

Evaluation of Household Water Quality in Spotsylvania and Stafford Counties, Virginia

OCTOBER 2011

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 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

The western half of Spotsylvania and Stafford Counties lies in the **Piedmont** physiographic province. This is the largest physiographic province in Virginia, extending west of the Fall Line to the Blue Ridge Mountains. The diversity of the subsurface geology results in wide variations in groundwater quality and well yields. Groundwater use at many locations is limited. For example, a few areas have problems with high iron concentrations and low pH. Hard crystalline igneous and metamorphic formations dominate this region. The size and number of fractures and faults, which store and transmit groundwater in the bedrock, decrease with depth, so the most significant water supplies are found within a few hundred feet of the surface. Large yields of water can be obtained where fracture and fault systems are extensive, as in the western Piedmont Province along the base of the Blue Ridge Mountains. Because of the range in groundwater quality and quantity in this region, as well as the varying potential for contamination, well site evaluation and routine well testing is very important (GWPC, 2008).

The eastern portions of Spotsylvania and Stafford Counties lie within the **Coastal Plain** physiographic province of Virginia. The Coastal Plain Province extends 110 miles inland from the coast to the Fall Line and passes roughly through Fairfax County, Fredericksburg, Richmond, Petersburg, and Emporia. The Coastal Plain region is the only province in Virginia that is composed mostly of unconsolidated deposits, primarily alternating layers of sand, gravel, shell rock, silt, and clay. More groundwater is stored in these pervious

materials than in any other province in the state. The pollution potential in the uppermost water table is high because of the permeability of the soil and the high population density and agricultural activities in the area.

The Coastal Plain Province has two separate groundwater systems, one shallow and one deep. In many places, a shallow, unconfined aquifer system lies above relatively impermeable clay beds and provides a source of water for hundreds of domestic and other small capacity wells. The primary source of groundwater withdrawals is a deeper system of confined aquifers, meaning a layer of clay overlays the aquifer. The recharge occurs miles away where the aquifer is exposed to the surface. Infiltration from the water table also recharges the confined aquifers. This recharge water could carry pollutants.

Except for some areas where saltwater, iron, and hydrogen sulfide occur, the natural water quality in the Coastal Plain aquifers is good. In aquifers near a saltwater interface, saltwater may migrate west as aquifers are pumped (GWPC, 2008).

Overview

In October 2011, 331 residents from Spotsylvania and Stafford Counties 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 high levels of manganese and sodium, low pH, 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 Spotsylvania/Stafford 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 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 331 participants at the clinic, helped to characterize the tested water supplies. Ninety-eight percent of participants in the clinic indicated their water supply was a well, while 2% indicated *other*.

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

For the Spotsylvania/Stafford clinic, rural community was the most common household setting (43%), followed by a subdivision (37%), and then a rural lot (15%).

Major sources of potential contamination near the home (within 100 feet of the well) were identified as septic (14%) and stream (6%).

According to participants, larger, more significant potential pollutant sources were also proximate (within one-half mile) to water supplies. Eighteen of respondents indicated that their water supply was located within one-half mile of a major farm animal operation while 12% indicated that their supply was within one half-mile of a field crop operation.

On the questionnaire, participants also described the type of material used for water distribution in each home. The two most common pipe materials were plastic (63%) and copper (43%).

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-four percent of participants reported at least one treatment device installed. The most commonly reported treatment device was a water softener (31%) 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 55% of clinic participants. Rusty (30%) and blue/green (20%) were the most commonly reported stains. An objectionable odor was reported by 18% of clinic participants, mainly citing a rotten egg smell in their water (14%). Sixteen percent reported unpleasant tastes, indicating metallic as the most common (9%). Fifteen percent reported having particles in their water, the most common being white flakes (7%). Finally, 11% reported an unnatural appearance in their water, mainly observed as yellow (5%).

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 331 samples collected, 39% tested positive (present) for total coliform bacteria. Subsequent *E. coli* analyses for all of these samples showed that 8% 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 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 Spotsylvania/Stafford 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 Spotsylvania/Stafford 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 331 Spotsylvania/Stafford County clinic samples, 55% 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 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 331 clinic samples, 34% 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.

Manganese

Manganese is a nuisance contaminant and does not present a health risk. The EPA recommended secondary 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.

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

Iron

Iron in water is considered a nuisance and does not usually present a health concern. The EPA recommended secondary maximum contaminant level for iron is 0.3 mg/L. Excessive iron can cause brown-orange stains on plumbing fixtures, and laundry, and may produce a bitter, metallic taste.

Eight percent of Spotsylvania/Stafford clinic samples had iron concentrations exceeding 0.3 mg/L. Depending on whether the iron is in solution (dissolved) or in particulate form, treatment options for excessive iron include a water softener, aeration and filtration, ozonation, and distillation.

Conclusions

Participants were asked to complete a program evaluation survey following the interpretation meeting. Thirty-six percent said they would work to determine the source of pollution, 29% said they would shock chlorinate, 23% said they would improve the functioning of their existing treatment and 89% plan to discuss what they learned with others.

References

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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

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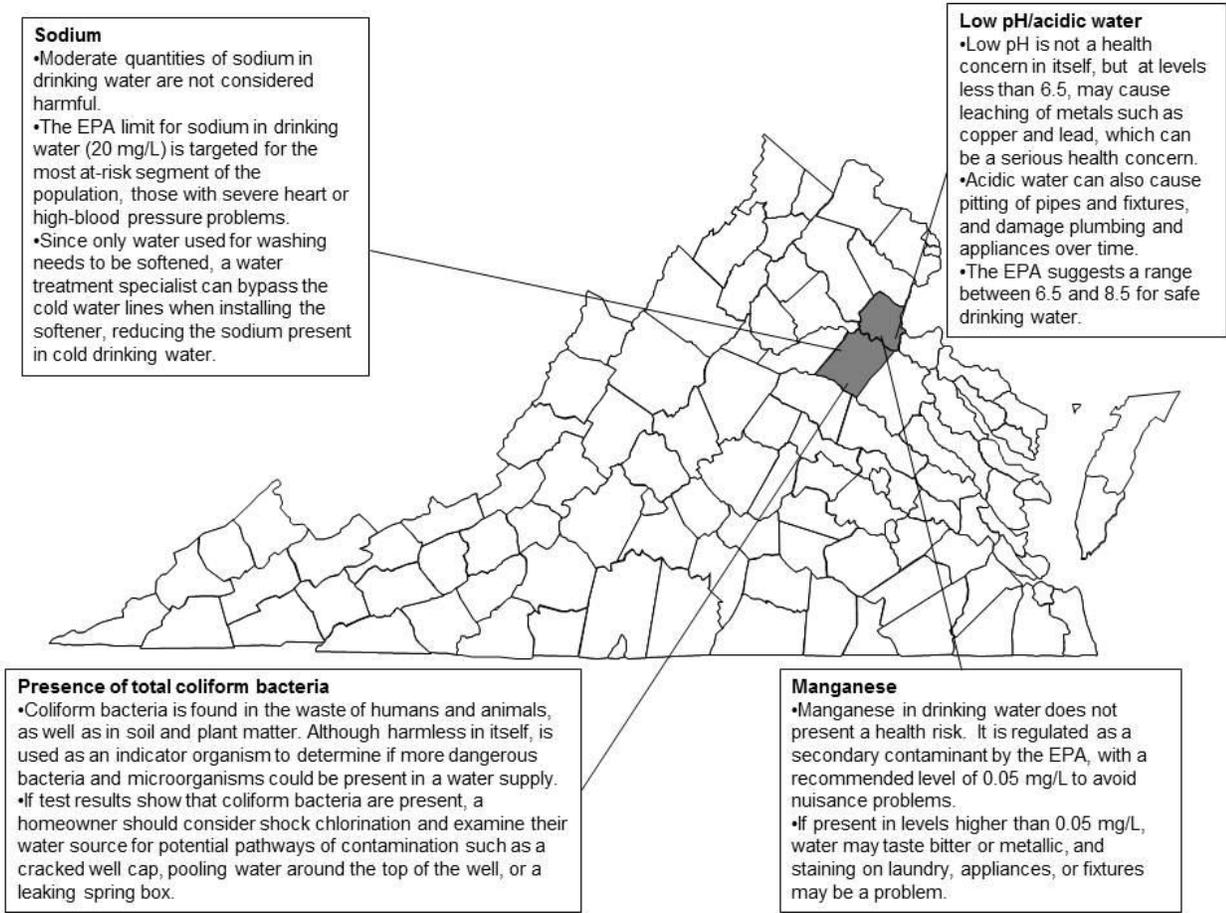


Figure 1. The most common household water quality issues found in the 331 Spotsylvania/Stafford clinic participant samples were high levels of sodium and manganese, low pH, and the presence of total coliform bacteria.

**2011 Spotsylvania/Stafford County
VAHWQP Drinking Water Clinic Results
N = 331 samples**

Test	EPA Standard	Average	Maximum Value	% Exceeding Standard
Iron (mg/L)	0.3	0.129	4.496	8.4
Manganese (mg/L)	0.05	0.030	0.541	14.5
Hardness (mg/L)	180	37.4	214.2	0.9
Sulfate (mg/L)	250	7.1	230.7	0
Chloride (mg/L)	250	8	210	0
Fluoride (mg/L)	2.0/4.0	0.14	2.23	0.3
Total Dissolved Solids	500	123	2345	0.6
pH	6.5 to 8.5	6.40	4.07 (min) 8.12 (max)	55.1 (<6.5) 0 (>8.5)
Copper (mg/L)	1.0/1.3	0.036	1.426	0.3
Sodium (mg/L)	20	24.48	567.90	33.7
Nitrate - N (mg/L)	10	0.737	8.180	0
Total Coliform Bacteria	ABSENT	--	--	38.9
E. coli Bacteria	ABSENT	--	--	8.1

Table 1. General water chemistry and bacteriological analysis contaminant levels for Spotsylvania/Stafford drinking water clinic participants (N=331). 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.