Evaluation of Household Water Quality in Page and Shenandoah Counties, Virginia

JUNE 2012

VIRGINIA HOUSEHOLD WATER QUALITY PROGRAM

Background

More than 1.7 million Virginians 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 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 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

Page and Shenandoah counties both lie within the ***Valley and Ridge*** physiographic province of Virginia. The Valley and Ridge is located to the west of the Blue Ridge province and is underlain by consolidated sedimentary rocks deposited by ancient seas. In the lowlands, such as the Shenandoah Valley, limestone and dolomite occur beneath the surface. These rock types have openings to yield water to wells and form the most productive aquifers in Virginia's consolidated rock formations. In contrast, the ridges and upland areas are often composed of sandstone and shale, which lack the cracks and pores to transmit or store water. Therefore, in ridges and upland areas, there is often only enough water for rural and domestic water supplies.

The connection between groundwater and surface water plays a major role in groundwater recharge in the Valley and Ridge. Streams often cross fault zones leading to recharge of aquifers and wells in the fault zone area. Recharge also occurs through surface runoff travelling into limestone sinkholes, bypassing filtration through the soil. This can cause serious water quality problems since polluted surface water may be introduced directly into the groundwater system. In addition, calcium and magnesium from carbonate formations contribute to high mineral content and can cause hard water (GWPSC, 2008).

Overview

In June 2012, 34 residents from Page County and 22 residents from Shenandoah County participated in drinking water clinics sponsored by local Virginia Cooperative Extension (VCE) offices and the Virginia Household Water Quality Program. The Page County Water Quality Advisory Committee had a small grant from the Shenandoah Valley Project of the Agua Fund and decided to use some of the grant to encourage participation in the Drinking Water Clinic. The WQAC purchased 2 advertisements in the Page News and Courier newspaper and voted to reduce the cost of the clinic by $20 for the first 50 participants from Page County.

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 were high levels of hardness, sodium, total dissolved solids, 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 resident relying on a well, spring, or cistern was welcome to participate in the clinic. Advertising began about 8 weeks prior to an initial kickoff 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 questionnaire also gathered basic demographic information about the household, including household income, age and education level of residents, and whether or not household members drink the water from the private water supply being tested. 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 in each 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, fluoride, sulfate, pH, total dissolved solids (TDS), hardness, sodium, copper, lead, arsenic, total coliform bacteria, and *E. coli*. General water chemistry and bacteriological analyses were performed by the Department of Biological Systems Engineering Water Quality Laboratory and Civil and Environmental Engineering Department at Virginia Tech. 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 not within range of these guidelines were identified on each water sample report. Reports were prepared and sealed in envelopes for confidential distribution to clinic participants.

Interpretation meeting: At the interpretation 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 54 participants, helped to characterize the tested water supplies. Ninety-four percent of participants in the Page County clinic indicated their water supply was a well; two participants reported having a spring. In Shenandoah County, all participants had a well except one, who had a spring.

The most commonly reported potential source of contamination near the home (within 100 feet of the well) was identified in the Page group as a stream (8.8%), a septic system (5.8%) or an oil tank (5.8%). In Shenandoah County, 18.1% reported their wells being located within 100 feet of an oil tank, and 9% as located near a septic system. According to participants, larger, more significant potential pollutant sources were also proximate (within one-half mile) to water supplies. Sixty-one percent of Page respondents indicated that their water supply was located within one-half mile of a major farm animal operation and 29.4% indicated that their supply was within one half-mile of a field crop operation. Similarly, 40.9% of Shenandoah participants indicated they were proximate to a farm animal operation and 27.2% of wells tested were located near field crop operations. Other nearby sources of potential contamination included old quarries and golf courses.

On the questionnaire, participants also described the type of material used for water distribution in each home. The two most common pipe materials in Page County were copper (70.5%) and plastic (44.1%), and in Shenandoah, were 68% copper and 50% plastic. Many homes were reported as having more than one type of plumbing material, which is quite common.

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-eight percent of Page participants reported at least one treatment device installed. The most commonly reported treatment device was a sediment filter (38.2%) followed by a water softener, installed by 20.5% of participants. In the Shenandoah County group, 72.7% of participants reported using water treatment. The most commonly installed devices were a water softener (54.5%), followed by a sediment filter (31.8%).

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.

Page County:

Staining problems were reported by 50% of clinic participants in Page County. Rusty (26.4%) was the most commonly reported stain. An objectionable odor was reported by 14.7% of clinic participants, mainly citing a rotten egg smell in their water (11.7%). About 12% reported unpleasant tastes, indicating sulfur and metallic as the most common (each chosen by 5.8% of participants). Almost 15% reported having particles in their water, the most common being white flakes (9%). Finally, nearly 9% reported an unnatural appearance in their water, observed as muddy (5.8%).

Shenandoah County:

Issues with corrosion were reported by 9% of Shenandoah participants. Just over 13% reported unpleasant taste in their water, with "sulfur" being the most common. About a fifth of this group stated that their water had an objectionable odor, most commonly described as "rotten egg" (18%). Nine percent reported their water having an unnatural appearance, with "muddy" or "yellow" being the most common descriptors. Particles in water were associated with 18% of samples. Finally, staining problems were the most common aesthetic problem reported: 45% of participants reported with rusty or white, chalky staining issues.

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.

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 (e.g. 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 in Page County, 36.4% 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. In Shenandoah County, 40.9% were positive for total coliform, and 13.6% showed presence of *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 with a sample that tested positive for *E. coli*, was 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 Page and Shenandoah drinking water clinic participants.

Chemical Analysis

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

Lead

Lead is not commonly found in groundwater, but may enter household water as it travels through plumbing materials. Lead can cause irreversible damage to the brain, kidneys, nervous system, and blood cells, and is a cumulative poison, meaning that it can accumulate in the body until it reaches toxic levels. Young children are most susceptible, and mental and physical development can be irreversibly stunted by lead poisoning. Lead may be found in household water from homes built prior to 1930 with lead pipes, prior to 1986 with lead solder, or in new homes with "lead-free" brass components, which may legally contain up to 8% lead. The EPA limit for lead in public drinking water is 0 mg/L, and the health action limit is 0.015 mg/L. In these drinking water clinics, participants collect two samples from their taps: 1) a *first draw* sample, which is drawn first thing in the morning after the water hasn't been used in at least 6 hours, and therefore has a substantial contact time with the plumbing and 2) a *flushed* sample, taken after water has been run for 5 minutes, and therefore has not had significant contact with pipes. If lead is present above 0.015 mg/L in the first draw sample, but is not detected in the flushed sample, simply running the water for a few minutes prior to collecting water for drinking may remedy the problem. Alternatively, addressing the corrosiveness (acidity) of your water by installing an acid neutralizing filter may solve the problem. Reverse osmosis systems or activated carbon filters (labeled to remove lead) can remove it from your water.

In the Page group, 12% of first draw samples exceeded 0.015 mg/L lead, and in Shenandoah, 19% did. In both groups, no flushed samples exceeded 0.015 mg/L.

Sodium

The EPA limit for sodium in drinking water (20 mg/L) is targeted for the most at-risk segment of the population, which are 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 34 Page clinic samples, 27.3%, and in Shenandoah, 52.4% 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. 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 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 effects and may lead to increased deterioration of household plumbing and appliances. The EPA secondary maximum contaminant level (SMCL) is 500 mg/L for TDS. 14.7% of Page county participants and 19% of Shenandoah samples exceeded this level.

Hardness

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

In Page County, 35.2% of the clinic samples were considered "very hard" (exceeding 180mg/L of hardness), and in Shenandoah, 42.9% exceeded this level. 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.

Conclusion

Clinic participants received objective information about caring for and maintaining their private water supply systems, and specific advice about addressing any problems that were identified through the analysis of their water sample.

References

U.S. Environmental Protection Agency. Drinking Water Contaminants. http://www.epa.gov/safewater/contaminants/index.html. Accessed online 8/2012.

Virginia Cooperative Extension. Virginia PowerPoint Map. http://www.intra.ext.vt.edu/marketing/maps/powerpoint.html Accessed online 8/2012.

Virginia Department of Environmental Protection Groundwater Protection Steering Committee. Virginia's Five Physiographic Provinces. http://www.deq.virginia.gov/Programs/Water/WaterSupplyWaterQuantity/GroundwaterProtectionSteeringCommittee.aspx. Accessed online 8/2012.

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

Acknowledgements

Many thanks to the residents of Page and Shenandoah Counties who participated in the drinking water clinic.

The Water Quality Laboratory of the Department of Biological Systems Engineering and Department of Civil and Environmental Engineering at Virginia Tech were responsible for water quality analyses, as well as data management.

This document was prepared by Brian L. Benham, Associate Professor and Extension Specialist at Virginia Tech; Erin James Ling, Extension Water Quality Program Coordinator; Karen Poff, VCE Shenandoah Office; and

Kristine Bronnenkant, Graduate Research Assistant.

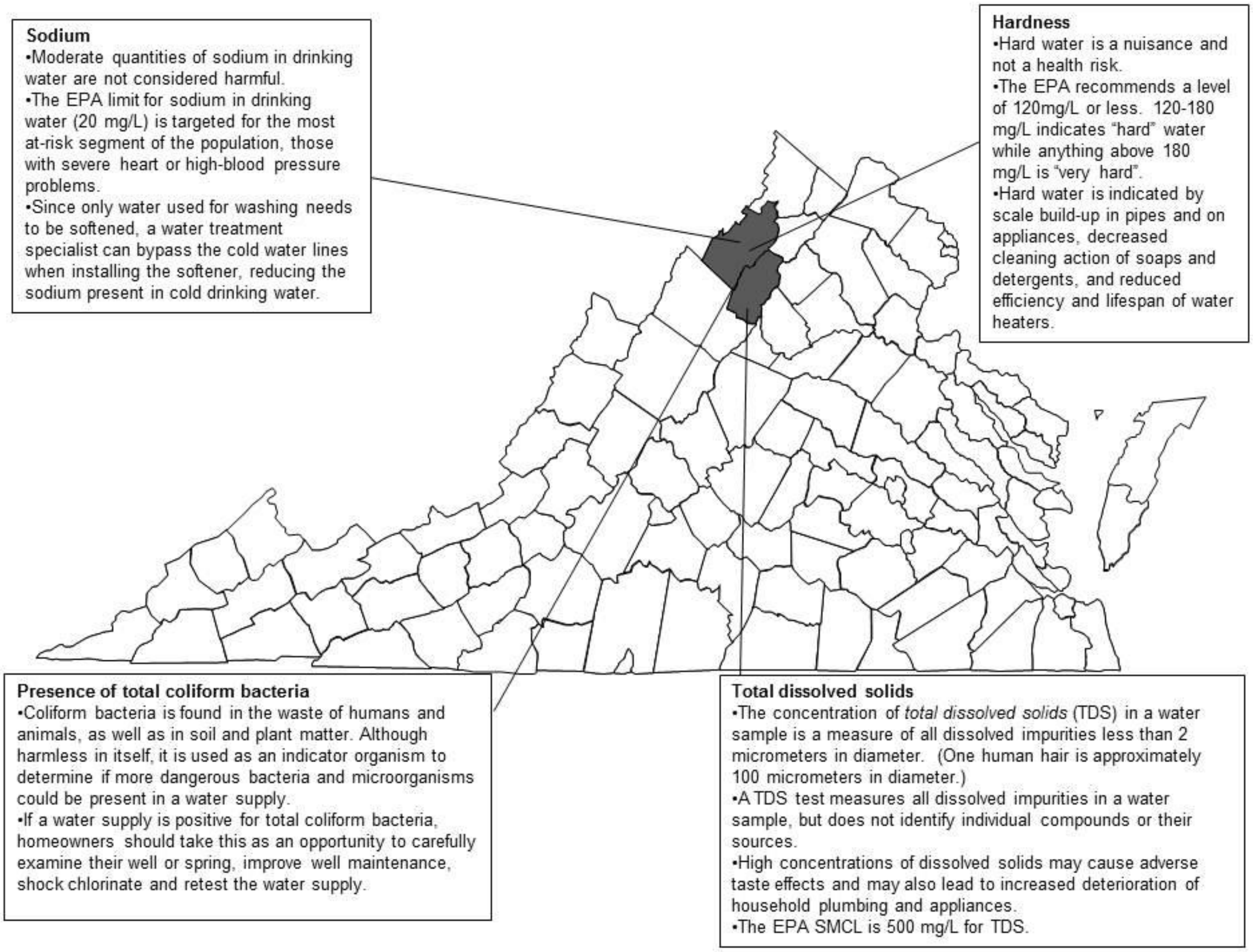

Figure 1. The most common household water quality issues found in the 34 Page County and 22 Shenandoah clinic participant samples were high levels of sodium, hardness, total dissolved solids, and the presence of total coliform bacteria.

Table 1. General water chemistry and bacteriological analysis contaminant levels for the Page (N=34) and Shenandoah (N=22) County drinking water clinic participants. 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.

2012 Page and Shenandoah County VAHWQP Drinking Water Clinic Results *N = 34 samples (Page) and 22 samples (Shenandoah)*							
Test	**EPA Standard**	**Average**		**Maximum Value**		**% Exceeding Standard**	
		Page	Shen	Page	Shen	Page	Shen
Iron (mg/L)	0.3	0.033	0.630	0.311	13.25	2.9	4.5
Manganese (mg/L)	0.05	0.020	0.041	0.545	0.471	5.9	13.6
Hardness (mg/L)	180	149	164.7	568.6	446.2	35.3	40.9
Sulfate (mg/L)	250	134	115.9	1,011	653	20.6	9.1
Fluoride (mg/L)	2.0/4.0	0.16	0.17	0.43	0.34	0.0	0.0
Total Dissolved Solids	500	310	287	951	654	14.7	18.2
pH	6.5 to 8.5	7.3	7.4	5.6 (min) 8 (max)	6.9 (min) 8.2 (max)	(<6.5) 5.9 (>8.5) 0	(<6.5) 0 (>8.5) 0
Sodium (mg/L)	20	37.01	68.08	202.7	250.8	29.4	50.0
Nitrate - N (mg/L)	10	1.324	2.984	7.789	17.51	0.0	4.5
Copper-First Draw (mg/L)	1.0/1.3	0.561	0.171	6.895	0.92	32.4	0
Copper-Flushed (mg/L)	1.0/1.3	0.046	0.024	0.51	0.161	5.9	
Lead-First Draw (mg/L)	0.015	0.007	0.009	0.033	0.052	11.8	18.2
Lead-Flushed (mg/L)	0.015	0	0.001	0.003	0.011	0.0	0
Arsenic-First Draw (mg/L)	0.010	0	0.001	0	0.001	0.0	0
Arsenic-Flushed (mg/L)	0.010	0	0.001	0	0.001	0.0	0
Total Coliform Bacteria	ABSENT	704	1108	22,749	22,749	35.3	40.9
E. coli Bacteria	ABSENT	0	9	8	189	2.9	13.6