Project Title: Elevated Groundwater Arsenic Concentrations In Private Wells in Central Maine

School: Waterville Senior High School

Grade Level:10-12

Your Name: Jon Ramgren and Justin Giroux

Project Partners: Dr. Juyoung K. Shim, University of Maine Augusta, was the scientist partner for this project. Justin Giroux and Jon Ramgren, the chemistry teachers at Waterville Senior High School, collaborated on the implementation of this project.

Teacher/Scientist Partner Profile:
Jon Ramgren has been teaching for 31 years. He has a Bachelor of Science in chemistry from North Park College and a Masters in Secondary Science Education from The Ohio State University. Over the last 11 years he has involved students in research opportunities at the Mount Desert Biological Laboratory during April vacations and summers. He coaches the Science Olympiad Team and the National Ocean Science Bowl Team. He enjoys seeing students get involved in new experiences that lead them to engage in further learning about - and exploration of - their world.

Justin Giroux has been teaching for 10 years. He has a biochemistry degree from Bates College with a focus on environmental chemistry. His undergraduate research focused on improving the efficiency of CdSe based photovoltaics. Justin is interested in bringing real life problems to his classroom to allow his students the chance to work on something meaningful to their community. To achieve this, his chemistry classes have a focus on energy and water.

Summary:
During the first weeks of school, Waterville High School students collected well water samples. This was done in the early fall with the idea that students could sample water at their camps before they were winterized. Obtaining samples was difficult for many of the students as they live on public water supplies. Obtaining a sample was worth a grade in each class. Adults in the building were able to help out students who could not find a well to sample. Some students who also attend the Mid-Maine Technical Center enlisted the help of peers from other schools who are not on public water to obtain a well water sample. Students also conducted experiments involving planaria and arsenic concentrations ranging from 0 to 50 ppb.

Project Details:

- How many students were in the class that was involved in this project? Justin had 40 students work on this project. Jon had 46 students.

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- Detail specific curricular items such as questions, articles, books, YouTube videos, and labs. It's helpful if you provide links.

    - "The Quest for a Clean Drink" https://www.acs.org/content/dam/acsorg/education/resources/highschool/chemmatters/gcquest-for-a-clean-drink.pdf
    - "The Flint Water Crisis: What's Really Going On?"

https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/pastissues/20 16-2017/december-2016/flint-water-crisis.html
    - Maine Geological Survey Bedrock Geology Maps https://www.maine.gov/dacf/mgs/pubs/online/bedrock/state.htm
    - "How Much Arsenic is in Rice" https://www.youtube.com/watch?v=9XK66S50oas
    - Tuva Video tutorials https://tuvalabs.com/resources/videos/
    - Tuva pre-made data sets and activities https://tuvalabs.com/content/?show=all&view=block&type=datasets&order_by=-last_modified
    - "Assessment of Arsenic Concentrations in Domestic Well Water, by Town, in Maine, 2005–09" https://pubs.usgs.gov/sir/2010/5199/
    - Questions for "All About Arsenic - Data to Action: A Secondary School-Based..., http://www.allaboutarsenic.org/
    - "Well, Should We Question the Water?" https://tuvalabs.com/datasets/arsenic_in_wellwater/activities/view/804
    - "Can Arsenic Be Filtered Out?" https://tuvalabs.com/datasets/arsenic_in_wellwater/activities/
    - Jon and Justin used Tuva activities to teach students how to use the program. Jon put the data from the penny density lab into Tuva and had students make graphs of the data. Jon also put the data from the planaria bioassay into Tuva and students make graphs to analyze the data. Jon used the Tuva with trends in the periodic table and incorporated a Tuva activity in the mid-year exam. Justin used Tuva with his periodic table unit. Students also made various graphs of the Arsenic Data Set.
    - Essential question: How widespread is arsenic in Maine's well water?
    - Essential question: How does arsenic affect the movement of planaria?
    - Essential question: How does arsenic affect the regeneration of planaria?
    - Essential question: Is lead in pipes an issue today in Waterville, ME?
    - Essential question: What conditions cause the water quality of Messalonskee Stream to change?
    - Essential question: How widespread is the PFOA contamination in Central Maine?
- Did you:
    - Collaborate with any other teachers in your school? *See above*
    - Go on any field trips? Why and where? *Only to the local stream.*
    - Conduct any experiments? What kinds of questions did students ask? *We used planaria as model organisms to ask two questions: How does arsenic concentration change planaria regeneration after the planaria are cut in two?*
    - Use your stipend to purchase anything for your classroom? If so, what, and how did you use it? *Water sample collection tubes, planaria, razorblades, paint brushes.*
    - Invite any guests to visit your classroom? *No*
- How did you use Tuva, both for the arsenic data and for other datasets? Students used the periodic table dataset as the introduction to Tuva. Students produced graphs of penny density data in Tuva. Students made graphs of their planaria movement data. Once the well water arsenic data was produced students used Tuva to look at the dataset to explore associations between the different attributes. Students then begin to understand that not all data is significant and work must be done to determine what is and what is not significant.
- How did you plan your community outreach?
    - What did the students do?
        - Justin's students worked creating content with the idea of making blog posts to inform

readers about arsenic.

- Jon's students wrote letters to the editor..

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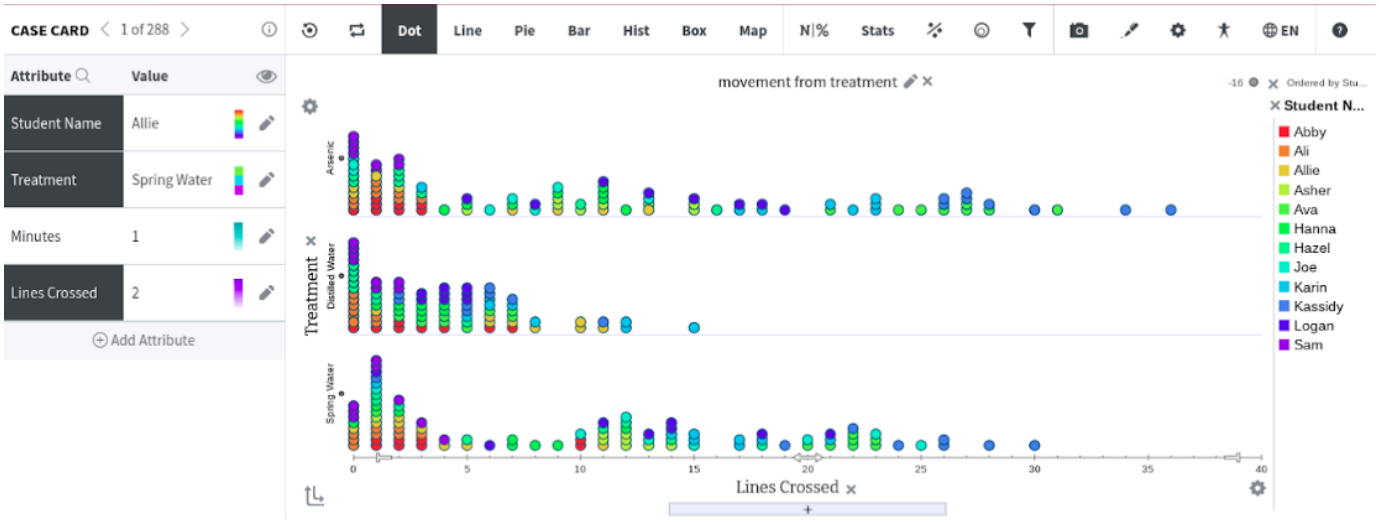
- What was the impact?
  - Justin's students did not publish their content.
  - Jon's students didn't mail their letters.

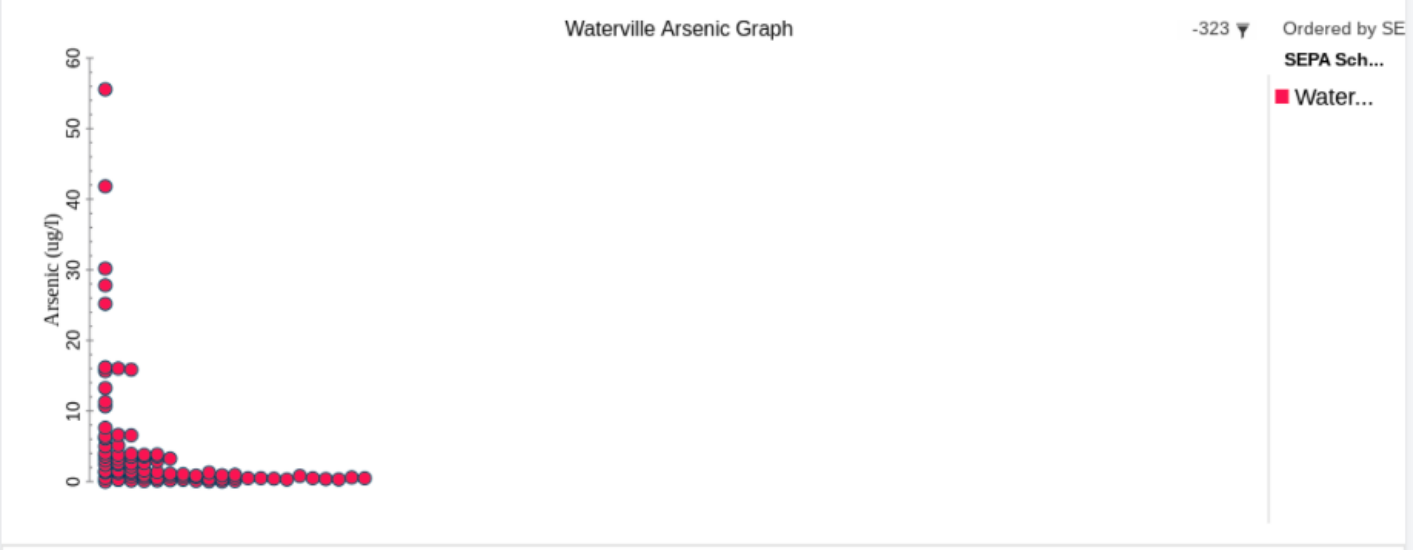
- Include any data analyzes your students did.

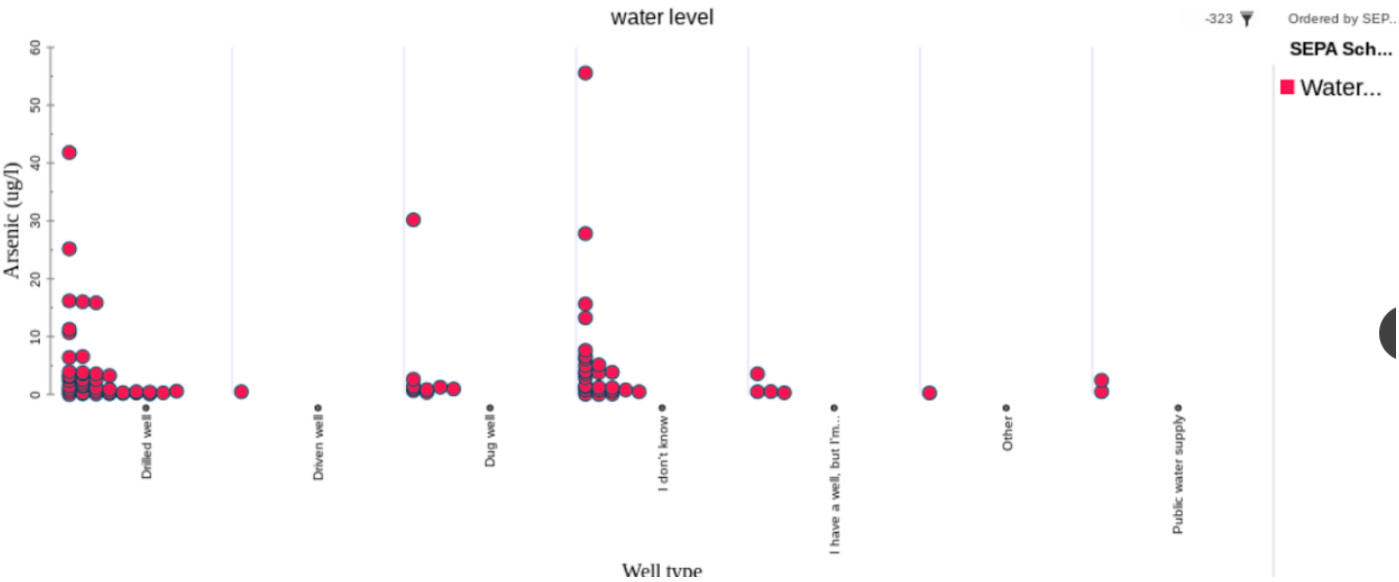
Discussion:

Jon's student's graphs of how many grid lines on ¼ inch graph paper planaria crossed per minute for 8 minutes in three different treatments: Spring water, distilled water, 50 ppb arsenic solution in 10% spring water and 50% distilled water.



Jon's student's graphs of the arsenic levels found in well water samples provided by Waterville Senior High school students in the 2021-2022 school year (similar graphs produced by Justin's students).





- What did students learn? It's great to include quotes if you have them.
    - "I'm glad that I got the water from our camp tested. It was high so now we can do something about it."
    - "I had no idea we had so many issues with drinking water quality here in Maine."
- What did you learn?
    - We continued to learn about the local PFOA issue as it ties into our drinking water theme.

- What would you do differently?
    - Work more closely with our scientist partner. We have a plan to do just that for the coming year.
    - Create a trifold brochure about arsenic and health effects. Connect with local doctors to review it and then distribute it in pediatricians and obstetricians offices.

- We have a lot of content and real world initiatives that we try to cover in our classes. We would like to continue to work on making it all more seamless going forward.

Conclusion: The arsenic project was well received by students. We did find several families have high levels of arsenic in their well water. We found the percent of wells tested with elevated arsenic was similar this year to the results from past years. We set a new highest level of arsenic for any water sample submitted by a Waterville student to date. We had more success with our planaria bioassays this year than we have had with the duckweed that we tried in past years. We were able to teach about what things can be done if there is a high level of arsenic in a given water supply. Making water quality the central theme of our chemical class has been helpful at engaging students. We will continue to work at refining curriculum and activities to improve student outcomes.

References: *Assessing effects of arsenic on behavior and regeneration on Planarian Bioassay* Gregory Spencer[1], Valerie Erhardt[1], Collin Frangos[1], Perla Moguel[1], Carmen Lopez[1], Jane Disney[2], Juyoung Shim[1] University of Maine at Augusta[1], Mount Desert Island Biological Laboratory[2] - poster for water conference

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