Project Title: All About Arsenic

School: Mount Desert Elementary School

Grade Level: 7/8

Teacher: Sarah Dunbar

Project Partners: Jane Disney, MDI Biological Laboratory, Anna Farrell, MDI Biological Laboratory

Teacher Profile: Sarah Dunbar is a middle school science teacher at Mount Desert Elementary. Sarah received a bachelor's degree in Elementary Education and a master's degree in curriculum and instruction with a focus on science education from University of Massachusetts. She is in her 11th year of teaching. Sarah looks for learning opportunities that inspire and motivate her students to have an impact. The All About Arsenic project provides a learning platform for students to inform and educate their community about the health effects of arsenic in drinking water.

Summary: The 7th and 8th grade at Mount Desert Elementary School participated in an arsenic investigation.
This project had three parts:

1. Classroom Investigation
2. Well water testing
3. Community outreach

MS.S.1-SEP-Asking Questions and Defining Problems
MS.S.3-SEP-Planning and Carrying Out Investigations
MS.S.8-SEP-Obtaining, Evaluating, and Communicating Information
MS.S.5-SEP: MS.S.5-SEP-Using Mathematics and Computational Thinking

1. Classroom Investigation

The students started the project with researching arsenic. The purpose of this project was to become "experts" in a subtopic about arsenic. The classes brainstormed what was most important for them to learn about arsenic so that they could be community advocates and help educate their community about arsenic. Groups researched and presented on topics like:

- What is arsenic?
- What are the health impacts of Arsenic exposure?
- What do you do if you have high levels of arsenic?
- Why do we have high levels of arsenic in Maine and New Hampshire?

- What is the history of arsenic?
- How does arsenic get in well water?

Understanding the issues regarding arsenic in well water provided a springboard for what their classroom investigation would look like. The groups brainstormed what they wanted to investigate. They knew investigation had been done on the zero water pitcher, so they decided to test filtered water bottles.

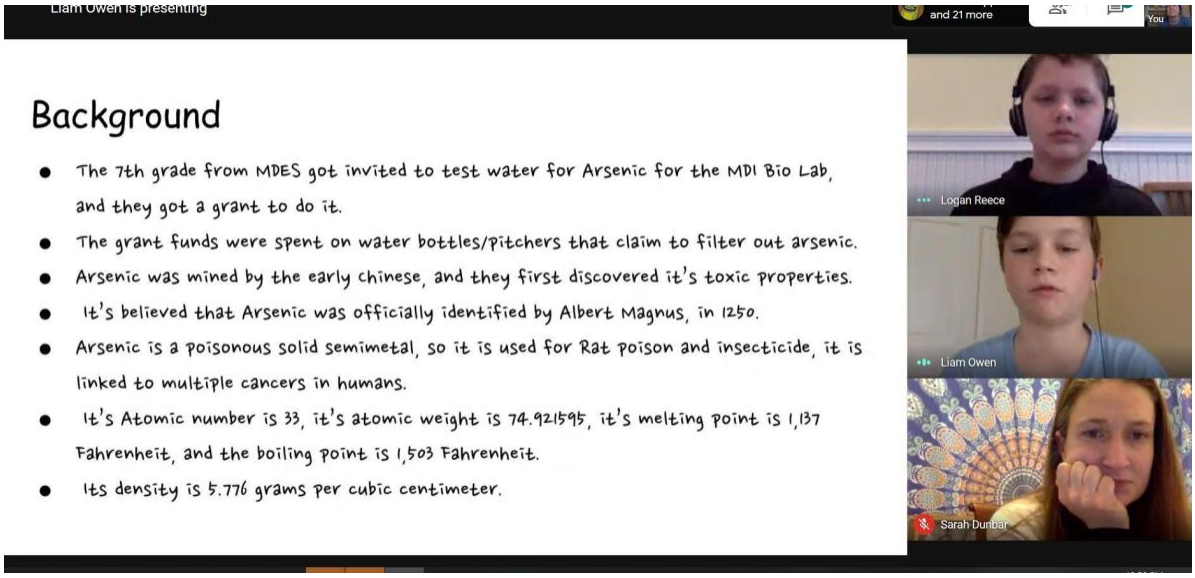
Students conducted a classroom investigation on the effectiveness of filtered water bottles in filtering arsenic contaminated water. Students selected three water bottles to use in this study; they ranged in price and types of filter:

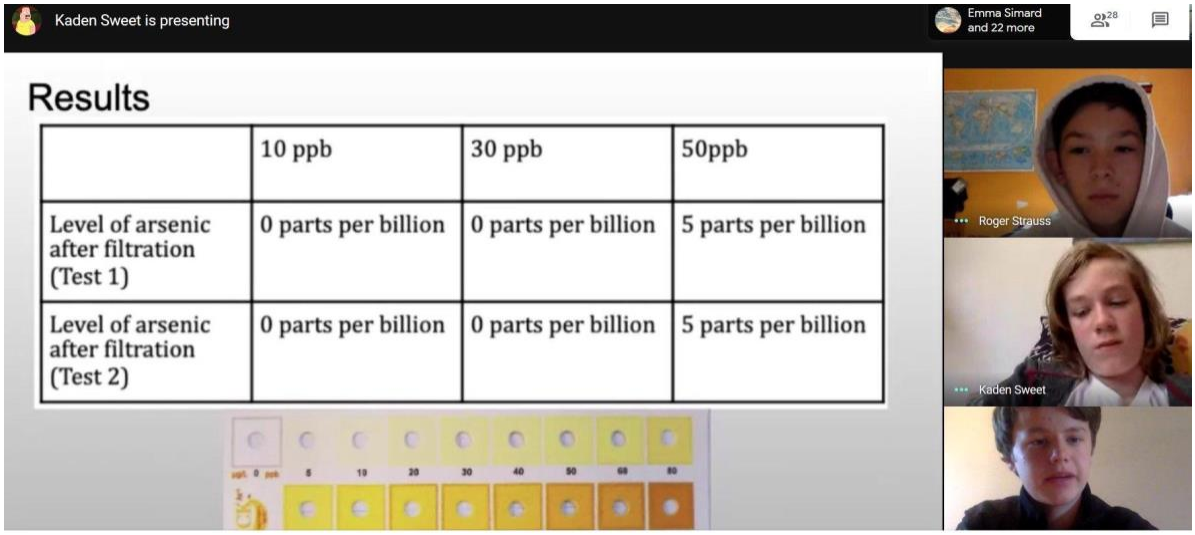
- The Grayl Ultralight purifying water bottle, which cost $70: https://www.amazon.com/gp/product/B07YNR2YB6/ref=ppx_yo_dt_b_asin_title_o03_s00?ie=UTF8&psc=1
- The Geekpure Collapsible Water bottle that cost $20: https://www.amazon.com/gp/product/B07YNR2YB6/ref=ppx_yo_dt_b_asin_title_o03_s00?ie=UTF8&psc=1
- The Zero Water Tumbler, which cost $11: https://www.amazon.com/gp/product/B012CEY1H4/ref=ppx_yo_dt_b_asin_title_o03_s00?ie=UTF8&psc=1
- The Nalgene OG Water Filtration Bottle which cost $35: ,https://www.amazon.com/gp/product/B07NDNHJYF/ref=ppx_yo_dt_b_asin_title_o03_s00?ie=UTF8&psc=1

Students looked to answer a range of questions about the water bottles:

- Does the cost of the water bottle impact effectiveness of filtering arsenic?
- Will the water bottle filter arsenic in juice?
- Does the temperature of the water impact how well the filter works?
- Is the Nalgene water bottle more effective than the Zero Water pitcher?
- Will the Grayl water bottle filter muddy arsenic contaminated water?
- The Zero Water tumbler does not claim to filter arsenic -- will it filter the arsenic like the Zero Water pitcher?

After conducting their experiment students wrote scientific reports about their findings, and also created slide shows that they presented via google meets.





2. Well water testing

Students collected water samples from their own homes. They were able to analyze and interpret the data for arsenic in well water in the town of Mount Desert.

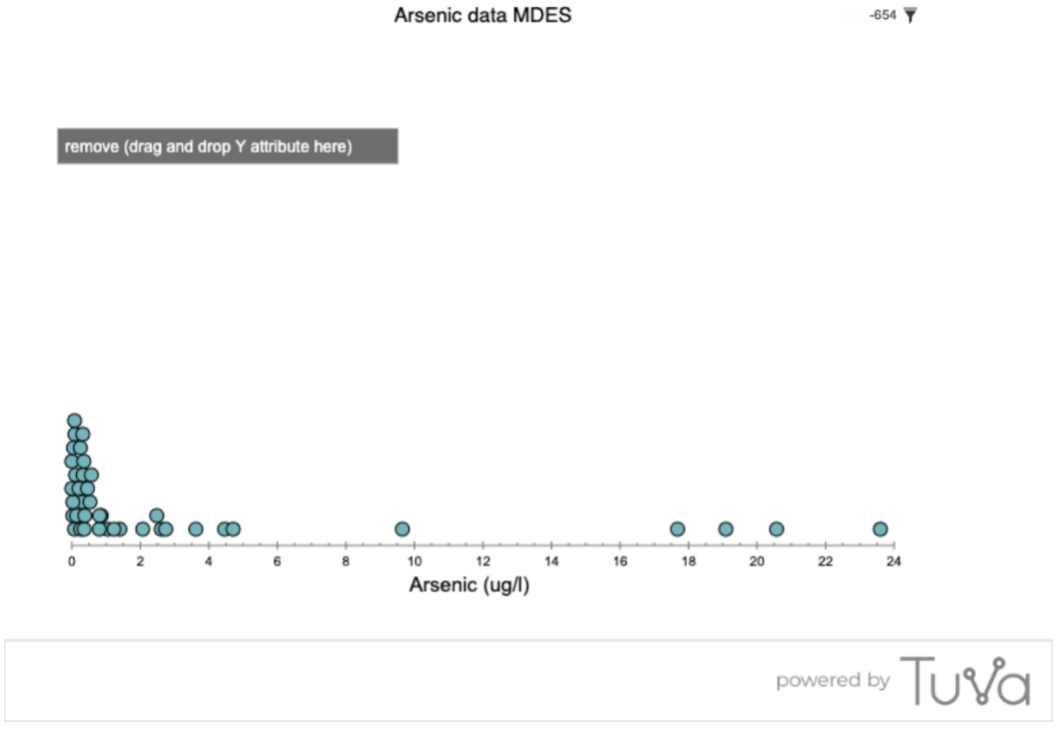
3. Community outreach

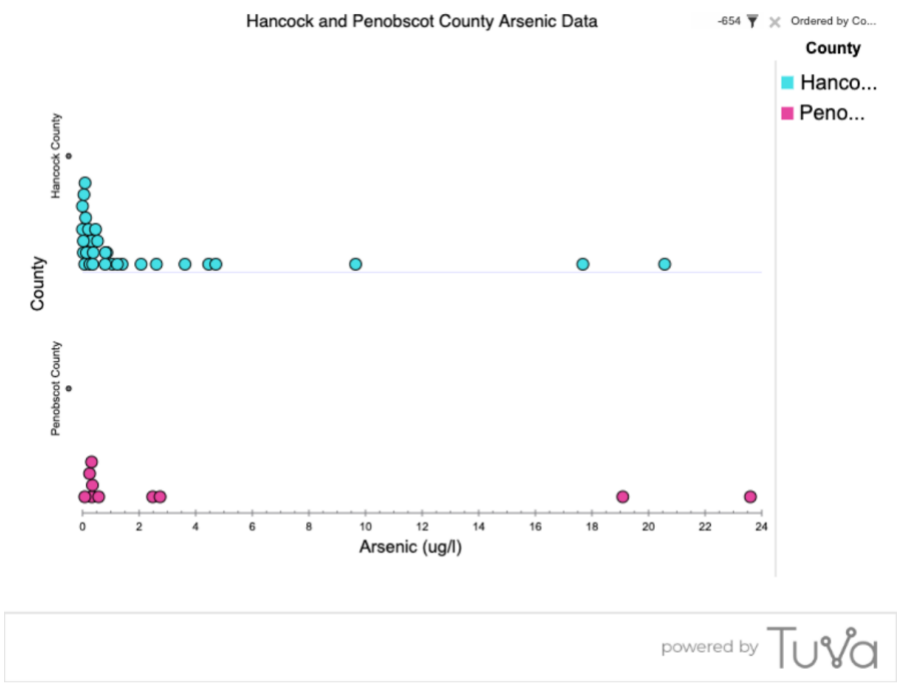
Students knew there was a lack of data for Northern Maine and wanted to provide well water tests to people of Northern Maine. The 8th grade had taken a trip to Katahdin Woods and Waters in the fall. This was an important connection for them, and they felt it was important to try and get as many

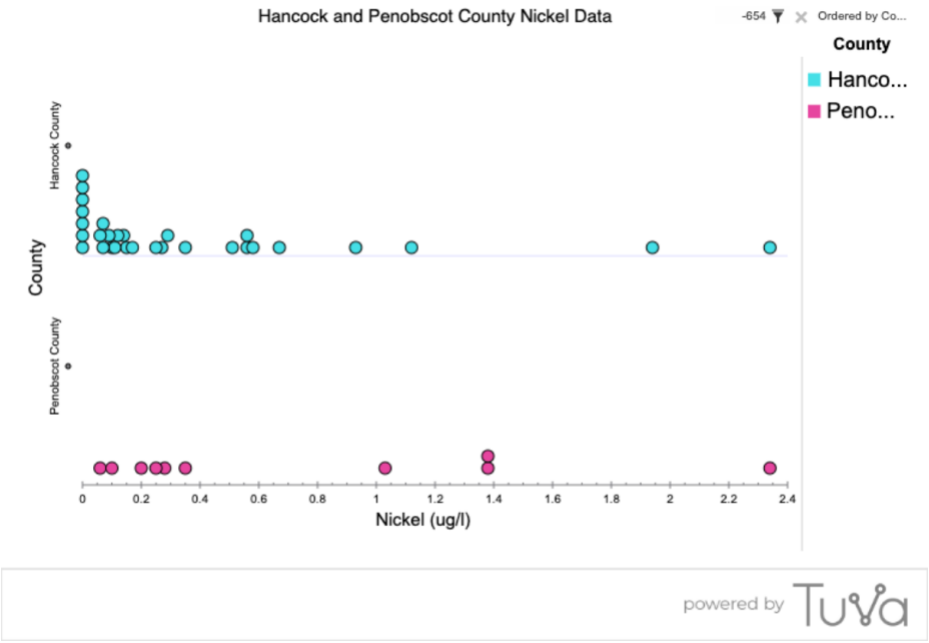
samples as they could. Students prepared kits and mailed them to Northern Maine. They were able to get 14 samples.

Project Details:

- 44 students in grades 7 and 8 were involved in the project.
- The focus of the classroom activity was to investigate the effectiveness of filtered water bottles in filtering arsenic contaminated water. Students looked to answer a range of questions about the water bottles:
    - Does the cost of the water bottle impact effectiveness of filtering arsenic?
    - Will the water bottle filter arsenic in juice?
    - Does the temperature of the water impact how well the filter works?
    - Is the Nalgene water bottle more effective than the Zero Water pitcher?
    - Will the Grayl water bottle filter muddy arsenic contaminated water?
    - The Zero Water tumbler does not claim to filter arsenic. WIll it filter the arsenic like the Zero Water pitcher?
- The stipend was used to purchase the filtered water bottles and the rapid arsenic test kit.
- Dr. Jane Disney visited the 7th and 8th grade classes to kick start the project. Dr. Disney helped introduce the project and answer questions.
- We used Tuva to compare the Northern Maine data and the data from MDES. There were a few questions that they explored with the Hancock and Penobscot data. Students wondered how the results from our school compared with Northern Maine. A group wondered if there was a similar "curve" for the results with any of the other trace metals. They found nickel to have the most similar curve to arsenic.







We also used Tuva to evaluate the COVID-19 data set. Students used the US Coronavirus data set to ask questions and make predictions about the continuously changing data set.

- Our community meeting was held virtually in a google meet session. Students shared the results of their classroom investigation. Our principal, curriculum coordinator, teachers, and community members attended our meeting.

Discussion:

My students gained a lot from this project. They developed skills in scientific writing, analyzing data, making claims, asking questions and presenting. They also learned about developing and following a procedure. They learned to work collaboratively in teams, but also work as a class towards common goals. There were many skills they gained that I didn't set out to teach. They learned to be resilient, adaptable and professional. They were able to plan, prepare and present presentations all while collaborating with their group members remotely. When I asked them what they learned, no one reflected on these skills, but I feel they were very important and valuable skills. Below are a few quotes from the students' reflections.

- "I learned that both the water bottles my group tested worked very well" -Iris
- "I learned that teamwork and communication is really important. A water bottle is a great way to filter arsenic if you don't want a full house filtration system" -Sasha
- "I learned about how bad arsenic is, and I learned that even though it doesn't claim that the zero water tumbler indeed filters out arsenic. Temperature does not impact the effectiveness of the filtering" -Jay
- "I learned how dangerous arsenic really is and I also learned more about how to write scientific reports." -Mallory
- "I learned about arsenic all around Maine, what it can do to the human body, how to test for arsenic, and much more". -Emma
- "I learned that arsenic can be filtered out through water bottles." -Lulu
- "I learned how dangerous arsenic can be for your health, and that some water bottles can filter out arsenic". -Nora
- "I learned that the Geekpure water bottle does not filter out arsenic" -Evan
- "How to use the Arsenic Testing Kits." -Aleksandra
- "I learned that the Grayl Ultralight compact purifier can actually filter out arsenic. I must admit, I never really thought a water bottle would be able to filter out a dangerous heavy metal like arsenic." -Sig

More than anything, I learned about being flexible, and being creative. I learned about the importance of bringing closure to a project that meant so much to the students. I learned a lot about TUVA and developed many new skills. In this time of remote learning it was challenging to walk the students through TUVA. To prevent them from getting frustrated, I would make videos walking them through

the process of using TUVA. I found I learned a lot and had to be very comfortable with using TUVA because I needed to make videos for the students to reference.

I think that we adapted and did a good job finishing this project in unusual circumstances. I would have liked to have a community forum where the student could engage with the community. I would have liked to find a way to tie in their data from Northern Maine and continue their outreach.

Conclusion: This project was engaging and exciting for my 7th and 8th grade students. Through the project they were able to meet project goals, even during a time of remote learning. I am grateful that I had this project to keep my students connected to our classwork and provide unique opportunities to share their results during remote learning.

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Arsenic Report

By Kaden, Roger and Sig

Mt. Desert Elementary School

Grade 8

3/10/20

Inquiry

How do different levels of arsenic affect the filter efficiency?

Introduction

Arsenic is an element that is found in the earth's crust, or in rocks, dirt and bedrock. Arsenic in liquid is tasteless, colorless, and odorless, it is very difficult to find. People can exhibit signs of arsenic poisoning only thirty minutes after it enters their system. High levels of arsenic symptoms include drowsiness, severe diarrhea, confusion and headaches. If the poisoning becomes more serious, it can cause vomiting and severe abdominal pain. It can also form keratoses and other visible skin afflictions. Treatment involves the pumping of the stomach. However, long exposure to low level arsenic can cause cancer, comas and even death. Once in the body, the arsenic will spread to the major organs like the lungs and liver and affects the red blood vessels, leading internal swelling and bleeding.

Arsenic is abundant in Maine and New Hampshire because of the bedrock wells, which are a source of arsenic. However, the bedrock isn't the only source. Arsenic can come from industrial pollution and agricultural pesticides which Maine has a lot of. Arsenic is in many foods but only trace amounts of arsenic comes from plants like fruits and vegetables, especially leafy vegetables like kale, spinach and celery because they suck up water and that water can have arsenic in it. Another killer is rice. Rice is grown in lots of water, which means they can suck up water that possibly has arsenic in it. Therefore, rice tends to contain more arsenic.

Inorganic arsenic is arsenic alone or combined with inorganic substances, usually toxic to most living organisms. Organic arsenic is arsenic combined with organic substances and usually are non toxic or less toxic. The maximum level of arsenic in the United states recommended before remediation in well water is ten parts per billion. Countries like America, Vietnam, India, China, Chile, and Taiwan are very high in arsenic in drinking water. Arsenic level in the United States is commonly found in the Northeast, Midwest and Southwest regions.

Arsenic is a large problem around the world not only because of it's terrible effects but also because most of the world is unaware to the problem because The goal of this experiment

is to not only educate and raise awareness about arsenic, but also to help create solutions to the arsenic problem by testing how well arsenic can be filtered.

The Grayl Ultralight Compact Purifier claims to filter 99.999% of chemicals, viruses, and heavy metals (like arsenic). The Grayl Purifier is advertised to be able to filter water from natural sources to a point of being drinkable. We will be using this water bottle to test to filter our arsenic samples because of its reported efficiencency in filtration
Hypothesis

Sig: The amount of arsenic filtered out is linear, meaning that no matter how much arsenic is in the water, a certain percentage of it will be filtered
Roger: I believe that the level of arsenic will not matter and that the level of arsenic after filtration will be almost exactly the same no matter how much arsenic is being filtered.

Materials

- Grayl Ultralight Compact Purifier
- A 200 milliliter sample of water with 10 parts per billion of arsenic
- A 200 milliliter sample of water with 30 parts per billion of arsenic
- A 200 milliliter sample of water with 50 parts per billion of arsenic
- A Rapid Arsenic Test Kit

Procedure

1. Remove the inner filtration component from the Grayl Ultralight compact Purifier and fill the bottle with tap water. Reinsert the filter component and apply necessary force until the filter component is pushed fully into the bottle.

2. Repeat the previous step two more times to ensure that the filter is clean from previous tests

3. Pull the inner filtration contraption out of the water bottle.

4. Place the 200 milliliter sample with 10 parts per billion of arsenic into the Grayl Ultralight Compact Purifier.

5. Place the inner filtration contraption back into the water bottle.

6. Proceed to push the filtration contraption down into the bottle. Use appropriate force to push the contraption fully fit into the rest of the bottle.

7. Remove 100 milliliters of filtered water into a separate container.

8. Test the new samples arsenic level with the Quick Rapid Arsenic Test Kit. Record the new arsenic level.

9. Repeat steps 1, 2, 3, 4, 5, 6, 7 and 8 with the 30 parts per billion and the 50 parts per billion samples.

Data

	10 ppb	30 ppb	50ppb
Level of arsenic after filtration (Test 1)	0 parts per billion	0 parts per billion	5 parts per billion
Level of arsenic after filtration (Test 2)	0 parts per billion	0 parts per billion	5 parts per billion

Conclusion

In conclusion, it does matter how much arsenic is in the water, and the relationship of amount filtered to total arsenic levels is not linear. When filtered, the water sample with 30 parts per billion of arsenic had 0 parts per billion of arsenic after filtration. Once filtered, the 50 parts per billion sample was left with 5 parts per billion of arsenic. Therefore, in the 30 parts per billion test 100% of the arsenic was filtered, while in the 50 parts per billion test, only 90% was filtered out. Based on this data, none of our hypotheses were correct. The sample's filtration levels were not linear and there was a lot of variation in how much arsenic was filtered.

After completing the testing, there were still many unanswered questions that we had about arsenic and its ability to be filtered. We hypothesize that other methods of filtration would yield different results, which would definitely diversify our data. Another question begs to be asked; why wasn't the Grayl Ultralight Filter unable to filter the arsenic properly? It leads one to draw the conclusion that this filter isn't nearly as effective as it was advertised to be.

Redesign

If this project was to be redesigned, there are multiple changes that could be made to make the project more efficient and effective in drawing conclusions. For one, the sampling method was very ineffective in terms of time. Each test took over 15 minutes to complete. For only three tests, this was an excessive use of time. In addition, the tests were fairly unreliable in terms of specificity. Because the levels of arsenic were determined by color coding and the increments of the levels of arsenic went up by 5 parts per billion, Each test could only be rounded to the nearest value of five parts per billion of arsenic. An addition that could be made to the experiment would be to perform more tests. With only two data points to back up our conclusion for each sample, this suggests that our data could be unreliable. If this test were to be performed again, more testing should be conducted for

each sample to draw a more accurate conclusion. Overall, these few changes could be made to create a more accurate and efficient experiment.