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Evaluation of Household Water Quality in Frederick County, Virginia
MAY 2012
VIRGINIA HOUSEHOLD WATER QUALITY PROGRAM

Background

More than 1.7 million (22%) 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 87 counties across Virginia and samples analyzed from more than 15,300 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 day-long 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

Frederick County lies completely within the ***Valley and Ridge*** physiographic province of Virginia. The other counties involved in this clinic, Warren and Clarke, lie mostly within the ***Valley and Ridge*** province, with the eastern edge falling in the ***Blue Ridge*** province.

The Valley and Ridge province is located to the west of the Blue Ridge Province and is underlain by consolidated sedimentary rocks. In the lowlands, such as the Shenandoah Valley, limestone and dolomite occur beneath the surface. These rock types have openings to yield water freely to wells and, therefore, form the most productive aquifers in Virginia, west of the Coastal Plain Province. In contrast, the ridges and upland areas are often composed of sandstone and shale. These rocks 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. Water can move quickly through fault zones and limestone sinkholes to reach aquifers, which 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, causing hard water.

The Blue Ridge province is a relatively narrow zone to the west of the Piedmont Province. The mountains within the province make up some of the highest elevations in the state. Beneath a thin layer of soil and weathered rock lies bedrock, a relatively impervious zone containing water primarily in joints, fractures, and faults. Steep terrain and a thin soil covering result in rapid surface runoff and low groundwater recharge.

The lower slopes of the mountains are the most favorable areas for groundwater 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).

Overview

In May 2012, 47 residents participated in a drinking water clinic sponsored by local Virginia Cooperative Extension (VCE) offices and the Virginia Household Water Quality Program. Table 1 shows the counties and number of participants from each county that participated in the Frederick clinic. 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 in the Frederick clinic were high levels of sodium, total dissolved solids, hardness, manganese, and the presence of total coliform bacteria. In addition, levels of lead exceeding recommendations for household water were detected in some first draw samples. 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, 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 the 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 47 participants at the clinic, helped to characterize the tested water supplies. Ninety-eight percent of participants in the Frederick clinic indicated their water supply was a well.

The most commonly reported sources of potential contamination near the home (within 100 feet of the well) were identified in the Frederick clinic as a septic system (17%) and an oil tank (6.4%). According to participants, larger, more significant potential pollutant sources were also nearby (within one-half mile) to water supplies. Thirty-two percent of Frederick clinic respondents indicated that their water supply was located within one-half mile of a major farm animal operation and 19.1% indicated that their supply was within one half-mile of a field crop operation. Other nearby sources of potential contamination included an active quarry, commercial tanks, 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 the clinic group were copper (72.3%) and plastic (61.7%). 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. Seventy-two percent of Frederick clinic participants reported at least one treatment device installed. The most commonly reported treatment device was a water softener (59.6%) followed by a sediment filter, installed by 23.4% of participants.

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 44.7% of clinic participants in the Frederick clinic. Rusty (23.4%) was the most commonly reported type of stain. An objectionable odor was reported by 23.4% of clinic participants, most citing a rotten egg smell in their water. About 19.1% reported unpleasant tastes, indicating bitter and metallic as the most common. About 17% reported having particles in their water, the most common being white flakes (8.5%). About 6.4% of participants reported having corrosion problems. Finally, about 14.9% reported an unnatural appearance in their water, most commonly observed as milky (6.4%).

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 47 samples collected in the Frederick clinic, 27.7% tested positive for presence of total coliform bacteria. Subsequent *E. coli* analyses for all of these samples showed that 6.4% 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 2, 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, fluoride, sulfate, pH, total dissolved solids (TDS), hardness, sodium, lead, arsenic, and copper. Selected parameters of particular interest for Frederick 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 for lead removal) can remove it from your water.

In the Frederick clinic, 17.0% of first draw samples exceeded 0.015 mg/L lead. 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 47 Frederick clinic samples, 57.4% 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. Thirty-four percent of the Frederick clinic participants 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 the Frederick clinic, 27.7% of the clinic samples were considered "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.

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.

Almost 24% of clinic samples tested above 0.05mg/L. Treatment options for manganese include a water softener, reverse osmosis, or distillation.

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

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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

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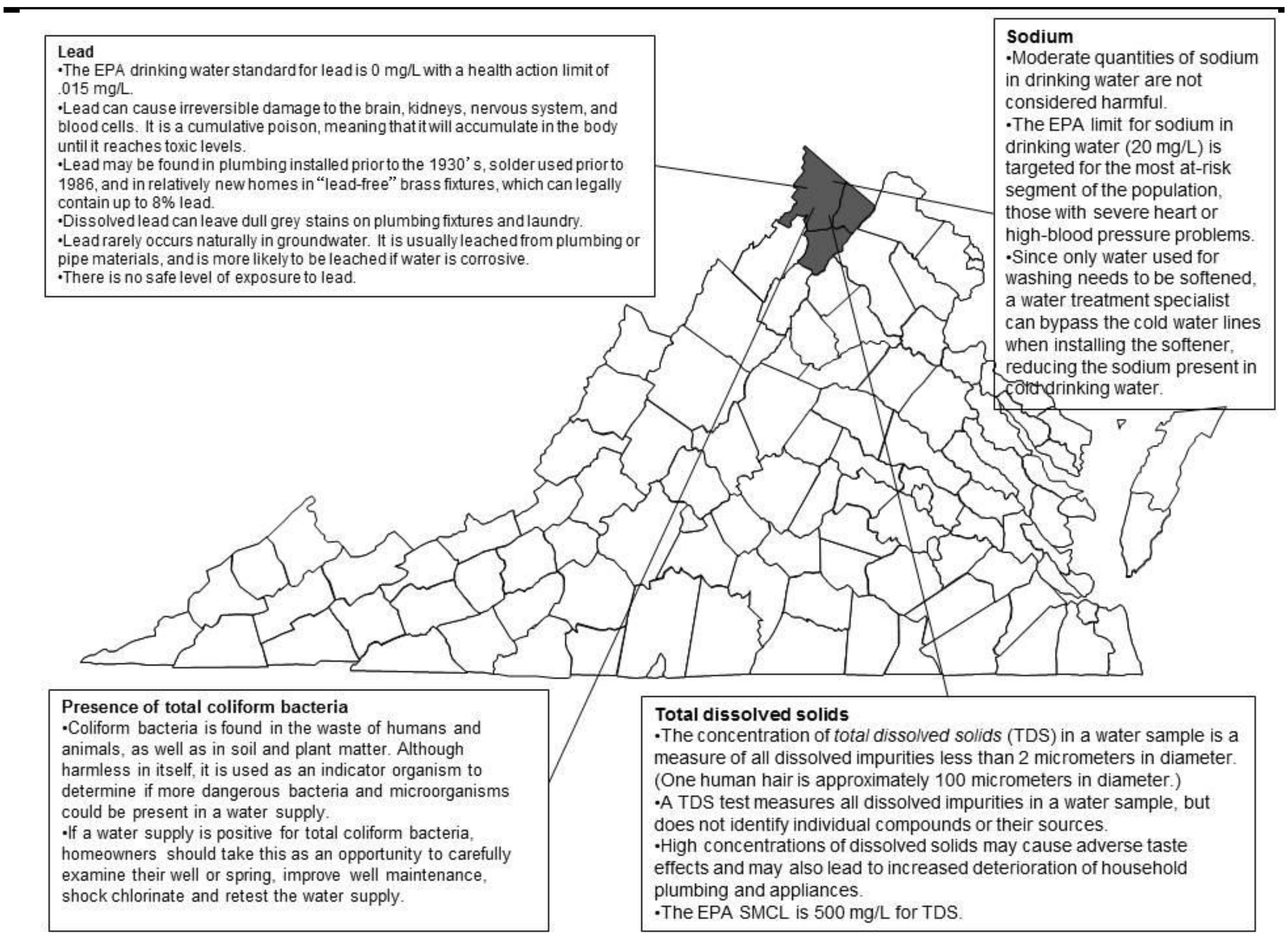

Figure 1. The most common household water quality issues found in the 47 Frederick clinic participant samples were high levels of sodium, total dissolved solids, lead, and the presence of total coliform bacteria.

Table 1. Participants from nearby counties in the Frederick clinic.

County	# participants
Frederick	43
Clarke	3
Warren	1

Table 2. General water chemistry and bacteriological analysis contaminant levels for the Frederick (N=43), Clarke (N=3), and Warren (N=1) 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 Frederick County VAHWQP Drinking Water Clinic Results *N = 47 samples (Frederick, Clarke, and Warren)*				
Test	**EPA Standard**	**Average**	**Maximum Value**	**% Exceeding Standard**
Iron (mg/L)	0.3	0.094	2.30	6.4
Manganese (mg/L)	0.05	0.087	1.542	23.4
Hardness (mg/L)	180	125.4	476.9	27.7
Sulfate (mg/L)	250	26.3	120	0
Fluoride (mg/L)	2.0/4.0	0.23	1.53	0
Total Dissolved Solids	500	433	924	34.0
pH	6.5 to 8.5	7	5.9(min) 7.7(max)	(<6.5) 6.4 (>8.5) 0
Sodium (mg/L)	20	60.41	127	57.4
Nitrate - N (mg/L)	10	1.671	9.188	0
Copper-First Draw (mg/L)	1.0/1.3	0.294	1.891	2.1
Copper-Flushed (mg/L)	1.0/1.3	0.030	0.653	0
Lead-First Draw (mg/L)	0.015	0.010	0.079	17.0
Lead-Flushed (mg/L)	0.015	0	0.002	0
Arsenic-First Draw (mg/L)	0.01	0.001	0.007	0
Arsenic-Flushed (mg/L)	0.01	0.001	0.008	0
Total Coliform Bacteria	ABSENT	492	22749	27.7
E. coli Bacteria	ABSENT	2.7	113	6.4