Determining the Ability of an At-home Test Kit to Detect Lead in Drinking Fountains at East Carolina University

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A Senior Honors Project Presented to the

Honors College

East Carolina University

In Partial Fulfillment of the

Requirements for

Graduation with Honors

by

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Greenville, NC

December, 2022

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Abstract

Lead and other contaminants in drinking water still pose as an important problem in today's society and can have detrimental effects on human health. At-home water testing kits can offer consumers an easy and affordable way to evaluate their risk, but their accuracy and reliability is still uncertain. This study examined the ability of the AquaScreen Drinking Water Test Kit to detect lead, among other contaminants, in drinking fountain water at East Carolina University. The results were inconclusive as many of the tests were contradicting and had results that were hard to discern. The results highlight areas for possible improvement and suggest that several changes need to be made to at-home water testing kits in order to make them more reliable.

Keywords: lead; water contamination; testing kit

Introduction

Water testing for regulated contaminants performed by certified laboratories can be costly and time consuming. Regulated contaminants include inorganic pollutants, such as lead, nitrite, and hardness, as well as microbial pollutants such as fecal coliform and *Escherichia* coli (*E. coli*). Lead in drinking water can cause several side effects and can pose a significant threat to human health. According to the United States Environmental Protection Agency (EPA), even low levels of lead in the blood of children can result in behavioral and learning problems, lower IQ and hyperactivity, slowed growth, hearing difficulties, and anemia (US EPA). In rare cases, lead can cause seizures, coma, and even death. In adults, exposure to lead can cause cardiovascular effects, increased blood pressure and incidence of hypertension, decreased kidney function, and reproductive problems in both men and women. Additionally, lead can accumulate in our bodies over time. Lead is stored in our bones along with calcium. During pregnancy, lead is released from the bones of the mother and is utilized to form the bones of the fetus. Lead can also cross the placental barrier exposing the fetus to lead. This can result in the reduced growth of the fetus and premature birth. Furthermore, distrust of drinking water quality has rapidly increased in the past several years due to water crises such as the Flint water crisis that occurred from 2014 to 2019 (Denchak, 2018) and the Camp Lejeune water contamination event that occurred from the 1950's through the 1980's (U.S. Department of Veteran Affairs, 2022). This avoidance of tap water has resulted in both health and economic implications. At-home water testing kits can provide the public with a convenient and affordable way to determine harmful levels of lead, among other potentially harmful water contaminants such as pesticides and fecal bacteria. However, the accuracy of these tests has been reported to be variable and many tests have not undergone rigorous testing and verification (Kriss et al., 2021). The goal of this research is to determine the accuracy and the ability of the AquaScreen Drinking Water Test Kit to detect lead along with pesticide, bacteria, nitrate, nitrite, pH, hardness, and chlorine levels. It is hypothesized that the lead test kit will be able to detect lead at higher concentrations while lead at lower concentrations may go undetected. It is also hypothesized that many, if not all, of the water samples will have low or undetected levels of lead, pesticide, and bacteria. Varying pH levels are expected since the recommended pH of drinking water is between 6.5 to 8.5.

Methods

Based on the research conducted by Rebecca Kriss and colleagues, the AquaScreen Drinking Water Test Kit was utilized during this study. The aforementioned study concluded that among the chosen testing kits, the AquaScreen Drinking Water Test Kit had the most accurate results. Testing was performed based on the manufacturer's instructions to test for the presence of lead, pesticide, nitrate, nitrite, and coliform bacteria, as well as tests for pH, hardness, and chlorine levels. A positive and negative control were used to compare the test group to. A sample with a known amount of lead was tested to act as the positive control. A sample of distilled or purified water acted as the negative control. As per instructions, the lead and pesticide tests were performed at the same time. Each of the lead and pesticide test pouches included two lead testing strips, two pesticide testing strips, two test tubes, and one reusable water dropper. The included water dropper was used to add exactly seven drops of the water sample to the test tube. The tube was then gently swirled for one minute to ensure the detection mixture was properly dissolved. The test tube was then placed on a flat surface and one lead test strip, and one pesticide test strip were inserted into the test tube with the arrows on the strips pointing downwards. After a 10-minute wait period, the test lines on the test strips were analyzed. If needed, a retest was performed if satisfactory results were not obtained, such as in the case of an inconclusive result. Similarly, to the lead and pesticide tests, the nitrate and nitrite tests were included in one pouch. The reagent pads on the test strips were immersed into the water sample and removed after two seconds. After waiting one minute, the results were immediately analyzed. The pH, hardness, and chlorine tests were all on one test strip. The reagent pads were immersed into the water sample and removed after one second. After waiting 15 seconds, the results were analyzed by comparing the color of the reagent pads to the chart included in the instruction manual. The bacteria test was the last to be performed. This test detects coliform bacteria. The test was performed by unwrapping the bacteria test tube and placing it on a flat surface. The cap was twisted off and the water sample was collected directly into the test tube and filled to the 5mL line. The cap was replaced, and the test tube was shaken vigorously for twenty seconds. The vial was then placed in a warm area that was between 70-90 °F where it was not to be disturbed for 48 hours. At the 48-hour mark, the results were analyzed. A total of 15 water samples were obtained from several different drinking water fountains on the campus of East Carolina University. 50 mL centrifuge tubes with caps were used to collect these samples. After testing the samples with the at-home test kit, the samples were methodologically tested at East Carolina University through Inductively Coupled Plasma- Mass Spectrometry (ICP-MS) analysis. This was done by transferring 25 mL of each water sample into a new 50 mL centrifuge tube. Approximately 368 µl of nitric acid (HNO_3) was added to each 25 mL sample using a P1000 pipette. The samples were allowed to settle overnight before being run through ICP-MS. Several different off-campus water samples were analyzed along with the 15 samples from campus including 6 surface water samples and 2 house samples. As per standard ICP-MS analysis protocol, calibration blank, calibration standard (CAL), internal standards, and quality control samples (QCS) were used to verify results and instrument performance. Calibration standards of 0.5, 1, 5, 10, and 50 ppb were used along with quality control samples of 100 and 200 ppb. After completing the ICP-MS, the lead and pesticide tests were performed on the calibration standards of 5, 10, and 50 ppb.

Results

The results from the Aqua Screen Drinking Water Testing Kit are summarized in Table 1. When compared to the chart included in the instruction manual, the testing strips indicated that all of the water samples had a hardness level of 50 parts per million (ppm), except Mamie Jenkins that had a hardness level of 50 and 120. Additionally, the lead and bacteria tests were negative for all 15 samples, and the nitrate and nitrite tests were all indicated to be 0. According to the image in the instruction manual, the lead test is considered negative if the bottom line is darker than the top line, or if the top line is not visible. Figure 1 displays an example of what all of the lead and pesticide tests looked like. All of the lead tests had a darker bottom line. This is in contrast to the pesticide tests, which all had bottom and top lines that were equally as dark. Similarly to the lead test, a positive result is indicated if the top line is darker than the bottom line, or if both lines are equally dark. An example of this result is also evident in Figure 1. All of the chlorine levels were found to be 0 with the exception of Greene which had a slight pink color that is evident on the bottom reagent pad in Figure 2. According to the given chart, this is indicative of a chlorine level of around 2. The pH results varied from 6.5 to 10, and a couple of the samples, including Flangan, Graham, Wright, Bate, Mamie Jenkins, and Recreation Center, had two different pH levels indicated by the color of the reagent pads. For example, as evident in Figure 3, the reagent pad turned a dark orange in addition to having sections of bright pink. When compared to the chart in the instruction manual, this

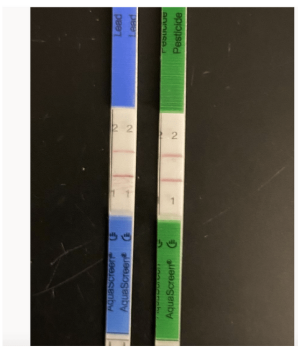

Figure 1: Rawl Lead and Pesticide Results

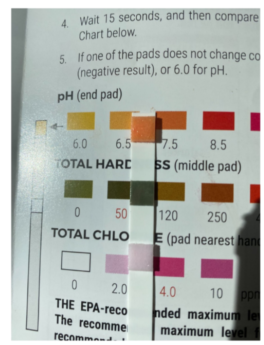

Figure 2: Greene pH, hardness, and chlorine results

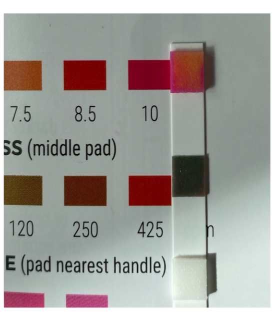

Figure 3: Mamie Jenkins pH, hardness, and chlorine results

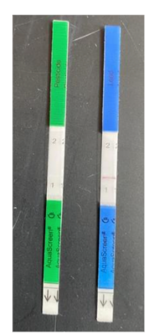
Figure 4: 50 ppb calibration standard lead and pesticide results

was indicative of pH values of 7.5 and 10, respectively. Also perceptible in Figure 3, the hardness reagent pad turned a dark green color along with a light brown color along the right edge of the pad. These colors indicate a hardness level of 50 and 120, respectively. As shown in the last column of Table 1 , the results of the ICP analysis concluded that all of the samples had low levels of lead with the exception of Graham which had a lead concentration of 4.83 ppb. The ICP lead concentration is marked not applicable (NA) for the Student Recreation Center (SRC) due to nitric acid accidentally not being added to that sample. For this reason, the results were disregarded. Figure 4 displays the results from the lead and pesticide tests on the 50 ppb calibration standard. Neither the lead or pesticide test strips produced results for any of the 3 samples. A second round of testing produced the same results.

Location	**Year Built**	**Nitrate (ppm)**	**Nitrite (ppm)**	**pH**	**Hardness (ppm)**	**Chlorine (ppm)**	**Lead (ppb)**	**Pesticide (ppb)**	**Bacteria**	**ICP Lead concentration (ppb)**
Bate	1988	0	0	10	50	0	-	+	-	0.12
BioTech	2021/22	0	0	6.5	50	0	-	+	-	0.09
Brewster	1970	0	0	6.5	50	0	-	+	-	0.09
Flangan	1939	0	0	10	50	0	-	+	-	0.23
Garret	1956	0	0	7.	50	0	-	+	-	0.09
Graham	1929	0	0	6.5	50	0	-	+	-	4.83
Greene	1969	0	0	7.5	50	2	-	+	-	0.09
Joyner	1954	0	0	7.5	50	0	-	+	-	0.08
MCSC	2018	0	0	10	50	0	-	+	-	0.08
Mamie	1909	0	0	10	50/120	0	-	+	-	0.14
Rawl	1959	0	0	7.5	50	0	-	+	-	0.13
Sci-Tech	2001	0	0	6.5	50	0	-	+	-	0.09
SHC	1930	0	0	6.5	50	0	-	+	-	0.07
SRC	1994	0	0	10	50	0	-	+	-	NA
Wright	1925	0	0	7.5	50	0	-	+	-	0.08

Table 1: Aqua Screen Water Test Kit Results

Discussion

Based on observations throughout the course of testing the water samples, it can be difficult to discern the results and make a final conclusion. The EPA recommended maximum level for hardness is 50 ppm. It is unlikely that all 15 water samples would have a hardness level that would make the water unsafe to drink; especially considering that most of the samples taken were from water fountains that contain filters. Additionally, a similar occurrence happened with the pesticide test. It is also unlikely that all 15 samples would test positive for the presence of pesticide. According to the manufacturer, the pesticide test detects atrazine and simazine at 3 and 4 parts per billion (ppb), respectively. Furthermore, the variation in the pH results suggests an inaccuracy. The EPA recommends that the pH of drinking water be between 6.5 to 8.5. While the orange color on the pH reagent pads is indicative of a pH of around 6.5 to 7.5, the pink color suggests a pH of 8.5 to 10, which is above the recommended pH level. The difference in the two colors is the difference between water that is safe and healthy to drink versuses water that is not. In order to get an accurate and discernable reading, the indicator pad should turn one color. Since the reagent pad turned multiple colors on many of the samples, it is difficult to definitively make a conclusion on the accuracy of the testing strips. Further testing with a pH meter could be done in order to verify the validity of the results. The lead and pesticide results from the calibration standards also suggests a defectiveness or faultiness. According to the instruction manual, the lead test detects lead at the EPA Action Level of 15 ppb. At a minimum, the calibration standard of 50 ppb should have resulted in a positive lead test. However, since an aliquot of nitric acid was added to the calibration standard for ICP analysis, it is possible this interfered with the testing strips. Additionally, the water sample from Graham had a lead concentration of 4.83 ppb, but since this is below the EPA Action Level, it went undetected by the lead testing strips. Yet, the EPA has now set the maximum contaminant level goal for lead at 0 since there has not been a safe blood level identified in children and even low levels of exposure can be harmful to human health. Overall, the results were inconclusive as many of the tests were contradicting and had results that were hard to discern. The results highlight areas for possible improvement and suggest that several changes need to be made to at-home water testing kits in order to make them more reliable including results that are easy to interpret and an increased sensitivity. The hope is that this project will aid in keeping the public safe and inform them about the importance of water quality. Sufficient testing has not been done on the reliability and accuracy of many at-home water tests that are widely available. It is vital that this research be executed to ensure consumers can confidently protect themselves and those around them, increase the confidence in tap water quality, and address water insecurity in affected communities. This research can also be used to further sustainable water management practices and enhance the current understanding of water quality.

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