Evaluation of Household Water Quality in Bedford County, Virginia
JUNE-JULY 2009
VIRGINIA HOUSEHOLD WATER QUALITY PROGRAM

Background

More than 1.5 million Virginia households use private water supplies such as wells, springs and cisterns. The Virginia Household Water Quality Program (VAHWQP) began in 1989 with the purpose of improving the water quality of Virginians reliant on private water supplies. Since then the program has conducted drinking water clinics in 86 counties across Virginia and has analyzed samples from more than 12,500 households. In 2007, the Virginia Master Well Owner Network (VAMWON) was formed to support the VAHWQP. Virginia Cooperative Extension (VCE) agents and volunteers participate in a 1-2 day VAMWON training workshop that covers private water system maintenance and protection, routine water testing, and water treatment basics. They are then able to educate others about private water supplies. More information about these programs may be found at our website: www.wellwater.bse.vt.edu.

Private water sources, such as wells and springs, are not regulated by the U.S. Environmental Protection Agency (EPA). Although private well construction regulations exist in Virginia, private water supply owners are responsible for the maintenance of their water systems, for monitoring water quality and for taking appropriate steps to address problems should they arise. The EPA public drinking water standards are good guidelines for assessing water quality. *Primary drinking water standards* apply to contaminants that can adversely affect health and are legally enforceable for public water systems. *Secondary drinking water standards* are non-regulatory guidelines for contaminants that may cause nuisance problems such as bad taste, foul odor, or staining. Testing water annually, and routinely inspecting and maintaining a water supply system will help keep water safe.

Geology

The western side of Bedford County lies within the Blue Ridge physiographic province of Virginia. The Blue Ridge province is a relatively narrow zone to the west of the Piedmont, from 4 to 25 miles wide, with mountains of some of the highest elevations in the state. Beneath a thin layer of soil and weathered rock lies the bedrock, a relatively impervious zone containing water primarily in joints, fractures, and faults. On the eastern flank of the Blue Ridge, igneous and metamorphic rocks are most common; sedimentary rocks are more common on the western flank. Steep terrain and thin soil covering result in rapid surface run-off and low ground water recharge. There has been little residential or industrial development in the Blue Ridge itself, so ground water use has been mainly for domestic needs rather than for public wells. The lower slopes of the mountains are the most favorable areas for ground water accumulation. Springs are common and are often used for private water supplies. Because the rocks in the Blue Ridge are relatively insoluble, the ground water is not severely mineralized, but iron content is high in some locations (GWPSC, 2008).

The eastern portion of Bedford County lies in the Piedmont physiographic provinces. The Piedmont province extends from the Blue Ridge Mountains to the center of the state. Hard, crystalline, igneous and metamorphic formations dominate this region interspersed with some areas of sedimentary rocks. Most significant water supplies are found within a few hundred feet of the surface due to the size and number of faults and fractures that store and transmit ground water. Because of the diverse subsurface geology in this region there are wide variations in ground water quality and well yields, with ground water use at many locations limited. A few areas, for example, have problems with high iron concentrations and acidity. Because of the range in ground water quality and quantity in this region, as well as the varying potential for contamination, well site evaluation and routine water quality monitoring is very important here (GWPSC, 2008).

Overview

In June 2009, 34 residents of Bedford County participated in a drinking water clinic sponsored by the local Virginia Cooperative Extension (VCE) office and the Virginia Household Water Quality Program. Clinic participants attended educational meetings where they learned how to collect a water sample, and after receiving a confidential water sample analysis, how to interpret their water test results and address potential issues. The most common household water quality issues identified as a result of the analyses for the Bedford participants was the presence of total coliform bacteria, water with low pH, and high levels of sodium and manganese. Figure 1, found at the end of this report, shows the common water quality issues along with basic information on standards, causes, and treatment options.

Drinking Water Clinic Process

Any Bedford resident relying on a well, spring or cistern was welcome to participate in the clinic. Advertising began 8 weeks prior to the first meeting and utilized local media outlets, announcements at other VCE meetings, and word of mouth. Pre-registration was encouraged.

Kickoff meeting: Participants were given a brief presentation that addressed common water quality issues in the area, an introduction to parameters included in the analysis, and instructions for collecting their sample. Sample kits with sampling instructions and a short questionnaire were distributed. The questionnaire was designed to collect information about characteristics of the water supply (e.g. age, depth, location), information about the home (e.g. age, plumbing materials, existing water treatment) and any existing perceived water quality issues. The purpose of the clinic is to build awareness among private water supply users about protection, maintenance and routine testing of their water supply.

Participants were instructed to drop their samples and completed questionnaires off at a predetermined location on a specific date and time.

Sample collection: Following collection at a central location in Bedford County, all samples were iced in coolers and promptly transported to Virginia Tech for analysis.

Analysis: Samples were analyzed for the following water quality parameters: iron, manganese, nitrate, chloride, fluoride, sulfate, pH, total dissolved solids (TDS), hardness, sodium, copper, total coliform bacteria, and *E. coli*. General water chemistry and bacteriological analyses were performed by the Department of Biological Systems Engineering Water Quality Laboratory at Virginia Tech. The Virginia Tech Soils Testing Laboratory performed the elemental constituent analyses. All water quality analyses were performed using standard analytical procedures.

The EPA Safe Drinking Water Standards, which are enforced for public water systems in the U.S., were used as guidelines for this program. Water quality parameters out of range of these guidelines were identified on each test report. Test reports were prepared and sealed in envelopes for confidential distribution to clinic participants.

Interpretation meeting: At this meeting, participants received their confidential water test reports and VCE personnel made a presentation providing a general explanation of what the numbers on the reports indicated. In addition, general tips for maintenance and care of private water supply systems, routine water quality testing recommendations and possible options for correcting water problems were discussed. Participants were encouraged to ask questions and discuss findings either with the rest of the group or one-on-one with VCE personnel after the meeting.

Findings and Results

Profile of Household Water Supplies

The questionnaire responses, provided by all 34 participants at the clinic, helped to characterize the tested water supplies. All participants in the Bedford clinic indicated their water supply was a well.

Participants were asked to classify their household environment as one of the following four categories: (1) a farm (2) a remote, rural lot (3) a rural community (4) a housing subdivision.

For the Bedford clinic, on a farm was the most common household setting (38%) followed by rural lot and rural community (26.5% each).

Sources of potential contamination near the home (within 100 feet of the well) were identified as septic systems (9%) and streams (6% of participants). Larger, more significant potential pollutant sources were also proximate (within one-half mile) to water supplies, according to participants. Thirty-five percent of respondents indicated that their water supply was located within one-half mile of a field crop production operation and 47% indicated that their supply was within one half-mile of a major farm animal operation.

The type of material used for water distribution in each home was also described by participants on the questionnaire. The two most common pipe materials were plastic (51%) and copper (45%).

To properly evaluate the quality of water supplies in relation to the sampling point, participants were asked if their water systems had water treatment devices currently installed, and if so, the type of device(s). Sixty-two percent of participants reported at least one treatment device installed. The most commonly reported treatment device was a sediment filter (35%). Other reported devices included acid neutralizer (9%) and water softener (9%).

Participants' Perceptions of Household Water Quality

Participants were asked whether they perceived their water supply to have any of the following characteristics: (1) corrosive to pipes or plumbing fixtures; (2) unpleasant taste; (3) objectionable odor; (4) unnatural color or appearance; (5) floating, suspended, or settled particles in the water; and (6) staining of plumbing fixtures, cooking appliances/utensils, or laundry.

Staining problems were reported by 44% of clinic participants. "Blue/green" stains were reportedly experienced by 27% of participants followed by "rusty" stains (18%) and "black/gray" stains (9%).

Five clinic participants reported having an objectionable odor in their water. All 5 noted having a "rotten egg" smell.

Twenty-one percent of participants at the clinic responded that floating, suspended, or settled particles were found in their water, the most common of which were "black specks" (18%) and "brown sediment" (6%).

Twenty-one percent of clinic participants responded that their water had an unpleasant taste. "Metallic" taste was the most commonly reported taste (12%) followed by "sulfur" and "bitter" at 9% each.

Six percent of participants reported that their water had an unnatural color or appearance. "Black/gray" and "oily film" were reported by 3% of the participants each.

Bacteriological Analysis

Private water supply systems can become contaminated with potentially harmful bacteria and other microorganisms. Microbiological contamination of drinking water can cause short-term gastrointestinal disorders, such as cramps and diarrhea that may be mild to very severe. Other diseases that may be contracted from drinking contaminated water include viral hepatitis A, salmonella infections, dysentery, typhoid fever, and cholera.

Microbiological contamination of a water supply is typically detected with a test for total coliform bacteria. Coliform bacteria are present in the digestive systems of humans and animals and can also be found in the soil and decaying vegetation. While coliform bacteria do not cause disease, they are indicators of the possible presence of disease causing bacteria, so their presence in drinking water warrants additional testing.

Since total coliform bacteria are found throughout the environment, water samples can become accidentally contaminated during sample collection. Positive total coliform bacteria tests are often confirmed with a re-test. If coliform bacteria are present in a water supply, there are several possible pathways or sources, including: (1) improper well location or inadequate construction or maintenance (well too close to septic, well not fitted with sanitary cap), (2) contamination of the household plumbing system (e.g. contaminated faucet, water heater), and (3) contamination of the groundwater itself (perhaps due to surface water/groundwater interaction).

The presence of total coliform bacteria in a water sample triggers testing for the presence of *E. coli* bacteria. If *E. coli* are present, it indicates that human or animal waste is entering the water supply.

Of the 34 samples collected, 53% tested positive (present) for total coliform bacteria. Subsequent *E. coli* analyses for all of these samples showed that 3% of the samples tested positive for *E. coli* bacteria.

Program participants whose water tested positive (present) for total coliform bacteria were encouraged to retest their water to rule out possible cross contamination, and were given information regarding emergency disinfection, well improvements, and septic system maintenance. Any participant samples that tested positive for *E. coli*, were encouraged to take more immediate action, such as boiling water or using another source of water known to be safe until the source of contamination could be addressed and the water supply system disinfected. After taking initial corrective measures, participants were advised to have their water retested for total coliform, followed by testing for *E. coli*, if warranted. In addition participants were provided with resources that discussed continuous disinfection treatment options.

Table 1, found at the end of this report, shows the general water chemistry and bacteriological analysis contaminant levels for the Bedford County drinking water clinic participants.

Chemical Analysis

As mentioned previously, all samples were tested for the following parameters: iron, manganese, nitrate, chloride, fluoride, sulfate, pH, total dissolved solids (TDS), hardness, sodium, and copper. Selected parameters of particular interest for the Bedford drinking water clinic samples are discussed below.

Manganese

Like iron, manganese is a nuisance contaminant and does not present a health risk. The EPA recommended maximum contaminant level is 0.05 mg/L. Excessive manganese concentrations may give water a bitter taste and can produce black stains on laundry, cooking utensils, and plumbing fixtures.

Twelve percent of Bedford clinic samples tested above 0.05mg/L. Treatment options for manganese include a water softener, reverse osmosis or distillation.

Hardness

Hard water contains high levels of calcium and magnesium ions that dissolve into groundwater while it is in contact with limestone and other minerals. Hard water is a nuisance and not a health risk.

Three percent of the clinic samples were considered to be "very hard" (exceeding 180mg/L of hardness). Hard water is indicated by scale build-up in pipes and on appliances, decreased cleaning action of soaps and detergents, and reduced efficiency and lifespan of water heaters. Ion exchange water softeners are typically used to remove water hardness.

pH

pH is a measure of the acidity or alkalinity of a substance. The EPA suggests the pH for public drinking water be between 6.5 and 8.5. Of the 34 Bedford County clinic samples, 12% were below the recommended pH of 6.5, indicating acidic water. Although not a health concern in itself, acidic water may be corrosive and can potentially leach metals like copper and lead from plumbing components. An option for dealing with low pH water is to install an acid neutralizing filter which raises pH by passing the water through a medium of calcite and/or magnesium oxide.

If the age of a home or the plumbing materials present in a home pointed to potential health problems associated with metals leaching into water, participants were encouraged to pursue lead testing, which is not currently available through the VAHWQP.

Sodium

The EPA limit for sodium in drinking water (20 mg/L) is targeted to the most at-risk segment of the population, those with severe heart or high-blood pressure problems. The variation in sodium added to water by softeners is very large (ranging from around 50 mg/L to above 300 mg/L). Sodium in drinking water should be considered with respect to sodium intake in the diet. The average American adult consumes 2000 - 4000 mg of sodium per day. If you are concerned about the presence of sodium in your drinking water, discuss your intake with your physician.

Of the 34 clinic samples, 12% exceeded the EPA standard of 20 mg/L. Some of these sodium levels could result from the sodium which is naturally present in the geology (rocks, sediment) where well water originates. The other primary source of sodium is a water softener. There are several options for addressing sodium levels in softened water. Since only water used for washing needs to be softened, a water treatment specialist can bypass cold water lines around the softener itself, softening only the hot water, which limits the sodium content in the cold drinking water. Another option is using potassium chloride instead of sodium chloride for the softener, although this option is more expensive.

Nitrate

High levels of nitrate may cause methemoglobinemia or "blue-baby" disease in infants under six months of age. The EPA public water supply standard is 10 milligrams per liter (mg/L) nitrate-nitrogen. Levels approaching 3-5 mg/L or higher may indicate contamination of the water supply by fertilizers or organic waste, so use of this water for infants under 6 months of age is discouraged.

Nitrate is tasteless, odorless, and easily dissolved, meaning it moves freely with water. Of the 34 clinic samples, 12% exceeded the 10 mg/L standard. Participants were warned that boiling water increases concentration of any dissolved pollutant like nitrates and thus is not a variable treatment option. Possible nitrate treatment options include distillation, reverse osmosis, ion exchange or use of another source of water for infants.

Conclusions

Participants were asked to complete a program evaluation survey following the interpretation meeting. Of those who completed the survey, 75% indicated they would test their water either annually or at least every few years. Seventy-five percent indicated that they would discuss what they learned during their participation in the clinic with others. Forty percent of respondents indicated that based on their analysis results, they would perform additional testing. Twenty percent stated that they would try to determine the source of pollution affecting their water supply. Finally, another 10% said they would pump out their septic system and 5% reported they would grade the area around their well or improve maintenance of their water system.

References

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Virginia Department of Environmental Protection Groundwater Protection Steering Committee. Virginia's Five Physiographic Provinces. http://www.deq.state.va.us/gwpsc/geol.html. Accessed online 9/2008.

Additional Resources

For more information about the water quality problems described in this document, please refer to our website to find resources regarding household water testing, interpretation, and solutions to water quality problems.
www.wellwater.bse.vt.edu/resources.php

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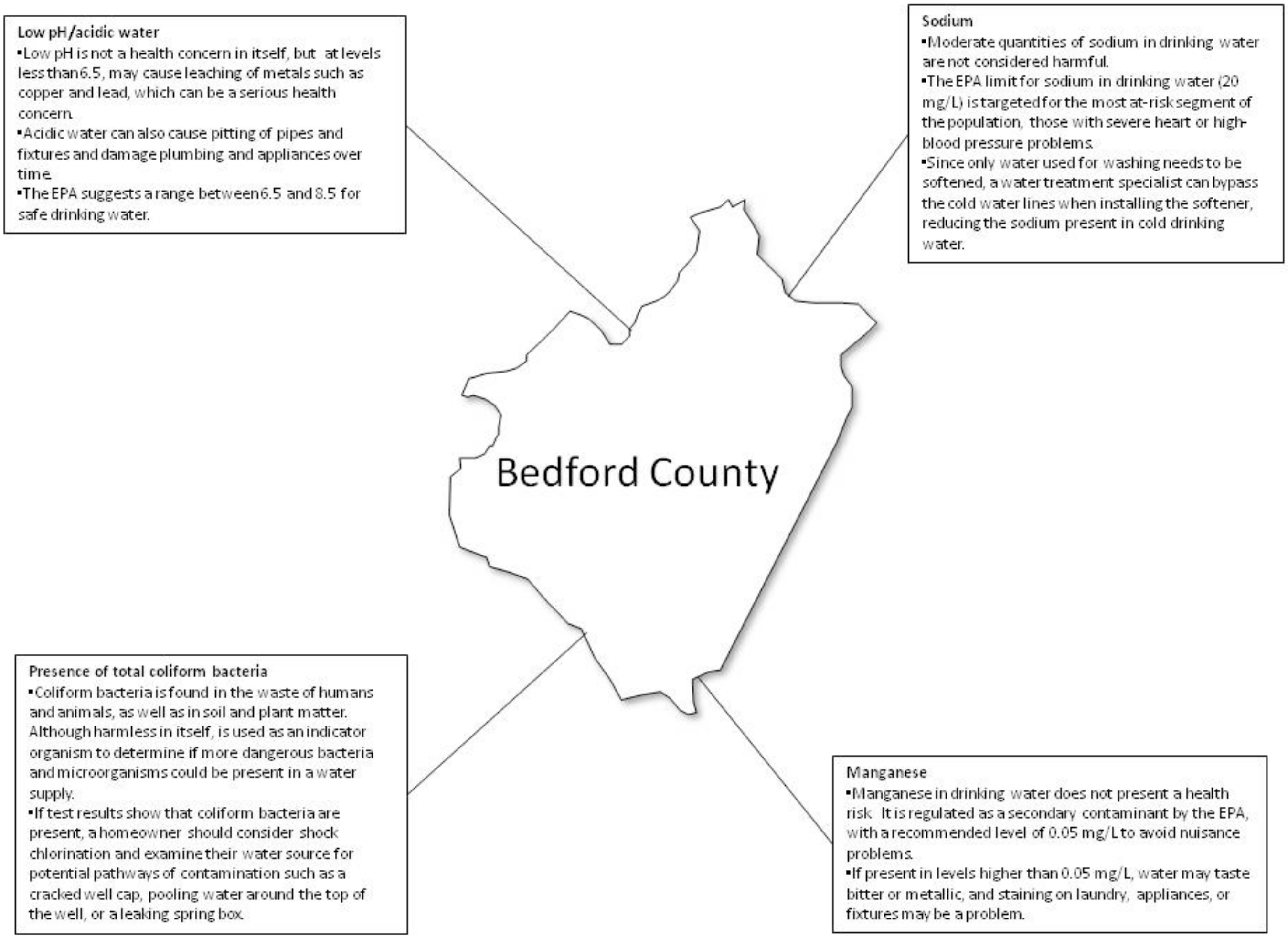

Figure 1. The most common household water-quality issues found in the 34 Bedford clinic participant samples were high levels of sodium and manganese, low pH, and the presence of total coliform bacteria.

2009 Bedford County ***VAHWQP Drinking Water Clinic Results*** *N = 34 participants*				
Test	**Std**	**Ave**	**Max/Extreme**	**% Exceeding Std**
Iron (mg/L)	0.3	0.009	0.064	0
Manganese (mg/L)	0.05	0.018	0.165	11.8
Hardness (mg/L)	180	54.2	202.2	2.9
Sulfate (mg/L)	250	5.8	87.1	0
Chloride (mg/L)	250	3	12	0
Fluoride (mg/L)	2.0/4.0	0.25	1.6	0
Total Dissolved Solids (mg/L)	500	92	288	0
pH	6.5 to 8.5	7.17	8	11.8 (< 6.5)
Copper (mg/L)	1.0/1.3	0.032	0.19	0
Sodium (mg/L)	20	9.67	44.03	11.8
Nitrate-N (mg/L)	10	3.854	26.4	11.8
Total Coliform Bacteria	ABSENT	--	--	52.9
E. coli Bacteria	ABSENT	--	--	2.9

Table 1. General water chemistry and bacteriological analysis contaminant levels for Bedford County drinking water clinic participants (N=34). This program uses the EPA *primary* and *secondary standards* of the Safe Drinking Water Act. While these standards are enforced by law for public water systems, this program uses them only as guidelines for the private water systems tested.