Drinking Water From Private Wells and Risks to Children

Committee on Environmental Health and Committee on Infectious Diseases

ABSTRACT

Drinking water for approximately one sixth of US households is obtained from private wells. These wells can become contaminated by pollutant chemicals or pathogenic organisms and cause illness. Although the US Environmental Protection Agency and all states offer guidance for construction, maintenance, and testing of private wells, there is little regulation. With few exceptions, well owners are responsible for their own wells. Children may also drink well water at child care or when traveling. Illness resulting from children’s ingestion of contaminated water can be severe. This policy statement provides recommendations for inspection, testing, and remediation for wells providing drinking water for children. Pediatrics 2009;123:1599–1605

INTRODUCTION

Approximately 15% to 20% of households in the United States obtain their water from private wells.1 Private wells are not subject to federal regulations of the US Environmental Protection Agency (EPA) or those of the Navajo Nation (which has its own EPA) and are minimally regulated by states. Coliform contamination of home private wells in Iowa in the 1990s was as high as 27%.2 According to the Centers for Disease Control and Prevention, there were 31 waterborne disease outbreaks reported in the United States in 2005–2006, the latest years for which data are published.3 Twenty of the outbreaks were from drinking water, of those, 8 were groundwater sources, usually private wells. Those caused illness in 458 people. The etiology of 5 of the outbreaks is known: 1 was Campylobacter, 3 were norovirus, and 1 was Hepatitis A. Waterborne illness is undoubtedly underrecognized and underreported.

GROUNDRWATER AND WELLS

Groundwater is water below the topsoil and above impervious bedrock. When groundwater collects in and saturates relatively porous fractured bedrock and soil, it is said to be in an aquifer. The water table is a depth below which the soil and fractured bedrock (ie, the aquifer) is saturated with water. The water table can vary from season to season and year to year. For a well to produce water reliably, it must be deep enough so that water can be pumped from the aquifer under virtually all weather conditions. Aquifers are recharged from above by precipitation and runoff.

WELL TYPES

Dug wells usually are shallow holes, 10 to 30 ft deep, lined with rock, brick, tile, or concrete, with a pump in a nearby pump house or in the dwelling. Dug wells usually are relics on older home sites. They are easy to contaminate and unreliable in most of the United States.

For driven wells, pipe is driven through gravel or sandy soil. These wells also tend to be shallow, usually approximately 50 ft deep; the pump is installed at the top of the well or in the dwelling. Driven wells are still relatively easy to contaminate because of their shallowness but can be installed rapidly and inexpensively if the geologic conditions are right. Dug wells and driven wells are often the water source at camps or vacation homes.

Drilled wells are 100 to 400 ft deep and reach bedrock. Most drilled wells have an electric submersible pump at the bottom. Because the water has been filtered by soil on the way down and is relatively safe from contamination while in the aquifer, water from these deeper wells is less likely to be contaminated.
COMPOSITION OF WELL WATER

Chemicals
The chemical composition of well water varies with region, underlying geologic formation, and environmental contamination and can be harmful, beneficial, or merely undesirable. For example, some fluoride is desirable in drinking water, whereas iron is undesirable. Many other chemicals, some of them potentially toxic, can contaminate well water, with their presence or absence attributable to naturally occurring geologic factors or dispersion from industry, farms, or business (Table 1).

Microorganisms
Microorganisms, including bacteria, viruses, fungi, and parasites, can contaminate the ground water that supplies wells (Table 2). The major source of these organisms is fecal material from animals and humans. Analyzing well water at its point of use for “total coliforms” is the commonest way of detecting fecal contamination of the water. Where available, testing for fecal coliforms and/or *Escherichia coli* may be performed as a combined assay with total coliforms and used for the annual bacterial testing. The absence of coliforms is good but not absolute evidence that significant fecal contamination is not present. Samples that contain any coliforms should be retested to determine if they are fecal coliforms; specimens that test positive should be examined for the presence of *E coli* or other pathogens.

MITIGATION

Bacterial
If test results confirm bacterial contamination, the water system must be treated. The first approach is to inspect the well to make sure that there are no structural defects that may have fostered the contamination. “Shock chlorination,” using concentrations of chlorine that are 100 times higher than the typical disinfecting concentration, is a typical approach used to achieve this. This practice is followed by a thorough inspection of the system to confirm that the problem has been resolved.

### TABLE 1  Relevant Chemicals in Well Water

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Source</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrates</td>
<td>Sewage</td>
<td>Methemoglobinemia</td>
</tr>
<tr>
<td></td>
<td>Fertilizer</td>
<td>Possible promoter of carcinogenesis</td>
</tr>
<tr>
<td>Volatile organics and pesticides</td>
<td>Dry-cleaning agents, gasoline, etc</td>
<td>Compound-specific effects</td>
</tr>
<tr>
<td>Lead</td>
<td>Leached from the brass in a submersible pump, from older lead pipes</td>
<td>Impairs neurocognitive development</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Occurs in specific rock formations (eg, the “slate belt” in the southeastern United States, Nevada, Alaska, and other areas in the western United States)</td>
<td>Acutely toxic carcinogenic (bladder, skin, and lung) in humans</td>
</tr>
<tr>
<td>Chromium VI</td>
<td>Used in the electroplating and other industries</td>
<td>Toxic and carcinogenic in laboratory animals</td>
</tr>
<tr>
<td>Radon</td>
<td>Naturally occurring radioactive gas</td>
<td>Carcinogenic (lung) in humans</td>
</tr>
<tr>
<td>Fluoride</td>
<td>Naturally in water in a few parts of the United States</td>
<td>Accepted preventive for dental caries, supplement if low concentrations</td>
</tr>
<tr>
<td>Uranium</td>
<td>Naturally occurring in western mountains in the United States and in areas that have granite outcrops in the eastern United States</td>
<td>Too much can cause dental fluorosis</td>
</tr>
<tr>
<td>Methyl tertiary butyl ether</td>
<td>Partially oxidized hydrocarbon fuel additive used to oxygenate gasoline</td>
<td>A source of ionizing radiation, which causes cancer</td>
</tr>
<tr>
<td>Perchlorate</td>
<td>Oxidizing agent used in rocket fuels, firework, and airbag inflators, among other applications</td>
<td>Inhibits synthesis of thyroid hormone</td>
</tr>
</tbody>
</table>

### TABLE 2  Pathogenic Microorganisms Found in Well Water

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Viruses</th>
<th>Parasites</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em>, including O157:H7</td>
<td>Norovirus, sapovirus</td>
<td><em>Giardia intestinalis</em></td>
</tr>
<tr>
<td><em>Salmonella species</em></td>
<td>Rotavirus</td>
<td><em>Cryptosporidium</em></td>
</tr>
<tr>
<td><em>Shigella species</em></td>
<td>Enteroviruses</td>
<td></td>
</tr>
<tr>
<td><em>Campylobacter jejuni</em></td>
<td>Hepatitis A and E</td>
<td><em>Cyclospora</em></td>
</tr>
<tr>
<td><em>Yersinia enterocolitica</em></td>
<td></td>
<td><em>Microsporidia</em></td>
</tr>
<tr>
<td><em>Mycobacterium avium-intracellulare</em></td>
<td></td>
<td><em>Isospora</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Naegleria fowleri</em></td>
</tr>
</tbody>
</table>
to 400 times the amount found in municipal water supplies, should be performed initially. This can be performed by the homeowner using household bleach (many Web sites [eg, www.water-research.net/shockwell disinfection.htm] have instructions), but consultation with the health department or other experienced individuals is advisable before the first time.

Most other treatment measures require the service of a trained home water-treatment professional. If bacterial contamination persists despite efforts at continuous disinfection, natural or structural factors may be present that may not be under the control of the well owner. This may require that the well be closed and a new well be drilled. A certified well contractor should fill or seal the contaminated well.

Chemical
Chemical contaminants are approached by investigating the possibility that the contamination exists on the homeowner’s or on an adjacent homeowner’s property, such as from agricultural application of nitrogen-containing fertilizers, pesticide application, or fuel tanks. If the water supply cannot be remediated further and the well is still contaminated or the chemicals in question are naturally occurring, then it is possible to filter out or treat for virtually any chemical or biological contaminant. However, treatment can become complex and/or expensive and can require meticulous or professional maintenance.

Because there are no standards for private wells for many contaminants of concern, those seeking a specific concentration to indicate potability have little choice but to apply the same standards that municipalities do under the Safe Drinking Water Act amendments of 1996 (Pub L No. 104–182 [for the current list of drinking water contaminants, see www.epa.gov/safewater/mcl.html]). Municipalities regard water that is persistently above these federal standards as not potable. Nonetheless, well owners or home occupants are under no obligation to apply this same standard to their well water.

RECOMMENDATIONS FOR PEDIATRICIANS

1. Pediatricians should ask whether a family drinks water from a private well at home, on vacation, when traveling, in child care, or other locations where they might drink water. This is particularly important for families with an infant. Families with children of high school age or younger should follow the algorithm in Appendix 1. A description of the tests and some rationale for their use is provided as follows.

Routine Testing

A. Purchase of a New Home With a Well
The builder should provide the results of coliform, nitrate, inorganic (total dissolved solids, iron, magnesium, calcium, chloride), fluoride, radon, and lead testing. If the well was shock-chlorinated after drilling, it should be retested for coliforms after some period of time as recommended by the local health department or agricultural extension agent. Have the builder or agent provide a site plan with the well, its water lines, and the septic tank and field.

B. Purchase/Rental/Lease of an Existing Home With a Well
Recommend including the well and septic field in any general inspection. If this cannot be performed, families should arrange for well inspection and testing as described in 1A and have the septic tank located and inspected to determine if it needs to be pumped. If there are filters, softeners, or other devices in the water-supply lines, determine from the seller or landlord what they are treating.

C. Vacation Homes, Camps, etc
A vacation home or camp with a shallow well and no other water source should be tested each season, if possible. If not, consider bottled water for infants or anyone with a compromised immune system. For a short stay, it may be safer and more convenient to use bottled water for drinking and cooking for everyone. Boiling water and filtration systems on the tap can reduce the risk of acquiring microorganisms from the untested well water. Boiling water means that the water must be brought to a full boil for 1 to 3 minutes, but recommendations vary and local advice should be sought. Filtration will allow viruses and possibly some Giardia cysts through.

Test kits are available for coliforms and nitrates, but it is difficult for the consumer to judge the accuracy and quality control for each product. Thus, for families with an infant, for whom it is crucial to know that the nitrate concentration is below 10 mg/L, home testing is inadvisable.

D. Child Care and School
Child care in rural and suburban areas can be in a setting where the water comes from a private well. Parents should inquire about the child care center’s water source if they have any doubt. If the water comes from a well, parents should ask whether the well has been regularly and recently tested for nitrate and coliforms and what the results were. If recent results are not available, infants should be given bottled water until the well is shown not to have excessive nitrate concentrations.

E. Scheduled Testing
Every spring, the well should be examined to make sure that there are no mechanical problems. Well water should be tested annually for coliforms and nitrates. Testing more than once per year may be warranted in the following special situations: (1) someone in the household is pregnant or nursing; (2) there are unexplained illnesses in the household; (3) neighbors find a dangerous contaminant in their well water; (4) there is a change in the odor or taste of the well water; (5) there is a chemical spill in proximity of the well; or (6) there was a significant repair or replacement in the well. Routine testing for Giardia and Cryptosporidium organisms is not recommended because of the technical difficulty.
Occasional Testing

F. New Infant
A new infant or a child younger than 1 year in the home should prompt testing if the yearly test has indicated any fluctuation in nitrate concentrations or has never been performed. Even a breastfed infant may need water at some time, and boiling does not remove and can concentrate nitrate.

G. Damage or Disturbance to the Well
If a new submersible pump is installed or the well integrity is compromised, such as by a falling tree, a vehicle collision, a flood, or a cut to the water line during landscaping, the well should be tested and, if necessary, shock-chlorinated.

H. Sentinel Illnesses
Every episode of gastroenteritis does not require well testing or an investigation of the cause of the illness. However, if multiple individuals become ill with gastroenteritis, if the gastroenteritis is recurrent, or if a pathogen causing the gastroenteritis is a bacteria or parasite that may have been present in the well water as a result of fecal contamination, then well testing for pathogens is indicated. Any occurrence of methemoglobinemia in an infant consuming well water requires testing the well water for nitrate. An elevated blood lead concentration in a child living in a home built after 1978, or a persistently elevated blood lead concentration, requires testing for lead in well water. At some point in the evaluation of unusual or cryptogenic illness, the possibility of contaminated well water should be considered. For a list of symptoms associated with various well contaminants, see the work by Wagenet et al.

2. Fluoride is an accepted preventive for dental caries, and if a child’s drinking water contains little or none, then supplements (available as drops or chewable tablets) are necessary. The American Academy of Pediatrics recommends no fluoride supplementation before 6 months of age; from 6 months to 3 years of age, children (including those who are breastfed) require fluoride supplementation if the water has a fluoride concentration of less than 0.3 ppm. Supplementation from 3 to 16 years of age is recommended where drinking water fluoride concentrations are less than 0.6 ppm. To avoid dental fluorosis, water with fluoride concentrations greater than 2 ppm should not be consumed by children younger than 9 years.

RECOMMENDATIONS TO GOVERNMENT

1. Local governments should provide access to information about local groundwater conditions. Recommendations for testing should be easily available with a telephone call or a Web-page visit. If water contamination becomes a public health issue, then multiple means of alerting and informing the public should be considered. In areas where agricultural land is being developed, paved, or put to any new use, local governments should consider mailing or using some other active means of getting their policies and recommendations concerning well testing to homes with permitted wells and the possibility of being affected by the new use.

2. Tests determined to be necessary for the safety and health of the families drinking well water should be convenient and, if possible, free or inexpensive (see Appendix 2 for current costs).

3. Community wells that serve just enough households to be regulated are sometimes exempted from testing that is required of larger systems. Although this may be appropriate, it should not be routine, and adequate local data should justify any exemption.

4. For housing that has drinking water supplied by a private well, states should require testing for coliforms, nitrate, fluoride, and any contaminant of local concern when a dwelling is sold, and the results should be made available to the buyer before closing.

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REFERENCES
APPENDIX 1 Flowchart for Testing Well Water

Well water?
- Infrequent travel, vacation, camping, visiting relatives
- Always or usually home or child care

Always or usually home or child care
- Public or private community water systems
  - <25 people or <15 households
  - No state (or federal) regulations except in New Jersey

Bottled water
- Regulated by FDA

Private water wells
- No state (or federal) regulations except in New Jersey

Public or private community water systems
- >25 people or >15 households
  - National Primary Drinking Water Regulations (NPDWR) and maximum contaminant levels (MCLs)
  - Regulated by EPA

Previously tested well
- Well changes or conditions requiring repeat of baseline tests
- Conditions or reality activities requiring testing

Baseline tests
- Total coliform bacteria
- Iron
- Fluoride
- Arsenic

Secondary (nonhealth) tests
- Total coliform bacteria
- Nitrates
- Lead (Chili test)
- Fluoride
- Arsenic

Annual tests
- Total dissolved solids (TDS)
- Hardness
- Chloride, total dissolved solids, sodium

Test results
- Fail
- Nitrates: Use bottled water
- Fix problem (ie, repairing tank, checking filtration)

Pass
- Return to annual testing
- Test again
- Repeated failures

Conditions or reality activities
- Saliency trends of different activities
- Gas drilling operations
- Failure of onsite sewage/septic systems
- Water treatment equipment

Water softener needed to treat hardness
- Manganese, iron
- Reverse-osmosis treatment
- Bottled water
- Home chlorination

Test for
- Coliform bacteria
- pH, lead, copper
- Chloride, pH, lead
- Radon
- Metals, pH, corrosion
- Nickel, perrhenate, cadmium bacteria
- Chloride, total dissolved solids, sodium
- Radon
- Lead, sulfate, barium, strontium
- Volatile organic compounds (VOCs)
- Hydrogen sulfide, ammonia, iron

Water appears cloudy, frothy, or colored
- Hardness
- Taste

Stained plumbing fixtures, laundry
- Odor, smell
- Taste

End of flowing well test results, unknown

Testing at sale/purchase of home is required by law in state of New Jersey.

Testing at sale/purchase of homes is often required by mortgage lender/bank, VA/FHA (Veteran Affairs/Federal Housing Administration), or county health department.

Maximum contaminant levels from the EPA, same as those used by public water systems. FDA indicates Food and Drug Administration.
## APPENDIX 2 Well Water Tests, Recommended Frequency, and Approximate Costs

<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
<th>Approximate Costs, 2006 $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual tests</td>
<td>Annually</td>
<td>30</td>
</tr>
<tr>
<td>Total coliform bacteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common inorganic test battery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoride</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Chloride</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>Every 3–5 y</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uranium</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Arsenic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FHA/VA loan for new well; additional 1-time tests</td>
<td>Every 10 y for homes built before 1985</td>
<td>15, stand-alone lead test</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Turbidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Odor</td>
<td>Every 3–5 y</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead (first draw) (1-time test free for FHA/VA loans)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional &quot;more thorough&quot; 1-time tests</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detergents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous individual tests</td>
<td></td>
<td>15 each</td>
</tr>
<tr>
<td>Nitrate, chloride, hardness, copper, iron, pH, manganese, color, turbidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoride, sodium, detergents, conductivity, total solids, ammonia nitrogen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arsenic, barium, cadmium, chromium, lead, silver, selenium, uranium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic compound tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volatile petroleum screen (gasoline, MTBE), in water</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Volatile petroleum screen (gasoline, MTBE), in soil</td>
<td></td>
<td>80</td>
</tr>
<tr>
<td>Diesel organics and fuel oil</td>
<td></td>
<td>140</td>
</tr>
<tr>
<td>Volatile organics screen (especially solvents, degreasers)</td>
<td></td>
<td>135</td>
</tr>
<tr>
<td>Semivolatile organic screen (including wood preservatives)</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>Semivolatile organic screen plus chlordane, PCBs, and toxaphene</td>
<td></td>
<td>275</td>
</tr>
<tr>
<td>PCBs</td>
<td></td>
<td>150</td>
</tr>
<tr>
<td>Chlorinated acids: herbicides screen</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>Carbamate pesticides</td>
<td></td>
<td>125</td>
</tr>
<tr>
<td>Radiologic tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radon in water</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Radon in air</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Radon in air (long-term) “α track”</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Gross α (radioactivity in water; does not test for radon)</td>
<td>Every 5–10 y</td>
<td>55</td>
</tr>
<tr>
<td>Gross β</td>
<td></td>
<td>55</td>
</tr>
<tr>
<td>Radium (if gross α &gt; 5 pCi)</td>
<td></td>
<td>195</td>
</tr>
<tr>
<td>Radium 228 (only)</td>
<td></td>
<td>150</td>
</tr>
<tr>
<td>Gamma</td>
<td></td>
<td>50</td>
</tr>
</tbody>
</table>

FHA indicates Federal Housing Administration; VA, Veteran Affairs; MTBE, methyl tertiary butyl ether; PCB, polychlorinated biphenyl.
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DOI: 10.1542/peds.2009-0751

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