Well Water Screening in Suffolk, VA, for Contaminants Affecting Human Health

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Abstract

Purpose: Despite regulations, one area that remains outside the scope of the clean water policies is well water. With the lack of oversight, the millions of home that rely on well water remain susceptible to numerous pollutants and contaminants. To ensure the safety of well water, development of screening and testing protocols is imperative. Many households in Suffolk, VA still use well water making it an apt location to conduct a preliminary study screening for potential water contaminants.

Methods: Water samples from kitchen and garden sources were collected from households in Suffolk, VA. These samples assessed for TDS via Milwaukee EC59 pen, pH via Sper Scientific test tube pen, arsenic via Quick Rapid Arsenic Test Kit, *E. coli* and coliform, and lead via Simpletek Micro Tester Pro self-filling test ampoules.

Findings: Four of the thirty kitchen-sourced samples tested positive for coliform contamination. The positive findings may represent hazards for health thus warranting further investigation.

Conclusion: Many Suffolk homes rely on well water but lack of regulations can bring risk for contamination. This study indicated a potential coliform problem in Suffolk and more work must be done to evaluate for coliform contamination and its resultant health consequences.

Background

The Clean Water Act of 1972 established safety requirements for water sources such as lakes, rivers, and other surface water; this was accomplished in part by regulating pollution into surface water as well as funding sewage facilities and water treatment plants for municipal water. However, many contaminants can still seep into groundwater from sources such as septic tanks, septic drain fields, urban runoff, fertilizers and pesticides, and underground fuel tanks. Common contaminants that may affect water quality include total dissolved solids (TDS), pH, lead, arsenic, *Escherichia coli* (*E. coli*), and coliform bacteria. TDS is associated with hardness, and in conjunction with acidic pH, can predispose pipes to corrosion (Isaac et al., 1997). Corroded pipes may then leach heavy metals into drinking water which was the case in Flint, Michigan. Lead levels in Flint water samples in 20-32% of 6 city wards exceeded the Lead and Copper Rule's threshold for remedial action. Some water samples even had lead concentrations greater than 1000 µg/L (Bellinger, 2016). Lead, even at low levels, has been associated with hypertension, growth retardation, neurological and cognitive deficits, immunosuppression, hepatotoxicity, cardiotoxicity, and congenital defects (Goyer, 1990; Mudipalli, 2007; Needleman & Bellinger, 1991).

Arsenic, another natural contaminant, is most often sourced from water (Kapaj et al., 2006). Arsenic may build up in tissues such nails, hair, and skin and is associated with cardiotoxicity, diabetes, peripheral neuropathy, and various types of cancer (Abernathy et al., 1999). Coliforms encompass a range of gram-negative, rod-shaped, lactose-fermenting bacterial species that reside in the intestinal tracts of organisms that can potentially cause a variety of different clinical presentations if infection occurs. Well-known species include *Escherichia*, *Klebsiella*, *Citrobacter*, *Serratia*, *Proteus*, and *Enterobacter* (Guentzel, 1996).

According to the Environmental Protection Agency (EPA) and the 2017 U.S. Census American Housing Survey, approximately 13 million homes in the U.S. use private wells supplied by groundwater sources for their drinking water (EPA, 2019a). The EPA does not regulate the safety of private wells, and it is up to homeowners to test the water frequently for safety. This creates the opportunity for wells to be a significant source of contamination since runoff from nearby industrial plants or farms can go unnoticed until health consequences arise. Broader water quality testing in rural drinking water wells found a greater prevalence of bacterial contamination compared to public wells (Invik et al., 2017).

In sixty of Virginia’s ninety-five counties, a majority of households rely on private well water. Suffolk County, VA is one such county (US Census Bureau, n.d.; Virginia Department of Health (VDH), n.d.). As a mostly rural area, many residents source their water from private wells like the regions described in the previous studies. This makes the region a good candidate for further water quality screenings and a good representation for other Virginian counties.

Methods

To choose our sample population, a map from the City of Suffolk website was obtained and confirmed with the Suffolk Health Department that the city supplied water to homes within a five mile radius of the city center. An area outside of the five mile radius was selected and Google Earth was used to confirm that physical homes were associated with addresses. Zip codes which contained houses were designated as clusters. Three zip codes were selected to obtain samples, and 100 homes were supplied with water sample selection kits. We hand delivered sample kits consisting of two 500mL glass bottles, a survey to collect information about the well, and a letter detailing an explanation of the study and instructions for collection. The survey asked for the depth of the well, how it was built, the distance between the well and septic tank, and the distance between the well and septic drain field. The residents were instructed to fill one bottle from the kitchen tap and the other from the garden tap. The kits were delivered on the weekend and were picked up the following weekend.

All tests, except TDS and pH, were done with colorimetric screening kits. We evaluated the water for the presence of *E. coli*, coliform, and lead using Simpletek Micro Tester Pro self-filling test ampoules. To test for *E. coli* and coliform, water was drawn up into the ampoules and inverted several times to ensure sufficient growth medium dissolution, placed into a desktop incubator at 35°C, and checked for the presence of color change at 4, 12, and 24 hours. In evaluating for coliforms, the color of the sample was observed to change from a pale yellow, indicating negative, to a vivid yellow, indicating a positive result. To determine the presence of *E. coli*, the samples needed to be viewed under ultraviolet light observing for a blue color to indicate a positive result. Testing for lead, water was drawn up into the ampoules and inverted several times for the reagent to mix, with the results read immediately. The presence of lead could be observed as yellow for negative, orange for low presence, or dark orange for high presence.

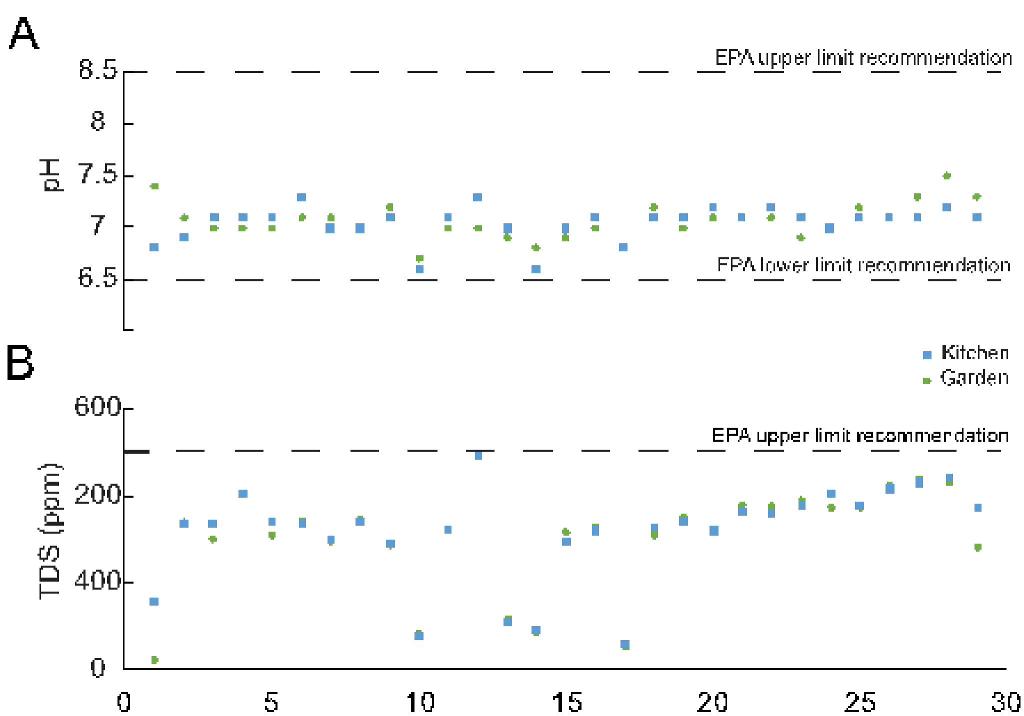
Arsenic was tested using the Quick Rapid Arsenic Test Kit for arsenic 3 and 5. For each sample, 100mL was mixed with three reagents in a reaction bottle from the kit, a test strip was placed in the cap of the bottle and the reaction was allowed to run for ten minutes, after which we observed for the presence of a color change to be matched against the color chart provided. TDS was measured with the Milwaukee EC59 pen and pH with the Sper Scientific test tube pen. Any locations that tested positive for contamination had the distance measured from the nearest body of water using Google Maps. Due to the fact that we tested by screening method, there were no quantitative numbers to run any statistical analysis; however, we did a comparison of the TDS, pH, and well information gathered from the survey.

Results

Out of the 100 kits, 30 were returned for a total of 60 samples tested. The results of the calorimetric screening kits showed that for all locations, both kitchen and garden water sources were negative for lead, arsenic, and *E. coli*. The EPA water pH ranges for all the homes was between 6.5 to 8.5 which falls within the EPA standards (EPA, 2019b). As shown in Figure 1a, all of the samples from both sources fall within this range. TDS findings were also non-significant. The recommendation for TDS is below 500 mg/L and all samples fell below that limit (Figure 2b).

Figure 1

Scatterplot Showcasing Individual pH and TDS Values Obtained from Each Home



There were positive coliform findings in four locations, all of which were seen from kitchen water sources while the garden water samples were negative. The geographical locations of the results are shown in Figure 2. The map depicts the greater Suffolk area from which samples were collected. Homes which provided negative samples are represented with a blue circle while homes with positive samples are represented by a green icon. Three samples were found in homes within 1.50km of a river; however, the fourth sample was located more than 27.00km away from any large water source. Most homeowners omitted well to drainage field and well to septic tank distances on surveys. As such, no conclusions were able to be made from these metrics and this data was excluded from analysis.

Figure 2

Geographical Depiction of the Location the Samples Originated From

Discussion

Groundwater used in private well water systems is susceptible to contamination by run off. This has been a growing concern over the past few decades as there has been an increase in waterborne disease outbreaks involving private water systems with the majority of these cases being linked to groundwater contamination (Craun et al., 2010). Compounded with the lack of EPA oversight, this issue remains unaddressed and unrecognized for many populations. However, screening well water can potentially catch and even prevent health conditions like lead poisoning and gastroenteritis.

Although our sample population was largely free of lead, arsenic, and *E. coli*, four homes with coliforms found in kitchen water samples were detected. At the time of the study, the species of the found coliform samples were not identified. Even if the coliforms present in a household's water supply are not pathogenic, the result is still concerning because their presence suggests structural compromises within the household's well system, increasing the likelihood of later water-borne illnesses (New York State Department of Health, 2017).

Due to the health consequences of water contamination, it is important to identify factors and patterns leading to contamination. Examining the geographic relationships between homes with positive coliforms, no apparent patterns were found. The four homes were not clustered together. Three of the four positive homes were near bodies of water, but other homes on the same street did not test positive. Also, the fourth positive home was not close to any potential contaminating water source. These findings suggest that the positive coliform homes likely had vulnerabilities within their individual well systems leading to contamination.

Due to the nature of the study and institutional policies, there are inherent limitations to the study. First, the researchers were not permitted to enter residents' homes and residents were required to collect the samples themselves. This could have introduced contaminants foreign to the water supply, failure to properly gather the sample, mislabeling, or other confounders. Additionally, the study was based on voluntary participation and thus some data was lost to follow up.

Conclusion

Ultimately, our water screening revealed that residential well water within Suffolk, VA is largely free of contamination; however, the positive findings indicate some homes would benefit from further well system assessment. As the present study was only a screening, it only provides preliminary data indicating that among populations that rely on well water, there is a plausible risk of contamination. Suffolk is a paradigm for most other counties in Virginia and this study may represent a larger scale problem. Moving forward, we aim to investigate the coliform burden in other Virginia counties and identify the potential health consequences of such contamination.

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