Project Title: Arsenic Project

School: Gorham High School

Grade Level: 9

Teacher: Ms. Sarah Clemmitt

Project Partners:

Dr. Kate Buckman, Dartmouth Toxic Metals Superfund Research Program, Dartmouth College

Teacher Profile:

I have been teaching science for 25 years, and have taught at five different high schools including a broad mix of small, large, urban, suburban, rural, private and public. I currently teach 9th grade Integrated Science, Chemistry, Physics and AP Chemistry at a small, rural school in New Hampshire. I completed my undergraduate work at Colgate University with a BS in Geology and my graduate work at George Washington University with a MEd in Secondary Science Education. Throughout my career, I have committed to bringing citizen science to my curriculum and have actively pursued opportunities for students to get out in the field, to work with real data, to be placed in internships with local scientific organizations, and to present their findings in venues beyond the classroom.

Summary:

At Gorham Middle High School we teach Integrated Science to all 9th graders, half during first semester and half during second semester. This course is a blend of introductory physics and chemistry intertwined with relevant earth science topics all in alignment with Next Generation Science Standards (NGSS). We are in an ongoing process of blending a curriculum thread focused on water quality, heavy metals and some of the chemistry involved. In addition to the core ideas, we are committed to the NGSS Science & Engineering Practices. This Data to Action project involving arsenic in well water fits in perfectly. In the 2021-2022 school year, the Integrated Science classes were composed of 33 students in two sections, leveled by ability. Most of the students live in homes with access to the town water supply so we were only able to collect five samples from students and three samples from community members for analysis. These samples were tested at Dartmouth College for fourteen metals. We focused only on the arsenic content in wells in Maine and New Hampshire - the percentage of wells above the state standards, where they are located, and the relationship to the type of well and filtration system. Students analyzed the data through TUVA and presented information during a class discussion. We planned to discuss this data analysis with Dr. Kate Buckman, but because of a COVID exposure she had to cancel at the last minute. As community outreach, students interviewed and discussed arsenic in water with a community member of their choice.

Project Details:

1) There were 33 students involved in this project from the 9th grade Integrated Science classes. Activities were done twice, once each semester
2) Samples were collected over the summer from three community members in the town of Randolph, NH. Five students supplied samples.
3) Students were introduced to TUVA with datasets I uploaded; earthquake data from the Bay Area, wave properties they collected using the PhET simulation, Wave on a String, and environmental mercury data they collected as part of another grant with Dartmouth Toxic Metals Research Program.

4) Data Analysis
   A. I began with a reintroduction to arsenic and the project, and they watched In Small Doses: Arsenic (10 min) and completed All About Arsenic Introduction (adapted version for Level 2 & 3 students). This exercise teases out some of the key points of the movie and orients the students to the data set. Units of measurement, the color coding in relationship to maximum MCL, and how the Gorham are fared. (Figure 1)

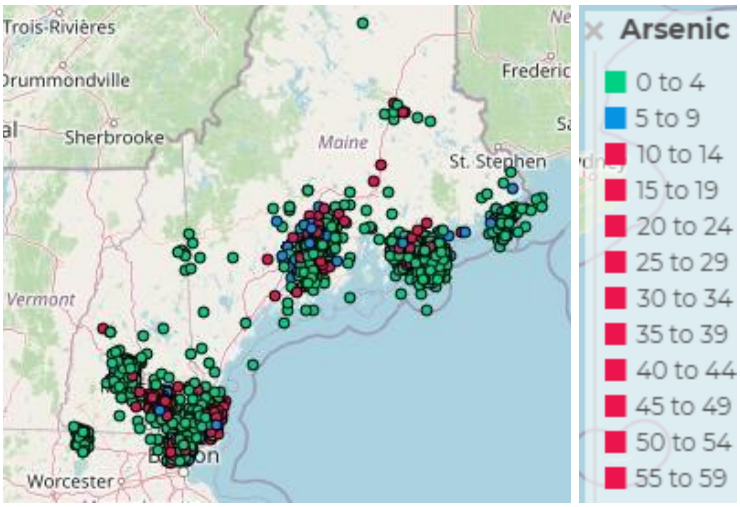

Figure 1: Geographic Distribution of Data

   B. The students were then walked through adding an attribute, As<=5 ppb, so they could better sort by the MCL level for New Hampshire. They were able to use this for Maine too.

   C. Students selected one of the following four questions to analyze.

      a. What percentage of the wells tested are above the state maximum? In New Hampshire, arsenic levels should be 5 ppb or lower. In Maine, arsenic levels should be 10 ppb or lower.
      b. Which counties in New Hampshire have the highest levels of arsenic in private wells, above 5 ppb?
      c. Are arsenic levels related to whether or not the water is filtered.
      d. Does the amount of arsenic depend on whether the well was dug or drilled?

   D. Students shared what the dataset revealed about the question they chose, Arsenic Data, 2022. The class not only discussed what the graph showed, but also focused on the value of the style of graph chosen and what alternatives or additions would enhance the graph. Unfortunately, at the last minute Dr Kate Buckman was unable to attend this session due to a COVID exposure. Below are samples of the graphs presented.

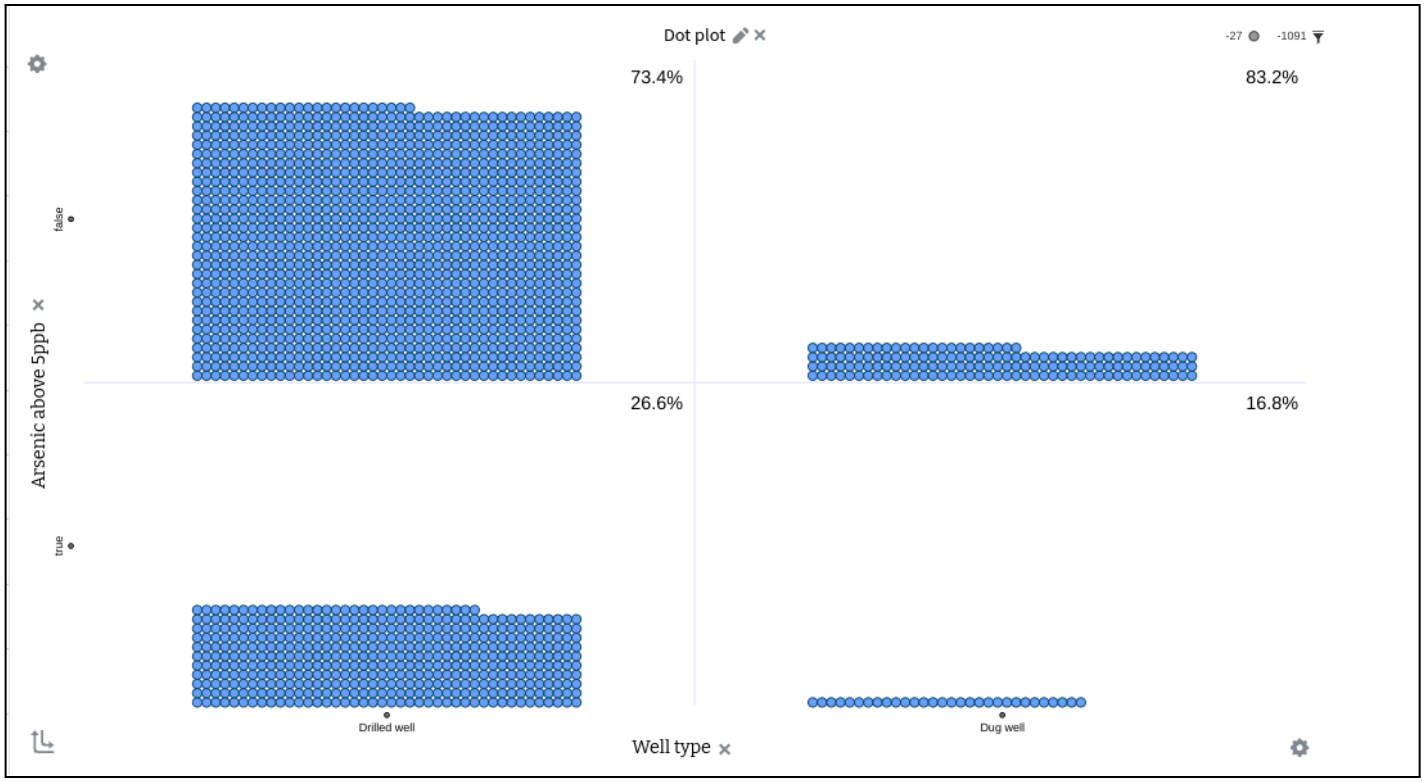

Figure 2a: This graph looks at which type of well, dug or drilled, has levels of arsenic above 5 ppb.

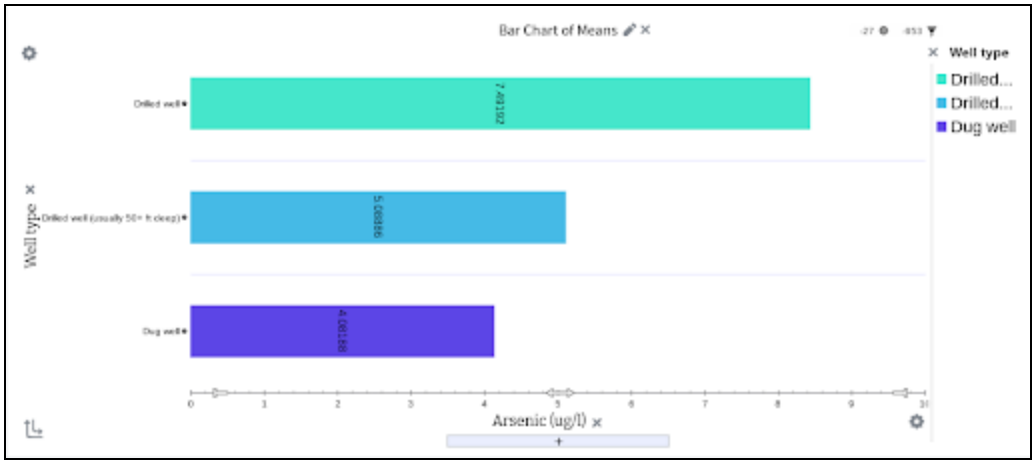

Figure 2b: This graph also looks at arsenic levels in dug versus drilled wells. This graph sparked a great discussion about not only combining the two drilled categories, but also the pluses and minuses of people self-reporting things such as type of well, depth, filter type etc.

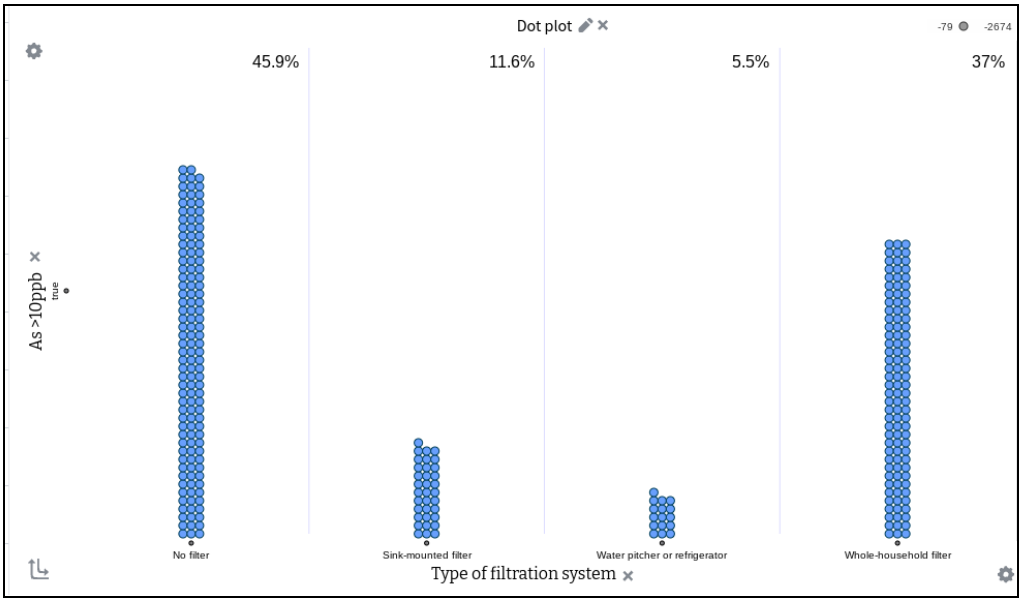

Figure 3a: This graph looks at arsenic levels and filtration systems. The ensuing discussion focused not only the fact that no filtration system shows the highest levels of arsenic, but also brought us back to the effect of people self-reporting things such as type of well, depth, filter type etc.

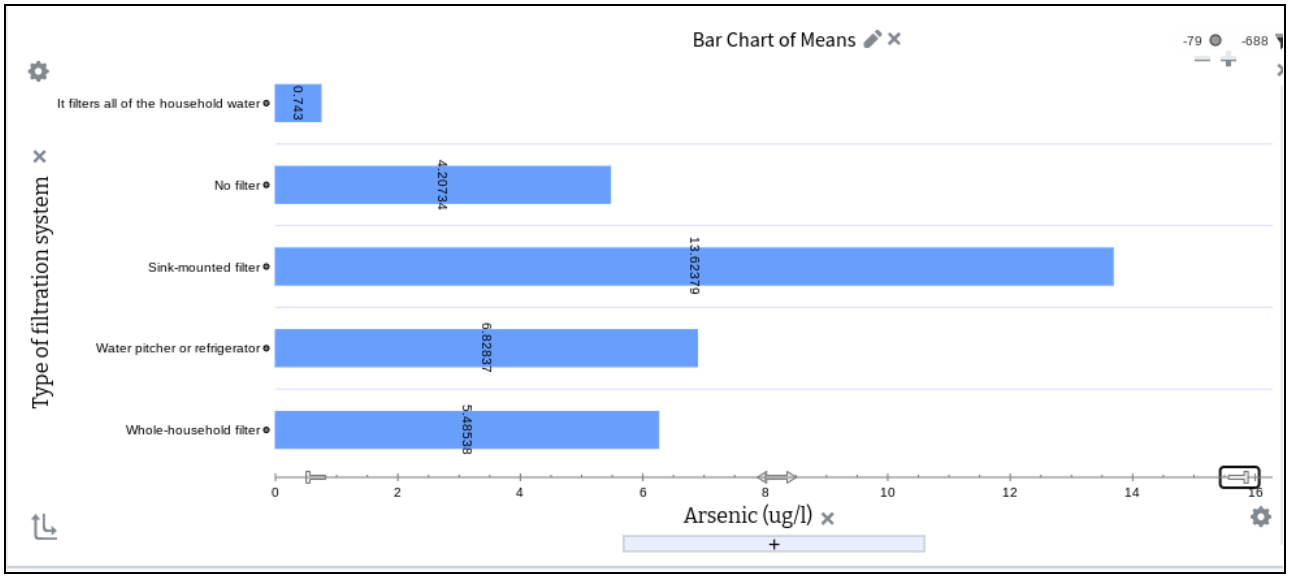

Figure 3b: This graph also looks at arsenic levels and filtration systems, but now the discussion centered around why this data appears to contradict that in Figure 7a.

6) As community outreach, the Level 1 students completed an interview with a parent/guardian, teacher, relative or friend, Heavy Metals Questionnaire. This idea was to have them find out what people knew and how many misconceptions there actually are, but also to share what they have learned and hopefully educate someone else.

Discussion:

Once again students are leaving this school year with a broader awareness of toxic metals and water quality. This year's outreach required each student to interview and discuss with a community member of their choice so they could see for themselves what people knew and how many misconceptions there actually are. In addition, this science was not something that came out of a textbook, rather the topic was intimately linked to their community and the broader communities of the state and New England, its geology and history.

When processing the data, my 9th graders began to appreciate how to handle larger volumes of data, Big Data. Working with the arsenic data set fits beautifully in the semester-long progression of working with spreadsheets and TUVA. Next year, I plan to expand the discussions we had concerning the graphs to other graphing activities throughout the semester.

In the previous two years working on this SEPA project, I have struggled a bit with the community outreach piece of this project. Coos County is unlikely to have any wells with elevated levels of arsenic. As a result, students are easily engaged in data analysis, but generating interest in advocacy around this topic is challenging. This year I tied the arsenic advocacy in with other heavy metals we studied and had students interview a community member of their choice. The idea was to have the students see how much other people know and do not know about arsenic in well water. In addition, I coached students to correct any misinformation. This approach was a perfect fit for us and I plan on continuing this - honing the questions and allowing for class analysis of the results.

Conclusion:

I have a strong commitment to citizen science and throughout my career have actively sought out data driven projects to foster a deeper connection between my students and their community. The All About Arsenic project is a beautiful fit. For students in Coos County, this project allows them to not only look at the water quality in their own homes and gain awareness of where their water is coming from, but the project also expands the definition of "community" to what is going on in other portions of the New Hampshire and New England that affect legislation. I cannot think of a better way to begin having them explore the interconnectedness of people and regions.

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