Project Title: Well, well, what's in your well?

School: Pinkerton Academy, Derry, NH

Grade Level: 11-12

Teacher: Michelle Mize

Project Partners: SEPA Team, Anecdata, Tuva, PIDL, MDI Biological Laboratory, Dartmouth College Geisel School of Medicine, Derry and Manchester, NH Municipalities.

Teacher Profile: Michelle Mize, a NH native is a Career and Technical Education teacher for the past 17 years in plant science, natural resources, forestry and previously worked in the field. She has a M.A.L.S. degree from UNH with a focus in Environmental Education and Natural Resource Inventory (N.R.I.) applications and case studies. In addition she has a great interest in water quality and is excited about her students being involved in an EPA study about arsenic in drinking water. She is also involved in lake monitoring in Southern NH and has long volunteered to serve the NH Dept. of Environmental Services "Weed Watch Program" as well as the Sunset Lake Association.

As a product of CTE herself (KHS- '85) she realizes the value of hands on application in real life scenarios to interest and motivate high school students to develop cross-curricular critical thinking skills.

Summary:

- The 2019-20 school year students planned the execution, budget and ordering of supplies to take 30 samples of class students well water and a set of CTE faculty samples as well as pH and Nitrites strips.
- Students had identified areas in need for testing and realized that Pinkerton students and staff cover a variety of towns that are in need of education. We planned to tour Derry and Manchester municipal water and wastewater plants and learned where much of our Town water in Derry comes from and where it goes as well as ways of remediation.

The students are from many NH towns in the surrounding area; Derry, Hampstead, Chester, Auburn, Hooksett and sending students from Windham, Exeter and Pelham for CTE courses. We focused on the issues of our soils types having high occurrence of potential arsenic, high past/present farm/apple orchards/pesticide and subsequent potential health issues. We broke town parts of a water test, EPA parameters and aesthetic issues with drinking water. We looked at previous tests and students brought in tests outcomes from home. Students were surprised that a few of them already had filters and many types of remediation, even arsenic and uranium. Some of our faculty members and students were excited for test results and others had a "don't know don't care" attitude which we found odd and wove into our next round of tests and education. We planned field trips and learned about the Massabesic watershed and its early conservation that has helped municipalities for decades. We also talked about who owns water and the USA Spring issues in nearby Nottingham and worldwide clean water availability and water privatization. We planned to do a bottled water taste

test to compare bottled water treatments such as reverse osmosis, distilled, mineral waters etc. The focus of our project was to understand arsenic, how it appears, and what it has been used for in the past and educating our community about the potential health problems it can cause.

Project Details: Several lectures and student research were completed as well as writing our proposal and obtaining materials.

- 2019- Sept.-Dec. Students developed an outline for the project with guidance and the questions were posed “what do you know, don’t you know and curious to know " about drinking water quality regarding arsenic and other factors and parameters. Students made test kits from supplies and parameters were discussed as well as Anecdata and TUVA use. Students took the kits home, explained/taught parents how to register and use the Allaboutarsenic.org portal. Students developed a collaborative slideshow and Kahoot about drinking water and health to be shown during Science Week.
- 2020- Jan.- March- Students received results and were put into groups and given several test results to analyze and come up with recommendation suggestions for each test comparing them to EPA and NH drinking water standards. We went over types of remediation for arsenic, uranium and aesthetics and how pH and correlative parameters such as soil and ionic exchange. Students became familiar with using Anecdata, TUVA and began using the tools. We planned to work on our part in Allabout arsenic.org on days we could not work in the sugar house due to temperature, wind, and lack of maple sap. Sugar maples were tapped March 1st and March 13th was our first bottling of maple syrup and the last time I saw my students.
- Remote Learning began on March 19th and I developed my lesson plans on All About Arsenic.org, Anecdata and TUVA. Students were charged to analyze all of the participating schools, chose 3 schools, develop a reason with documentation regarding arsenic and other parameters of why their communities needed education and then develop an output flyer, infographic, presentation, letter to the editor to educate their chosen schools and communities. Students became more aware of their impact on community related environmental issues and took a great deal of ownership and did a fantastic job using the tools and working as independent scientists. I was thankful to have this study in place for students to have a meaningful remote learning experience.
- Student sample projects were sent to Dr. Disney as the projects for Community Outreach were complete.
- A virtual field trip was provided by Manchester, NH Water Works for the last week in May.
- We then began a collaborative migrating bird study that if time allows we plan to upload to Anecdata and TUVA for our class and other students to participate in.

Discussion: Students learned that it was important to be aware of one’s own well and that municipalities have a responsibility under EPA requirements to provide clean drinking water. This happens to coincide with the St. Gobain plant contamination in Merrimack, NH and it was relevant timing as well as local zone of influence issues in the Town of Hampstead from local water company wells.

The project was exciting in that the students could see real life results and of samples, mapping and their community.

I think students are more apt to see other environmental issues in their communities and the world because of this experience and I found them much more willing as learners and presenters than normal due to a close reality connection. What do you think that students learned?

Student input on what they learned:

- “Which elements are common in water, Types of water sources, processing and pH levels. What arsenic is.
- Arsenic is a carcinogen.
- Arsenic is very common in certain soils. How arsenic affects the body. E.PA. standards for levels acceptable in drinking water and how they have changed over time. That arsenic is a health problem that can be remediated if one is aware of the presence of the contaminant(s) and well water testing is important.
- They learned that several of the areas surrounding Derry were in apple production for many years and several of those property wells have an abundance of arsenic in soil and well water.

References:
***See 2019

Acknowledgements:
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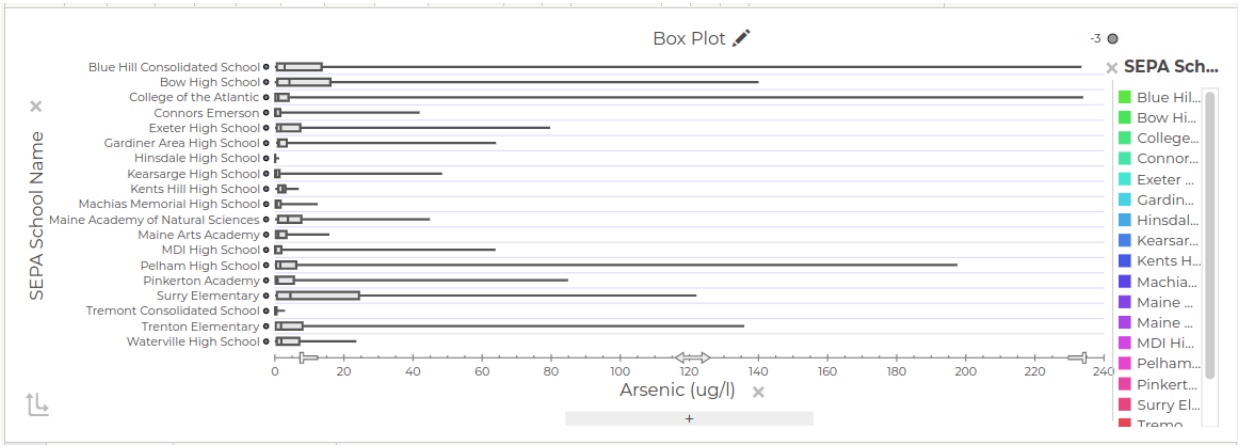
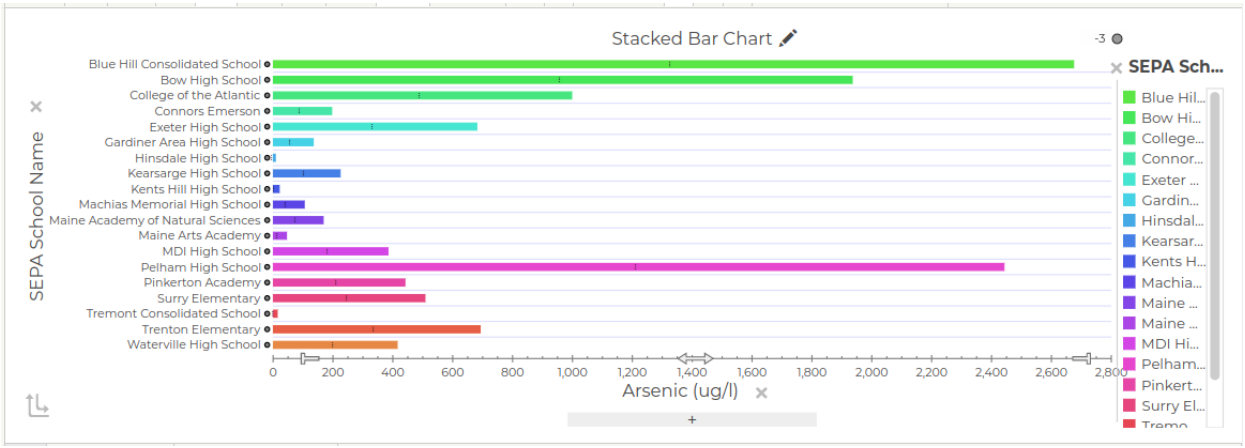
Appendix:
Well well, What’s in Your Well_ - Google Slides.html

Sample Student Report:
https://arsenicdata.tuvalabs.com/dataset/195/

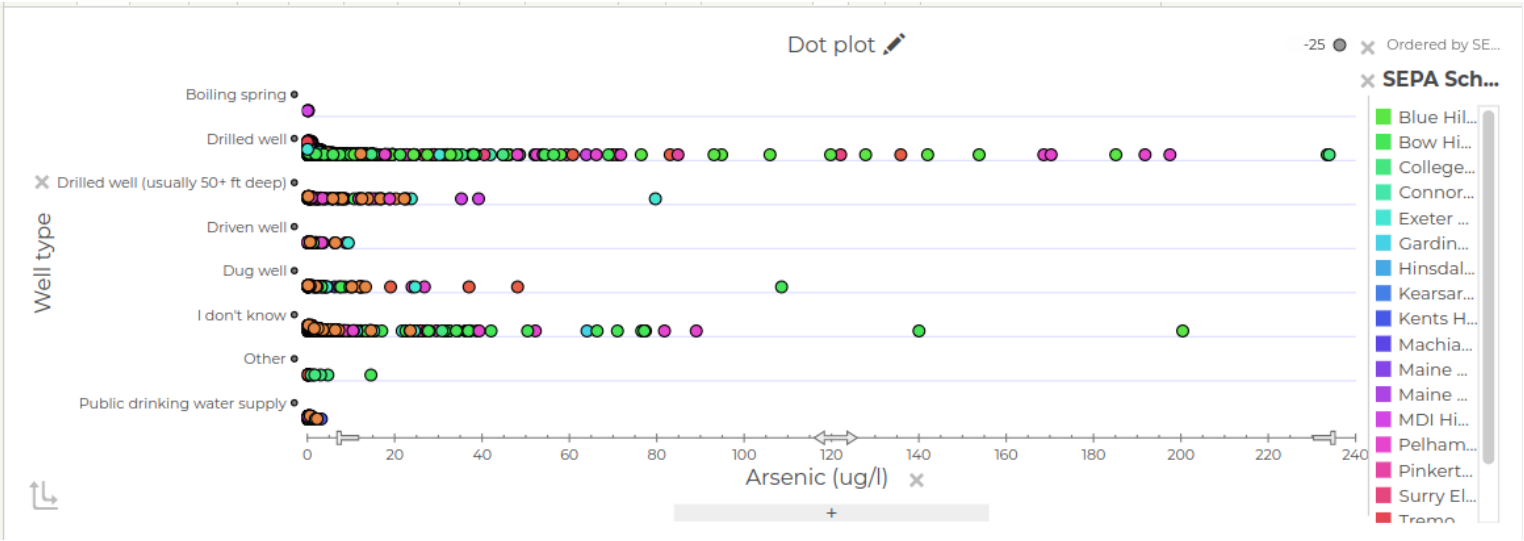
Item	Date Completed
Watch Videos	3/19
3 Charts/Graphs	3/19
Data-to-Action	In Progress
Questions & Sample Investigations	Questions: 3/20; SI: 3/20





3/23 - I chose to focus on Blue Hill Consolidated School, Bow High school, and Pelham High School for my analysis because these areas have the highest arsenic levels. I am looking to find a correlation between soil types and arsenic levels, as well as types and arsenic levels.

3/24 - Compared well types, researched correlations between well type and arsenic level, and arsenic levels and read “Graph Chart Choice” and “Thinking Your Way Through Data Analysis”



3/25 - More research on the correlation between well types and arsenic levels

- I looked into soil types and arsenic levels but couldn't find anything correlating the two
- Found some sources for well types and ages and mineral/arsenic levels

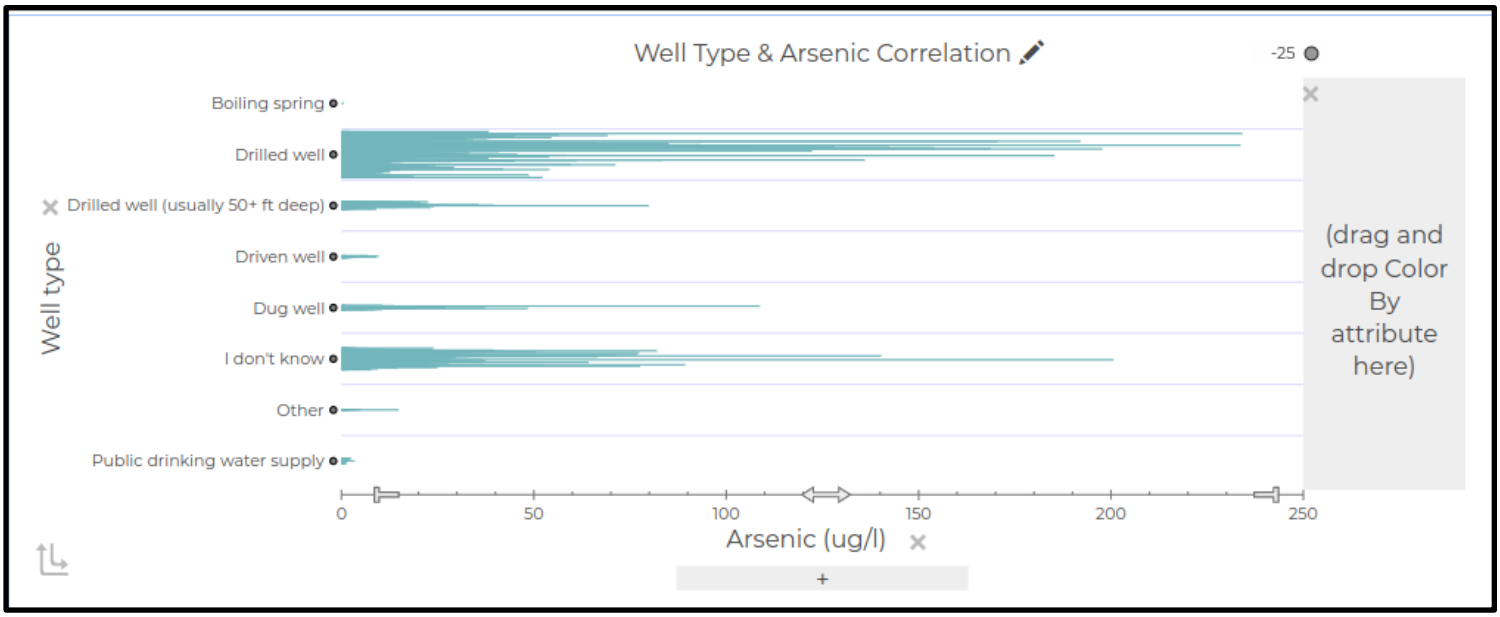
https://dhss.delaware.gov/dph/files/arsenicsoilfaq.pdf
https://pubs.usgs.gov/sir/2010/5047/pdf/SIR10-5047.pdf
https://www.sciencedirect.com/science/article/pii/S1674987119300313

3/26 - 3/27 - I came up with some investigation questions that I will work on answering for my data-to-action.
Investigation:

To find a correlation between well type and amount of arsenic in the drinking water.

Questions:

1) Is there a ***correlation*** between well type and amount of arsenic in the drinking water?
    a) Is the arsenic coming from public water or private water sources?



Yes - as seen on the above graph, of the homes registered, the houses with drilled wells typically have more arsenic than other types. In these cases, the arsenic levels above the legal limit are found in private water sources, not public sources.

2) Is there a ***causation*** between well type and amount of arsenic in the drinking water?

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3) Does the depth of a well have any effect on the amount of arsenic in the drinking water? Arsenic-Related Water Quality with Depth and Water Quality of Well-Head Samples from Production Wells, Oklahoma, 2008

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4) Does soil type have any correlation or causation with the amount of arsenic?

Distribution of Arsenic in the Environment - Arsenic

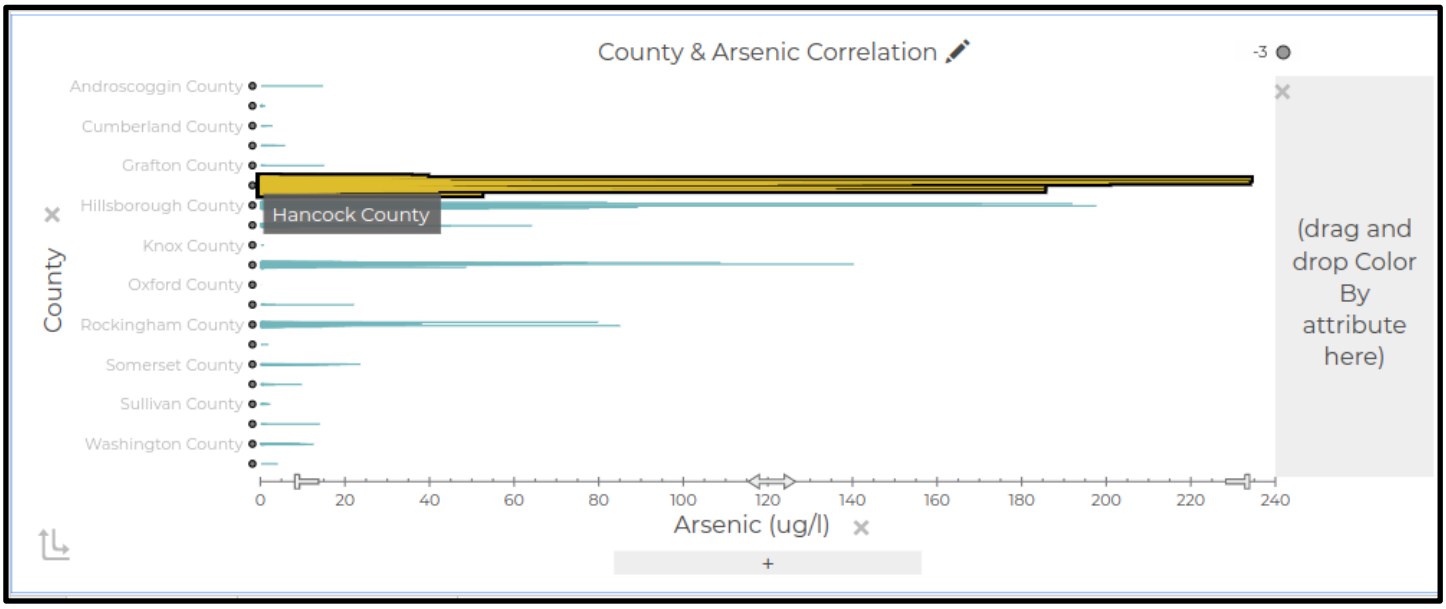
"Arsenic is present in all soils, and the geologic history of a particular soil determines its arsenic content"(Greaves).
"Soils overlying sulfide ore desposits commonly contain arsenic at several hundred parts per million" (Colbourn).
"Inorganic arsenate may be bound to iron and aluminum cations or oxides or to any other cation present (such as calcium, magnesium, lead, and zinc)" (Colbourn).
"The amount of available arsenic (extracted with 0.05 *N* hydrochloric acid and 0.025 *N* sulfuric acid) is small in virgin soils and averages about one-tenth of the total arsenic present in most cultivated soils" (Greaves).

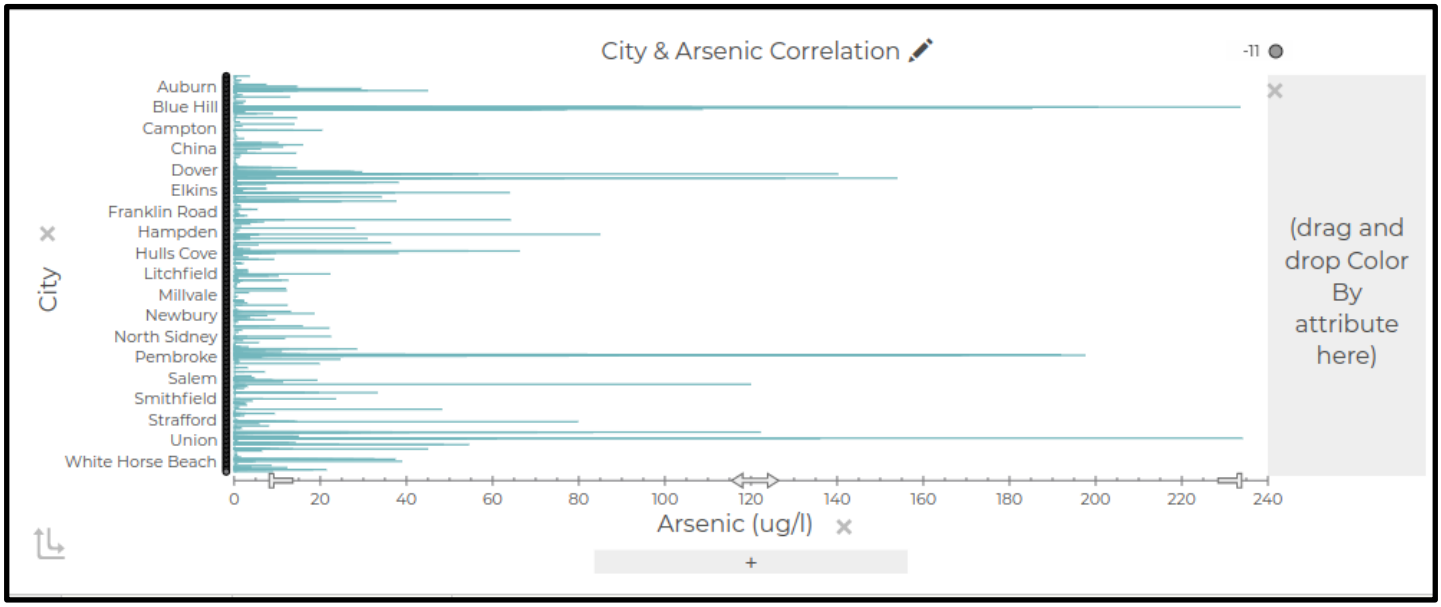
Colbourn, P., B. J. Alloway, and I. Thornton. Arsenic and heavy metals in soils associated with regional geochemical anomalies in south-west England. Sci. Total Environ. 4:359–363,1975.
Greaves, J. E. The occurrence of arsenic in soils. Biochem. Bull. 2:519–523,1913.

Arsenic in high concentrations is typically found in sulfide deposits. In a study done at Lake Michigan, arsenic found in surface sediments (0-6cm) averaged 12.4 ppm, almost double the amount of arsenic found at depths greater than 20cm (5.3 ppm). This means that there may be a correlation between sulfide levels in soil and arsenic levels as runoff into water. A positive correlation between iron content and arsenic has been found. There are also no known correlations between concentrations of phosphorus pentoxide, organic matter, or other major constituents and arsenic.

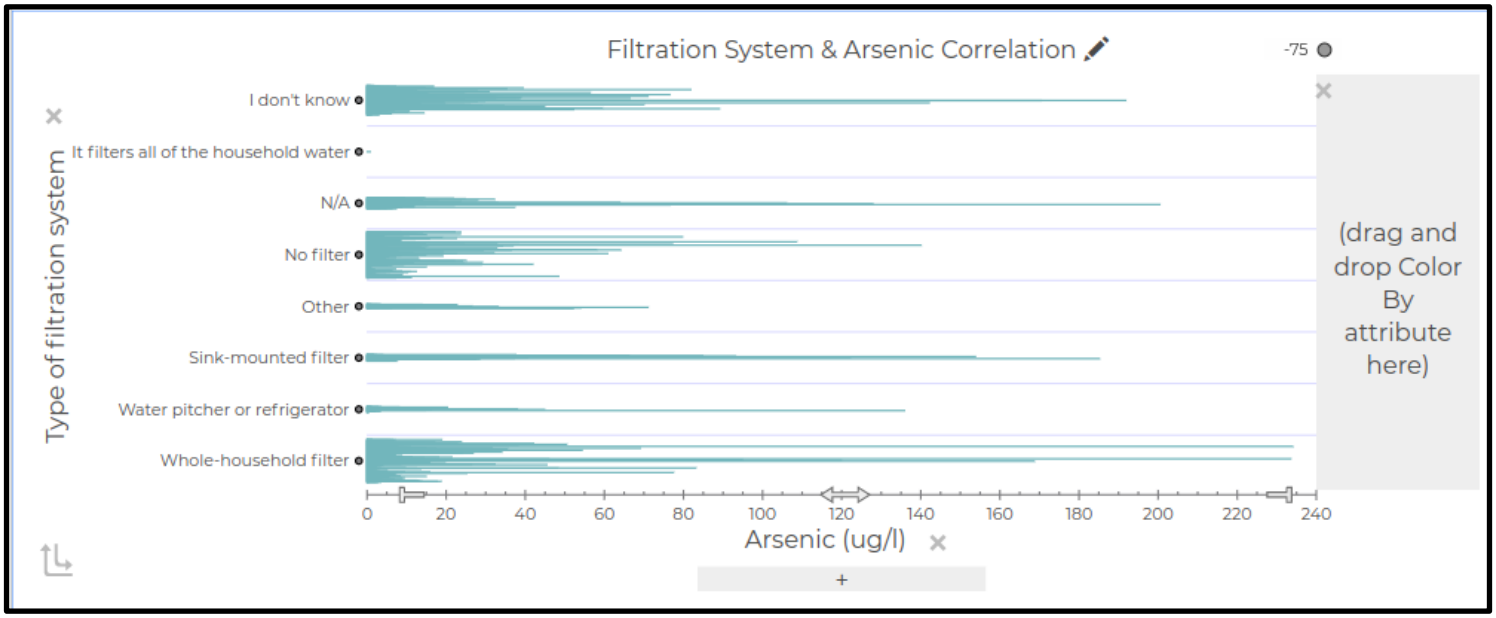
5) Outside of schools, do these areas of investigation (Blue Hill, Maine; Bow, NH; and Pelham, NH) have a known predisposition to high arsenic levels in drinking water?

Use a graph comparing areas with other minerals which have high correlations with the presence of arsenic





6) How can high arsenic levels best be treated (which method of removal is most successful)?

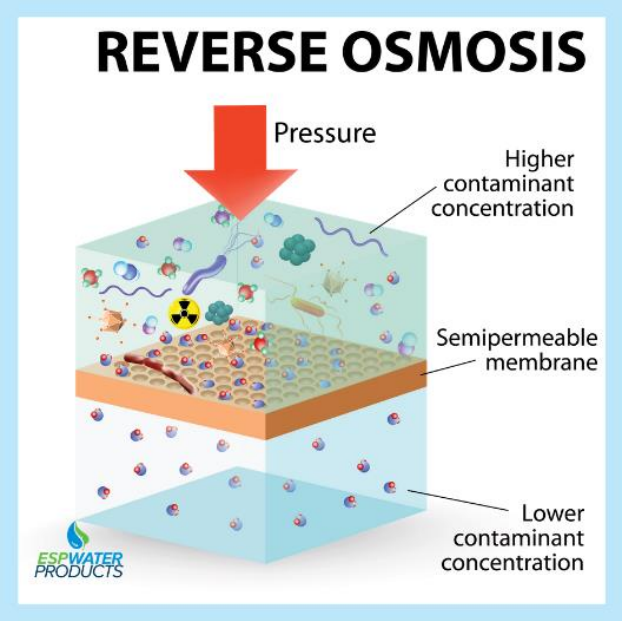


As the graph only shows correlations between filtration systems and the presence of arsenic, the levels can be due to a number of causes and thus the most effective filtration system cannot accurately be determined. However, by using outside sources, some successful methods of removal can be found. According to the Center for Disease Control, the most effective methods for reducing arsenic in drinking water are reverse osmosis, ultra-filtration, distillation, or ion exchange.
https://www.des.nh.gov/organization/commissioner/pip/factsheets/dwgb/documents/dwgb-1-2.pdf
https://www.cdc.gov/healthywater/drinking/private/wells/disease/arsenic.html#how_remove_from_water

3/30 - Continued to work on answering questions
- Looked at http://nhwaterwell.com/index.php and https://www.dartmouth.edu/~childrenshealth/arsenic/

3/31 - Worked on research for action plan:
- https://www.waterlogic.com/en-us/resources/contaminant-filters/how-to-remove-arsenic-from
- https://science.howstuffworks.com/reverse-osmosis.htm

I found that reverse osmosis is a common method of arsenic removal



4/1 - Began working on my data-to-action:

- I'm thinking that I will make posters and promote awareness for water testing since many people think that testing their water often is necessary
- I would also like to make a proposal for free or very discounted water testing kits (maybe similar to the ones we tried in class if there is a version of that for arsenic) available to NH state residents once a year or every two years if funding every year is not possible

4/2 - Kept working on my data-to-action

- I'm going to stick with making an infographic to promote awareness for water testing

4/3 + 4/7 + 4/8 + 4/9 - Working on summarizing my research and putting it into my infographic

- Designing and adding images/graphs to the infographic

Sources:

- Arsenic-Related Water Quality with Depth and Water Quality of Well-Head Samples from Production Wells, Oklahoma, 2008
- Distribution of Arsenic in the Environment - Arsenic
- https://www.des.nh.gov/organization/commissioner/pip/factsheets/dwgb/documents/dwgb-1-2.pdf
- https://www.cdc.gov/healthywater/drinking/private/wells/disease/arsenic.html#how_remove_from_water
- https://www.waterlogic.com/en-us/resources/contaminant-filters/how-to-remove-arsenic-from
- https://science.howstuffworks.com/reverse-osmosis.htm
- https://arsenicdata.tuvalabs.com/dataset/195/