Hope 2 Others (H2O) - ABSTRACT

780 million people in the world lack access to safe water, and more than 3 million will die each year after drinking from a contaminated source. Every 21 seconds, a child dies from a waterborne disease. Waterborne illnesses can be caused by sediment, metals, and bacteria. There are many water purification devices and methods, but these are often ineffective, expensive, or inaccessible. Bioremediation is the use of bacteria or plant matter to solve environmental problems. Moringa oleifera (moringa) and Coriandrum sativum (cilantro) are two plants that grow widely in regions around the world that lack clean water. Our team compared the purification abilities of these plants and used them to create an effective, inexpensive, and accessible method of purifying water. Through our experiments, we discovered that moringa was able to purify water of sediment, metals, and bacteria more effectively than either fresh or dried cilantro. We then created a prototype that utilized our methods, and made the purification process simpler and more effective. We used science to design and run our experiments. We used technology to collect our research and create our graphs. Engineering was used to create our prototype, and mathematics was used to analyze our data. By using science, technology, engineering, and math, we found that the moringa tree is an inexpensive, effective, and widely available solution to the need for clean water in developing nations. Bioremediation of water using native plants holds exciting potential to eradicate death and suffering from waterborne diseases and bring hope to others.

Mission Folder: View Mission for 'Hope 2 Others (H2O)'

State
California
Grade
7th
Mission Challenge
Food, Health and Fitness
Method
Scientific Inquiry using Scientific Practices
Students

cel2002
agl2002
sam2002

Team Collaboration

(1) Describe the plan your team used to complete your Mission Folder. Be sure to explain the role of each team member and how you shared and assigned responsibilities. Describe your team's process to ensure that assignments were completed on time and deadlines were met.
In order to ensure that all responsibilities were met, we did our best to collaborate and evenly divide work. We formed our group and began brainstorming topics in October, 2014. Once we had decided on our general area of research, we met every Wednesday for research for 1-2 hours. We also came up with a preliminary study design and began to test. Angela and Christina were in charge of the experimentation process. They visited the Los Angeles River to determine whether this was a possible source for contaminated water. They then ordered and gathered the supplies needed for preparing and testing samples. Samantha communicated with the different experts we used through email correspondence and provided other supplies needed for preparing samples. All team members were involved in the research portion. Experiments were run on weekends and occasionally after school, in about 4-6 hour blocks. We also met at school for about 3 hours a week as our project progressed. For the portion of our experiment that was written, each member of our group was assigned certain sections. When a section had been written, it was then thoroughly revised by the other group members. One way that allowed us to work together collaboratively at any time we had an opportunity was through Google Docs. Through this program, we could all see each other's progress and give each other notes. Overall, we were able to work together effectively and in a friendly fashion.

Scientific Inquiry

Uploaded Files:

- [View] **Figure 1** (By: cel2002, 02/26/2015, .docx)

  An example of the problem of lack of access to clean water.
- [View] **Figure 2** (By: cel2002, 02/26/2015, .docx)

  Moringa oleifera
- [View] **Figure 3** (By: cel2002, 02/26/2015, .docx)

  Coriandrum sativum
- [View] **Figure 4** (By: cel2002, 02/26/2015, .docx)

  The experimentation process
- [View] **Figure 5** (By: cel2002, 02/26/2015, .docx)

  The experimentation process
- [View] **Figure 6** (By: cel2002, 02/26/2015, .docx)

The results of the turbidity tests

- [View] **Figure 7** (By: cel2002, 02/26/2015, .docx)

  The results of the copper tests
- [View] **Figure 8** (By: cel2002, 02/26/2015, .docx)

  Results of the iron tests
- [View] **Figure 9** (By: cel2002, 02/26/2015, .docx)

  The results of the lead tests
- [View] **Figure 10** (By: cel2002, 02/26/2015, .docx)

  The results of the bacteria tests
- [View] **Figure 11** (By: cel2002, 02/26/2015, .docx)

  Results of the bacteria plating tests
- [View] **Figure 12** (By: cel2002, 02/26/2015, .docx)

  The prototype water filter
- [View] **Figure 13** (By: cel2002, 02/26/2015, .docx)

  Bibliography/Resources used to complete our research

Problem Statement

(1) What problem in your community did your team try to solve? Why is this problem important to your community?

780 million people in the world lack access to safe water, and more than 3 million will die each year after drinking from a contaminated source. Every 21 seconds, a child dies from a waterborne disease (Figure 1). The contaminants polluting the water include bacteria, heavy metals, toxins, and sediment. One common bacteria that contaminates water is Escherichia coli (E. coli), which is introduced to water by fecal matter from humans and animals. E. coli infection can result in fever, abdominal pain, and diarrhea, which can lead to dehydration and death. Common metals that contaminate well water include lead, iron, and copper, among others. Lead poisoning can cause slow development, learning difficulties, memory loss, headaches, pain, and sometimes death. Iron poisoning can build up fluid in airways, cause diarrhea, and affect the heart and nervous system. Copper poisoning can cause pain, diarrhea, vomiting, jaundice, fever, and various other problems.

There are many highly advanced water purification technologies available. However, these technologies are not available to the vast majority of people in developing nations. There are also other methods of purifying water that can be used in households. Purifying with gravel and sand is an old method that clarifies the water but does not remove the bacteria or metals. Boiling water can reduce most bacteria, however, it cannot reduce metals. Chemicals can also be used, including bromine, chlorine, iodine, hydrogen peroxide, silver, non-toxic organic acids, mild alkaline agents, neutralizing chemicals, and ion exchange. However, these materials are often too expensive for citizens living in developing nations, unavailable, ineffective, or can cause harm. In addition, filters can be donated by non-governmental organizations (NGOs). However, the filters are not plentiful enough to satisfy needs, they can break, they have limited duration of use, and are often not replenished. Therefore this is not a sustainable resource and can cause dependence. People need a method and device for purifying water that is widely available, inexpensive, accessible, and easily replenished. This problem was especially important to our group because two of our group members had the opportunity to visit a developing nation. When we were there, because we were volunteering in a medical facility, we saw many of the people living there that had become sick from contaminated water. We realized how widespread and serious waterborne diseases can be and we wished to find a solution to this problem.

(2) List at least 10 resources you used to complete your research (e.g., websites, professional journals, periodicals, subject matter experts).

Please refer to Figure 13.

(3) Describe what you learned in your research.

Our research helped us to better understand our project, and served as a foundation for our experiments and hypothesis. As we began our research, we learned how many people in the world lack access to clean water. We also learned about bioremediation. Bioremediation is the use of bacteria or plant matter to solve environmental problems. Moringa oleifera, or the moringa tree (Figure 2), is a plant that grows widely in Asia and Africa, where 90 percent of those lacking clean water live. Moringa is being studied as a solution to malnutrition and lack of clean water. Moringa has been referred to as the “miracle tree”. Not only does it grow where it is most needed, moringa leaves have 2 times the protein in yogurt, 7 times the vitamin C in oranges, 3 times the potassium in bananas, 4 times the vitamin A in carrots, 4 times the calcium of milk, and contain all of the essential amino acids. Moringa seeds, when ground, can be pressed for oil. However, related to our topic, moringa seeds have also been shown to be able to purify water. To purify water, the moringa seeds filter water using a process called coagulation-flocculation. The seed powder of the plant contains positively charged proteins that can attach to negatively charged particles, bringing them to the bottom of the container to be filtered out, rather than leaving them as suspended particles. Previous research has shown that moringa can purify the water of 90-99% of bacteria and remove 80% of turbidity. Moringa is mostly being studied for its abilities to purify water of bacteria. However, interestingly, one study by the University of the South Pacific in Fiji suggested that moringa may also have the capability to purify water of metals.

Coriandrum sativum, or cilantro (Figure 3), is another plant that is inexpensive and grows widely in places that are lacking clean water. A recent study by Dr. Douglas Schauer in Indiana has shown that cilantro may be able to purify water of heavy metals effectively. The study has suggested that cilantro’s complex outer wall structure absorbs and retains metals. To our knowledge, there have not been any studies researching cilantro’s ability to purify water of bacteria.

Hypothesis

(4) State your hypothesis. Describe how your hypothesis could help solve your problem.

We will be studying and comparing the abilities of moringa, fresh cilantro, and dried cilantro to purify water in terms of turbidity, metals, and bacteria. Regarding turbidity, we believe that moringa will attain the highest level of clarity, and that neither fresh nor dried cilantro will clarify turbid surface water. This is based on our research, which presented overwhelming evidence that moringa could clarify water. However, none of our research reported either fresh or dried cilantro’s ability to do this. In terms of metal purification, we believe that dried cilantro will be the most effective. However, while the studies we reviewed regarding cilantro only tested with dried cilantro, we think that fresh cilantro may also prove effective in metal purification. As we have little prior evidence that moringa can purify water of metals, we expect it to be fairly ineffective, or at least less effective than either fresh or dried cilantro. With respect to the purification of bacteria, we think that moringa will purify the water of bacteria extremely well; much of our research says that moringa can purify 90-99% of bacteria from water. However, we believe that neither fresh nor dried cilantro will be able to purify water of bacteria, because we have found no studies that report its effectiveness in this area.

(5) Identify the independent variables and the dependent variables in your hypothesis.

The independent variables for the turbidity experiment were the type of plant used (moringa, fresh cilantro, dried cilantro) and the timing of testing. The dependent variable was the decrease in turbidity. In the metals test, the independent variables were the type of plant used and the times at which we tested, and the dependent variable was the reduction of metals. Finally, in the bacteria test, the independent variables were the type and amount of plant matter we put in the water, and the dependent variable was the reduction of bacteria.

(6) How did you measure the validity of your hypothesis? (In other words, how did you determine that your hypothesis measures what it is SUPPOSED to measure?)

In our turbidity test, we measured the validity of our hypothesis by creating turbid solutions, treating them with either nothing (control), moringa, fresh cilantro, and dried cilantro and observing reduction in turbidity over time. In the metals test, we measured the validity of the hypothesis by creating a standard metals solution (containing copper, iron and lead) and using metal test strips to measure metal concentrations of the solutions before and after treatment with the plants. In the bacteria test, we measured the validity of our hypothesis by creating bacteria solutions and using bacteria test strips to measure the presence or absence of bacteria before and after treatment with the plants. We also plated the solutions on Petri dishes to visualize bacteria levels.

Experimental Design

(7) List the materials you used in your experiment. Include technologies you used (e.g., scientific equipment, internet resources, computer programs, multimedia, etc.).

Distilled water
1000 ppm copper solution
1000 ppm iron solution
1000 ppm lead solution
12 copper test strips
12 iron test strips

12 lead test strips
8 bacteria test strips
Camera
76 Moringa oleifera seeds
3 ½ cups of fresh cilantro
3 ½ cups of dried cilantro
384 grams of soil
80 grams of fecal matter (obtained from a healthy domestic dog)
Cheesecloth
Mortar and pestle
25 Mason jars
7 Petri dishes
7 sterile swabs
Heat lamp
Graduated cylinders
Pipettes
40 grams of clay
Sand
Gravel
Funnel
Stopper
Chain
Hex nut
2 6-liter buckets
Protective clothing- lab coats, goggles, gloves
Digital balance
Thermometer
Computer
Timer
Microsoft Excel
Google Docs
Microsoft Word
Internet resources

(8) Identify the control group and the constants in your experiment.
The control groups in our experiments (turbidity, metals, bacteria) were the samples that were not treated with moringa or cilantro. In our turbidity test, our constants were the type and amount of soil used, as well as the type and amount of water mixed with the soil. In the metals test, the type and amount of metals and water were our constants. Finally, in the bacteria test, the source and quantity of the bacteria solution and amount of water were our constants. For each type of experiment, the temperature and environment were kept constant.

(9) What was your experimental process? Include each of the steps in your experiment.
Originally, we planned to find a source of contaminated water to run our tests on. We collected water from our school pond and the Los Angeles River. Upon testing these water samples, we found that they contained too few contaminants for the purpose of our experiments. We then decided to make our own contaminated water samples by mixing soil, metals, and fecal matter together. However, after testing our control group, we found that it contained no bacteria, which led us to research further. We learned that metals, particularly copper, kill bacteria. As a result, we chose to conduct three separate tests for turbidity, metals, and bacteria (Figures 4 and 5).

Turbidity Test
Four turbid solutions were prepared by mixing 32 grams of soil and 400 mL of distilled water into each jar, and then shaking vigorously.
Moringa paste was prepared by grinding 5 mature moringa seeds and mixing them with 5 mL of water.
The moringa paste was placed in one of the turbid solutions by pouring through a piece of cheesecloth. Then, this solution was stirred rapidly for 30 seconds and slowly for 5 minutes.
A ½ cup of dried cilantro leaves was placed in another solution, and a ½ cup of fresh cilantro leaves was placed in another solution. Both solutions containing cilantro were shaken vigorously for 5 minutes. The remaining solution served as the control.
The turbidity of the solutions were observed and recorded through photographs at 30, 60, 90, and 120 minutes.

Metals Test
A heavy metals solution was prepared by placing 8 mL of a 1000 ppm iron solution, 8 mL of a 1000 ppm copper

solution, 32 mL of a 1000 ppm lead solution, and 1552 mL of distilled water. This resulted in a solution of 5 ppm iron, 5 ppm copper, and 20 ppm lead. This solution was then divided into 4 glass jars each containing 400 mL of solution.
5 mature moringa seeds were ground and placed into one of the solutions and stirred rapidly for 30 seconds and slowly for 5 minutes.
A ½ cup of dried cilantro was placed in another solution, and a ½ cup of fresh cilantro was placed in another solution. Both solutions were shaken vigorously for 5 minutes. The remaining solution was used as the control.
For each solution, the levels of iron, copper, and lead were tested and recorded at 30, 90, and 210 minutes.

Bacteria Test
A bacteria solution was prepared by mixing 80 grams of fecal matter (from a healthy, domestic dog) with 1600 mL of distilled water.
Seven solutions, each containing 300 mL of distilled water and 5 mL of the bacteria solution, were prepared.
Four separate moringa pastes were prepared using 1, 5, 10, or 20 moringa seeds. Each of these pastes were filtered through a cheesecloth into four of the solutions and stirred vigorously for 30 seconds, then stirred slowly for 5 minutes.
A ½ cup of dried cilantro and a ½ cup of fresh cilantro were put into two other samples; both were shaken vigorously for 5 minutes. The remaining sample was kept as the control.
The solutions were left to sit for two hours.
Seven filters were prepared by layering one inch each of cheesecloth, sand, and gravel in plastic bottles.
The solutions were poured through the filters.
The filtered water was then tested for bacteria with the bacteria test strips, and the results were recorded.
As another test for bacteria, the filtered water samples were plated onto Petri dishes, incubated for 18 hours, and recorded through photographs.

In addition to testing our hypotheses, we wanted to create a prototype that is inexpensive, accessible, and easy to make, and would also take into account the purifying mechanisms of the plants we are studying.

Prototype Construction
Two buckets of the same size were stacked on top of each other. The lid of the lower bucket was on.
A hole was drilled from the bottom of the upper bucket through the lid of the lower bucket.
A filter was created by layering one inch each of cheesecloth, sand, and gravel inside of a funnel, and the stem of the funnel was placed through both of the drilled holes.
Clay (40 grams) was molded around the hole to prevent leaks.
A chain was attached to a stopper, which was placed over the mouth of the funnel. A hex nut counterweight was placed on the other end of the chain.

Prototype Use
With the stopper on the funnel, pour the water to be purified into the upper bucket.
Create the moringa paste (using 5-10 seeds per liter of water to purified) and pour it into the contaminated water.
Let the water stand for 1-2 hours.
Pull the stopper off with the chain. Use the counterweight to keep the stopper off of the mouth of the funnel.
When all the water has passed through the filter, open the bottom bucket and use the purified water inside. If possible, the water can be boiled before use for further sterilization.
In the top bucket, the water below the level of the mouth of the funnel will have remained in the bucket. The sediment, bacteria, and metals will have coagulated with the flocs of the moringa and gathered in this area and this sediment can be discarded.

Data Collection and Analysis

(10) Describe the data you collected and observed in your experiment. The use of data tables, charts, and/or graphs are encouraged.

Figure 6 shows photographs of the turbidity test at the beginning of the experiment, and at 30, 60, 90, and 120 minutes. The turbid water in the jar that was mixed with the moringa solution became progressively clearer over time. This happened fairly rapidly, first becoming a milky white color, then becoming clear. The fresh cilantro made little difference in the turbidity of the water. The dried cilantro, however, turned the water a dark rust color.

Figure 7 shows levels of copper after 30, 90, and 210 minute time intervals when purified with moringa, fresh cilantro, and dried cilantro. After 30 minutes, moringa had reduced the copper concentration from 5 ppm to 0 ppm, and remained at that level for the duration of the tests. Both fresh and dried cilantro were able to decrease copper concentrations significantly, but to a lesser extent than moringa. At 30 minutes, both the fresh and dried cilantro had decreased the amount of copper to 0.2 parts per million, and that result remained the same in the 90 minute test as well. After 210 minutes, the final concentration in both cilantro solutions was 0.1 ppm. Both fresh and dried cilantro purified most of the metals quickly and then the rate of purification of the remaining metals was much slower.

Figure 8 shows the levels of iron present in the samples of water after purification with moringa, fresh cilantro, and dried cilantro at the 30, 90, and 210 minute marks. Moringa was able to purify the water of all 5 parts per million in a span of 30 minutes, and sustained that level of purity throughout the duration of the tests. Though dried cilantro purified slower, it had brought the levels down to 0.2 parts per million in 30 minutes, 0.05 ppm in 90 minutes, and 0.02 ppm in 210 minutes. Fresh cilantro had decreased concentrations of iron to 0.5 ppm in 30 minutes, 0.2 ppm in 90 minutes, and 0.05 ppm in 210 minutes.

Figure 9 shows the concentration of lead remaining in the water samples after being purified by moringa, fresh cilantro, and dried cilantro for 30 minutes, 90 minutes, and 210 minutes. Moringa was able to quickly and dramatically decrease concentrations of lead from 20 ppm to 0 ppm in a span of 30 minutes, maintaining this level for the duration of the test. Dried cilantro was able to decrease levels of lead to 15 ppm in 30 minutes, however, at 90 minutes, it purified all the lead from the solution, maintaining this level of purity for the duration of the tests. We also found that fresh cilantro was not able to decrease the concentration of lead at all; the concentration of lead was constant throughout all of our tests.

Figure 10 shows the results of the bacteria tests as measured with bacteria testing strips. Neither fresh nor dried cilantro were able to purify the water of bacteria. Solutions treated with 5, 10, or 20 moringa seeds contained no bacteria after two hours. However, 1 moringa seed was not able to purify the water of bacteria.

Figure 11 shows the results of the bacteria plating tests. Water treated with fresh and dried cilantro had the same amount of bacteria as the control. When only one moringa seed was used, the water had the same amount of bacteria as the control. However, when 5, 10, and 20 moringa seeds were used, the number of colonies of bacteria was significantly reduced in a dose-responsive manner.

Figure 12 is a photograph of our prototype water filter. We wanted to design a prototype that could be easily constructed and used to conveniently filter water based on the properties of the moringa seed that we learned about in the course of our research. We chose moringa over cilantro as the former was more effective overall in purifying water of sediment, metals, and bacteria. Contaminated water is poured into the upper bucket and moringa paste is added and allowed to sit for 1-2 hours, allowing the sediment to coagulate and aggregate at the bottom of the upper bucket. The funnel has a stopper attached to a chain; the stopper prevents water from dripping into the lower bucket until the coagulation process is complete. Then the chain can be pulled to remove the stopper, allowing the water to pass through the funnel containing gravel, sand, and cheesecloth, which filter the moringa-bacteria flocs. Since the sediment is below the mouth of the funnel, it remains in the upper bucket and does not get reintroduced into the lower bucket. The water in the lower bucket is clear and clean.

(11) Analyze the data you collected and observed in your experiment. Does your data support or refute your hypothesis? Do not answer with a yes or no. Explain your answer using one of the following prompts: 'Our data supports/refutes the hypothesis because...'

The data from our experiments partially support our hypotheses. As we had hypothesized, moringa was very effective at clarifying turbid water, while both fresh and dried cilantro were not effective and resulted in water with an unpleasant appearance. Originally, we had also believed that cilantro would prove more effective than moringa at purifying metals, regardless of the time. However, after testing, we have found that this is not true, as moringa actually removed metals more effectively and efficiently than cilantro. It was interesting to find that dried cilantro was more effective than fresh cilantro in metal purification. We believe that this may be because fresh cilantro contains more water in the leaves, and therefore cannot absorb as much metal. Our results were as we expected regarding the purification properties of moringa and cilantro with bacteria. Moringa did purify bacteria well, and it purified within the time frame that we had expected, about 1-2 hours. Against our expectations, however, the water sample containing moringa required filtration before the water became negative of bacteria. This is because moringa does not kill bacteria, but rather aggregates it, and thus needs to be passed through a filter to trap the particles. As we expected, neither fresh nor dried cilantro purified the water of bacteria. Overall, we found that moringa was the better choice for water purification, but that cilantro could also be used to reduce metals.

(12) Explain any sources of error and how these could have affected your results.

There are a few possible sources of error that could have occurred in our experiments. When testing with metals, any of the test strips used to measure levels of contaminants (i.e. copper, iron, lead) could have been faulty. In addition, as the test strips are measured by color, it is possible that we may have misjudged the color. In the bacteria test, although the bacteria samples were taken from the same source, it is theoretically possible that the bacteria may not have been evenly distributed. Although we repeated the turbidity test 3 times with similar results, also repeating our metals and bacteria experiments several times may have helped to confirm our results.

Drawing Conclusions

(13) Interpret and evaluate your results and write a conclusion statement that includes the following: Describe what you would do if you wanted to retest or further test your hypothesis. Evaluate the usefulness of the data your team collected. What changes would you make to your hypothesis and/or experimental design in the future, if any?

Moringa was extremely effective at clarifying water and purifying it of metals; it was able to purify faster than either types of cilantro, reducing levels of copper, iron, and lead to 0 ppm in merely 30 minutes. Furthermore, it was able to disinfect water of bacteria. However, we discovered that because moringa does not kill bacteria but instead binds to contaminants in water, the water needs to be poured through a filter of gravel, sand, and cheesecloth before the bacteria is sufficiently removed. Fresh cilantro was not able to clear turbid water or remove bacteria. However, it was able to remove metals to some degree. Dried cilantro did not clarify the water; on the contrary, it turned the water a rust color. It was not able to purify the water of bacteria, but did reduce the concentrations of metals more effectively than fresh cilantro. However, this plant was still less effective than moringa.

If we were to retest, we would make a few changes in our experiment. First, we would try to use a more specific way to measure the level of contaminants. In our tests, we used test strips that displayed colors to show metal concentrations. As it was sometimes difficult to determine the specific shade, it may be helpful to use a test that has a more distinct way of showing results. A more quantitative way to measure bacteria levels would also be useful. This may involve using sophisticated technology available in laboratories, such as a spectrophotometer. In order to experiment further with our ideas, we would have also liked to conduct a few more tests. For instance, we would like to explore what would happen if we allowed the plants more time to purify the water of bacteria. Would the plants be more effective if given a couple of days? We could also try testing how effectively the plants remove metals or clarify water after a longer time period.

The results of our studies can be extremely useful in providing a solution to the problem of death and illness from contaminated water. Bacteria and heavy metal pollution of water is unfortunately a common problem in developing nations and our study shows that common native plants can address these issues. Furthermore, we wanted to provide a convenient method of water purification with moringa. We designed our prototype to be an effective, accessible, and inexpensive method of purifying water. Purification of water using moringa requires that sediment be separated from clean water, and that water must be passed through a filter before the purification process is complete. Therefore, our prototype was designed to meet these needs in a convenient fashion, and has been found to be highly effective. It can be easily reconstructed and could change and save millions of lives.

Community Benefit

(1) How could your experiments and data help solve your problem and benefit your community? Describe next steps for further research/experimentation and how you have or how you could implement your solution in the future.

Waterborne disease is a tremendous problem in our world and kills millions of people every year. We believe that our experiments can solve this problem because they reveal an inexpensive, effective, and widely available method for purifying water. Our tests have proven that moringa is not only effective in purifying bacteria from water and clarifying turbid water, but also remarkably effective in purifying metals such as lead, iron, and copper from water. The moringa tree is easily grown and therefore an affordable solution. Lastly, the moringa tree is spread throughout the world. It grows widely in Asia, Africa, and South America, the continents that are most challenged by the lack of availability of clean water. Through our tests, moringa has proven that it is capable and effective in purifying water of contaminants, making it a solution that could save lives. To further develop our solution, we also created a water filter that utilized the data from our experiments to simplify the water purification process.

Another contaminant in water that we would like to research further is arsenic. Arsenic is a heavy metal that is a common contaminant in well water. Although we chose not to research it because of its toxicity, it would be useful to study whether moringa or cilantro could purify it because of the potent negative health effects that arsenic can cause. Another contaminant that would be interesting to research further is the bacteria Vibrio cholerae, or cholera. Cholera is a deadly bacteria that can be spread through contaminated water and can quickly cause death through diarrhea and dehydration. Because cholera is dangerous and would require lab analyzation, we did not experiment with this bacteria, but experimenting with cholera would be an interesting and important point of future research.

Lastly, we would also like to spread the knowledge of moringa’s purifying abilities. Many people lacking clean water are not yet aware of moringa’s purification abilities. If we spread the knowledge that moringa can purify water, we believe that it would positively affect our global community because millions more people would have access to clean water. Bioremediation of water using native plants holds exciting potential to eradicate death and suffering from waterborne diseases and bring hope to others.

Mission Verification

(1) Does your Mission Folder project involve vertebrate testing, defined as animals with backbones and spinal columns (which includes humans)? If yes, team must complete and attach an IRB.
No

(2) Did your team use a survey for any part of your project? If yes, team must complete and attach a survey approval form.
No

(3) You will need to include an abstract of 250 words or less. As part of the abstract you will need to describe your project and explain how you used STEM (Science, Technology, Engineering and Mathematics) to improve your community
780 million people in the world lack access to safe water, and more than 3 million will die each year after drinking from a contaminated source. Every 21 seconds, a child dies from a waterborne disease. Waterborne illnesses can be caused by sediment, metals, and bacteria. There are many water purification devices and methods, but these are often ineffective, expensive, or inaccessible. Bioremediation is the use of bacteria or plant matter to solve environmental problems. Moringa oleifera (moringa) and Coriandrum sativum (cilantro) are two plants that grow widely in regions around the world that lack clean water. Our team compared the purification abilities of these plants and used them to create an effective, inexpensive, and accessible method of purifying water. Through our experiments, we discovered that moringa was able to purify water of sediment, metals, and bacteria more effectively than either fresh or dried cilantro. We then created a prototype that utilized our methods, and made the purification process simpler and more effective. We used science to design and run our experiments. We used technology to collect our research and create our graphs. Engineering was used to create our prototype, and mathematics was used to analyze our data. By using science, technology, engineering, and math, we found that the moringa tree is an inexpensive, effective, and widely available solution to the need for clean water in developing nations. Bioremediation of water using native plants holds exciting potential to eradicate death and suffering from waterborne diseases and bring hope to others.

Figure 1

780 million people in the world lack access to clean water. More than 3 million will die each year after drinking contaminated water. Every 21 seconds, a child dies of a waterborne disease.

Moringa oleifera

***Moringa oleifera* is currently being studied as a solution to both malnutrition and water purification.**

Coriandrum sativum

***Coriandrum sativum*, or cilantro, is commonly known as a herb used in cooking but a recent study has shown that it may have potential in purifying water.**

Figure 4

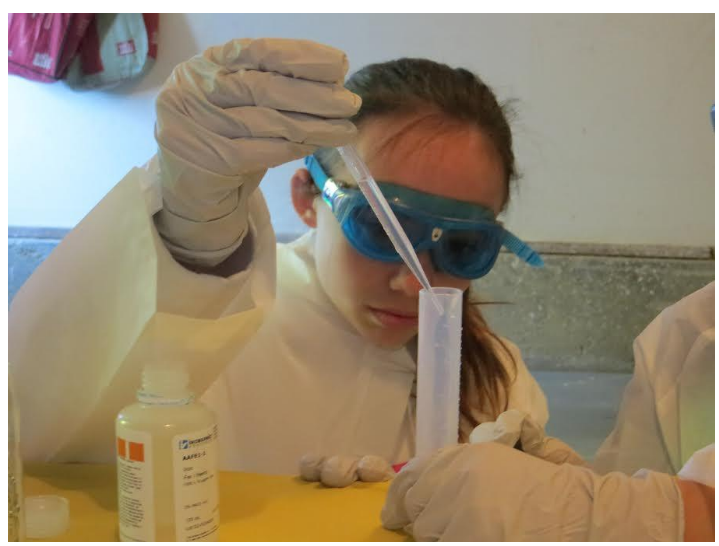
Photographs of the research and experimentation process

Team members researching our topic.

Initially, we collected water from the Los Angeles River, but found that it was negative for metals and bacteria.

Team members getting ready to start testing.

Pouring the water into a graduated cylinder.



Making the metals solution.

Figure 5

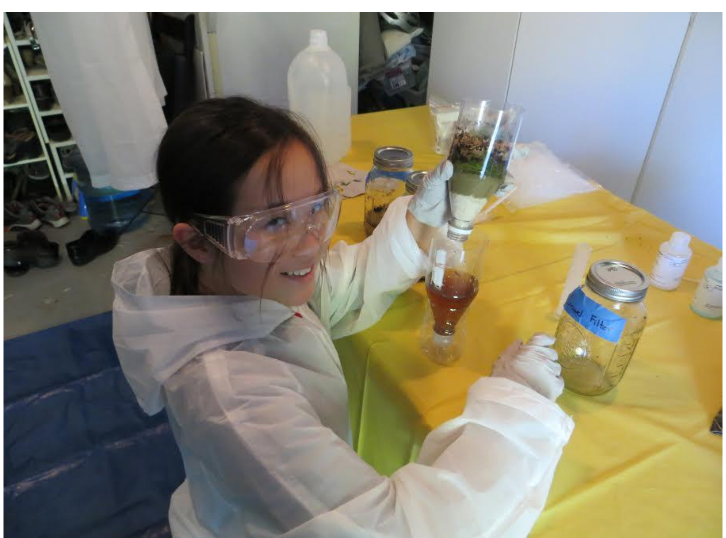
Photographs of the research and experimentation process

Pouring the water into mason jars.

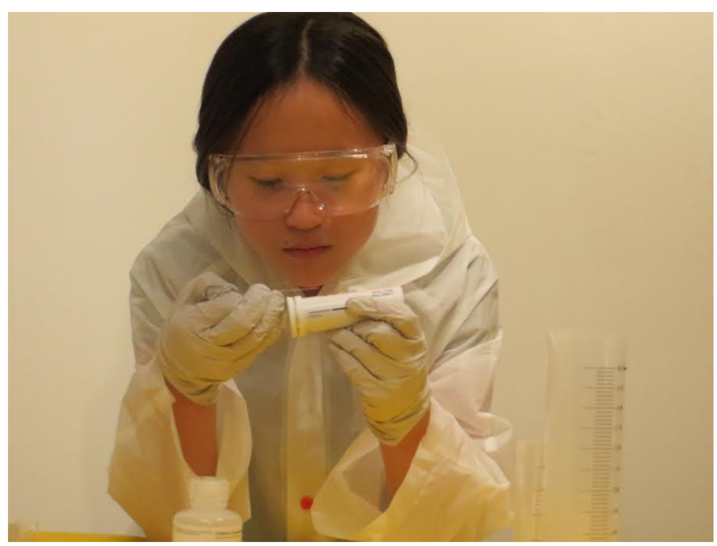
Preparing the moringa seeds.

Fresh cut cilantro leaves.

Weighing the soil for the turbidity tests.



Filtering water through a gravel, sand, and cheesecloth filter.



Reading the metal test strips.

Figure 6

These photographs show the results of the turbidity test at the beginning of the experiment, and at 30, 60, 90, and 120 minutes. The turbid water in the jar that was mixed with the moringa solution became progressively clearer over time. This happened fairly rapidly, first becoming a milky white color, then becoming clear. The fresh cilantro made little difference in the turbidity of the water. The dried cilantro, however, turned the water a dark rust color.

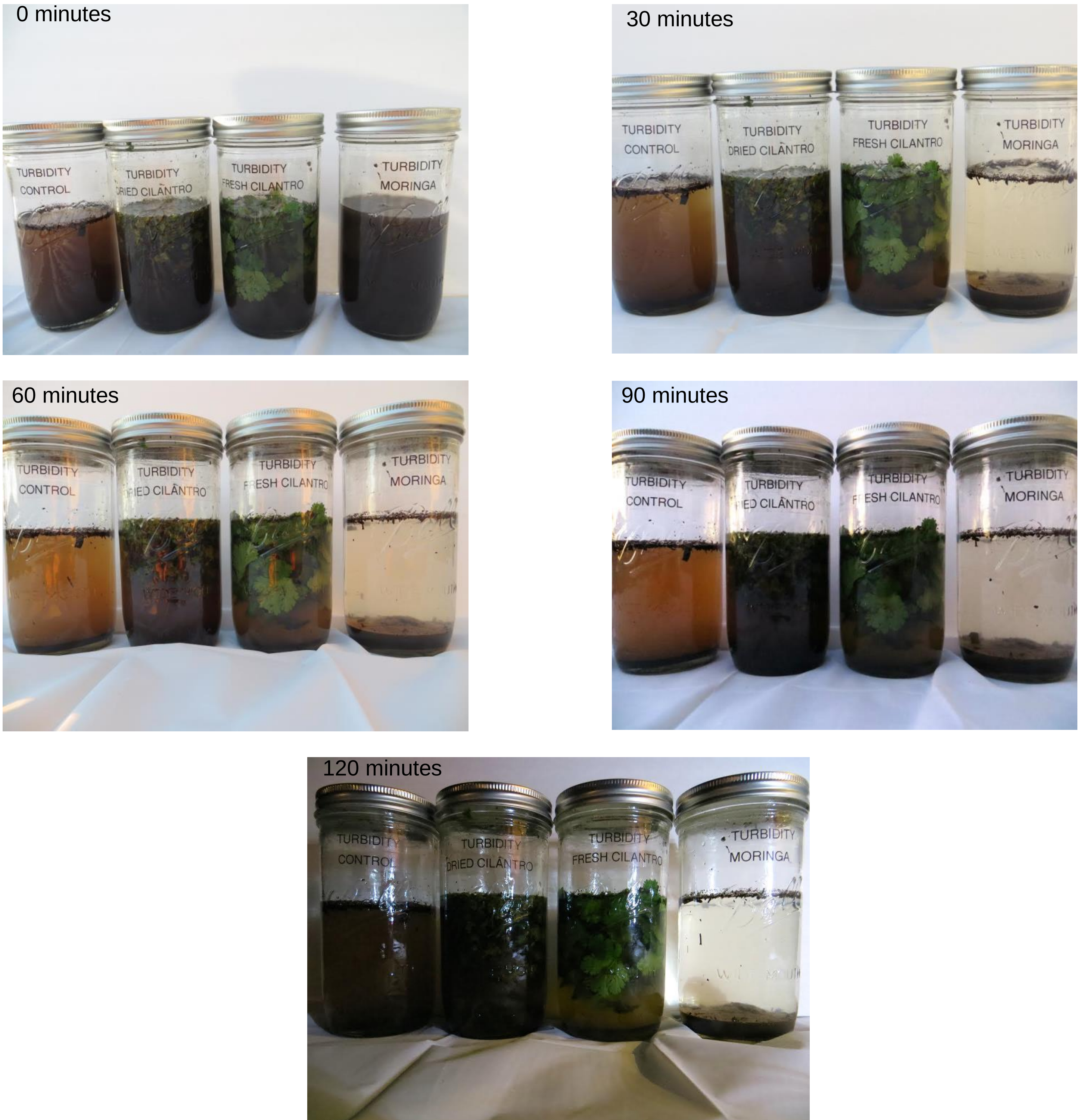


Figure 7

This figure shows levels of copper after 30, 90, and 210 minute time intervals when purified with moringa, fresh cilantro, and dried cilantro. After 30 minutes, moringa had reduced the copper concentration from 5 ppm to 0 ppm, and remained at that level for the duration of the tests. Both fresh and dried cilantro were able to decrease copper concentrations significantly, but to a lesser extent than moringa. At 30 minutes, both the fresh and the dried cilantro had decreased the amount of copper to 0.2 parts per million, and that result remained the same in the 90 minute test as well. After 210 minutes, the final concentration in both cilantro solutions was 0.1 ppm. Both fresh and dried cilantro purified most of the metals quickly and then the rate of purification of the remaining metals was much slower.

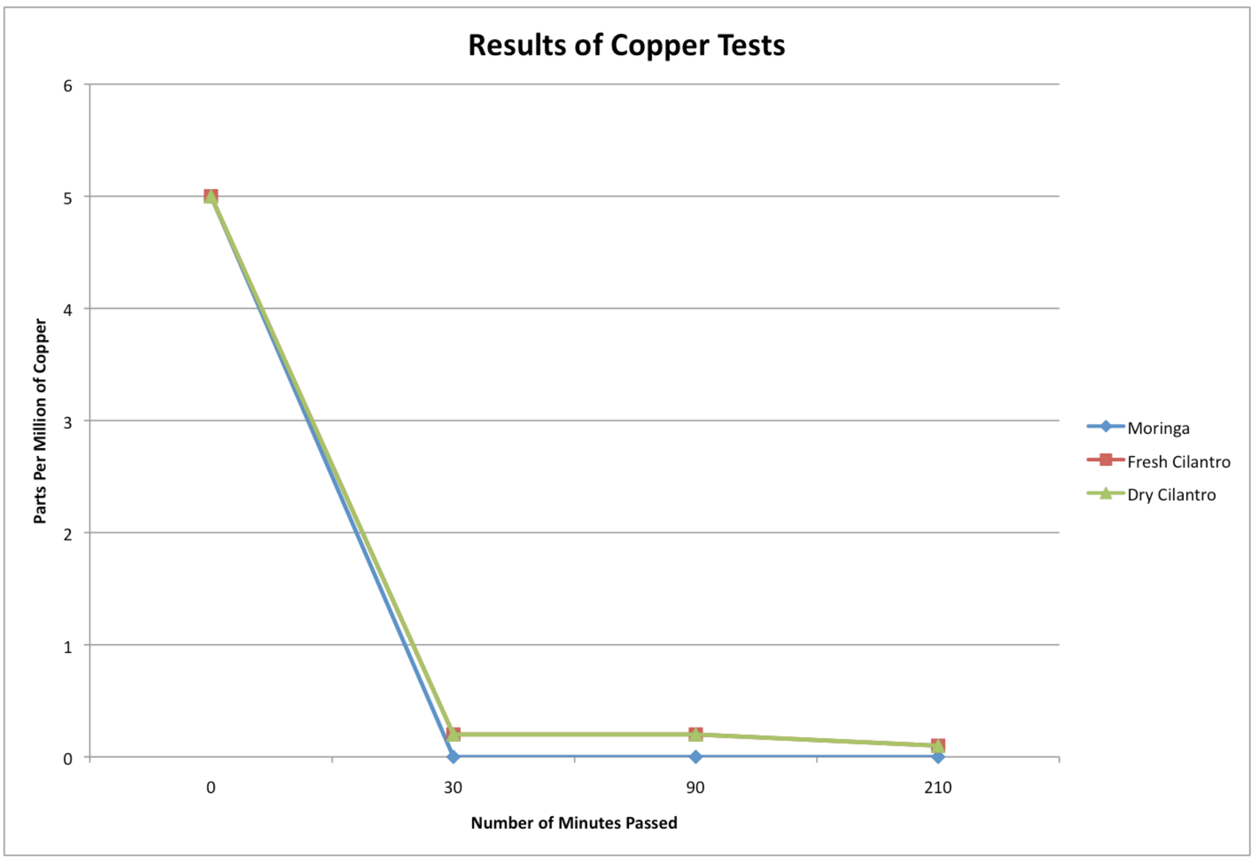
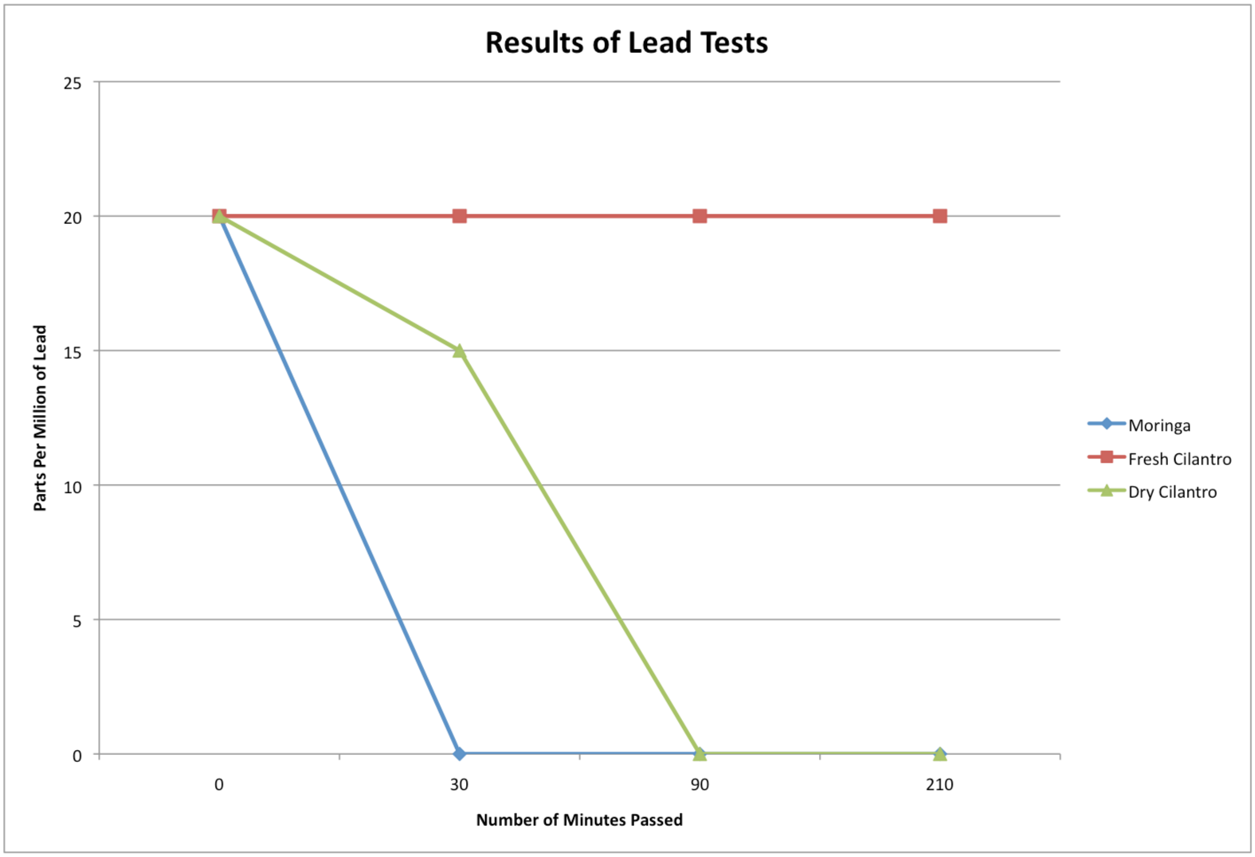


Figure 9

This figure shows the concentration of lead remaining in the water samples after being purified by moringa, fresh cilantro, and dried cilantro for 30 minutes, 90 minutes, and 210 minutes. Moringa was able to quickly and dramatically decrease concentrations of lead from 20 ppm to 0 ppm in a span of 30 minutes, maintaining this level for the duration of the test. Dried cilantro was able to decrease levels of lead to 15 ppm in 30 minutes, however, at 90 minutes, it purified all the lead from the solution, maintaining this level of purity for the duration of the tests. We also found that fresh cilantro was not able to decrease the concentration of lead at all; the concentration of lead was constant throughout all of our tests.



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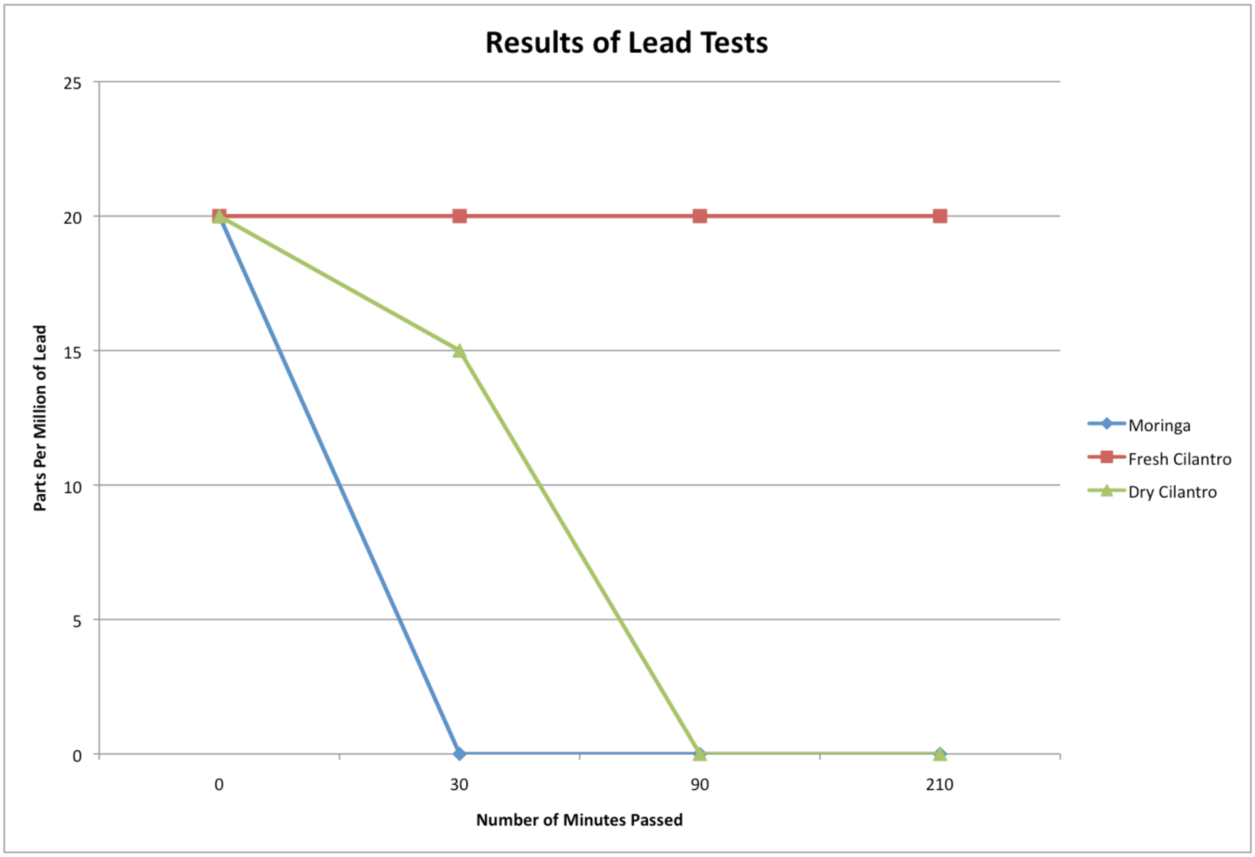

Figure 10

This chart shows the results of the bacteria tests, as measured with bacteria testing strips. Neither fresh nor dried cilantro were able to purify the water of bacteria. Solutions treated with 5,10, or 20 moringa seeds contained no bacteria after two hours. However, 1 moringa seed was not able to purify the water of bacteria.

Results of Bacteria Tests using Test Strips

Plant	Bacteria
Control	Positive
Fresh Cilantro	Positive
Dried Cilantro	Positive
Moringa-1 seed	Positive
Moringa-5 seeds	Negative
Moringa-10 seeds	Negative
Moringa-20 seeds	Negative

Figure 11

These photographs show the results of the bacteria plating tests. Water treated with fresh and dried cilantro had the same amount of bacteria as the control. When only one moringa seed was used, the water had the same amount of bacteria as the control. However, when 5, 10, and 20 moringa seeds were used, the number of colonies of bacteria was significantly reduced in a dose-responsive manner.

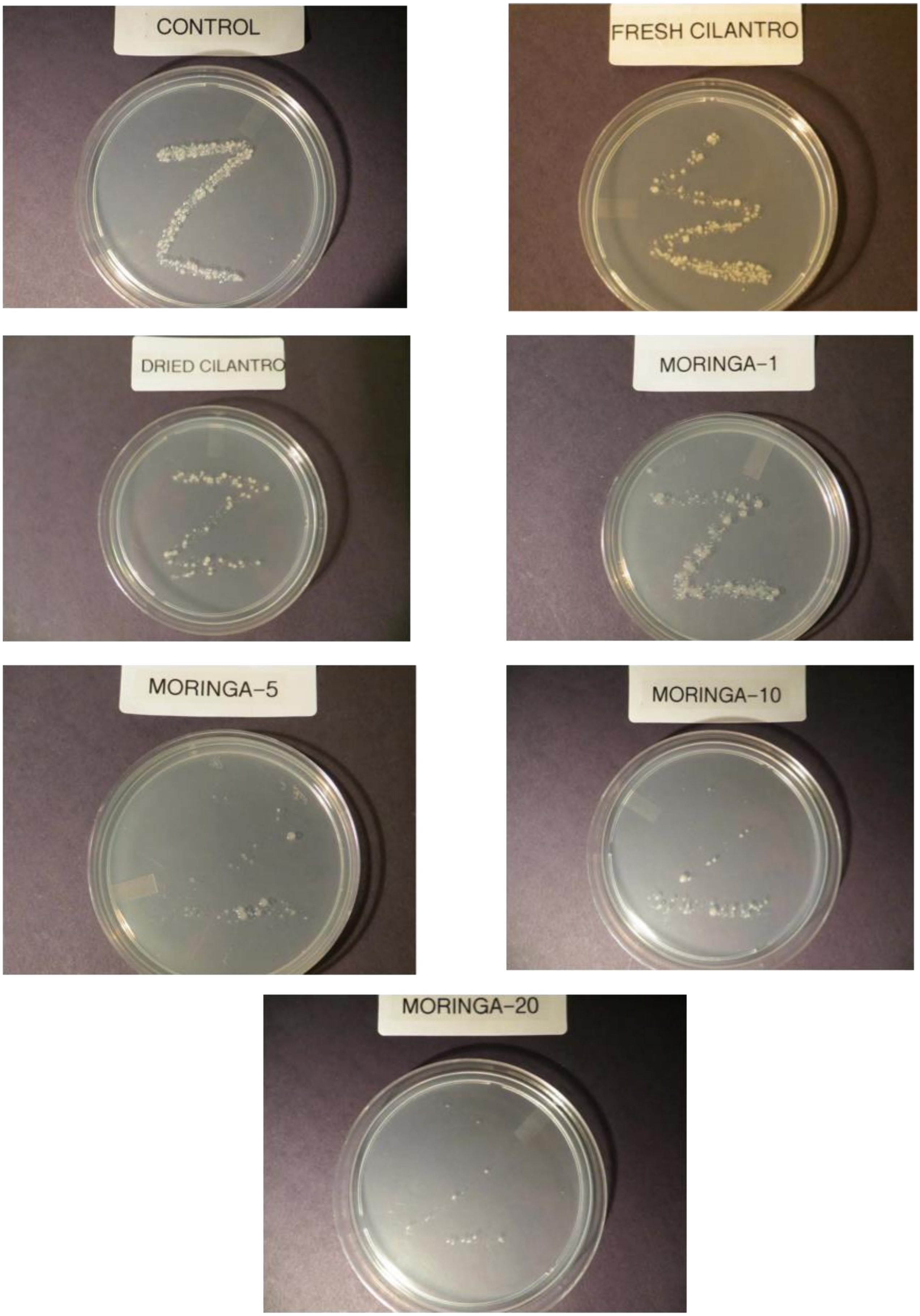

Figure 12

This is a photograph of our prototype water filter. We wanted to design a prototype that could be easily constructed and used to conveniently filter water based on the properties of the moringa seed that we learned about in the course of our research. We chose moringa over cilantro as the former was more effective overall in purifying water of sediment, metals, and bacteria. Contaminated water is poured into the upper bucket and moringa paste is added and allowed to sit for 1-2 hours, allowing the sediment to coagulate and aggregate at the bottom of the upper bucket. The funnel has a stopper attached to a chain; the stopper prevents water from dripping into the lower bucket until the coagulation process is complete. Then the chain can be pulled to remove the stopper, allowing the water to pass through the funnel containing gravel, sand, and cheesecloth, which filter the moringa-bacteria flocs. Since the sediment is below the mouth of the funnel, it remains in the upper bucket and does not get reintroduced into the lower bucket. The water in the lower bucket is clear and clean.

Figure 13

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To aid us in our project and research, we contacted experts, used online sources, and journal articles.

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