Evaluation of Household Water Quality in Augusta County, Virginia
SEPTEMBER-NOVEMBER 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

Augusta County is located predominantly in the Valley and Ridge physiographic province in 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 the rock types often present in the ridges and upland areas, which yield only enough water for rural and domestic supplies.

The connection between ground water and surface water plays a major role in ground water recharge in the Valley and Ridge, where streams often cross fault zones recharging 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 can cause serious water quality problems since polluted surface water may be introduced directly into the ground water system. Ground water quality can also be adversely affected by private trash dumps located in sinkholes that receive surface run-off. In addition, carbonate formations contribute to the "hardness" of the ground water (GWPSC, 2008).

Overview

In September 2009, 223 residents of Augusta 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 Augusta participants 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 Augusta 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. These clinics are intended 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 Augusta 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 223 participants at the clinic, helped to characterize the tested water supplies. All participants in the Augusta 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 Augusta clinic, farm was the most common household setting (38%), followed by rural community (33%).

Sources of potential contamination near the home (within 100 feet of the well) were identified as home-heating oil tanks (16%) and septic systems (12% of participants). Larger, more significant potential pollutant sources were also proximate (within one-half mile) to water supplies, according to participants. Forty-nine percent of participants indicated that their water supply was located within one-half mile of a field crop production operation and 76% 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 copper (45%) and plastic (33%).

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). Fifty-one percent of participants reported at least one treatment device installed. The most commonly reported treatment device was a water softener (34%), followed by sediment filter (20%).

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 40% of clinic participants. "White/chalky" stains were reportedly experienced by 23% of participants followed by "rusty" stains (19%).

An objectionable odor was reported by 13% of participants, of which the most common response was as a "rotten egg" smell (25%). Four percent indicated that their water had a "musty" smell.

Eighteen percent of participants at the clinic responded that floating, suspended, or settled particles were found in their water, the most common of which were "white flakes" (13%).

Ten percent of clinic participants responded that their water had an unpleasant taste. "Metallic" taste was the most commonly reported taste (4%) followed by "sulfur" (3%).

Ten percent of participants reported that their water had an unnatural color or appearance. The most common responses were "muddy" (4%) and "milky" (2%).

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 retest. 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 223 samples collected, 46% tested positive (present) for total coliform bacteria. Subsequent *E. coli* analyses for all of these samples showed that 9% 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 Augusta 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 Augusta 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.

Six percent of Augusta clinic samples tested above 0.05 mg/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.

Fifty-five percent of the Augusta 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.

Total Dissolved Solids (TDS)

High concentrations of total dissolved solids (TDS) may cause adverse taste effects and may also lead to increased deterioration of household plumbing and appliances. The EPA recommended level is 500 mg/L for TDS. Seventeen percent of Augusta samples exceeded this standard. High TDS levels may be attributed to high levels of hardness or softened water.

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 223 Augusta County clinic samples, 5% were below the recommended pH of 6.5, indicating acidic water. Although not a health concern in itself, acidic water is 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. One teaspoon of table salt has 2,325 mg of sodium. If you are concerned about the presence of sodium in your drinking water, discuss your intake with your physician.

Of the 223 clinic samples, 32% exceeded the EPA standard of 20 mg/L. It is possible that some of these sodium levels could result from the sodium which is naturally present in the geology (rocks, sediment) where well water originates. The primary source of sodium, however, 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 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 less than 6 months of age is discouraged.

Nitrate is tasteless, odorless, and easily dissolved, meaning it moves freely with water. Of the 223 clinic samples, 1% 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, 87% indicated they would test their water either annually or at least every few years. Eighty percent indicated that they would discuss what they learned during their participation in the clinic with others. Thirty-three percent of respondents indicated that based on their analysis results, they would perform additional testing. Nineteen percent stated that they would try to determine the source of pollution affecting their water supply. Finally, another 30% said they would pump out their septic system and 19% reported they would grade the area around their well or improve maintenance of their water system.

References

Mayo Clinic. Sodium: How to tame your salt habit now. http://www.mayoclinic.com/health/sodium/NU00284. Accessed online 9/2010.

U.S. Environmental Protection Agency. Drinking Water Contaminants. http://www.epa.gov/safewater/contaminants/index.html. Accessed online 9/2008.

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. 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 Augusta County who participated in the evaluation of their household water quality.

The Water Quality Laboratory of the Department of Biological Systems Engineering (Gail Zatcoff) and Soils Testing Laboratory of the Department of Crop and Soil Environmental Sciences (Athena Tilley) 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 in the Virginia Tech Biological Systems Engineering Department; Erin James Ling, Extension Water Quality Program Coordinator, Virginia Tech Biological Systems Engineering Department; Cristin Sprenger, Family and Consumer Sciences Agent, Augusta County; Amber Vallotton, Agriculture and Natural Resources Agent, Rockingham County; Stephanie Diehl, Family and Consumer Sciences Agent, Rockingham County; Jason Carter, Agriculture and Natural Resources Agent, Augusta County; Jennifer Mercer, 4-H Agent, Augusta County; Tom Stanley, Agriculture and Natural Resources Agent, Augusta County; Jen Pollard, Extension Staff; Caty Gordon, undergraduate intern; and Scott Forrester, graduate student intern.

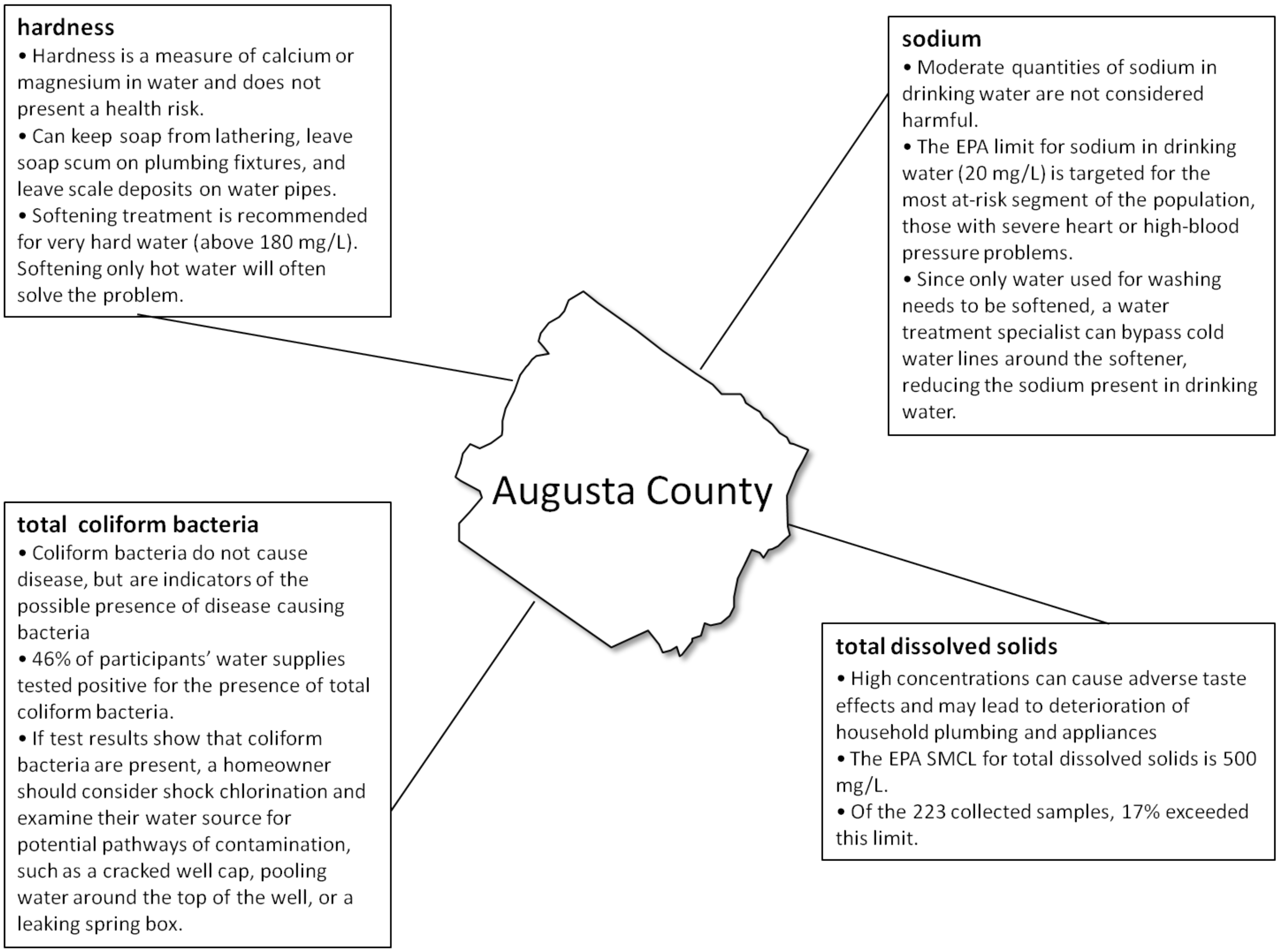

Figure 1. The most common household water-quality issues found in the 223 Augusta clinic participant samples were high levels of sodium, hardness, total dissolved solids, and the presence of total coliform bacteria.

2009 Augusta County ***VAHWQP Drinking Water Clinic Results*** *N = 223 participants*				
Test	**Standard**	**Average**	**Max/Extreme**	**% Exceeding guideline based on EPA standard**
Iron (mg/L)	0.3	0.012	0.22	0
Manganese (mg/L)	0.05	0.029	2.234	5.8
Hardness (mg/L)	180	188.5	584.5	55.2
Sulfate (mg/L)	250	19.7	419.1	0.9
Chloride (mg/L)	250	18	340	0.4
Fluoride (mg/L)	2.0/4.0	0.21	1.93	0
Total Dissolved Solids (mg/L)	500	374	1052	16.5
pH	6.5 to 8.5	7.24	8.52	5.4 (below 6.5) 0.4 (above 8.5)
Copper (mg/L)	1.0/1.3	0.029	0.734	0
Sodium (mg/L)	20	41.97	272.05	32.3
Nitrate-N (mg/L)	10	1.824	13.806	1.3
Total Coliform Bacteria	ABSENT	--	--	45.7 (present)
E. coli Bacteria	ABSENT	--	--	9 (present)

Table 1. General water chemistry and bacteriological analysis contaminant levels for Augusta County drinking water clinic participants (N=223). 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.