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 24 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 2020-2021 school year, the Integrated Science classes were composed of 32 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 three samples from a student and eleven 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. Each student either presented their information via a poster or during a class discussion. One student co-wrote an article for a local newsletter, and students met virtually with Sergio Cahueque, of Defend Our Health, and Isidora Segovia, a student at College of the Atlantic, to discuss advocacy.

Project Details:

1) There were 32 students involved in this project from the 9th grade Integrated Science classes. Activities were done twice, once each semester
2) To increase my own knowledge, in July 2020 I met with Dyk Eusden, a professor of Earth & Climate Studies at Bates College, to discuss and clarify the rock structures and types contributing to the arsenic leached into well water in Maine and New Hampshire.
3) Samples were collected over the summer from 11 community members in the town of Randolph, NH. As most students live in the boundaries of the town water supply, only 3 students supplied samples.
4) 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 a grant with Dartmouth Toxic Metals Research Program.

5) Data Analysis
   A. I began with a reintroduction to arsenic and the project, and they watched In Small Doses: Arsenic (10 min).
   B. Next they looked at the data, Arsenic Data (adapted version for Level 2 & 3 students). First they responded to a series of questions requiring them to orient themselves to the data set itself; the volume of data collected, when and where it was collected, units of measurement and the value of the default color coded scale. As geography plays a significant role, they were asked to create a map of the data so they could see the geographic distribution. (Figure 1)

Figure 1: Geographic Distribution of Data

   C. The students were then walked through adding an attribute so they could better sort by the MCL level for New Hampshire. (Figure 2)

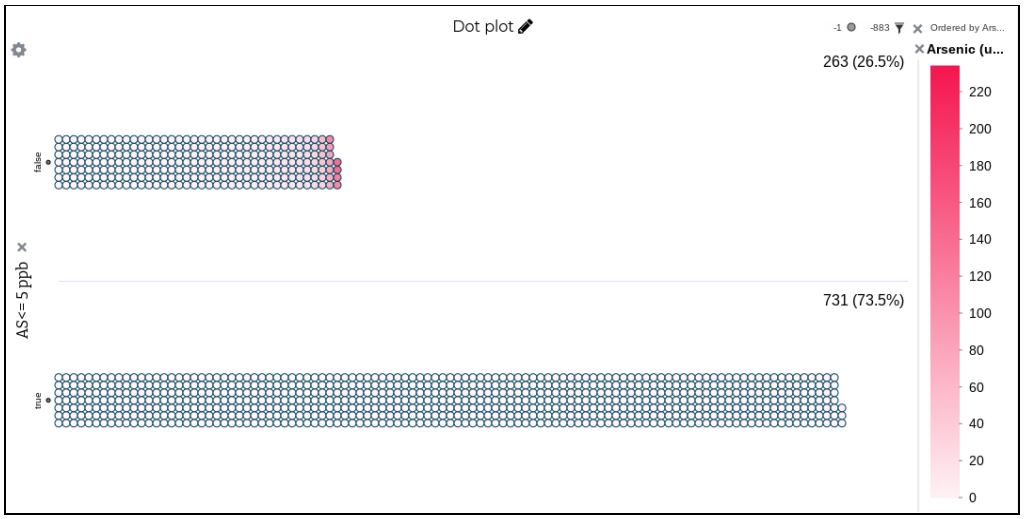

Figure 2: Sample Graph Using Added Attribute, As<=5 ppb

   D. I asked them to select one of the following four questions to analyze.

      a. What percentage of the wells tested are above the NH state maximum? In New Hampshire, arsenic levels should be 5 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?

E. Level 2 & 3 students used LucidPress to create a poster sharing information about arsenic in well water and what the dataset revealed about the question they chose, Arsenic Project Wrap Up, 2020-21. Below are samples of the posters students produced.

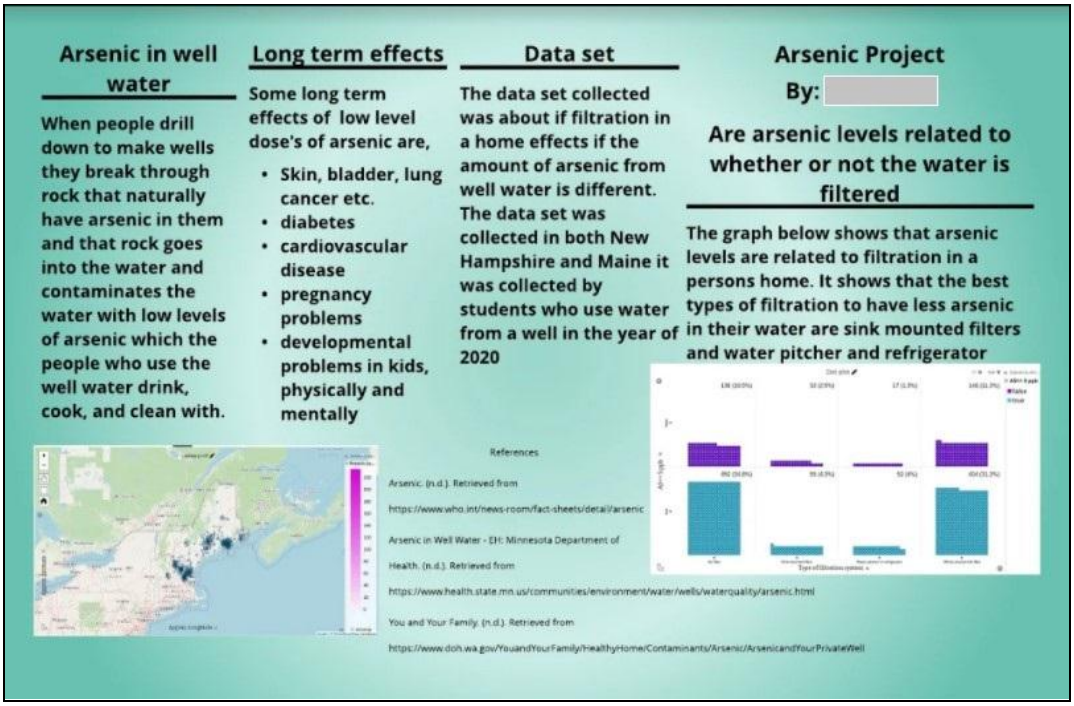

Figure 3: Sample Poster from Level 2 Student

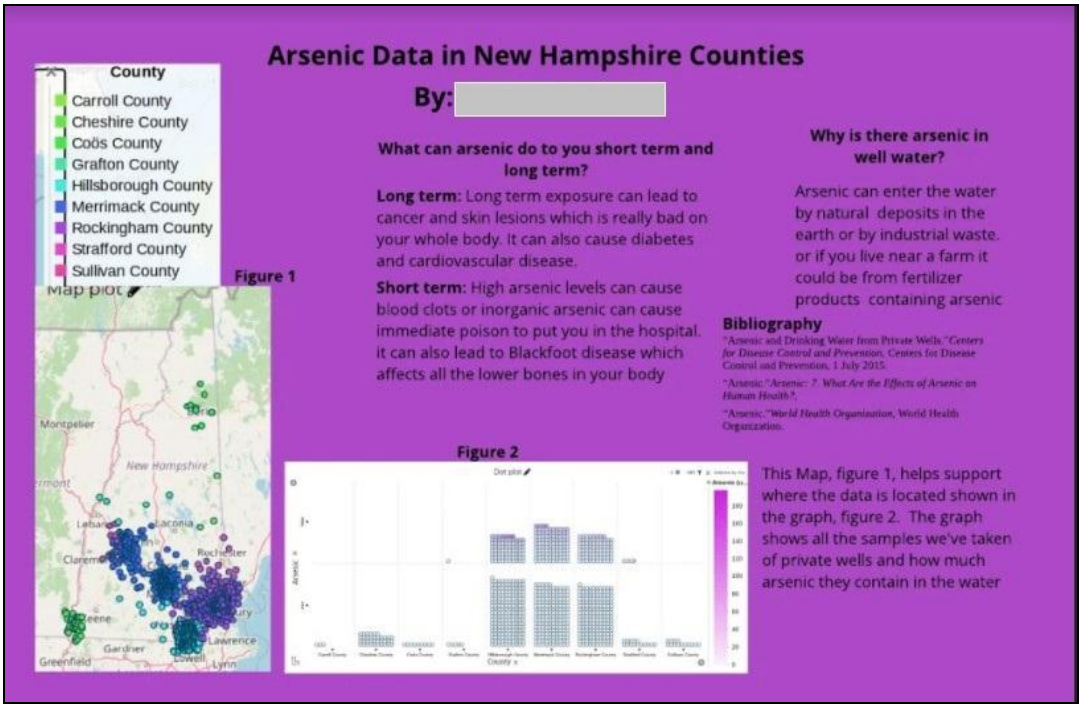

Figure 4: Sample Poster from Level 2 Student

Figure 5: Sample Poster from Level 3 Student

F. Level 1 students shared what the dataset revealed about the question they chose, Arsenic Project Wrap Up, 2020-21. 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. Below are samples of the graphs presented.

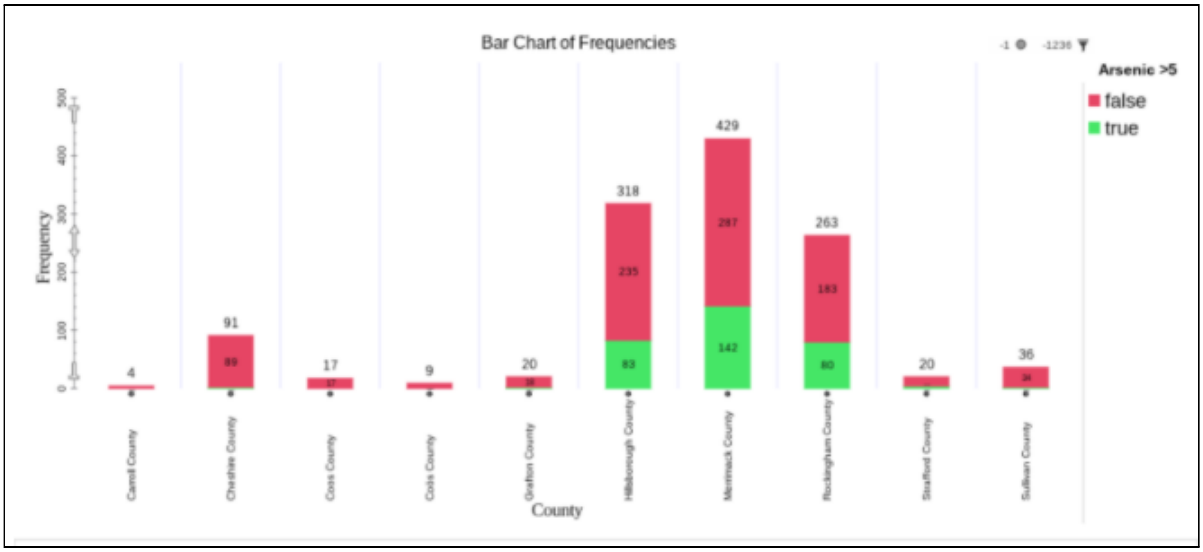

Figure 6: Which counties in New Hampshire have the highest levels of arsenic in private wells, above 5 ppb?

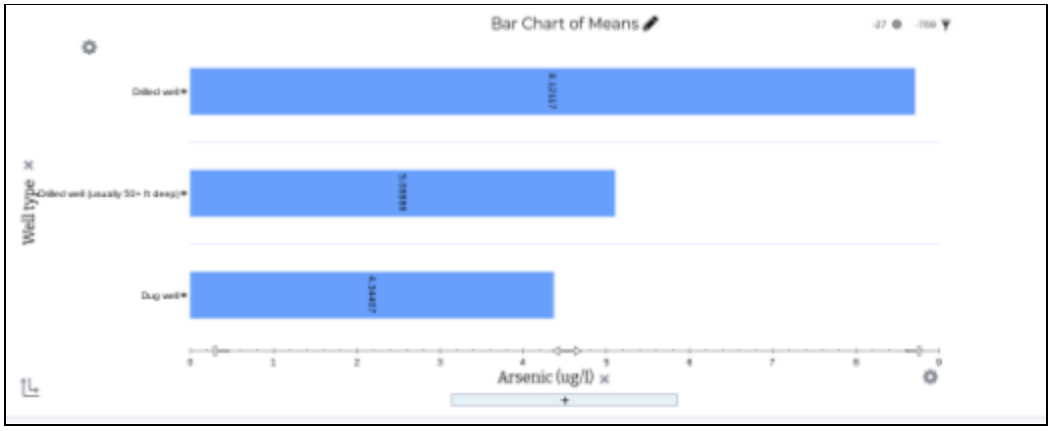

Figure 7: Does the amount of arsenic depend on whether the well was dug or drilled?

6) As community outreach, one Level 2 student co-wrote an article for the *Mountain View*, a quarterly publication for the town of Randolph NH, explaining the project, thanking those who provided samples and soliciting samples for next year. This writing was coordinated with an English teacher and incorporated into a community outreach assignment already in place. *Well Water Samples Collected for Gorham High School Science Partnership* will appear in the June 2021 edition of the *Mountain View*.

7) In support of community outreach, the Level 1 students ...
   A. met virtually with Sergio Cahueque, of Defend Our Health, and Isidora Segovia, a student at College of the Atlantic, to discuss advocacy not only for legislation concerning arsenic in well water, but also advocacy in general.
   B. were given a bonus opportunity to write
      a) comments to the Maine Appropriations Committee to advocate for funding
      b) ME Commissioner of Health & Human Service, Jeanne Lambrew, to alert her of the bill that
         i) requires rulemaking sooner rather than later
         ii) consideration of MCL set to a more health-protective level of 5 ppb, like NH
      c) letter of appreciation to one of two key players in the passing of NH bill's lowering As levels
         i) Mindy Messmer, no longer in office, but one of the sponsors of bill HB1592
         ii) Paul Susca supervises the Planning, Protection and Assistance Section for DES (Department of Environmental Services) and was one of the key compilers for the DES report.

      Unfortunately no student took advantage of these opportunities.

Discussion:

Once again students are leaving this school year with a broader awareness of toxic metals and water quality. This year they participated in two citizen science water quality projects, both of which demonstrate that there are protocols for sample collection and the role citizens can play in the acquisition of data. In addition, the science was not something that came out of a textbook, rather the science 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. As I had not used TUVA last year, this year I focused on incorporating TUVA into not only this project, but the overall curriculum. Next year, I plan to focus on better blending the work with TUVA with the spreadsheet skills they need so both flow nicely throughout the semester.

As this was my second year working on this SEPA project, I felt more comfortable with my knowledge of arsenic and well water concerns in Maine and New Hampshire and was able to shift my focus to incorporating advocacy into the students' experience. Living in Coos County, it is unlikely that we will sample 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 continues to be a challenge. It is too removed from their immediate community. My plan is to continue having students present their findings in some way around town. This year was the article in the *Mountain View*. Next year I am hoping for a poster display in the town library, assuming they are fully operating. I was also extremely pleased with the advocacy meeting with Sergio and Isi. They not only shared what was happening with arsenic legislation in Maine, but provided a broader context to advocacy. I plan on working with this broader definition next year.

In addition, I intend on collecting samples over the summer as well as partnering with the elementary school to increase the number of samples we provide.

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 us, up in Coos County, this project allows students 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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