Project Title:

Elevated Groundwater Arsenic Concentrations In Private Wells in Central Maine which is part of *Data to Action: A Secondary School-Based Citizen Science Project to Address Arsenic Contamination of Well Water*.

School:

Waterville Senior High School

Grade Level:

11-12

Teachers:

Justin Giroux
Jon Ramgren

Project Partners:

Thom Klepach of Colby College was the mentor for this project. Justin Giroux and Jon Ramgren, the chemistry teachers at Waterville Senior High School, collaborated on the implementation of this project.

Teacher Profile:

Justin Giroux has been teaching for 7 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.

Jon Ramgren has been teaching for 28 years. He has a Bachelors of Science. in chemistry from North Park College and a Masters in Secondary Science Education from The Ohio State University. Over the last 9 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.

Summary:

In the fall, Waterville High School students were given a brief water quality unit. They learned about the arsenic problems in groundwater in India and Bangladesh. They also learned about arsenic's effects on the body and the history. Collecting samples done in the late fall with the idea that students could sample water at their camps before they were winterized. Obtaining samples was difficult since many of the students live on public water supplies. Justin made obtaining a sample a grade, all but one of his students was able to find a sample. Adults in the building were able to help out students who could not find a well to sample. Jon did not make obtaining a sample a grade and had 29 samples returned from 40 given out. Waterville High School sent 82 samples to Dartmouth College for analysis. It was the student's responsibility to report the results of their sample to the person they obtained the sample from. The students worked on data processing in Tuva and prepared a presentation for the public at our community forum. Students also worked on a duckweed experiment involving arsenic concentrations ranging from 0 to 100 ppb. The data collected did not show any correlation between the arsenic concentrations and the number and health of the plants. A lack of nutrients and light proved to be more significant than the arsenic levels.

Project Details:

- Materials used
  - "The Quest for a Clean Drink" https://www.acs.org/content/dam/acsorg/education/resources/highschool/chemmatters/gc-quest-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/past-issues/2016-2017/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 premade 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/

- Stipend Use

  - Justin Giroux and Jon Ramgren collaborated on a duckweed experiment involving arsenic concentrations ranging from 0 to 100 ppb. Stipend money was used to purchase the duckweed. The data collected did not show any correlation between the arsenic concentrations and the number and health of the plants. The Duckweed starting to turn yellow around week 2 so the experiment was aborted at week 3. It was determined that the duckweed did not have adequate nutrition and, in the case of Jon's room, adequate light.

- Stipend money was used to buy water sample tubes and to ship the samples out to Dartmouth.
- Stipend money was used to provide food at the community forum.
- Stipend money was used to purchase 4 ZeroWater WaterFilters

- Sample Collection
  - Students were required to obtain at least one well sample for a grade
  - Students were responsible for registering the sample on the AnecData website. On the due date, students had their sample on their table and the sample registration loaded on a computer so the teacher could confirm that everything was done properly.
  - The samples were mailed to Dartmouth College.
  - When Dartmouth had analyzed the samples, students looked at the data and notified the proper people of the results.
- Data Processing and The Community Meeting
  - Students worked in Tuva for a while to learn the program and to understand what the data was telling them. They used tutorial videos and premade learning modules provide by Tuva.
  - Students created a PowerPoint presentation. A group of the students presented the slides to the attendees.
  - The community meeting was held at Colby College's Chase Forum downtown. There were about 60 people in attendance. The majority of attendees already had links to this project. The majority were either teachers, parents of students, or the students who worked on this study. Improvements should be made on attracting the general public.

Discussion:

- Waterville high school sampled 82 wells. Of those wells 16 had an arsenic concentration over 10 ppb.
- At the start of the school year very few students know about arsenic much less about arsenic in local groundwater. Most importantly students learned that arsenic is a problem in a small, but significant number of wells in the area. Many appeared motivated to encourage family members to test their private wells. Perhaps most importantly, the students now know enough about arsenic that many say they will test if they ever purchase a home with a private well.
- Justin Giroux and Jon Ramgren both learned about teaching students to work with the data. The students did good work, but the process was inefficient and caused a time crunch at the end of the year for completing state required chemistry standards. They have been approved by the district for paid time this summer to work on the chemistry curriculum. As a part of that work, they will be looking at ways to better integrate the study of arsenic and the use of TUVA into their classes.
- Both Justin Giroux and Jon Ramgren look to improve on the duckweed experiment and develop a more successful laboratory protocol. They would also like to expand in-class laboratory experiments that focus on water quality. Finally, they will work to improve community outreach to people not tied to Waterville Senior High School. They would like

to make community members aware of the sampling the students have to offer along with providing education on the problem of arsenic in the groundwater.

Conclusion:

Based on the small sample size, around 20% of wells in Central Maine have arsenic concentrations over the EPA's limit of 10 ppb. The students did a good job collecting and analyzing data. Justin Giroux's students created a comprehensive yet understandable presentation for the community forum. Jon Ramgren's students created graphs that showed various correlations in the data and that showed examples of the how the TUVA platform could be used to create different displays of the same data. These graphs were printed out in a large format and incorporated into posters that were displayed at the community forum. In the future, improvements should be made in educating people who are not linked to Waterville Senior High School on the problem of arsenic in groundwater in Central Maine.