Coping With Contaminated Wells

The test results are unmistakable—your water is **"unsafe."** Now what? This is a common problem in rural Iowa. Of nearly 10,000 private water samples sent to the University Hygienic Laboratory each year, about 40 percent are high in coliform bacteria, and 15 to 20 percent exceed the drinking water standard for nitrate.

The most common cause of bacterial problems is well deterioration. Many people use old wells in rural Iowa ... some were poorly constructed to begin with. In others, age has taken its toll, resulting in loose or missing caps, corroded or cracked casings, and other defects.

If excessive nitrate is the problem, insufficient depth, poor construction, well deterioration, or location next to concentrated sources of nitrogen (feedlots, septic tanks, heavily fertilized cropland) all can be culprits.

No matter how a well becomes contaminated, the questions you're faced with remain the same. What do the lab results mean? How do contaminants get into my well? What are my options for solving this problem?

It's easiest to address these questions by looking at coliform and nitrate problems separately. In many cases, a well will have only one of these problems. If you're faced with both problems, however, you'll need to look at the likely causes for each and select a combination of strategies.

Coping With Coliforms

What do coliform tests mean? Will your family become ill? Not necessarily, but your *risks* of contracting a waterborne illness are increased if coliform bacteria are found in your drinking water. Many illnesses can be waterborne, such as salmonellosis, shigellosis, hepatitis, and diarrhea. Each can be caused by different kinds of bacteria, viruses, or parasites. Testing water for *all* of these organisms would be time consuming and expensive. So laboratories test for **coliform** bacteria; these can be identified quickly and at low cost.

Coliforms themselves don't generally cause illness. But they are common in sewage and livestock wastes where disease-causing organisms also can be found. So if coliforms are found in your water supply, it's a warning that disease-causing organisms may be present too.

How Do Bacteria Enter a Well?

Coliforms and disease-causing organisms originate above ground. Storm runoff picks up and carries these biological contaminants. But as water percolates slowly through the soil and into the groundwater, bacteria and viruses are filtered out. As a result, coliforms are rarely found more than a few feet below ground. If you do find coliforms in your well, it warns of possible well defects, such as those illustrated in Figures 1 and 2 on the next page, that allow water—and the bacteria carried by it—to seep directly into the well without first being filtered through the soil.

Loose or defective caps are a common problem. They let dust, insects, and rodents enter, bringing bacteria with them. A well cap must fit the casing tightly. Loose boards, rags stuffed inside the casing, or a coffee can over the top, won't do.

If the cap is vented, the vent should face downward toward the ground (so that dust cannot settle into it) and it should be screened to block entry of insects and rodents. A tight seal also should be installed around pump wiring where it enters the well. Even tiny holes can let bacteria into your well.

Seepage, along the outside of the well casing, is another way contaminants get into wells. When a well is drilled, the diameter of the borehole is

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generally several inches larger than the casing. This makes it easy to install the casing, but it also leaves open space around the casing. Modern well construction standards call for grout, an impermeable slurry of cement or clay, to be placed around the outside of the casing to block contaminant entry (Figure 4). Unfortunately, many older wells were not grouted.

To prevent discharge lines from freezing, wells used to be constructed inside pits built below the frost line. During wet weather, however, frost pits can be flooded by heavy runoff or a high water table. Since most well caps are not watertight, submerged well heads in flooded pits allow contaminated water to flow directly into the well (Figure 1).

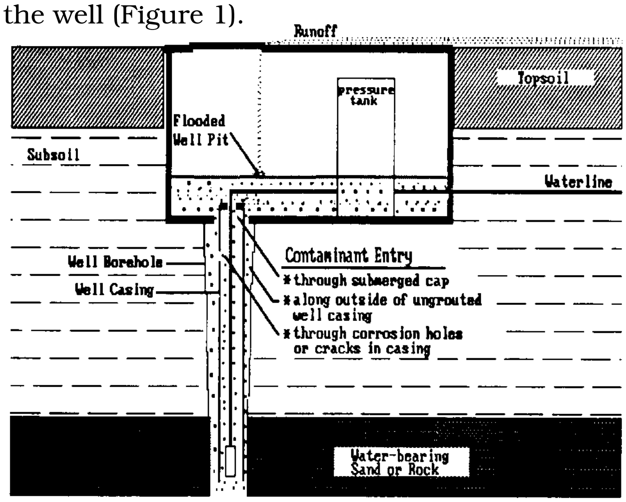

Figure 1. Flooded well pits frequently lead to well contamination.

State regulations prohibit construction of new wells inside pits. Instead, well casing must be extended above ground so that the top of the well cannot be submerged. A pitless adapter routes pump discharge directly through the casing wall below the frost line (Figure 4).

Holes or cracks in the casing wall also are a problem, particularly in old wells (Figures 1 and 2). If these occur near the top of the well, they allow contaminated water to enter without being filtered through the soil. Wells with concrete tile, or brick casing are prone to this type of contamination since these materials leak.

A faulty plumbing system can cause problems too. If a water sample taken from a tap at the well is safe, while samples drawn at other locations are contaminated, plumbing system problems may be the cause.

Low water system pressure, for example, can allow contaminants to be drawn in through leaky joints and pipes, or through submerged hoses left dangling in watering troughs or sinks. Buried connections with abandoned water lines can cause contamination too. These problems can be hard to identify. If you suspect plumbing system defects, you may need help from an experienced sanitarian or water system contractor.

Bacteria ... What Are the Options?

Coliform bacteria are found nearly everywhere (above ground), so it's very easy to accidentally contaminate a water sample as you fill the bottle. As a result, bacteria occasionally show up in a water sample even though the water system itself is safe. If your well is relatively new, and visual inspection reveals no obvious defects, submit another sample to the lab to verify a bacteria problem before making costly water system changes.

If high bacteria is the only water quality problem, you have three general options: well repair, well replacement, or installation of continuous disinfection equipment.

Well Repair ... Successful well repair generally is feasible if defects are simple and few in number. A defective well cap, for example, is easily replaced or tightened at relatively little expense. Simple landscaping improvements can be used to divert storm runoff, and the contaminants it carries, away from the well site.

Seepage through cracks or corrosion holes in steel well casing is a more difficult problem. If they are very near the top of the well, these openings can be repaired by excavating around the well and replacing the damaged section.

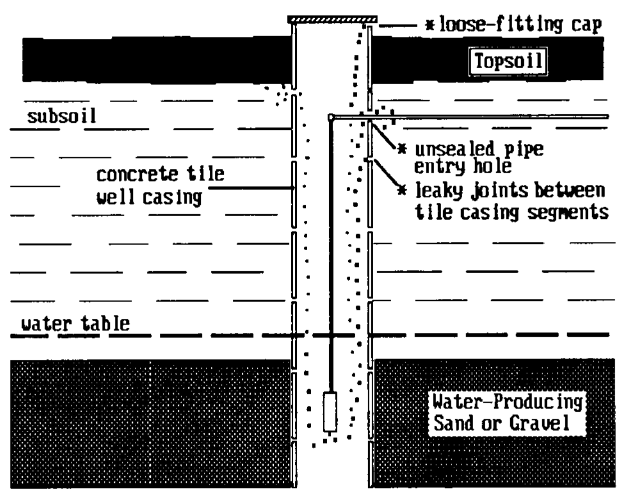

Figure 2. Typical defects that allow bacterial contaminants to enter concrete tile walls.

Wells cased with 36-inch diameter concrete tile are popular in southern Iowa where shallow wells tap groundwater deposits that often yield less than five gallons per minute. But leaky joints between tile casing segments at the top of the well can lead to bacterial contamination. To prevent this, have a driller remove the tile segments in the top 10 or 15 feet of the well. A precast concrete slab, fitted with a coupling for steel or plastic well casing, is lowered onto the top of the remaining casing segments.

Watertight steel or plastic well casing (6-inch diameter) is attached to the slab and extended above ground level (Figure 3). Concrete is poured over the buried slab to seal it. A pitless adapter is installed on the watertight casing, and a tight cap at the top. Clay soil is compacted around the small diameter casing to minimize seepage. This "buried slab" design, incorporating watertight casing at the top, is recommended for new concrete tile well construction in southern Iowa.

Flooded well pits are a common problem with old wells. If the casing appears sound at the top (no evidence of holes or cracks), and if the well was grouted during construction, it may be a candidate for pit elimination. Remove the pit roof and the top foot or so of the pit walls. Add well casing, extending it above ground, and install a pitless discharge fitting below the frost line. Then fill the pit with soil (preferably with high clay content), compacting it tightly around the casing.

Seepage along the outside of the casing is difficult to remedy. It's nearly impossible to place grout around old wells after soil and rock have collapsed against them. Occasionally old casing can be pulled and new casing installed and grouted. But this can be so expensive and time consuming that a new well may be a better investment.

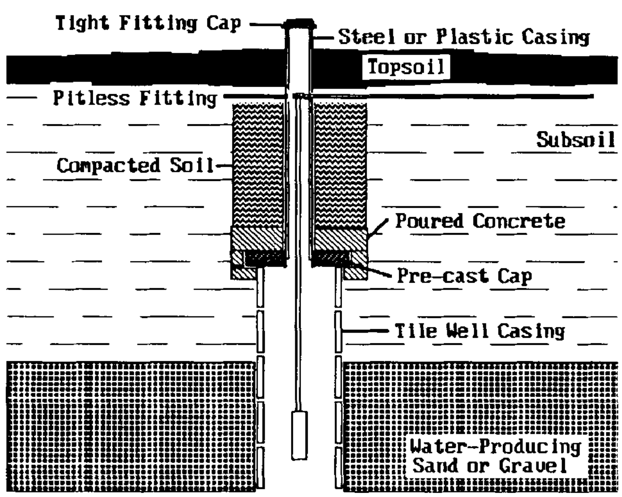

Figure 3. Recommended construction to prevent bacterial contamination of concrete tile wells.

Since dirt and bacteria are likely to be introduced, be sure to sanitize the well and plumbing system after repairs are completed. For more information, see ISU Extension bulletin Pm-899, *Shock Chlorinating Small Water Systems*. After chlorine dissipates from the system, submit another sample to the laboratory to verify the repair's success and the water's safety.

Well repair isn't a "sure thing." If several defects are present and all are not located and repaired, bacteria problems will persist. Before making the decision to repair a well, discuss the problem thoroughly with your county sanitarian and well driller. Extensive repair of antiquated wells can be nearly as expensive as a new well, and the resulting water quality may not match your expectations, particularly if the repaired well is located near septic tanks, feedlots, and other sources of contamination.

Well Replacement ... Well construction is a complex field requiring knowledge not only of modern well construction techniques, but also of groundwater law, geology, and the potential health effects of water supply contamination. Poor well construction or repair techniques can lead to water supply contamination and groundwater pollution.

As of July 1993, businesses that construct or reconstruct wells, install pitless equipment in wells, or plug abandoned wells are required by Iowa law to have a state-certified well contractor in direct charge of work at the job site. To become certified in Iowa, well contractors must meet minimum work experience requirements, successfully complete an examination, and participate in continuing education.

Certified well contractors also are required to provide potential customers with a free copy of *Water Well Construction: A Consumer Information Booklet* by the Iowa Department of Natural Resources. Before drilling begins, ask for proof of state certification, and be sure to read the consumer information booklet. (Note: Contractors who specialize in pump installation and maintenance work that does not involve modification of the well itself are not currently required to be state certified. To remain current on the most recent information concerning water supply development and maintenance, however, pump installation contractors can voluntarily participate in the well contractor certification program. As a consumer of well contracting services, you can encourage continued improvement in Iowa's water well industry by requesting that pump installation work be performed by a state-certified contractor.)

Iowa law also requires that a construction permit be issued by the Department of Natural Resources or your county board of supervisors **prior** to drilling a new well. Contact your county sanitarian for advice on permit requirements and local well construction regulations that help ensure safe water.

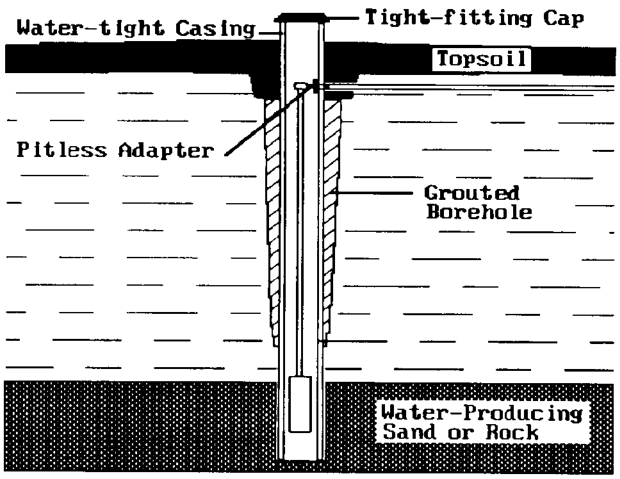

Figure 4. Protective features for wells with steel or plastic casing.

As you make plans for a new well, remember that abandoned wells can lead to serious personal injury or property damage. Open wells also can permit groundwater contamination that may eventually affect your new well. Ask your well drilling contractor to properly plug your old well at the same time your new well is constructed. For more information, see ISU Extension bulletin Pm-1328, *Successfully Plugging Your Abandoned Well.*

Continuous Disinfection ... Most public health officials agree that the best solutions to bacterial problems are to prevent contamination by repairing water system defects or to find a new water source that is safe. If well repair or a new well is not feasible, however, you may want to consider installing continuous disinfection equipment.

For more complete information on coliform bacteria and disinfection methods, contact your county ISU Extension office for videotape #75704, *Coliform Bacteria.* This videotape and the viewer's guide that accompanies it are part of the Iowa State University *Quality Water* videotape series. The viewer's guide is yours to keep for future reference.

Many people have heard about "shock chlorinating" a well. This involves placing a **single** highly-concentrated dose of chlorine into the well and plumbing system. Shock chlorination is commonly used to sanitize newly constructed wells and water systems or those that have been opened for repair or maintenance.

Many people confuse shock chlorination with continuous disinfection. **But shock chlorination is not a continuous process, and it cannot provide continuous protection against contaminants.** As soon as the highly-concentrated chlorine solution dissipates, your protection is gone. If your well or plumbing is defective, contaminants will enter continuously. Don't rely on shock chlorination to cure bacterial problems. If your water system is defective, it must be tightened up—to prevent continuous bacterial contamination—or be **continuously** disinfected.

What About Nitrate?

High levels of nitrate in the groundwater generally are due to concentrated sources of nitrogen. These could include leaking septic tanks, feedlots, landfills, and heavily fertilized cropland.

What Do Nitrate Tests Mean?

Nitrate test results can be expressed in two different ways, and this often causes confusion. Some laboratories measure and report the actual amount of nitrate (abbreviated NO_3) in the water. The drinking water standard for NO_3, as established by the U.S. Environmental Protection Agency, is 45 milligrams per liter (mg/l). Other laboratories report only the nitrogen component of the nitrate. This is referred to as nitrate-nitrogen (abbreviated NO_3-N). The drinking water standard for NO_3-N is 10 mg/l.

These two standards are **equivalent**. It is very important, however, that you read your water test results carefully—noting which type of nitrogen is reported—so that you can compare your results with the appropriate standard.

The main concern about nitrate is its effect on infants less than six months of age. Nitrate levels in excess of 45 mg/l (or NO_3-N levels above 10 mg/l) increase the risks of methemoglobinemia, a potentially serious blood disorder. **Water that exceeds these standards should not be used for infant drinking water or in preparation of infant formula.**

How Does Nitrate Enter a Well?

Like bacterial contaminants, nitrate can enter a well by seeping along an ungrouted casing, through holes in the casing wall, or into submerged well caps inside flooded frost pits. But unlike bacteria, nitrate is not filtered out by the soil. It migrates as easily through the soil as the water that carries it.

So, while good well construction can help to reduce the risk of nitrate contamination, it cannot eliminate it. If a well taps shallow nitrate-contaminated groundwater, the water pumped from it is going to be contaminated, no matter how carefully the well is constructed.

Nitrate ... What Are the Options?

Practical remedies for nitrate contamination generally focus on well repair and replacement, or on water treatment.

Well Repair ... If nitrate enters through the well cap (flooded well pit) or through holes near the top of the well casing, this can be prevented by extending or repairing the casing, or by diverting runoff away from the well site. But if an ungrouted well is allowing nitrate to seep downward along the casing, this is difficult to stop.

Well Replacement ... The risks of nitrate contamination in new wells can be reduced by constructing them as far from strong sources of nitrogen (feedlots, septic tanks, heavily fertilized fields), as is practical, and by drilling to greater depths to tap aquifers that have not been affected by nitrate. In some locations—particularly in parts of southern Iowa where groundwater resources are sparse—neither of these strategies may be feasible. Throughout much of the state, however, groundwater is plentiful, and drilling at alternate locations or to greater depths are feasible options.

Drilling to greater depths takes advantage of protective layers of clay, shale, or similar material that block downward migration of local precipitation and water-soluble contaminants. **Properly constructed** wells that penetrate the protective layers, drawing water from beneath them, will be less prone to contamination by nitrate or other chemicals originating above ground. **It is essential, however, that wells penetrating through contaminated groundwater and protective layers be carefully grouted to prevent contaminant migration along the casing and into the well (Figure 5).**

Water Treatment ... Three treatment processes—distillation, reverse osmosis, and anion exchange—have potential to remove nitrate from drinking water.

Distillation is a two-step process. First, water is boiled, causing it to turn to steam. Then, the steam is captured, condensed back into liquid, and stored in a separate container for later use. As water vaporizes and leaves the boiling water surface, nitrate, minerals, and other contaminants that do not vaporize easily are left behind and discarded before the next batch of water is distilled. Small stills designed for household use will generally treat five to ten gallons of water per day. Although this is only a small fraction of total water use in most homes, it generally is adequate for drinking and food preparation.

Reverse osmosis uses a semi-permeable membrane to separate contaminants from water. The membrane acts like a molecular sieve. When contaminated water is pressurized against the membrane, the water molecules readily pass through it. Contaminants consisting of large molecules or highly charged ions, however, find it difficult to pass through the membrane.

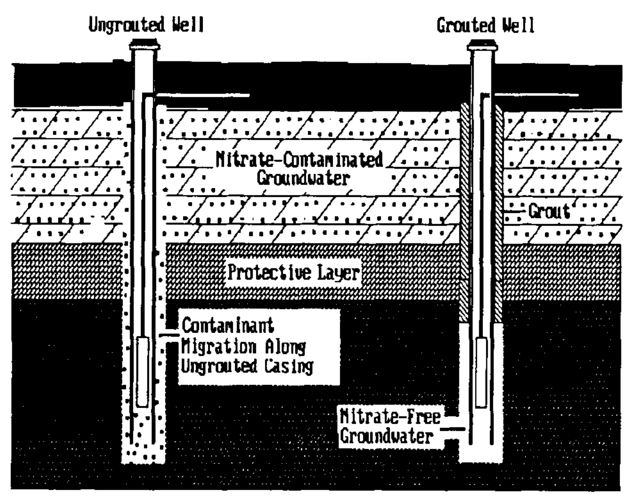

Figure 5. Grouted wells help block nitrate migration from shallow groundwater into deeper aquifers.

There are several kinds of reverse osmosis membranes on the market, and all do not remove nitrate to the same extent. Before purchasing reverse osmosis equipment, ask your equipment supplier what percentage of the nitrate a particular unit is capable of removing. With proper membrane selection, 80 percent or more of the nitrate can be removed by reverse osmosis. Also, ask how long the membrane is likely to last and how much it will cost to replace it. Most of the reverse osmosis equipment sold for household use has treatment capacities of five to ten gallons per day.

Anion exchange looks and works much like a water softener. Water is passed through a tank of exchange resin that absorbs certain negatively-charged ions such as nitrate and sulfate. When the resin exchange capacity is exhausted, the unit must be regenerated, generally with salt, to restore its ability to remove anionic contaminants.

There are complications that can limit the use of anion exchange. Sulfate, common in some water supplies in western and southern Iowa, can seriously interfere with the nitrate removal capabilities of some anion exchange units. If you have sulfate in your water, discuss this thoroughly with your equipment supplier before purchasing anion exchange equipment for nitrate removal.

For more information about dealing with nitrate in your water supply, ask for tape #75705 at your county ISU Extension office. It's part of the *Quality Water* videotape series.

Buying Water Treatment Devices

To help prevent misleading sales claims about water treatment equipment that is claimed to remove health-related contaminants from drinking water, the Iowa Consumer Protection Law requires the following:

1. **Any residential water treatment system that is claimed to remove health-related contaminants from drinking water must be tested** according to state-approved procedures.

2. The results of these tests must be provided to potential customers on a "performance data sheet" that specifies which health-related contaminants are removed, and the extent of their removal.

3. The performance data sheet must be signed by the buyer or renter, and the Iowa Department of Public Health consumer information pamphlet entitled *Residential Water Treatment Systems* must be given to prospective buyers or renters prior to their purchase, lease, or rental of the system.

The Iowa law does not guarantee the performance of a particular unit or system. But it does provide consumers with access to valuable performance information that can aid in selecting treatment equipment from among the many competing brands and models being sold.

If you're planning to buy or rent equipment to treat nitrate, bacteria, or any other health-related contaminant in your water, ask for and carefully review the performance data sheets for each treatment unit that you are considering buying or renting before you make a final decision.

Test and Inspect Often

Occasionally, even wells with obvious visible defects test "safe" because the concentration of contaminants in a well may vary with time. Contaminants are most likely to show up during warm and wet weather and are least likely to appear during very dry weather or when the ground is frozen.

So don't be misled by a **single** "safe" water test result. Test frequently—at least once every year. And even if your test results are "safe," be sure to carefully inspect your well and plumbing system for defects that may permit contamination to enter at another time.

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