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Evaluation of Household Water Quality in the Northern Neck, Virginia (Northumberland, Lancaster, Richmond, Westmoreland, and Essex Counties)

MARCH AND SEPTEMBER 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 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

Northern Neck lies completely within the ***Coastal Plain*** physiographic province of Virginia. The Coastal Plain province extends 110 miles inland from the coast to the Fall Line, which runs approximately along the I-95 corridor. The geology here is composed mostly of 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 Coastal Plain province has two separate groundwater systems, one shallow and one deep. The pollution potential in the upper, shallower, water table is high because of the permeability of the soil and the high population density and agricultural activities in the area. The primary source of groundwater withdrawals is a deeper system of confined aquifers, meaning a layer of clay overlays the aquifer. Except for some areas where saltwater, iron, and hydrogen sulfide occur, the water quality in the Coastal Plain aquifers is good. In aquifers near a saltwater interface, saltwater may migrate west as aquifers are pumped (GWPSC, 2008).

Overview

In the spring and fall of 2012,159 residents participated in several drinking water clinics sponsored by local Virginia Cooperative Extension (VCE) offices and the Virginia Household Water Quality Program. Subsidized funding to assist with sample analysis cost was provided by a grant from USDA Rural Health and Safety Education Program (Competitive Grant No. 2011-46100-31115). Table 1 shows the counties and number of residents from each county that participated in the Northern Neck clinics. The Northern Neck 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 Northern Neck clinic were high levels of sodium, total dissolved solids, fluoride, low and high pH, and the presence of total coliform bacteria. In addition, levels of lead and copper exceeding recommendations for household water were detected in some first draw samples. One flushed sample also exceeded recommendations for copper. 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 a 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 water sample analysis, and instructions for collecting their sample. Sample kits with sampling instructions and a short questionnaire were distributed. The questionnaire is 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 in each county 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 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 the VAHWQP drinking water clinics. 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 159 participants at the clinics, helped to characterize the tested water supplies. Ninety-eight percent of participants in the Northern Neck clinic indicated their water supply was a well; one participant reported having a cistern.

The most commonly reported source of potential contamination near the home (within 100 feet of the well) was identified in the Northern Neck clinics as a septic system (16.4%) and a shoreline or marsh (12.6%). According to participants, larger, more significant potential pollutant sources were also proximate (within one-half mile) to water supplies. Sixty-one percent of Northern Neck clinic respondents indicated that their water supply was located within one-half mile of a field crop operation and 14.5% indicated that their supply was within one half-mile of a major farm animal operation. Other nearby sources of potential contamination included commercial tanks, illegal dumps, manufacturing, 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 plastic (70.4%) and copper (47.8%). 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. Twenty-one percent of Northern Neck clinic participants reported at least one treatment device installed. The most commonly reported treatment device was a sediment filter (8.2%) followed by a reverse osmosis filter, installed by 4.4% 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 29.6% of clinic participants in the Northern Neck clinic. Rusty (18.2%) was the most commonly reported stain. An objectionable odor was reported by 22% of clinic participants, citing a rotten egg smell in their water as the most common odor. About 17% reported unpleasant tastes, indicating sulfur as the most common. About 10% reported having particles in their water, the most common being brown sediment (5%). About 10.7% of participants reported having corrosion problems. Finally, about 11.3% reported an unnatural appearance in their water, most commonly observed as yellow, muddy, and milky, each representing 2.5% of the samples.

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 159 samples collected in the Northern Neck clinics, 40.9% tested positive presence of total coliform bacteria. Subsequent *E. coli* analyses for all of these samples showed that 2.5% 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 Northern Neck 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 Northern Neck 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 has not been used for 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 lead

In the Northern Neck clinic, 11.3% of first draw samples exceeded 0.015 mg/L lead. No flushed samples exceeded the 0.015 mg/L standard.

Copper

The EPA health standard for copper in public drinking water supplies is 1.3mg/L. If the concentration of copper exceeds this level, it can cause gastrointestinal illness. Children and infants may be particularly susceptible. Indications of high levels of copper include bitter or metallic tasting water and blue-green stains on plumping fixtures.

Ten percent of the clinic first-draw samples, and one flushed sample exceeded the EPA standard. Raising the pH of the water using an acid neutralizing filter, may make the water less corrosive and may reduce copper levels.

pH

pH is a measure of the acidity or alkalinity of a substance. The EPA suggests pH for public drinking water be between 6.5 and 8.5. Of the 159 Northern Neck clinic samples, 22.0% 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.

About 23.3% of the samples were above the recommended pH of 8.5, indicating alkaline water. Alkaline water with a pH above 8.5 is rarely found naturally, and may indicate contamination by alkaline industrial wastes.

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. Nearly 25% of Northern Neck samples exceeded this level.

Fluoride

Fluoride is a concern because of its effect on teeth and gums. Small concentrations are considered beneficial in preventing tooth decay while moderate to high concentrations can cause brownish discoloration of teeth and tooth and bone damage. The EPA has set a secondary maximum contaminant level (SMCL) and a maximum contaminant level (MCL) of 2 and 4 mg/L, respectively. About 23% of the participants exceeded the SMCL standard of 2 mg/L.

Treatment options for fluoride include adding activated alumina to the water source, reverse osmosis, and 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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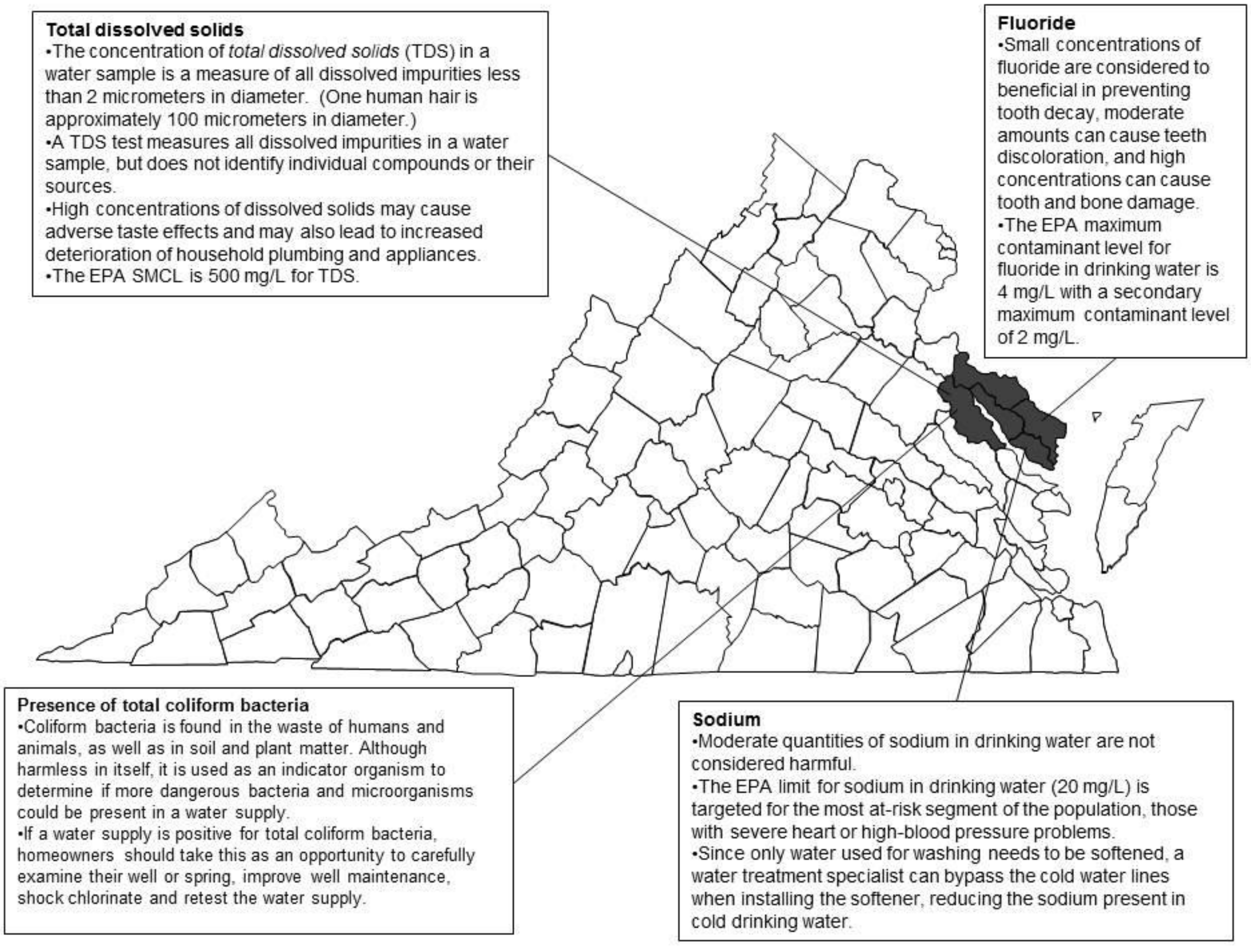

Figure 1. The most common household water quality issues found in the 159 Northern Neck clinic participant samples were high levels of fluoride, sodium, TDS, and the presence of total coliform bacteria.

Table 1. Counties involved in the Northern Neck clinic and the number of participants from each county.

County	# participants
Northumberland	50
Westmoreland	49
Lancaster	36
Richmond	23
Essex	1

Table 2. General water chemistry and bacteriological analysis contaminant levels for the Northern Neck 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 Northern Neck ***VAHWQP Drinking Water Clinic Results*** *N = 159 samples (Northumberland, Westmoreland, Richmond, Lancaster, and Essex)*				
Test	**EPA Standard**	**Average**	**Maximum Value**	**% Exceeding Standard**
Iron (mg/L)	0.3	0.086	2.498	4.4
Manganese (mg/L)	0.05	0.008	0.401	3.1
Hardness (mg/L)	180	29.3	207.3	0.6
Sulfate (mg/L)	250	22	184	0.0
Fluoride (mg/L)	2.0/4.0	1.12	4.4	22.6
Total Dissolved Solids	500	334	1,833	24.5
pH	6.5 to 8.5	7.7	4.8 (min) 9.8 (max)	(<6.5) 22.0 (>8.5) 23.3
Sodium (mg/L)	20	90.17	385.2	75.5
Nitrate - N (mg/L)	10	0.82	9.853	0.0
Copper-First Draw (mg/L)	1.0/1.3	0.551	11.99	10.1
Copper-Flushed (mg/L)	1.0/1.3	0.07	4.397	0.6
Lead-First Draw (mg/L)	0.015	0.007	0.079	11.3
Lead-Flushed (mg/L)	0.015	0	0.014	0.0
Arsenic-First Draw (mg/L)	0.01	0.001	0.009	0.0
Arsenic-Flushed (mg/L)	0.01	0.001	0.01	0.6
Total Coliform Bacteria	ABSENT	1,100	22,749	40.9
E. coli Bacteria	ABSENT	0	7	2.5