Evaluation of Household Water Quality in Frederick County, Virginia

MAY 2010

VIRGINIA HOUSEHOLD WATER QUALITY PROGRAM

Background

More than 1.7 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 drinking water clinics have been conducted in 86 counties across Virginia and samples analyzed from more than 14,500 households. In 2007, the Virginia Master Well Owner Network (VAMWON) was formed to support the VAHWQP. Virginia Cooperative Extension agents and volunteers participate in a 1 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 their private water supply. 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 maintaining their water systems, for monitoring water quality and for taking appropriate steps to address problems should they arise. The EPA Safe 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

Frederick County lies within the ***Valley and Ridge*** physiographic province of Virginia. Consolidated sedimentary rocks deposited beneath ancient seas underlie the Valley and Ridge province to the west of the Blue Ridge. In the lowlands, such as the Shenandoah Valley, limestone and dolomite occur beneath the surface, forming the most productive aquifers in Virginia's consolidated rock formations. In contrast, sandstone and shale are often present on ridges and upland areas, which yield only enough water for rural and domestic supplies. (GWPSC, 2011)

The connection between groundwater and surface water plays a major role in ground water recharge in the Valley and Ridge, where streams often cross fault zones and recharge aquifers. Wells in the fault zones have the greatest yields. Recharge also occurs through surface run-off into limestone sinkholes, bypassing filtration through the soil. This process can cause serious water quality problems since polluted surface water may directly enter the groundwater system. Groundwater quality can also be adversely affected by private trash dumps located in sinkholes that receive surface runoff. In addition, carbonate geology contribute to the "hardness" of the ground water. (GWPSC, 2008)

Overview

In May 2010, 36 residents from Frederick County participated in a drinking water clinic sponsored by the local Virginia Cooperative Extension (VCE) offices and the Virginia Household Water Quality Program. Clinic participants received a confidential water sample analysis and attended educational meetings where they learned 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 participants were low and high pH, high levels of

manganese, hardness, TDS, and sodium, and the presence of total coliform bacteria. *Figure 1*, found at the end of this report, shows these common water quality issues along with basic information on standards, causes, and treatment options.

Drinking Water Clinic Process

Any Frederick County 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, and location), the home (e.g. age, plumbing materials, existing water treatment), and any existing perceived water quality issues. The purpose of the clinic was to build awareness among private water supply users about protection, maintenance, and routine testing of their water supply.

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

Sample collection: Following collection at a central location, 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 Environmental Protection Agency (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 not within 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 final 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 36 participants at the clinic, helped to characterize the tested water supplies. All participants in the clinic indicated their water supply was a well.

Participants were asked to classify their housing location as one of four categories. The choices, ranging from low to high density development, are: (1) on a farm, (2) on a remote, rural lot, (3) in a rural community, and (4) in a housing subdivision.

For the Frederick clinic, rural community was the most common household setting (47%), followed by a subdivision (25%).

Major sources of potential contamination near the home (within 100 feet of the well) were identified as septic systems (8%) and oil tanks (6%). Larger, more significant potential pollutant sources were also proximate (within one-half mile) to water supplies, according to participants. Forty-four percent of respondents indicated that their water supply was located within one-half mile of a major farm animal operation and nineteen percent indicated that their supply was within one half-mile of a field crop 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 copper (64%) and plastic (22%).

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. Fifty-six percent of participants reported at least one treatment device installed. The most commonly reported treatment device was a water softener (47%) followed by a sediment filter (17%).

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 47% of clinic participants. Rusty (25%) and white/chalky (22%) stains were the most commonly reported.

An objectionable odor was reported by thirty-nine percent of clinic participants, all citing a rotten egg smell in their water.

Eleven percent of participants reported unpleasant tastes, indicating sulfur (8%) and bitter and metallic tastes (3% each).

Finally, six percent reported an unnatural appearance in their water, observed as muddy or milky (3% 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 be found in the soil and in 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, possible pathways or sources include: (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 36 samples collected, 53% tested positive (present) for total coliform bacteria. Subsequent *E. coli* analyses for all of these samples showed that 17% 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 Frederick 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 Frederick drinking water clinic samples are discussed below.

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 36 Frederick County clinic samples, 6% 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.

Three percent of the clinic samples were above the recommended pH of 8.5. Water with a high pH level is characterized by a slippery feel, soda taste, and scaly deposits. Acid injection is used to lower the pH level, a process in which sulfuric, phosphoric, or hydrochloric acid is injected into the water supply.

Sodium

The EPA limit for sodium in drinking water (20 mg/L) is targeted for 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 concerned about sodium in water, intake should be discussed with a physician.

Of the 36 clinic samples, 53% exceeded the EPA standard of 20 mg/L. Some of this sodium could result from sodium naturally present in the geology (rocks, sediment) where well water originates, but the primary source of sodium is a water softener. Forty-seven percent of Frederick participants reported having a water softener installed. 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, softening only the hot water and reducing the sodium in the cold drinking water. Another option is using potassium chloride instead of sodium chloride for the softener, although this option is more expensive.

Total Dissolved Solids (TDS)

As water moves underground or over land, it dissolves a variety of compounds including minerals, salts and organic compounds. The concentration of *total dissolved solids* (TDS) in a water sample is a measure of all dissolved impurities. A TDS test measures all dissolved impurities in a water sample, but does not identify individual compounds or their sources. High concentrations of dissolved solids may cause adverse taste and may lead to increased deterioration of household plumbing and appliances. The EPA secondary drinking water standard is 500 mg/L for TDS. Twenty percent of the Frederick samples exceeded this standard.

Sulfate

High sulfate concentrations may result in adverse taste, and may have a laxative effect on those who are unaccustomed to drinking high sulfate water. The Secondary Maximum Contaminant Level for sulfate is 250 mg/l. Sulfates are often found in groundwater, and may be linked to other sulfur-related problems, such as hydrogen sulfide gas, which gives water a “rotten-egg” odor or taste. Hydrogen sulfide gas occurs naturally as a result of the activities of sulfur-reducing bacteria, which feed on small amounts of sulfur in water and thrive in low oxygen environments common in groundwater wells. These bacteria may cause an unpleasant taste or odor, but they do not present a health threat to humans. Sulfate levels exceeding 250 mg/L were found in 3 percent of samples in Frederick County.

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.

Thirty-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. Hard water is very common in the Valley and Ridge physiographic province because of the prevalence of carbonate formations in the region. Ion exchange water softeners are typically used to remove water hardness.

Nitrate

High levels of nitrate may cause methemoglobinemia or “blue-baby” syndrome in infants less than 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 and odorless, and easily dissolved, meaning it moves freely with water. Although none of the clinic samples exceeded the 10 mg/L standard, 2 samples were found within the 3-10 mg/L standard. Participants were warned that boiling water increases concentration of any dissolved pollutant like nitrate and thus is not a viable 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 that completed the survey, 100% indicated they would test their water either annually or at least every few years. Ninety-one percent indicated that they would discuss what they learned through their participation in the clinic with others. Finally, 55% will determine the source of pollution in their well and 27% of respondents plan on improving the functioning of their existing treatment systems.

References

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Virginia Cooperative Extension. Virginia PowerPoint Map. http://www.intra.ext.vt.edu/marketing/maps/powerpoint.html Accessed online 4/2011.

Virginia Department of Environmental Protection Groundwater Protection Steering Committee. Virginia’s Five Physiographic Provinces. http://www.deq.virginia.gov/gwpsc/geol.html Accessed online 4/2011.

Additional Resources

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

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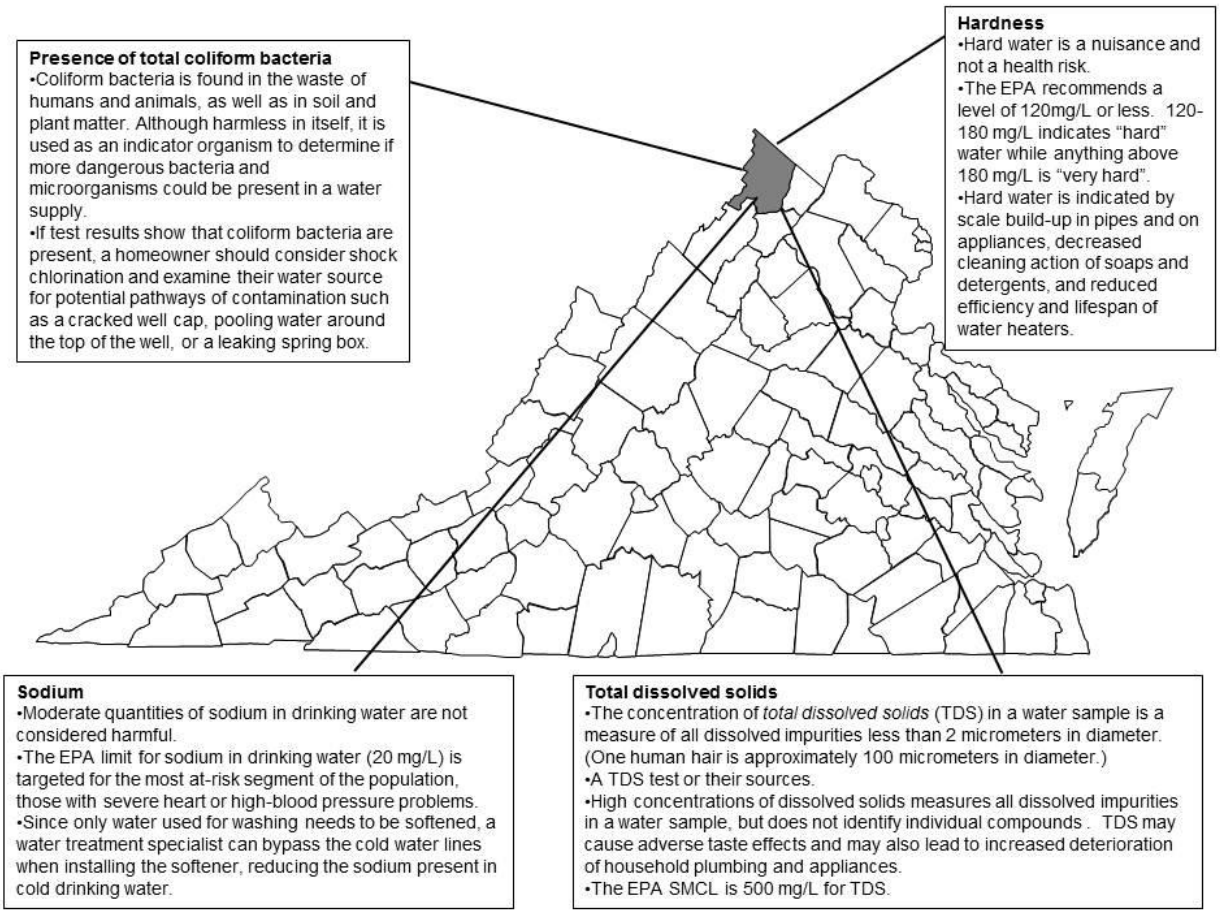

Figure 1. The most common household water-quality issues found in the 36 Frederick clinic participant samples were high levels of sodium, hardness, total dissolved solids, and the presence of total coliform bacteria.

2010 Frederick County VAHWQP Drinking Water Clinic Results N = 36 participants				
Test	EPA Standard	Average	Maximum Value	% Exceeding Standard
Iron (mg/L)	0.3	0.013	0.103	0
Manganese (mg/L)	0.05	0.109	2.397	13.9
Hardness (mg/L)	180	143.2	454.5	33.3
Sulfate (mg/L)	250	37.0	506.4	2.8
Chloride (mg/L)	250	17.0	173	0
Fluoride (mg/L)	2.0/4.0	0.16	1.06	0
Total Dissolved Solids	500	381.0	1541	19.5
pH	6.5 to 8.5	7.17	5.6/9.1	5.6 (<6.5) 2.8 (>8.5)
Copper (mg/L)	1.0/1.3	0.010	0.033	0
Sodium (mg/L)	20	65.19	430.83	52.8
Nitrate - N (mg/L)	10	0.905	3.99	0
Total Coliform Bacteria	ABSENT	--	--	52.8
E. coli Bacteria	ABSENT	--	--	16.7

Table 1. General water chemistry and bacteriological analysis contaminant levels for the Frederick County drinking water clinic participants (N=36). This program uses the EPA primary and secondary standards of the Safe Drinking Water Act, which are enforced for public systems, as guidelines for private water supplies.