours to get dispersal throughout the area and then five more to ensure penetration. Therefore, we need to let the chlorine solution remain in the well for a minimum of eight hours and possibly up to 11 hours before pumpout. The pumpout is important because we remove the high concentration of chlorine and the bacteria and debris that have been oxidized. We need to thoroughly pump the well a minimum of 10 well volumes — and 20 is twice as good. The removal of the debris, the byproducts of oxidation, will ensure much less chance of a quick regrowth of the bacteria.

Chlorine calculations and the proper treatment dose

It is important that we properly calculate the dosage. We want to use the maximum effective concentration and not hurt the environment or overtreat the well. Let's use a 5-inch-diameter well with 75 feet of standing water and a casing and screen to a total depth of 95 feet and a naturally developed gravel pack as our example. The 75 feet of standing water amounts to approximately 75 gallons. If we assume that the area around the well will consist of another 75 gallons, we will need to treat a volume of 150 gallons. Assuming a 200 mg/L treatment rate and the use of a 10% sodium hypochlorite solution, we have

$$150 \text{ gallons} \times 8.3 \text{ pounds/gal} = 1245 \text{ pounds of water}$$

$$200 \text{ mg/L chlorine} = 0.02\%$$

$$\frac{\text{weight of water treatment volume} \times \text{desired chlorine level}}{\%\text{ hypochlorite product} \times \text{weight of product}} = \text{gallons of hypochlorite}$$

$$\frac{1245 \text{ pounds/gal water} \times 0.02\% \text{ hypochlorite}}{10\% \text{ hypochlorite} \times 9.6 \text{ pounds/gal}} = 0.26 \text{ gallons of } 10\% \text{ hypochlorite}$$

A simpler way

$$\frac{\text{water treatment volume} \times \%\text{ chlorine desired}}{\%\text{ active hypochlorite}} = \text{gallons of hypochlorite}$$

$$\frac{150 \text{ gallons} \times 0.02\%}{10\%} = 0.3 \text{ gallons of } 10\% \text{ hypochlorite}$$

If you are going to disinfect this well using the above method, you should add the hypochlorite to the 50 gallons of water. After mixing, pump it into the well, placing the solution near the screen and a portion in or near the well bottom.

And finally a word of caution. Many of us purchase sodium hypochlorite at the grocery store as household bleach. In years past, this product was approved for well service. Today, most of the household bleach sold is "ultra bleach" which is a product designed to provide more stability to the chlorine concentration. Unfortunately, the formulation is detrimental to well operation and may result in contamination and some plugging. *WWJ*