Mission Folder: View Mission for 'The CQuestrators'

State	Virginia
Grade	7th
Mission Challenge	Environment
Method	Scientific Inquiry using Scientific Practices
Students	Veda Murthy (vmurthy) Varsha Gunda (vgunda)

Team Collaboration

(1) How was your team formed? Was your team assigned or did you choose to work with each other?

Answer to this question is provided in the document Team_Collaboration.pdf

(2) Provide a detailed description of each team member's responsibilities and jobs during your work on the Mission Folder.

Answer to this question is provided in the document Team_Collaboration.pdf

(3) Did your team face any problems working together? If so, how did you solve them? If not, why do you think you were able to work together so well?

Answer to this question is provided in the document Team_Collaboration.pdf

(4) What were some possible advantages to working together as a team on this project? How would working as individuals have made this project more difficult?

Answer to this question is provided in the document Team_Collaboration.pdf

Uploaded Files:

- [View] **Team_Collaboration** (By: Advisor, 03/08/2021, .pdf)
  Answers to Team Collaboration is given in Team_Collaboration.pdf
- [View] **Meeting Minutes_2020_2021.xls** (By: Advisor, 03/08/2021, .xlsx)
  Meeting Minutes of the team
- [View] **Project_Timeline.xls** (By: Advisor, 03/08/2021, .xlsx)
  Project Timeline of The CQuestrators team
- [View] **CQuestrators_Presentation.pdf** (By: Advisor, 03/08/2021, .pdf)
  The CQuestrators Presentation to Professionals

Scientific Inquiry

Problem Statement

(1) What problem in your community will your team be investigating through scientific inquiry using scientific practices? Specifically, based on this problem, what question will you be trying to answer?

Answer to this question is given in Problem_Statement.pdf

(2) Research your problem. You must learn more about the problem you are trying to solve and also what testing has already been done. Find AT LEAST 10 different resources and list them here. They should include books, periodicals (magazines, journals, etc.), websites, experts, and any other resources you can think of. Be specific when listing them, and do not list your search engine (Google, etc.) as a resource.

Answer to this question is given in document Problem_Statement.pdf

(3) What did you find out about your problem that you didn't know before? What kinds of experiments have been done by other people before you? Be sure to put this in your OWN words, do not just copy And paste information. Also, be sure to cite your sources.

Answer to this question is given in document Problem_Statement.pdf

Experimental Design

(4) Based on the question you are trying to answer, and your research, what is your team's hypothesis for this investigation? Be sure to include the independent and dependent variables and how they are related along with evidence of your research.

Answer to this question is given in the document Experimental_Design.pdf

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

Answer to this question is given in the document Experimental_Design.pdf

(6) What are the constants in your investigation?

Answer to this question is given in the document Experimental_Design.pdf

(7) Will your investigation have a control group? If so, describe the control group. If not, why not?

Answer to this question is given in the document Experimental_Design.pdf

Experimental Process

(8) List all of the materials you used in your experiment. Be sure to include all physical materials as well as any technology or website used to collect data (not websites you used in your research).

Answer to this question is given in the document Experimental_Process.pdf

(9) Explain your experimental process. Be sure to list all of the steps and ALL SAFETY PRECAUTIONS for your experiment. Remember to write it so someone else could follow the steps and recreate your experiment.

Answer to this question is given in the document Experimental_Process.pdf

Data Collection and Analysis

(10) Present the data you collected from your experiment. Be sure to include all of the data you collected from your observations and measurements. Use of graphs and charts is HIGHLY encouraged. Explain how your data supports or refutes your hypothesis.

Answer to this question is given in the document Data_Collection_Analysis_Part1_CO2AbsorptionExperiments.pdf

Answer to this question is given in the document Data_Collection_Analysis_Part2_GrassGrowthExperiments.pdf

(11) What are your potential sources of error? Remember, this doesn't mean "Did everything work?", all tests have potential sources of error, so make sure you understand what that means. Explain how these sources of error could have affected your results.

Answer to this question is given in the document Data_Collection_Analysis_Part2_GrassGrowthExperiments.pdf

Drawing Conclusions

(12) What conclusions can you draw based on the data you gathered during your experiment(s)? Be sure to include data and how it relates to the experiment(s) and the original question. Your conclusion should be related to your original problem and your experiment, include the data you collected, and discuss if your hypothesis was supported or refuted by your experiment.

Answer to this question is given in the document Drawing_Conclusions.pdf

Uploaded Files:

- [**View**] **eCybermission_Experiments_Final.xls** (By: Advisor, 03/08/2021, .xlsx)
  eCybermission_Experiments_Final.xls Experimental data of all the experiments conducted
- [**View**] **Sources_References.pdf** (By: Advisor, 03/08/2021, .pdf)
  All sources and references used in the mission folder
- [**View**] **Professional_Emails.pdf** (By: Advisor, 03/08/2021, .pdf)
  Email correspondence with professionals for feedback regarding the project.
- [**View**] **ProfessionalOutreach_Questions.pdf** (By: Advisor, 03/08/2021, .pdf)
  Questions asked during the interviews with the professionals to solicit feedback regarding the project.
- [**View**] **Problem_Statement.pdf** (By: Advisor, 03/08/2021, .pdf)
  Problem statement with answers to all 3 questions
- [**View**] **Experimental_Design.pdf** (By: Advisor, 03/08/2021, .pdf)
  Experimental Design document with all the 4 questions answered
- [**View**] **Experimental_Process.pdf** (By: Advisor, 03/08/2021, .pdf)
  Experimental Process with two questions answered.
- [**View**] **Data_Collection_Analysis_Part1_CO2AbsorptionExperiments.pdf** (By: Advisor, 03/08/2021, .pdf)
  Data_Collection_Analysis_Part1_CO2AbsorptionExperiments.pdf This has the answer for Data Collection and Analysis of CO2 experiments
- [**View**] **Data_Collection_Analysis_Part2_GrassGrowthExperiments** (By: Advisor, 03/08/2021, .pdf)
  Data_Collection_Analysis_Part2_GrassGrowthExperiments has the answer for Question 1 - part 2 of the question on Data Collection and Analysis Question 2
- [**View**] **Drawing_Conclusions.pdf** (By: Advisor, 03/08/2021, .pdf)
  Drawing_Conclusions.pdf. This has the answer for 1 question in Drawing conclusion

Community Benefit

(1) Explain how investigating the problem your team chose will help the community. Be sure to include the impacts your research will have on individuals, businesses, organizations, and the environment in your community (if any). Make it very clear why solving this problem would help your community.

Answer to this question is given in the document Community_Benefit.pdf

Uploaded Files:

- [**View**] **Community_Benefit.pdf** (By: Advisor, 03/08/2021, .pdf)
  Answer to the question in the Community Benefit section of the mission folder

- [View] **InformationPamplet_CommunityOutreach** (By: Advisor, 03/08/2021, .pdf)

  Information Pamplet to the neighbors to bring awareness on the carbon emissions problem and solution to creating urban carbon sinks.

Mission Verification

We have reviewed the eCYBERMISSION Rules and Guidelines

Yes

We have worked with our Team Advisor and we have discussed the possible risks involved in the project and completed the Risk Assessment Form (and attached it to our Mission Folder).

Yes

The project involves hazardous chemicals, activities, or devices.

No

The project involves potentially hazardous biological agents (If yes, complete this form and attach to your Mission Folder).

No

We acknowledge that we followed proper safety precautions during the work on our project.

Yes

The project involves testing one or more of the following and requires prior approval by an Institutional Review Board (IRB):

Humans

Yes

Non-Human Vertebrates

No

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

Answer to this question is given in Mission_Verification.pdf

Uploaded Files:

- [View] **IRBForm** (By: Advisor, 03/08/2021, .pdf)

  IRBForm_TheCQuestrators.pdf
- [View] **Mission_Verification.pdf** (By: Advisor, 03/08/2021, .pdf)

  Abstract of the mission folder
- [View] **RiskAssesmentForm_TheCQuestrators.pdf** (By: Advisor, 03/09/2021, .pdf)

  Risk Assessment Form

Community Benefit

PROBLEM 1: Explain how investigating the problem your team chose will help the community. Be sure to include the impacts your research will have on individuals, businesses, organizations, and the environment in your community (if any). Make it very clear why solving this problem would help your community.

Dr. Neelima Tummala (ENT) physician in Virginia correlated the impacts of reducing Carbon emissions on the community. CO_2 emissions increase the temperature which decreases the air quality. Higher temperature increases the pollen production which is the number one trigger of asthma and other respiratory illness. Northern Virginia experienced the hottest summer in July 2020, which impacted patients with allergies across the region. Apart from human impacts, fauna and flora in the Shenandoah region saw the impacts with increase in noxious plants and increase in gypsy moth population [1]. Additionally, many coastal communities along the shoreline of Virginia and in the Chesapeake bay region are at risk of flooding.

There is a need in the community to reduce carbon emissions. Although government agencies are regulating the amount of CO_2 emissions, there is a need to fix the issue at a grass root level. Climate change has many detrimental effects on humans such as allergy induced asthma, mental health diseases, vector borne diseases, etc, and our solution helps reduce this impact.

Chesapeake Bay, Virginia is one of the most vulnerable ecosystems in the US. The rising CO_2 emissions are acidifying the oceans. When CO_2 levels increase, it reacts with ocean water to produce carbonic acid. The carbonic acid reduces the calcium carbonate levels in the ocean making it harder for the oysters and other shellfish to produce calcium carbonate shells. The decrease in oysters and shellfish not only affects the reefs and its habitat but it also brings down the water quality thereby other aquatic fish are also affected. The reduction in the oyster population impacts the fishery and restaurants across the bay region that are primarily dependent on the oyster, crab, and shell population in the Chesapeake Bay and surrounding area.

Hence, solving the issue of increasing CO_2 levels in the atmosphere is not only important to mitigate health and ecological related risks but also to reduce the impact on the economy of our region.

Our solution, carbon sink pellets, aims to increase the carbon sinks in the urban green spaces. It helps in both decreasing CO_2 levels and enriching the soil with eco friendly materials.

Community Outreach:

We reached out to our neighbors to spread awareness on the increasing carbon emission and its detrimental effects in our region. We created pamphlets with information on the problem as well as creating urban carbon sinks with our solution i.e carbon sink pellets. We made zeolite, clay and cow manure pellets. We made about 6 for each neighbor, enough pellets to put in a plant pot.

We also had to include instructions on how to use these pellets and also suggested that they use these pellets in an outdoor pot. Due to the COVID situation, we did not meet our neighbors in person but we put the packets into our neighbor's mailbox to stay safe. Our neighbors were thrilled to try our carbon sink pellets and be a part of having a positive impact on our community.

<table>
<tr>
<td>


Preparing Carbon sink pellets for distribution to neighbors
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Carbon sink pellets with information on carbon emissions and its harmful effects
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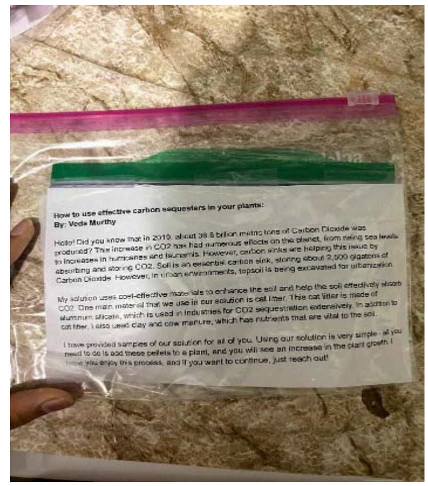
<td>


Carbon sink pellets ready for distribution.
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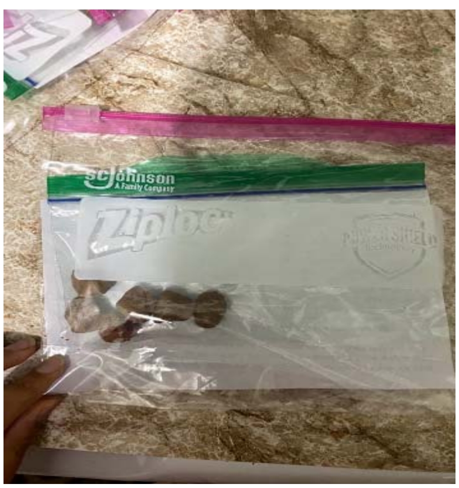
<td>


Carbon sink pellets ready for distribution.
</td>
<td>


Community outreach in our neighborhood to bring awareness
</td>
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Community outreach in our neighborhood to bring awareness
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</table>

Data Collection and Analysis

Data Collection and Analysis:

1. **Question: Present the data you collected from your experiment. Be sure to include all of the data you collected from your observations and measurements. Use of graphs and charts is HIGHLY encouraged. Explain how your data supports or refutes your hypothesis.**

Summary

We completed 2 groups of experiments: 1) Measuring CO_2 Absorption and 2) Measuring Quality of Grass Growth. We have collected and visualized the data for each experiment, as well as performed analysis to determine if our results are statistically significant.

Description and Data Tables for CO_2 Absorption Experiments

We measured the CO_2 Absorption of Only Soil, Zeolite, Zeolite + Cow Manure, Zeolite + Clay. This group has 3 experiments: Measuring CO_2 Absorption at the Surface Level, 1 inch deep, and 3 inches deep in the soil. We decided to measure the amount of CO_2 absorbed in pH. This is because CO_2 reacts with H_2O to form the weak Carbonic acid, which indicates the pH value. It follows the reaction $CO_2 + H_2O \rightarrow H_2CO_3$ (carbonic acid). The more CO_2 in the soil, the more acidic the soil is and lower the pH value.

The table shows the measurements of each experiment with 3 trials and the trial average.

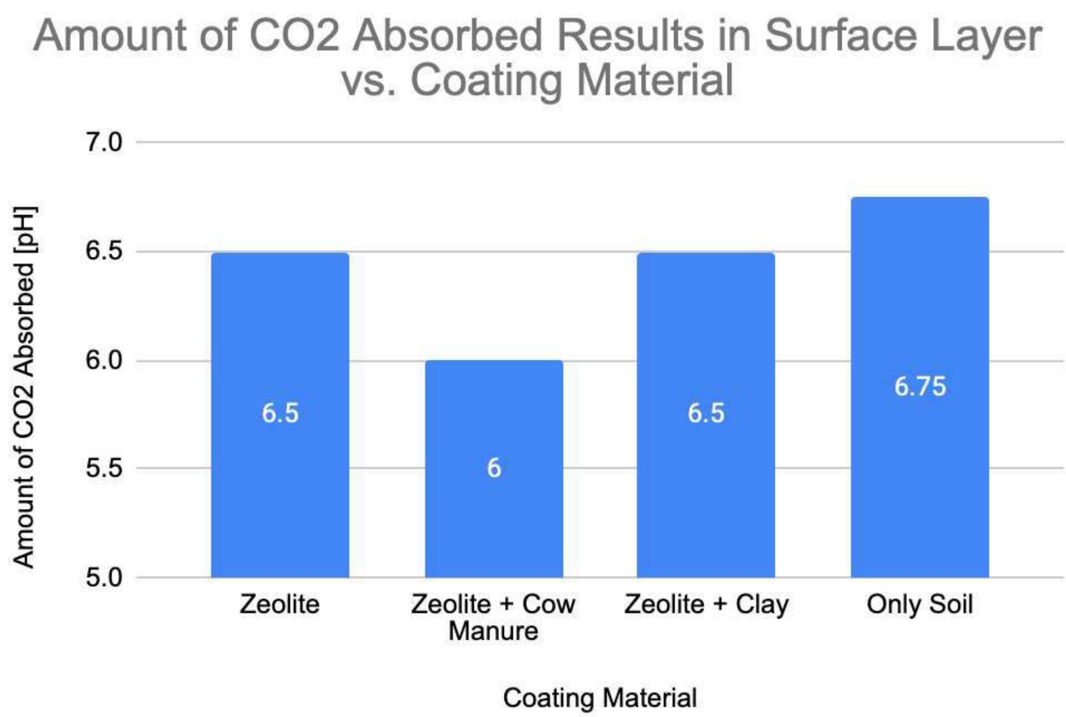
Coating Material	Trial	Experiment 1a: CO2 Absorption at Surface Layer [pH]	Experiment 1b: CO2 Absorption at 1 inch deep [pH]	Experiment 1c: CO2 Absorption at 3 inch deep [pH]
	Trial 1	7	7	7
	Trial 2	6.5	7	7
	Trial 3	7	7	7
Only Soil (Control)	Average	6.75	7	7
	Trial 1	6.5	6.5	6.5
	Trial 2	6.5	6.5	6.5
	Trial 3	6.5	6.5	6.5
Zeolite	Average	6.5	6.5	6.5
	Trial 1	6	6.25	6.25
	Trial 2	6	6	6.25
	Trial 3	6	6.5	6.25
Zeolite + Cow Manure	Average	6	6.125	6.25
	Trial 1	6.5	6.25	6.5
	Trial 2	6.5	6.25	6.5
	Trial 3	6.5	6	6.5
Zeolite + Clay	Average	6.5	6.25	6.5

CO_2 Absorption at Surface Layer, 1 inch deep, and 3 inches deep

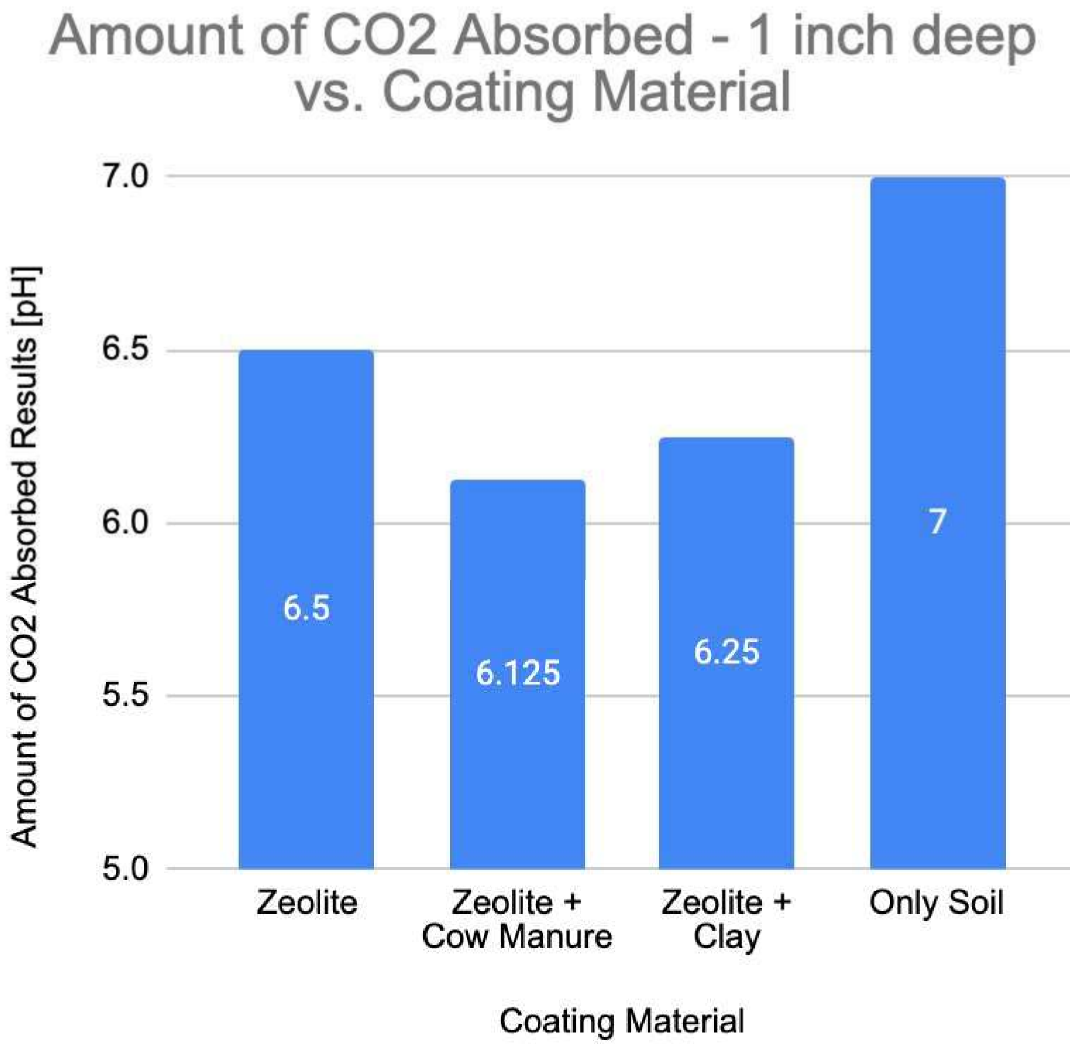
Coating Material	Nitrogen Test	Potassium Test
Zeolite	N1 Deficient	K2 Adequate
Zeolite + Cow Manure	N3 Sufficient	K3 Sufficient
Zeolite + Clay	N0 Depleted	K3 Sufficient
Only Soil	N1 Deficient	K2 Adequate

Nutrient value: Data on the Nitrogen and Potassium levels for each of the coating layers (As an additional test). As you can see, Cow Manure is sufficient in these nutrients.

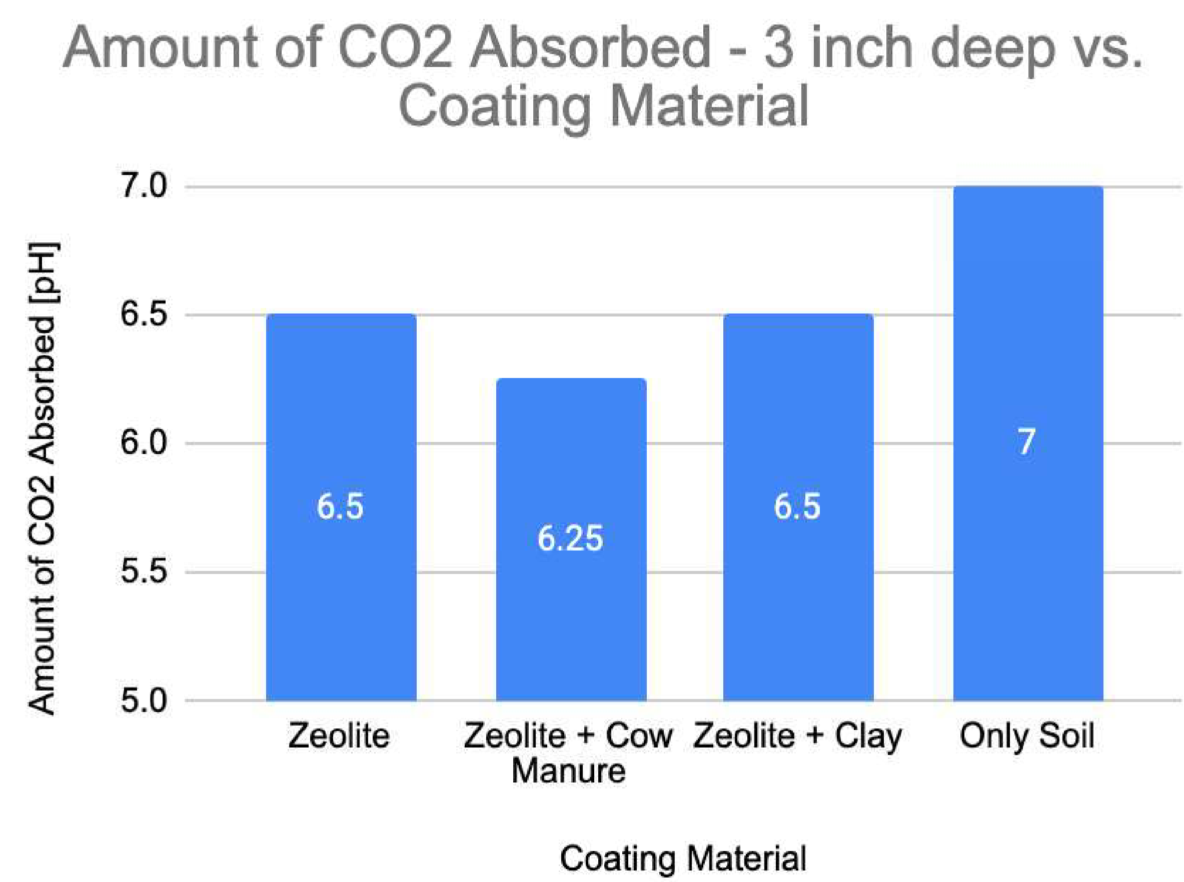
Graphs for CO_2 Absorption Experiments



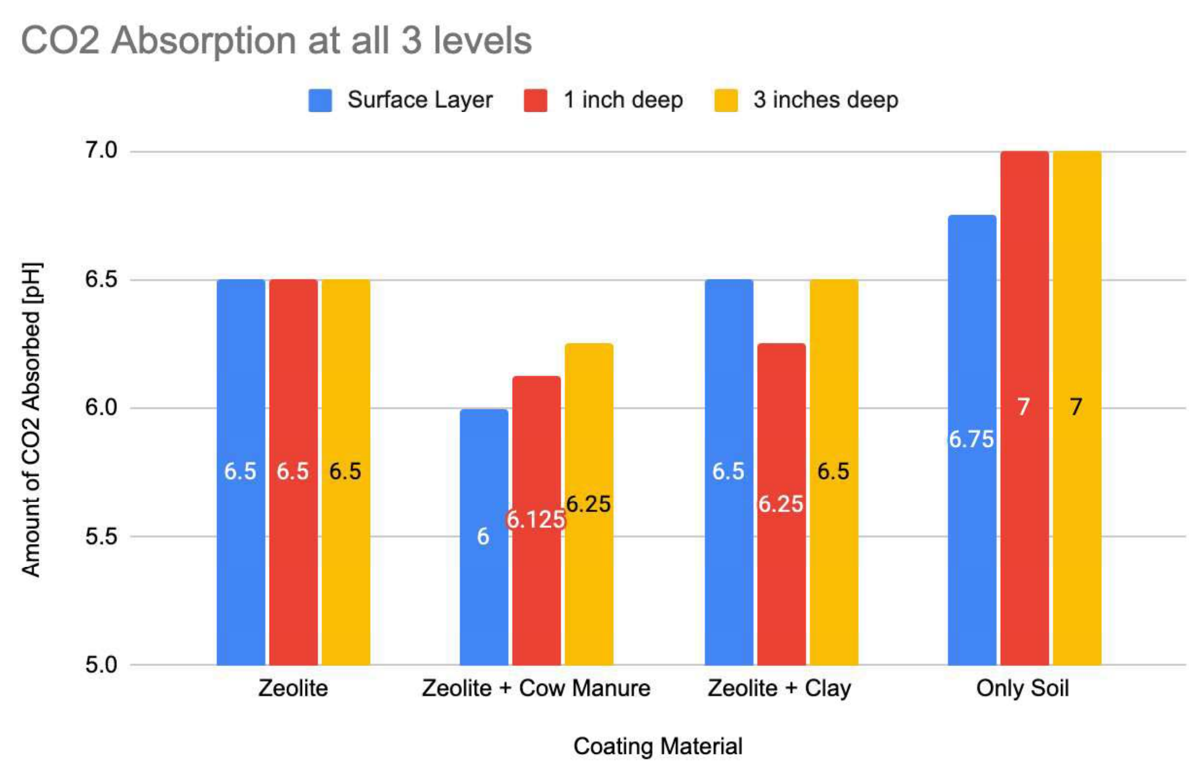
Bar Graph depicting results of Experiment 1a. As the graph indicates, zeolite + cow manure had the most absorption (least pH value).



Bar Graph depicting results of Experiment 1b. As the graph indicates, Zeolite + Cow manure had the most absorption (least pH value) at 1 inch deep.



Bar Graph depicting results of Experiment 1c. As the graph indicates, zeolite + cow manure had the most absorption (least pH value) at 3 in deep.



Bar Graph depicting results of Experiments 1a, 1b, 1c. As the graph indicates, zeolite + cow manure had the most absorption (least pH value) at all 3 levels of the soil.

Statistical Analysis for CO_2 Absorption Experiments

We tested for statistical significance using the Chi-Squared test [41]. Chi-Squared tests if two groups of categorical variables are statistically different. This aligns with our experiment as the independent variable is categorical, thus we used the Chi-Squared test. The two groups of categorical variables are "Observed" and "Expected". Observed values are the values we record during the experiment. For expected values, we used the Only Soil measurement, as it was the control of our experiment.

We ran into an issue when testing for statistical significance, which is that pH values are on a logarithmic scale. For example, liquid with a pH of 6 is 10 times more acidic than one with a pH of 7. A Chi-Squared test assumes a normal/linear distribution. The article "Direct Use of pH values in Statistical Analysis of Soil Reactions" [41] suggests rescaling values to H+ concentrations which is on a linear scale. We rescaled pH values using the following equation [42]: $10^{-pH} * 10^{7}$, which converts pH values to H+ concentration. We then performed the Chi-Squared test based on the rescaled values. Note that the p-values were not exactly 0, rather very close to 0.

Experiment 1a: CO2 Absorption at Surface Layer [pH]				
Null Hypothesis H0: There is no statistical difference between the Carbon Absorption of soil with coating materials and soil without coating materials at the surface layer.				
Alternative Hypothesis Ha: There is a statistical difference between the Carbon Absorption of soil with coating materials and soil without coating materials at the surface layer.				
Coating Material	Observed [pH]	Expected [pH]	Observed [H+ Conc]	Expected [H+ Conc]
Zeolite	6.5	6.75	3.162	1.778
Zeolite + Cow Manure	6	6.75	10	1.778
Zeolite + Clay	6.5	6.75	3.162	1.778
Chi-Squared Test p-value				0.000
Because p-value 0.00 < alpha = 0.05, we reject the null hypothesis.				

Statistical analysis for Experiment 1a

Experiment 1b: CO2 Absorption at 1 inch deep [pH]				
Null Hypothesis H0: There is no statistical difference between the Carbon Absorption of soil with coating materials and soil without coating materials at 1 inch deep.				
Alternative Hypothesis Ha: There is a statistical difference between the Carbon Absorption of soil with coating materials and soil without coating materials at 1 inch deep.				
Coating Material	Observed	Expected	Observed (Log Scale)	Expected (Log Scale)
Zeolite	6.5	7	3.162	1
Zeolite + Cow Manure	6.125	7	7.499	1
Zeolite + Clay	6.25	7	5.623	1
Chi-Squared Test p-value				0.000
Because p-value 0.00 < alpha = 0.05, we reject the null hypothesis.				

Statistical Analysis for Experiment 1b

Experiment 1c: CO2 Absorption at 3 inch deep [pH]				
Null Hypothesis H0: There is no statistical difference between the Carbon Absorption of soil with coating materials and soil without coating materials at 3 inches deep.				
Alternative Hypothesis Ha: There is a statistical difference between the Carbon Absorption of soil with coating materials and soil without coating materials at 3 inches deep.				
Coating Material	Observed	Expected	Observed (Log Scale)	Expected (Log Scale)
Zeolite	6.5	7	3.162	1
Zeolite + Cow Manure	6.25	7	5.623	1
Zeolite + Clay	6.5	7	3.162	1
Chi-Squared Test p-value				0.000
Because p-value 0.00 < alpha = 0.05, we reject the null hypothesis.				

Statistical Analysis for Experiment 1c

Pictures of CO_2 Absorption Experiments

 Surface layer for zeolite	 Surface layer for zeolite + clay	 Surface layer for zeolite + cow manure
 Surface layer for only soil.		
 Soil with yeast fermentation and zeolite	 Zeolite coated with cow manure	 Zeolite coated with clay

Potassium and Nitrogen tests for zeolite + cow manure

Nitrogen test for zeolite

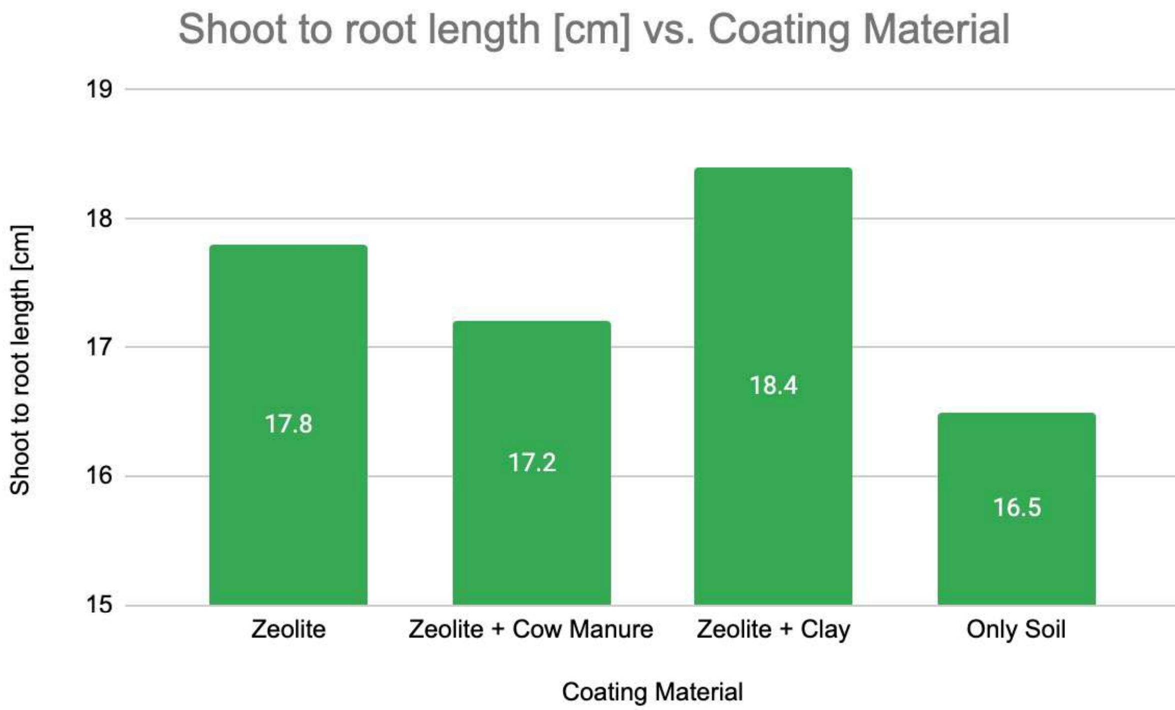
Description and Data Tables for Grass Quality Experiments

We planted grass with each of the soil types and measured the quality of growth using the following soil categories: Only Soil, Zeolite, Zeolite + Cow Manure, Zeolite + Clay. We used two growth quality metrics - shoot to root length and blade density. Shoot to root length is defined as the length of grass measured from the root to the top of the grass blade. We considered both the length of the shoot and root because both parts store and fix CO_2. Shoots capture CO_2 through photosynthesis. Roots house and have a symbiotic relationship with mycorrhizal fungi, which in turn supplies the plant and roots with carbon, water, and vital nutrients. The second measurement of grass growth quality was density, which is the number of grass blades in 1 cm^2 of soil.

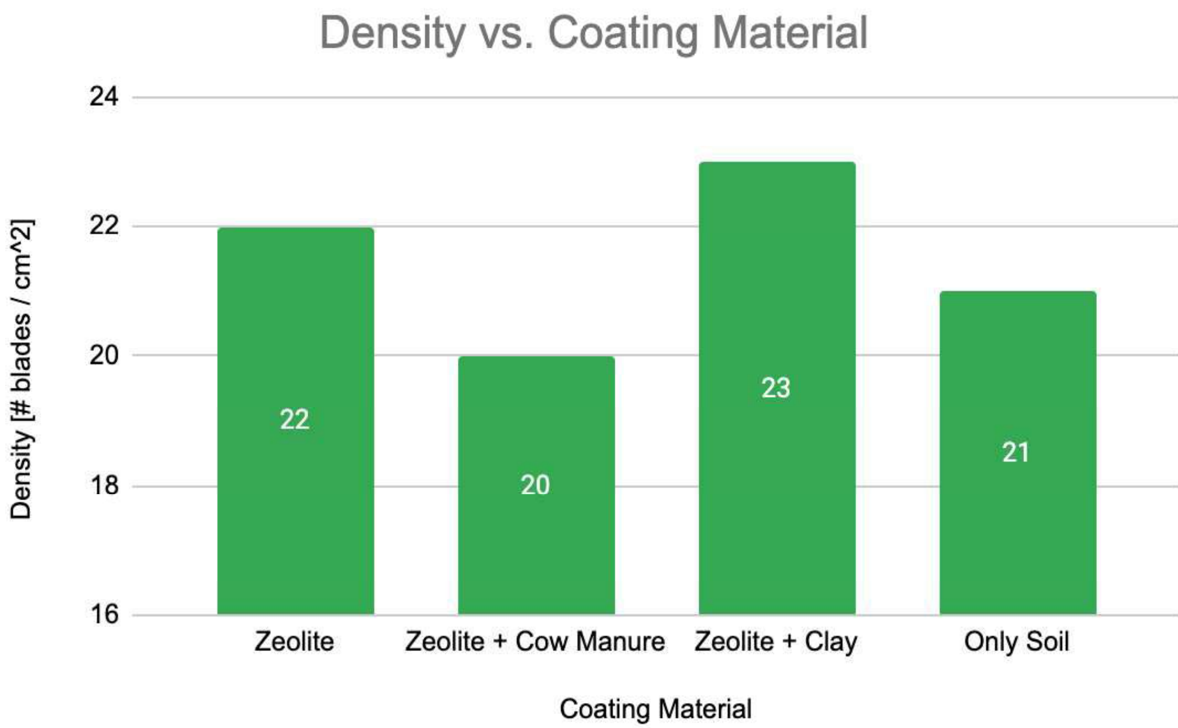
Experiment 2: Grass Quality		
Coating Material	2a: Shoot to root length [cm]	2b: Density [# of blades / cm^2]
Zeolite	17.8	22
Zeolite + Cow Manure	17.2	20
Zeolite + Clay	18.4	23
Only Soil	16.5	21

Experiments 2a, 2b results. As you can see, zeolite + clay had the best grass growth.

Graphs for Grass Quality Experiments



Bar graph depicting results of Experiment 2a. As you can see, zeolite + clay had the best grass growth.



Bar graph depicting results of Experiment 2b. As you can see, zeolite + clay had the best grass growth.

Statistical Analysis for Grass Quality Experiments

We also performed Chi-Squared significance testing on Experiments 2a and 2b. We have also included the percent difference with respect to the Expected (control) values.

Experiment 2a: Grass shoot to root length			
Null Hypothesis H0: There is no statistical difference between the shoot to root length of grass in soil with coating materials and grass in soil without coating materials.			
Alternative Hypothesis Ha: There is a statistical difference between the shoot to root length of grass in soil with coating materials and grass in soil without coating materials.			
Coating Material	Observed [cm]	Expected [cm]	Percent Difference (%)
Zeolite	17.8	16.5	7.879
Zeolite + Cow Manure	17.2	16.5	4.242
Zeolite + Clay	18.4	16.5	11.515
Chi-Squared Test p-value		0.8390755361	Average: 7.879
Because p-value 0.84 > alpha = 0.05, we fail to reject the null hypothesis.			

Statistical analysis for Experiment 2a

Experiment 2b: Grass Density [cm]			
Null Hypothesis H0: There is no statistical difference between the grass density in soil with coating materials and grass density in soil without coating materials.			
Alternative Hypothesis Ha: There is a statistical difference between the grass density in soil with coating materials and grass density in soil without coating materials.			
Coating Material	Observed [# blades / cm^2]	Expected [# blades / cm^2]	Percent Difference (%)
Zeolite	22	21	4.762
Zeolite + Cow Manure	22	21	4.762
Zeolite + Clay	23	21	9.524
Chi-Squared Test p-value		0.867	Average: 6.349
Because p-value 0.87 > alpha = 0.05, we fail to reject the null hypothesis.			

Statistical analysis for Experiment 2b

Pictures of Grass Quality Experiments

Grass seeds

Grass seeds control

Grass + zeolite

Grass + zeolite coated with clay

Grass + zeolite coated with manure

Grass control side view

Grass + zeolite side view

Grass + zeolite coated with clay side view

Grass + zeolite coated, manure side view

Grass growth

Grass growth shoot vs. root


Grass growth shoot + root


Grass control


Grass + zeolite


Grass + zeolite coated with clay


Grass + zeolite coated with cow manure

Analysis of our hypothesis:

Is our hypothesis correct?

- Experiment 1a: Our hypothesis is correct, as Zeolite + Cow Manure had the lowest pH and thus the highest amount of CO_2 absorbed at the surface layer.
- Experiment 1b: Our hypothesis is correct, as Zeolite + Cow Manure had the lowest pH and thus the highest amount of CO_2 absorbed at 1 inch below the surface.
- Experiment 1c: Our hypothesis is correct, as Zeolite + Cow Manure had the lowest pH and thus the highest amount of CO_2 absorbed at 3 inches below the surface.

All of our hypotheses were correct for Experiment 1. Zeolite + Cow Manure was the most effective CO_2 absorber at all three depth measurements. Also, since the pH is on a logarithmic scale, the differences in amount of CO_2 absorbed between Zeolite + Cow Manure and the rest of the levels of IV are larger than the pure pH value.

- Experiment 2a: Our hypothesis is correct, as Zeolite + Clay has the highest shoot to root length
- Experiment 2b: Our hypothesis is correct, as Zeolite + Clay has the highest density (# blades / cm^2)

All of our hypotheses were correct for Experiment 2 as well. Zeolite + Clay resulted in the best quality of plant growth, in terms of shoot to root length and density.

Statistical Significance: After performing a statistical analysis with Chi-Squared testing, we found that Experiment 1's results were statistically significant. Our Chi-Squared test gave a p-value of ~0.01.
Since we used alpha=0.05, this means that we can be 95% confident in our results, and that Zeolite + Cow Manure is the most effective CO_2 absorber. It is important to note that since pH is on a logarithmic scale, each point difference is actually a 10x difference. Thus, an inaccurate pH reading would only exacerbate the H+ concentration. One of our potential sources of error is that the pH scale was difficult to read, thus we should ensure the veracity of our results with more experimentation and trials.

Experiment 2's results were statistically insignificant, meaning that the difference in the results for each IV level is not large enough to be confident about our results. Our Chi-Squared test gave a p-value of ~0.84. More trials should be conducted to be more confident in our results. We also calculated the percent difference between each level of IV and the control (Only Soil) and found that Zeolite + Clay resulted in a ~10% higher shoot to root length and density, which is still noteworthy.

Interestingly, Zeolite outperformed Zeolite + Cow Manure, suggesting that even though Cow Manure is an effective CO_2 absorber, it should be mixed with other coating materials such as Clay to encourage quality of plant growth as well. An effective carbon sink would have multiple coating materials mixed with the soil.

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2. **Question: What are your potential sources of error? Remember, this doesn't mean "Did everything work?", all tests have potential sources of error, so make sure you understand what that means. Explain how these sources of error could have affected your results.**

Error Due to Reading Measurements: The following could be the potential sources of error during the data collection process.

- pH Scale: To measure the pH of the soil, we used a pH test with a color coded scale to indicate the pH. At times, it was difficult to determine the color of water, as the color was often times subjective in borderline cases. Thus, it was a potential source of error that may have impacted our pH readings. We mitigated this error by having the same team member (Veda) take the readings. In the future, we plan to use a CO_2 probe for more accurate readings.

Procedure and Materials Improvements:

- Clay/Cow Manure: For the Zeolite + Clay and Zeolite + Cow Manure, we added clay/cow manure (golf ball size) on top of the surface of the soil before the start of the experiment, with the idea that these materials would seep down into the soil. However, upon further research we realized that this may have not been the most optimal strategy to mix the clay/cow manure with the soil. In the future, we will make smaller pellets which we will mix in the soil itself. Additionally, we would like to aerate the soil before adding pellets in order to prevent runoff. We believe that this may be a more effective strategy to absorb more CO_2 and increase quality of plant growth.
- Duration of Carbon Absorption process: In our procedure, we waited for 1 day after starting the experiment to record the level of CO_2. Upon further research, we realized that it may have been more effective to wait at least 3-5 for the CO_2 absorption process to provide the most accurate results. Waiting for at least a week may also yield a higher increase in CO_2 absorption.

Drawing Conclusions

Drawing Conclusions

1. **Question: What conclusions can you draw based on the data you gathered during your experiment(s)? Be sure to include data and how it relates to the experiment(s) and the original question. Your conclusion should be related to your original problem and your experiment, include the data you collected, and discuss if your hypothesis was supported or refuted by your experiment.**

Our solution addresses the problem CO_2 emissions by creating effective carbon sinks, a natural reservoir that captures carbon dioxide, using cost-effective materials found in our community. We used Zeolite, an aluminum silicate mineral, as our main material because it has been extensively used in industrial practices for carbon sequestration. Zeolite is environmentally safe and it is used in cat litter and aquarium filters. However, due to the cost of Zeolite, starting at $23 per bag, we wanted to increase the volume but decrease the amount of zeolite used. We found that different coating materials, such as clay and cow manure, are also effective carbon sequesters, to fulfill this task. Our solution has a 2 part experiment to test:

1) The Effect of Zeolite + Coating Materials on the Amount of CO_2 in the Soil.
2) The Effect of Zeolite + Coating Materials on the Grass Length and Quality.

For experiment 1, we hypothesized that zeolite with a coating material of cow manure was the most effective in the absorption of CO_2. Our results support this. The pH value for Zeolite + Cow Manure was 6.25 pH. The microorganisms in the soil are the main carbon fixers. This proves that cow manure, in the compost form, had the most microorganisms, thus being the most effective carbon sink. Additionally, this reinforced our research about regenerative farming, as many farmers use cow manure to effectively sequester CO_2, as well as bring vital nutrients to the soil.

For experiment 2, we hypothesized that zeolite with a coating material of clay was the most effective in grass growth and quality. Our results also support this. We also found that the zeolite and clay had a higher shoot to root than the other coating materials, although since our results were not statistically significant we would need further experimentation to be confident in our results. This aligned with our research that clay retains water and vital nutrients for the soil.

In addition to experimentation, we distributed our solution to neighbors in our community. We supplied them with zeolite + clay and zeolite + cow manure pellets to use as lawn fertilizer and growing plants.

Our experiments' results clearly show that we can create carbon sinks using cost-effective materials. The above experiments, with our innovative carbon sink pellets, clearly indicate that we can create carbon sinks in our own lawns and green spaces. We plan to produce our pellets out of Zeolite, Clay, and Cow Manure, as all three coating materials have vital properties in CO_2 absorption and plant growth. We believe that our innovative solution of fixing carbon emissions in urban green spaces will have a significant impact on our community and globally. If we implement carbon sink pellets in our urban lifestyle, climate change impacts will be reduced for all of us.

Future Work

We shared our solution, CO_2 absorbing pellets, and the experimental data with Soil Scientist Mr. Dan Schwartz & Conservation specialists Ms. Ashley & Ms. Meredith Keppel from Northern Virginia Water and Soil Conservation district. They were very impressed that we were tackling an important issue in our community and finding a way to solve it. We were very excited to hear from them that our experiments were scientifically correct and on the right track. They gave us valuable feedback on how we can take the next steps on furthering our experiments in terms of testing and reaching out to county resources so it can be included as a part of county landscaping. They also gave suggestions on how we can aerate the soil and add the pellets so that it would stay in ground and not get washed away with rain/routine plant watering. Mr. Schwartz also gave us contacts of the resources in our county whom we could contact to help implement our solution. We are excited to implement our solution and help our community create carbon sinks to reduce carbon emissions.

We also would like to improve upon the materials used and are particularly interested in coating zeolite with mycorrhizal fungi [43]. Mycorrhizal fungi forms a natural symbiotic relationship with the plant, and supplies the plant with carbon and nutrients. 50-60% of the carbon bound in the soil is due to the mycorrhizal fungi in tree roots. This fungi is extremely vital for plants, and we planned to have mycorrhizal fungi as one of our coating materials. However, due to safety guidelines, we could not use this in our experiments. We plan to further our experiments and test the increase of CO_2 absorption as a result of adding mycorrhizal fungi coating on zeolite.

Our solution, carbon sink pellets, empowers every citizen to reduce the carbon footprint on the planet. Creating carbon sinks in urban environments is the path to reduce and trap harmful carbon emissions. We are excited to do our part with our solution to reduce the carbon footprint on the planet.

ARMY EDUCATIONAL OUTREACH PROGRAM

eCYBERMISSION ACCEPT THE CHALLENGE

U.S. ARMY

IRB Review and Approval Form (TWO pages)

For a print version click here.

To be completed by the team with the Team Advisor

Team Name: The CQuestrators

Student Usernames: vmurthy, vgunda

Team Advisor Name: Sharmila Murthy

Description of project: Investigate effective materials to absorb carbon dioxide in the soil to create carbon sinks.

The team's interaction with humans/animals will be through (check all that apply):

- [x] Surveys, questionnaires, focus groups, interviews
- [ ] Games, experiments in physical or in electronic environments
- [ ] Physical or biomedical procedures – blood collection
- [ ] Diet, nutrition studies, taste tests
- [ ] Studies examining effectiveness of educational tools or curricula
- [ ] Use of instruments or devices, including phones, to collect data or monitor or influence behavior
- [ ] Studies examining individuals' responses to manipulation of their physical or online environment
- [ ] Activity that involves observation of, or interaction with, individuals to gather information for research
- [ ] Physical exertion (exercise, sports, etc.)

Explain in detail how your team will interact with humans/animals in your project? If you will be conducting a survey or having humans answer questions of any kind please include the survey and all questions in the text or as an attachment.

Students will interact with people (professionals, friends, community members) to solicit feedback on the problem of carbon emissions in our community, feedback on the developed solution and their project work. Questions to the professionals will be included in the mission folder.

As Team Advisor, I certify this is a viable eCYBERMISSION project in which neither humans nor animals will be harmed.

Sharmila Murthy

Team Advisor Signature

12/20/2020

Date

(continued)

aeop ARMY EDUCATIONAL OUTREACH PROGRAM | eCYBERMISSION ACCEPT THE CHALLENGE U.S. ARMY

To be completed by a school administrator:
Have you reviewed the proposed human interaction required for this project? ☑ YES ☐ NO

Does participation in this project require parental permission for minors? ☑ YES ☐ NO

Do you consent for this project to move forward as proposed? ☑ YES ☐ NO

Is a check-up of the human or animal subjects required? ☐ YES ☑ NO

School Administrator Signature

Date 2/10/2021

To be completed by a doctor or medical professional:
Have you reviewed the proposed human interaction required for this project? ☒ YES ☐ NO

Does participation in this project require parental permission for minors? ☒ YES ☐ NO

Do you consent for this project to move forward as proposed? ☒ YES ☐ NO

Is a check-up of the human or animal subjects required? ~~☒~~ YES ☒ NO

Doctor/Medical Professional Signature

Date 02/25/21

To be completed by a STEM educator (generally, another STEM teacher at the school) other *than the Team Advisor*
Have you reviewed the proposed human interaction required for this project? ☑ YES ☐ NO

Does participation in this project require parental permission for minors? ☑ YES ☐ NO

Do you consent for this project to move forward as proposed? ☑ YES ☐ NO

Is a check-up of the human or animal subjects required? ☐ YES ☑ NO

STEM Educator Signature

Date 2/2/2021

Meeting Date:	Attended by	What did we do?
9/18/2020	Veda, Karthik	We went through videos of some of the exciting projects
9/25/2020	Veda, Karthik	global community. Veda also talked about previous year's
10/2/2020	Veda, Karthik	our problem. Also looked into extending last year's
10/9/2020	Veda, Karthik	Looked into extending last year
10/16/2020	Veda, Ria, Karthik	
10/23/2020	Veda, Ria	We looked at different issues of winter composting
11/14/2020	Veda, Varsha	We went through videos of some of the exciting projects
11/20/2020	Veda, Varsha	Continued going over the work done so far.
12/4/2020	Veda, Varsha	Team members brainstormed new ideas for the project.
12/18/2020	Veda, Varsha	emissions and ways to fix the issue.
1/3/2021	Veda, Varsha	emissions.
1/8/2021	Veda, Varsha	that help with absorbing CO_2
1/15/2021	Veda, Varsha	experiments.
2/5/2021	Veda, Varsha	experiments, created a spreadsheet to identify dependent
2/7/2021	Veda, Varsha	recorded our data.
2/12/2021	Veda, Varsha	Conducted second set of trials and recorded the data.
2/13/2021	Veda, Varsha	meetings
2021-02-14	Veda, Varsha	statement, community benefit, and mission verification
2020-02-23	Veda, Varsha	Varsha: Worked on Experimental Design and proccess
2020-02-26	Veda, Varsha	on revisions and edits to all the other documents.
2020-02-28	Veda, Varsha	analysis
2020-03-01	Veda, Varsha	analysis
2020-03-02	Veda, Varsha	Final revisions of the mission folder
2020-03-07	Veda, Varsha	Final revisions of the mission folder

Meeting Outcome

competition and its exciting topics

research documents, plan for our project, meeting

extend last year's project. We reviewed some of the

discussed various techniques for problem

dependencies fully.

We sorted all our research into the catagories.

school/activities conflict so we had new team

Eliminated ideas we did not want to do.

Research new ideas including carbon emissions.

emissions. Create problem statement, definition and

CO2.

experiments. Formulated hypothesis.

the problem and solution.

are the dependent variables in our design and what

Also looked into subject matter experts that we could

Started to work on the mission folders.

solicit feedback. We also reached out to Ms.Ashley

do minor revisions.

proccess. Additionally, we mostly finished problem

finished this section.

Finished data analysis and other sections.

Edited our documents.

Edited our documents.

Edited our documents.

ToDo for next meeting
the project videos
Explore some of the eCybermission topics
Karthik
Karthik
Tracker: Ria
Tracker: Veda
Tracker: Veda
Tracker: Varsha
Tracker: Varsha
Tracker: Varsha
Tracker: Varsha
Tracker: Varsha
Tracker: Veda
Tracker: Veda
Tracker: Veda
Tracker: Veda
Tracker: Veda
Tracker: Veda
Tracker: Veda
Tracker: Veda
Tracker: Veda
Tracker: Veda
Tracker: Veda
Tracker: Veda

No.	Task Description	Start Date	End Date
1	Team Formation and Team advisor team registration	September, 2020	November 20, 2020
2	Start Team meetings	September, 2020	March, 2021
3	**Select a Topic**	September, 2020	December 1, 2020
4	Exploring probable topics	September, 2020	October 10, 2020
5	Use scientific techniques to assess and connect topics	October 10, 2020	October 15, 2020
6	Identify and delineate sub-topics	October 15, 2020	October 25, 2020
7	Narrow down the topics of interest.	October 25, 2020	November 1, 2020
8	**Identify a Problem**	**November 1, 2020**	**December 1, 2020**
9	Delve into the selected topics to determine problems	November 1, 2020	November 6, 2020
10	Verify it is relevant in our community	November 8, 2020	November 13, 2020
11	Use scientific techniques to narrow down the problem statements	November 13, 2020	November 20, 2020
12	Develop problem statements.	November 23, 2020	November 27, 2020
13	**Research and finalize the Problem statement & solution**	**December 1, 2020**	**December 30, 2020**
14	Research the topic online as well as determine other sources	December 1, 2020	December 4, 2020
15	Gather the data and research to support your problem statement - why is	December 7, 2020	December 11, 2020
16	Brainstorm solutions	December 14, 2020	December 18, 2020
17	Discuss solutions and how to resolve the problem	December 21, 2020	December 25, 2020
18	Finalize solution	December 25, 2020	December 31, 2020
19	**Complete Experimental Design**	**January 2, 2021**	**February 6, 2021**
20	Designing experiments	January 4, 2021	January 8, 2021
21	Complete Experiment setup - Gather materials	January 11, 2021	January 15, 2021
22	Complete measurements and start experiments	January 18, 2021	January 22, 2021
23	Collect experiment data. records	January 25, 2021	January 29, 2021
24	**Consultation with Experts**	**February 1, 2021**	**Feb 29, 2021**
25	Email reachout to professionals	February 1, 2021	February 5, 2021
26	Fairfax County Soil and Water Conservation	February 8, 2021	February 12, 2021
27	School resources	February 15, 2021	February 19, 2021
31	**Work on Mission Folder**	**February 1, 2021**	**March 3, 2021**

32	Team Collaboration	February 1, 2021	February 5, 2021
33	Scientific Inquiry - Document Research	February 5, 2021	February 26, 2021
34	Community Benefits	February 8, 2021	February 12, 2021
35	Mission Verification	February 15, 2021	February 19, 2021
36	Attachments verification, compilation	February 22, 2021	February 26, 2021
37	Final Reviews	February 28, 2020	March 1, 2021
38	Celebrate success!!	March 1, 2021	March 3, 2021

CQuestrators

Veda Murthy
Varsha Gunda

Problem Statement

- In 2019, about 36.8 billion metric tons of carbon dioxide (CO_2) was produced globally.
  - Urban cities account for more than 70% of global CO_2 emissions
- The increase in carbon emissions have numerous effects on our climate and humans
  - Climate change effects - severe weather patterns, such as hurricanes, rising sea level rise, melting ice glaciers, etc.
- We need a solution to absorb vast amounts of CO_2 in a short period of time!

Our Research

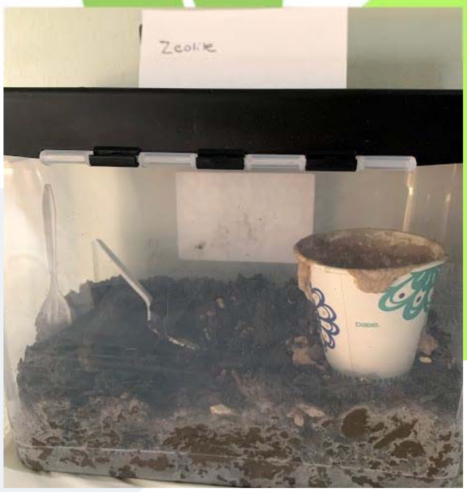
- Carbon sinks
  - Natural or artificial reservoirs that absorb and store carbon dioxide.
- Soil → essential carbon sink
  - It stores about 2,500 gigatons of carbon globally
- However, in urban environments, trees are cut down AND topsoil is being excavated for urbanization.
- **There is an immediate need to create effective carbon sinks in the urban environments.**

Our Solution

- We wanted to use cost-effective materials to enhance the soil and help the soil absorb CO2 (microorganisms in the soil).
- Zeolite (cat litter)
  - A natural aluminium silicate mineral that is extensively used in industrial practices to absorb CO_2. Zeolite is very porous, thus can absorb vast amounts of CO_2. The high thermal temperature and chemical stability of these crystals make them the perfect materials to achieve precise and specific separation of gases including H_20, CO_2 and SO_2, they can separate most light gas mixtures.
- Other coating materials → cost effective
  - Cow Manure → many studies have shown that cow manure is an effective Carbon Sequester.
  - Clay → Carbon sequester and retains nutrients

CO2 Absorption in the soil summary

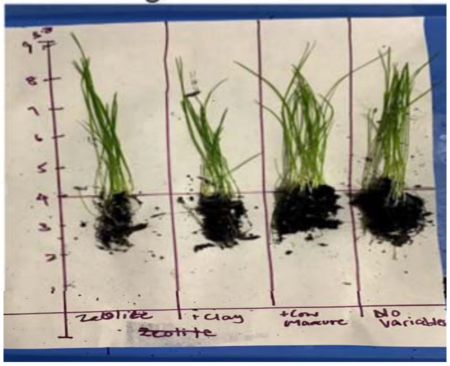
- We tested the absorption of CO_2 with zeolite + coated materials on soil by taking a pH test. Carbon dioxide reacts with water to create carbonic acid
- These are our test results
- We concluded that zeolite + cow manure was the optimal coating material to effectively absorb CO_2



Coating Material	Trial	Experiment 1a: CO2 Absorption at Surface Layer [pH]	Experiment 1b: CO2 Absorption at 1 inch deep [pH]	Experiment 1c: CO2 Absorption at 3 inch deep [pH]
	Trial 1	7	7	7
	Trial 2	6.5	7	7
	Trial 3	7	7	7
Only Soil (Control)	Average	6.75	7	7
	Trial 1	6.5	6.5	6.5
	Trial 2	6.5	6.5	6.5
	Trial 3	6.5	6.5	6.5
Zeolite	Average	6.5	6.5	6.5
	Trial 1	6	6.25	6.25
	Trial 2	6	6	6.25
	Trial 3	6	6.5	6.25
Zeolite + Cow Manure	Average	6	6.125	6.25
	Trial 1	6.5	6.25	6.5
	Trial 2	6.5	6.25	6.5
	Trial 3	6.5	6	6.5
Zeolite + Clay	Average	6.5	6.25	6.5

Grass Experiment Summary

- We tested the grass growth with the zeolite + coated materials.
  - This was done to see if the zeolite + coated materials would enhance the soil as well
  - We tested this by taking shoot and root lengths of the grass
- The chemical science behind it is that Zeolite improves soil structure by essentially buffering the excess amount of ammonia and potassium. The prevents the buildup of ammonia that result in toxicity, unlike most soil amendments zeolite does not break over time. Zeolite contains moisture, which reduces water requirements.
- We concluded that zeolite + clay was optimal for the grass growth - it had grown 7.5 inches in 10 days
- These are our test results



Nutrient Summary

- We tested the nutrient value of the zeolite + coating materials
  - This was done because we needed to see if the zeolite and the coating materials were good for the soil as well.
- Our conclusion was that zeolite + cow manure was the best nutrient value for the soil

	Test for Nitrogen	Test for Potasium
Experiment 1 - Zeolite	N1 deficient	K2 adequate
Experiment 2 - Zeolite + Clay	N1 deficient	K1 deficient
Experiment 3 - Zeolite + Cow Manure	N0 depleted	K3 sufficient
Experiment 4 - Only Soil	N1 deficient	K2 adequate

We plan to produce our pellets out of Zeolite, Clay, and Cow Manure, as all three coating materials have vital properties in CO2 absorption and plant growth. This is because Clay and Cow Manure both have extremely valuable aspects. Although Cow Manure is the best CO2 absorber and has excellent nutrient value for plant growth, cow manure on its own is prone to mold growth and was detrimental to grass growth.

We can fix the Carbon emission problem at a grassroot level!
Bring awareness among residents on the issue.
Fund more research so citizens are empowered to solve the issues.

Soil in container: 6kg	**No Soil (Baseline)**	**Surface Layer**
Experiment 1	Zeolite - 100g	Zeolite - 100g
Experiment 2 - Cow Manure	Zeolite - 100g Cow Manure - 100g	Zeolite - 100g Cow Manure - 100g
Experiment 3 - Clay	Zeolite - 100g Clay - 100g	Zeolite - 100g Clay - 100g

1 inch deep	**3 inch deep**
Zeolite - 100g	Zeolite - 100g
Zeolite - 100g Cow Manure - 100g	Zeolite - 100g Cow Manure - 100g
Zeolite - 100g Clay - 100g	Zeolite - 100g Clay - 100g

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Problem Statement

Problem Statement:

1. **Question: What problem in your community will your team be investigating through scientific inquiry using scientific practices? Specifically, based on this problem, what question will you be trying to answer?**

Overview
Climate change is one of the most consequential threats facing humanity. The exponential increase in greenhouse gases predominantly due to human activities is resulting in rising global temperatures. This has many disastrous effects including extreme weather patterns, rising sea levels, pollution, and adverse health effects. Developing innovative solutions to help solve the climate crisis is a pressing need across the globe.

Introduction
Greenhouse gas emissions are primarily composed of carbon dioxide (CO_2), as well as nitrogen, methane, and water vapor. According to the Environmental Protection Agency (EPA) [1], CO_2 emissions have increased by 90% since 1970, which contributes to 78% of total greenhouse gas emissions. The United Nations states that global temperatures have risen by one degree Celsius since preindustrial times, and causing irreversible damage to our ecosystems.

The direct impact of climate change due to carbon emissions is alarming. Warmer temperatures result in severe weather patterns such as hurricanes, tsunamis, melting ice glaciers, melting permafrost, and rising sea levels. 90% of the world's urban areas are situated on the coastline and are at a high risk from some of the devastating impacts of climate change. Carbon emissions are also directly linked to health issues such as cancer, vector-borne diseases, and heat-related illnesses. This results in carbon emissions killing millions of people all over the world. In the US alone, around 250,000 people [2] die due to the impacts of climate change annually. Carbon emissions also affect our ecosystem including breeding of animals in their natural habitat and production of crops. The large scale impact of climate change necessitates solutions to reduce carbon emissions and needs to be developed as soon as possible.

Impact in the Community
Climate change not only has a global impact, but also has taken a toll on the local environment and our community. In Fairfax County, Virginia, where our team resides, CO_2 levels have significantly risen in the past few years. According to Dr. Neelima Tummala, an ENT doctor (Virginia Clinicians for Climate Action) "*Increased* CO_2 *levels and temperatures have been shown to directly affect pollen allergenicity, contributing to worsening of symptoms and longer length of allergy symptoms."* Dr. Tummala has cited that increasing Carbon emissions in our area has led to worsening levels of asthma, anxiety, and mental health disease, especially in children [3].

July 2020 was recorded as being the hottest month in Northern Virginia [4], emergency rooms saw increased numbers of kidney and heart disease, secondary to dehydration from increased temperatures in our area. Also, scientists project that Virginia will experience 1.5 feet of sea level rise during the next 20-50 years, putting the coastal communities increasingly at risk [5].

Urbanization & Carbon Sinks

Urbanization is a major factor that is leading to the acceleration of climate change. Urban cities consume over two-thirds of the world's energy and account for more than 70% of global CO_2 emissions. Urban residents control 12-40% of the land carbon uptake and 15-40% (117 billion tons) of the carbon emissions globally [6]. The excess amounts of carbon emissions in the urban environment is leading to drastic changes in weather, health problems, and ecological imbalance.

Urbanization and industrialization is leading to an increase in new sources of carbon emissions, such landfills (30 billion tons of carbon emissions) and construction of buildings (6.7 billion tons of carbon emissions) [7]. Additionally, urbanization and industrialization has a direct impact on the increasing CO_2 levels due to reduced forests. Forest Service Chief Dale Bosworth has noted that one major threat to forest sustainability is "Loss of open space, urban sprawl, transportation corridors, and changes in forest ownership are fragmenting the forest estate. That makes it difficult to meet the multiple demands on forests, even though the total forestland base is stable" [8].

At the same time, there is also a decrease in carbon sinks. Carbon sinks are natural or artificial reservoirs that absorb and store carbon dioxide [9]. Oceans are the biggest carbon sinks on earth. However, on land, plants, trees in the forests, and organic matter in the soil are the main carbon sinks. Carbon sinks absorb carbon through a process called carbon sequestration. Soil can contain up to 5% carbon by weight, including decomposing plant and animal matter and biochar. Hence soil is regarded as the hidden gem of the carbon cycle.

Soil is an effective carbon sink, storing about 2,500 gigatons of carbon which is over three times the global amount of atmospheric carbon and four times the amount of carbon stored in all living plants and animals [10]. Most soil is in the form of Soil Organic Matter (SOM) which contains microorganisms that help the soil absorb vast amounts of CO_2. SOM provides numerous benefits to the physical and chemical properties of the soil. Additionally, SOM helps the soil retain and absorb CO_2 effectively.

In urban areas, trees are being cut down and topsoil is being excavated for construction to accommodate the ever growing population. This is leading to reduction of natural carbon sinks at an alarming rate.

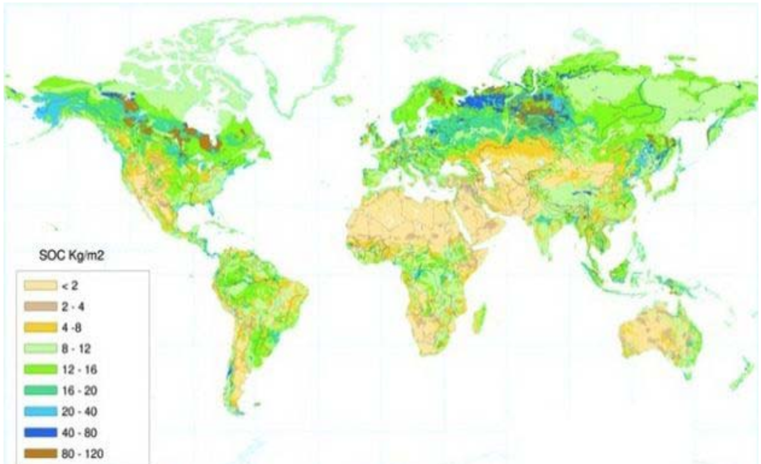

Figure 1: The soil organic carbon map shows the distribution of the soil organic carbon to 1 meter depth [11].

The increase in carbon sources and decrease in carbon sinks especially in urban areas have accelerated climate change. Therefore, **there is an immediate need to create effective carbon sinks in urban environments.**

Through the scientific inquiry process, the CQestrators' mission is to address the following problems:
Problem 1: Could we create an effective carbon sink in limited green spaces in an urban environment using cost-effective materials?
Problem 2: If we conduct community outreach, will we be able to encourage more people to reduce carbon footprint?

Our mission objectives

1. **Create an effective carbon sink in urban areas to reduce carbon footprint.**

Front yard lawns are quintessentials of most American suburban homes. A survey conducted by NALP found that 81% of all Americans have a lawn [12]. In urban areas, many apartments contain rooftop gardens or other green outdoor community spaces. Although these spaces are relatively small compared to carbon sinks such as forests or oceans, *en masse* these spaces within urban environments can act as effective carbon sinks with large scale impact. As the proverb goes, "*Tiny drops of water makes a mighty ocean.*" Thus, maximizing the effectiveness of carbon absorption in small green urban spaces can significantly decrease carbon emissions.
If we can enhance the lawns and outdoor green spaces with materials that can absorb and retain CO_2, then we will create new carbon sinks in the urban environment and reduce the carbon emissions in the most vulnerable areas.

Our solution is to research and develop pellets that contain environmentally safe CO_2 absorbing materials. These pellets can be added to soil in green spaces such as gardens and lawns to enhance CO_2 absorption capacity and plant growth. If these pellets are added to green spaces, *en masse* it will increase the effectiveness of carbon sinks especially in urban environments and contribute to the reduction of carbon emissions and climate change.

2. **Increase awareness about the effects of the carbon emissions by involving our community.**

Increasing awareness of the problem is an important part of solving the issue. Our team reached out to people in the neighborhood to bring awareness about the problem of urban carbon pools due to emissions in our region. We presented the statistics on carbon emissions in our area, and its detrimental health impacts. We explained the need to develop carbon sinks in every urban house. We shared our solution of developing aids to absorb CO_2 in the soil. Our neighbors were thrilled to enhance their soil with our innovative solution and reduce the carbon footprint.

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2. **Question: Research your problem. You must learn more about the problem you are trying to solve and also what testing has already been done. Find AT LEAST 10 different resources and list them here. They should include books, periodicals (magazines, journals, etc.), websites, experts, and any other resources you can think of. Be specific when listing them, and do not list your search engine (Google, etc.) as a resource.**

Below are some of the references we used in our research. Additional sources used in other sections of the mission folder is given in Sources_References.doc

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Subject Matter Experts/Professionals we met:

1. **Dr. Neelima Tummala**
   Division of Otolaryngology
   GW Medical Faculty Associates

While we were researching environmental issues in our community, we came across the important health hazards faced by our community as a result of carbon emissions. We reached out to Dr. Neelima Tummala, ENT (Ear/Nose/Throat) physician and a member of the Virginia Clinicians for Climate Action [3].

Dr. Tummala gave a good insight on what carbon emissions does to the environment and to the people. We asked her questions related to health impacts of carbon emissions (Outreach_Questions.pdf). Dr. Tummala gave valuable feedback saying that the reduction in carbon emissions affects the air quality. She also mentioned that the reduction in carbon emissions affects the global temperature scale. The reduction in carbon emissions leads to the reduction of direct health impacts such as allergies and indirect impacts due to ecoanxiety, depression, sucide rates, posttraumatic stress disorder from the loss of family or homes from natural disasters, and the extinction of animals from the increased global temperature.

Dr. Tummala also gave extremely valuable feedback about our solution and the impacts it may have on humans. She gave good insights about our coating materials, and even suggested using compost as a coating material, as it has good nutrient value as well. We asked Dr. Tummala if our solution would have a direct impact towards human health. She explained that climate change has many detrimental effects on humans such as allergy induced asthma, mental health diseases, vector borne diseases, etc. Our solution is geared towards absorbing CO_2, which will help reduce this impact of climate change. In addition, our solution would also encourage people in urban areas to grow plants around their homes which will positively impact mental health, and increases awareness about the need for carbon sinks.

2. **Mr. Dan Schwartz**
   Soil Scientist
   Northern Virginia Soil & Water Conservation District
   Ms. Ashley Palmer, Ms. Meredith Keppel
   Conservation Education Specialists
   Northern Virginia Soil & Water Conservation District

While researching Northern Virginia programs that promote soil enhancement & conservation, we came across the Northern Virginia Soil & Water Conservation District [39]. We reached out to Ms. Palmer, Ms. Meredith Keppel and Mr. Schwartz who are Soil & Conservation Specialists.

Mr. Schwartz, Ms. Palmer, Ms. Keppel gave valuable feedback and insights on our project. We presented our experimental design and solution, and they affirmed that it was scientifically correct. They also confirmed that our coating materials used in the experiments were valuable to CO_2 absorbers. We were very happy with their positive feedback about our solution.

Mr. Schwartz suggested compost as an additive to our solution as it has many vital nutrients for the soil. In addition to giving feedback on our experiment, they also gave feedback on furthering the implementation of our solution. They suggested that adding these pellets in county wide landscaping would allow us to gain a larger reach. However, there was an issue which is that our solution could be washed off as stormwater runoff. They explained that we would have to aerate the soil and lawn (creating holes down into the soil to alleviate compaction) so air, water, and nutrients can reach the roots. We would have to aerate the soil then put our additives to retain our pellets. This tremendously helped our project since we were unaware of this. Mr. Schwartz guided us with good websites and other resources to research more into this topic. Ms. Palmer gave us good insight on whom to approach to implement this in our district, and other resources regarding spreading awareness about our research and solution.

We are very excited to take our solution to the next step, we are reaching out to our Fairfax county and district level resources and would like to implement our solution to create urban carbon sinks in Fairfax county. We are very thankful for the feedback from Dr. Tummala, Ms. Palmer, Mr. Schwartz for their valuable feedback and are looking to take our solution to the next step.

Online meeting with Dr. Neelima Tummala

Presenting our solution to the professionals to solicit their feedback

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3. **<u>Question: What did you find out about your problem that you didn't know before? What kinds of experiments have been done by other people before you? Be sure to put this in your OWN words, do not just copy And paste information. Also, be sure to cite your sources.</u>**

Below are some of the important concepts we learned while researching carbon emissions.

<u>Carbon Sequestration</u>:
Carbon sequestration is the process of capturing and storing CO_2. There are three types of carbon sequestration; Biological Carbon Sequestration, Geological Carbon Sequestration, and Industrial Carbon Sequestration. Biological Carbon Sequestration is a nature made carbon sink. Geological Carbon Sequestration is when carbon dioxide is stored in underground geologic formations. Industrial sources of carbon dioxide, such as steel production companies or energy-related sources, will release their carbon dioxide which is injected into porous rocks for storage. These are all different methods of carbon sequestration [13].

<u>Carbon Sinks:</u>
Carbon sinks are natural or artificial reservoirs that absorb and store carbon dioxide. They remove excess carbon dioxide from the atmosphere. The biggest carbon sink is the ocean.
The main carbon fixers in the oceans are phytoplankton and blue green algae, which absorbs CO_2 during the photosynthesis process. Oceans by itself absorbs about 30 to 50% of the CO_2 produced by burning fossil fuel [15]. In 2017, oceans absorbed 2.6 billion tons of carbon from human activities [14]. However, the problem relying on natural carbon sinks is that they have a limit; the ocean is now acidifying because of the excess amounts of CO_2 in the ocean. The acidification of

the oceans negatively impacts species such as corals, algae, shellfish, mollusks. We then researched another important carbon sink which is soil. As mentioned above, soil is a powerful carbon sink storing up to 2,500 gigatons of carbon [10]. Our solution is to create a soil based carbon sink.

Regenerative farming:

Regenerative agricultural practices are being researched to slowly enhance and transform the topsoil from a carbon contributor to a carbon sequester. This is done by building organic matter back into the soil (Soil organic matter or SOM), improving its ability to store carbon. For example, farmers are adding cow manure [16] as a fertilizer to their soil. Cow manure is rich in nitrogen, potassium, phosphorus, and is an effective carbon sequester. Farmers found that by adding cow manure to their soil, the soil quality and nutrient value tremendously increased. Additionally, farmers found that cow manure keeps weeds from invading their soil and pasture.

Another trend we learned that is becoming popular among regenerative farmers is biochar. Biochar is a carbon-rich charcoal which can boost soil carbon storage. Not only does biochar increase absorption of CO_2 in the soil, but it can also increase crop productivity and stabilize crop production.

We also learned that scientists are looking into restoring peatlands and wetlands, which help to absorb large amounts of CO_2 and greenhouse gases. Peatlands are carbon-dense environments that are made of partially decomposing organic matter, similar to SOM. Peatlands and wetlands cover just 3% of the world's surface but hold up to a third of the global soil carbon [16].

Existing Solutions:

There are many steps taken both at national and international level to combat carbon emissions. The Paris Agreement mandates the reduction of greenhouse gases globally. The US Federal Government's Environmental Protection Agency and Department of Energy is funding many programs towards research and development of clean energy solutions such as Natural Energy Star and Hydrokinetic turbine development [17].

Carbon dioxide removal includes natural as well as industrial processes. The natural methods include afforestation and agricultural practices that sequesters carbon. The other methods that have been used in the industries are bio energy carbon capture and storage, direct air capture, and ocean fertilization.

During industrial processes, the biomass (ex - burning of fossil fuels) releases carbon dioxide. Carbon capture and storage technology is used to intercept the release of CO_2 by using a series of chemical filters, and the CO_2 released is redirected to geological storage solutions. These are solutions used by the industries to reduce CO_2.

In order to reduce the amount of CO_2 factories emit, industries have resorted to Direct Air Capture (DAC) [18]. Direct Air Capture technology captures carbon dioxide from the source through a series of chemical reactions. Ambient air makes contact with chemical media, which is stripped of CO_2. However, this has its drawbacks. First of all, DAC is extremely expensive, ranging at $600-$800/ton [36]. We need a cost effective solution in order for the solution to be widespread. DAC uses chemicals and equipment which is mainly for industrial purposes.

As mentioned above, one of the main carbon sinks in the world is the ocean. Scientists are researching ways to increase the carbon sinks in the ocean. They are conducting experiments to increase the amount of phytoplankton in the ocean with iron called iron fertilization [37].

Experimental Design

Experimental Design:

1. **Question: Based on the question you are trying to answer, and your research, what is your team's hypothesis for this investigation? Be sure to include the independent and dependent variables and how they are related along with evidence of your research.**

Our mission is to create pellets that contain environmentally safe, cost effective CO_2 absorbing materials. In order to create CO_2 absorption pellets, we researched various CO_2 absorbers and performed an experiment to see which ones would yield the highest CO_2 absorption and plant growth. The materials with the highest yields would be used in our final solution.

Based on our research, we found that **Zeolite**, a natural aluminium silicate mineral, is extensively used as commercial adsorbents and catalysts [38]. Zeolite membranes are currently being used in industries for water purification, softening, ion-exchange beds, and post CO_2 combustion capture especially in the petro-chemical industries. Zeolite is also very porous, which helps with the absorption of CO_2. Zeolite is used in household products like cat litter and fish aquariums to absorb odors and harmful toxins. Since zeolite is environmentally safe, we wanted to explore if zeolite, when added to soil, would aid the absorption of CO_2 in the soil.

For our experiment, we researched into different **coating materials** that can be coated on top of zeolite to enhance CO_2 absorption. This is because zeolite on it's own is expensive, starting at $23 per bag (cat litter form). We wanted our carbon enhancers to be cost-effective and easily blend with available garden compost and other materials. In order to decrease the cost of zeolite, we wanted to increase the volume, by adding coating materials. We researched into different materials including Clay, Cow Manure, and Mycorrhizal fungi. However, we could not use Mycorrhizal fungi due to safety guidelines. We then focused on Clay and Cow Manure as our coating materials. Studies have shown that Cow Manure [39] has helped in regenerative agriculture, and has shown to help with carbon sequestration. Clay has shown to be an effective carbon absorber and retains essential nutrients in the soil. For these reasons, we chose to experiment with zeolite, clay, and cow manure.

Experimental Design for Enhancing Carbon Sinks in Urban Environments

Experiment 1: The Effect of the Types of CO_2 Absorption Materials on the CO_2 Levels in the Soil at the Surface Layer, 1 Inch Deep, and 3 Inches Deep.

Independent Variable: Type of CO_2 Absorption Material / Coating materials

Levels of Independent Variable:
Level 1 (control): Only Soil [100 g]
Level 2: Zeolite [100 g]
Level 3: Zeolite [100 g] + Clay [100 g]
Level 4: Zeolite [100 g] + Cow Manure [100 g]

Dependent Variable: CO_2 Absorption [pH level]
Experiment 1a: Measured at Surface Level
Experiment 1b: Measured at 1 inch deep into the soil
Experiment 1c: Measured at 3 inches deep into the soil

Hypothesis: If Zeolite coated with Cow Manure is added to the soil, then the amount of CO_2 in the soil will be the highest amount amongst all other coating materials at all 3 levels (surface, 1 inch, 3 inches).

Justification: This is because Zeolite can absorb vast amounts of CO_2 in a short period of time. Additionally, the Cow Manure is an effective carbon sequester and commonly used in regenerative farming.

Experiment 2: The Effect of the Types of CO_2 Absorption Materials on the Quality of Grass Growth.
Why: Since we plan to add the zeolite with coating materials on lawns, we wanted to test if the materials will help with lawn growth and enhancement of the nutrient value.

Independent Variable: Type of CO_2 Absorption Material / Coating materials

Levels of Independent Variable
Level 1 (control): Only Soil [100 g]
Level 2: Zeolite [100 g]
Level 3: Zeolite [100 g] + Clay [100 g]
Level 4: Zeolite [100 g] + Cow Manure [100 g]

Dependent Variable: Quality of Grass Growth

Experiment 2a: Shoot to root length [cm] - Shoot to root length is the length from the bottom of the root tip to the top of the grass blade
Experiment 2b: Density [# of blades / cm^2] - Density is is defined as the number of blades present in a square centimeter of soil

Hypothesis: If Zeolite coated with Clay is added to the soil, then both shoot to root length and density of the grass will be the highest amongst all other coating materials.

Justification: This is because Zeolite has rich nutrient properties. Additionally, clay can hold vast amounts of water and contains nutrients.

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2. **<u>Question: Identify the independent and dependent variables in your investigation</u>**

Experiment 1: The Effect of the Types of CO_2 Absorption Materials on the CO_2 Levels in the Soil at the Surface Layer, 1 Inch Deep, and 3 Inches Deep.

Independent Variable: Type of CO_2 Absorption Material / Coating materials

Levels of Independent Variable:
Level 1 (control): Only Soil [100 g]
Level 2: Zeolite [100 g]
Level 3: Zeolite [100 g] + Clay [100 g]
Level 4: Zeolite [100 g] + Cow Manure [100 g]

Dependent Variables: CO_2 Absorption [pH level]
Experiment 1a: Measured at Surface Level
Experiment 1b: Measured at 1 inch deep into the soil
Experiment 1c: Measured at 3 inches deep into the soil

Experiment 2: The Effect of the Types of CO_2 Absorption Materials on the Quality of Grass Growth.

Independent Variable: Type of CO_2 Absorption Material / Coating materials

Levels of Independent Variable:
Level 1 (control): Only Soil [100 g]
Level 2: Zeolite [100 g]
Level 3: Zeolite [100 g] + Clay [100 g]
Level 4: Zeolite [100 g] + Cow Manure [100 g]

Dependent Variable: Quality of Grass Growth
Experiment 2a: Shoot to root length [cm] - Shoot to root length is the length from the bottom of the root tip to the top of the grass blade
Experiment 2b: Density [# of blades / cm^2] - Density is is defined as the number of blades present in a square centimeter of soil

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3. **<u>Question 3: What are the constants in your investigation?</u>**

Procedure
- Duration of the experiment before recording data for CO_2 absorption - 24 hrs
- The process of generating the CO_2 as given in Experimental Process
- Location of experimental environment - House Garage/ Passage leading to house garage
- CO_2 Measuring Procedures - Rapitest pH soil indicator
- Experimental environment - Clear plastic storage bin
- Data recorder - Same team member (Veda) recorded the data

Materials
- Baker's yeast for CO_2 production - 7gms
- Temperature - 72° F
- Soil - 6kg RSSY(Rock stone and soil) topsoil
- Amount of air exposure - sealed plastic bin for CO_2 absorption experiments
- Volume of bin - 70 Quart ultra bin
- Brand of Zeolite (in the form of cat litter) - All-Natural Kitty Litter (Home Depot)
- Brand of Clay - RED Soil Dirt Clay Georgia
- Brand of Cow Manure - Composted Cow Manure (Home Depot)

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4. **<u>Question 4: Will your investigation have a control group? If so, describe the control group. If not, why not?</u>**

The control group for both groups of experiments is topsoil [100 g] without any CO_2 absorption material. We chose this level of IV as the control group because we will measure the effectiveness of CO_2 absorption materials by comparing it to the results of no CO_2 absorption materials.

Experimental Process

Experimental Process

1. **Question: List all of the materials you used in your experiment. Be sure to include all physical materials as well as any technology or website used to collect data (not websites you used in your research).**

a. Safety equipment	b. Materials used in the experiment	c. Technology/Stationary
1. Gloves (Garden gloves, rubber gloves) 2. K95 Face masks 3. Goggles 4. Full arm clothing 5. Closed-toed shoes 6. Ventilated area	1. Baker's Yeast (Active dry yeast 7gms) 2. Zeolite - All-Natural Kitty Litter (home depot) 3. Clay - RED Soil Dirt Clay Georgia 4. Cow manure - Composted Cow Manure (home depot) 5. Topsoil - RSSY (Rock stone and soil) from Home Depot 6. Rubbermaid Container (Banker's box 11cm L x 14 cm W x 8.5cm H) 7. Sterilite storage boxes (14cm L x 8cm W x 4.5cm H) 8. Plastic Cups, stirrers, plastic container, plate 9. Plastic sheet 10. Rapitest pH indicator 11. Kitchen Scale 12. Garden shovels 13. Thermometers (soil, water) 14. Water 15. Icing Spatula	1. Laptops 2. Google Chrome 3. Google Sheets 4. Google Docs 5. Google Photos 6. Stationary: Pens, Papers, books, Pencil, ruler 7. Zoom video conferencing for meetings and calls with professionals 8. iPhone to take pictures

Table 1. List of all the materials used.

2. **<u>Question: Explain your experimental process. Be sure to list all of the steps and ALL SAFETY PRECAUTIONS for your experiment. Remember to write it so someone else could follow the steps and recreate your experiment.</u>**

We designed and conducted two sets of experiments to achieve our goal of enhancing carbon sinks in the urban environment. Below is the overview of the procedures for each experiment.

<u>Experiment 1</u>: The Effect of the Types of CO_2 Absorption Materials (Coating Materials) on the CO_2 Levels in the Soil at the Surface Layer, 1 Inch Deep, and 3 Inches Deep.

1. Safety Procedures and Protocols used in all the experiments
2. Preparing soil containers
3. Adding Zeolite + CO_2 Absorption Materials for each level of IV
4. Testing and collecting data for CO_2 Absorption at the 3 levels in the soil
5. Repeating procedures for 3 trials

<u>Experiment 2</u>: The Effect of the Types of CO_2 Absorption Materials (Coating Materials) on the Quality of Grass Growth.

1. Safety Procedures and Protocols used in all the experiments
2. Preparing soil containers with grass
3. Adding Zeolite + CO_2 Absorption Materials
4. Testing and collecting data for shoot to root length and blade density.

Below are the details:

1) **Safety Procedures and Protocols used in all the experiments:**
   We made sure that we used full safety equipment as listed in Table 1. We wore safety goggles, masks, closed-toed shoes and full arm clothing. We did most of the experiments in the garage / ventilated passage leading to the garage with the garage door open to ensure there is enough air circulation and a constant environment.

2) **Detailed procedure to conduct the experiments:**

<u>Experiment 1 Procedures: The Effect of the Types of CO_2 Absorption Materials (Coating Materials) on the CO_2 Levels in the Soil at the Surface Layer, 1 Inch Deep, and 3 Inches Deep.</u>

Step No.	Objective	Task Description	Materials
1	<u>*Work in a safe manner*</u>	Wear safety gear listed in Table 1 while conducting the experiments	Safety glasses, face masks, gloves, full-sleeved

			clothing, and closed-toe shoes in a garage or open environment
2	<u>*Preparation of container*</u>	1. Place a plastic sheet on the table 2. Place a dry rubbermaid container (dimensions: Table 1) 3. Measure 6 kg of topsoil 4. Add the topsoil in the rubbermaid container 5. Make sure the container is sealable *All measurements are done using the Kitchen scale. For liquids a glass beaker is used.*	Plastic sheet to spread on the floor, Rubbermaid, topsoil, Kitchen scale, container,
3	<u>*Baker's yeast to produce CO_2*</u>	1. Add the packet of Baker's yeast in a cup 2. Measure and add the 50gms of sugar to the same cup 3. Use a beaker to measure 100 mL of water 4. Heat the water in the microwave and make sure the temperature is 79°F using a thermometer 5. Add water into the cup containing sugar and yeast and stir 6. Place the cup in the rubbermaid container with soil 7. Repeat the above steps for 3 more containers (total of 4 containers) 8. For the additional 3 containers, add Zeolite, Zeolite + Clay, and Zeolite + Cow Manure in accordance with the <u>*Zeolite Additional Procedures*</u> section below 9. Make sure the rubbermaid container is sealed 10. Once the yeast and sugar have dissolved, the bubbles are produced as the yeast produces carbon dioxide 11. Let the sealed container sit for 24 hours 12. Test the CO_2 absorption levels in accordance with the <u>*Procedure to test CO_2 absorption*</u> below 13. Repeat 3 times for 3 trials	Baker's yeast, soil Water, sugar, cup, stirrer, measuring beaker, thermometer, zeolite, clay, cow manure

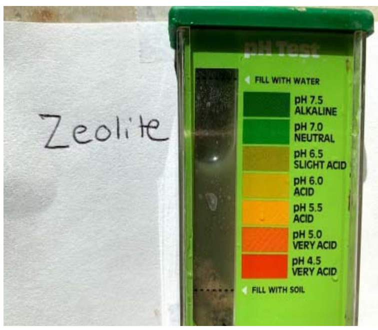


Zeolite Additional Procedures			
Procedure	**Objective**	**Task Description**	**Additional Materials**
Zeolite	Prepare container for Zeolite only	1. Measure Zeolite [100 g] using a kitchen scale and spread it on the soil evenly 2. Cover it with 50 gms of soil on top	Zeolite, plastic container, stirrer/fork
Zeolite + Clay	Prepare container for Zeolite + Clay	Make Zeolite + Clay pellets 1. Measure 100 g of zeolite using a kitchen scale and add to a plate 2. Measure 100 g of clay and add it to the plastic container with zeolite 3. Add 50 mL of water to the plate and mix zeolite and clay with water using a stirrer/fork and make round pellets (2 cm to 5 cm across - size of a small golf ball). Make sure zeolite + clay is compacted 4. Make 15 pellets and add this to the soil	Zeolite, clay, plate, stirrer/fork
Zeolite + Cow Manure	Prepare container for Zeolite + Cow Manure	Make Zeolite + Cow Manure pellets 1. Measure 100 g of zeolite using a kitchen scale and add to a plate 2. Measure 100 g of cow manure and add it to a plate with zeolite 3. Add 50 mL of water to the plate and mix zeolite and cow manure with water using a stirrer/fork and make round pellets (2 cm to 5 cm across - size of a small golf ball). Make sure zeolite + cow manure is compacted.	Zeolite, cow manure, plastic container, plate, stirrer/fork

		4. Make 15 pellets and add this to the soil	

From left to right: 1) Team members performing the experiments, 2) Sealed rubbermaid containers with zeolite, zeolite + clay, zeolite + cow manure, 3) Zeolite + Clay Pellets, 4) Zeolite + Cow Manure Pellets

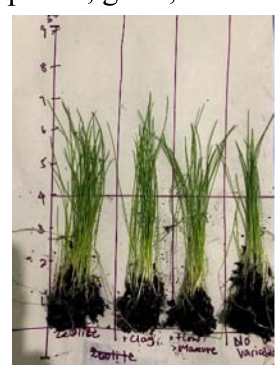
Procedure to test CO_2 absorption			
Step No.	**Objective**	**Task Description**	**Materials**
1	*Collecting the Soil Sample at 3 different levels*	Surface layer: 1. Using a tablespoon collect the topsoil from the rubbermaid container 2. Measure 50gms of the soil 1 inch deep: 1. Measure 1 inch depth in the soil using a ruler 2. Collect topsoil from the container 3. Measure 50 gms of the soil 3 inch deep: 1. Measure 3 inch depth in the soil using a ruler 2. Collect soil at that depth from the container 3. Measure 50 gms of the soil	Soil, container, table spoon, measuring scale, kitchen scale, ruler
2	*Procedure to test the soil sample*	1. Put the measured amount of experimental soil (1 cm) into the pH rapitest kit indicator	Experimental soil, distilled water,

		2. Put the measured amount of water into the soil 3. Add the pH rapitest kit tablet into the water 4. Shake for 10 seconds 5. Leave this for 3 min 6. Analyze the results using the below row	Rapitest pH indicator kit
3	*Ensure Veracity of Results*	1. To analyze results: The more acidic the solution is, the more CO_2 is absorbed, thus it should be ideally 7 pH or below	Pencil, paper, Rapitest pH indicator kit
	 pH Rapitest results for Zeolite + Clay	 pH Rapitest results for Zeolite + Clay	 pH Rapitest results for Zeolite + Clay

Experiment 2 Procedure: The Effect of the Types of CO_2 Absorption Materials (Coating Materials) on the Quality of Grass Growth.

Step No.	Objective	Task Description	Materials
1	*Work in a safe manner*	Wear safety gear mentioned above while conducting the experiments	Safety glasses, face masks, gloves, full-sleeved clothing, and closed-toe shoes.
2	*Grass with Only Soil*	1. Measure 550 g of topsoil using kitchen scale 2. Spread it across the bottom of the sterilite container 3. Measure 50 g of grass seeds in a cup using Kitchen scale 4. Spread it on the soil, cover it with a layer (1 inch) of soil 5. Water the container and leave it covered in a sunny location for 10 days	Soil, grass seeds, Kitchen scale, sterilite container, plastic cup, water
3	*Grass with Zeolite*	1. Measure 550 g of topsoil using kitchen scale 2. Spread it across the bottom of the sterilite container 3. Measure 150 g of zeolite using kitchen scale 4. Add this to the soil 5. Cover a layer of soil (1 inch) on top 6. Measure 50 g of grass seeds in a cup using Kitchen scale 7. Spread it on the soil on top of the zeolite layer, cover it with a layer of soil (1 inch) 8. Water the container and leave it covered in a sunny location for 10 days	Zeolite, soil, grass seeds, testing environment, Kitchen scale

4	*<u>Grass with Zeolite + Clay</u>*	1. Measure 550 g of topsoil using kitchen scale 2. Spread it across the bottom of the sterilite container <u>Make Zeolite + Clay pellets</u> 4. Measure 100 g of zeolite using a kitchen scale and add it to a plate 5. Measure 100 g of clay and add it to a plate 6. Add 50 mL of water to the plate and mix zeolite and clay with water using a stirrer/fork and make round pellets (2 cm to 5 cm across - size of a small golf ball). Make sure zeolite + clay is compacted. 7. Make 15 pellets 8. Add the pellets to the soil 9. Measure 50 g of grass seeds in a cup using Kitchen scale 10. Spread it on the soil on top of the zeolite + clay layer, cover it with a layer of soil (1 inch) 11. Water the container and leave it covered in a sunny location for 10 days	Zeolite, clay, soil, grass seeds, testing environment, scale, plastic container, plate, cup, fork
5	*<u>Grass with Zeolite + Cow Manure</u>*	1. Measure 550 g of topsoil using kitchen scale 2. Spread it across the bottom of the sterilite container <u>Make Zeolite + Cow Manure pellets</u> 4. Measure 100 g of zeolite using a kitchen scale and add it to a plate 5. Measure 100 g of cow manure and add it to a plate 6. Add 50 mL of water to the plate and mix zeolite and cow manure with water using a stirrer/fork and make round pellets (2 cm to 5 cm across - size of a small golf ball). Make sure zeolite + cow manure is compacted. 7. Make 15 pellets 8. Add the pellets to the soil 9. Measure 50 g of grass seeds in a cup using Kitchen scale	Zeolite, cow manure, soil, grass seeds, testing environment, scale, plastic container, plate, cup, fork

		10. Spread it on the soil on top of the zeolite + cow manure layer, cover it with a layer of soil (1 inch) 11. Water the container and leave it covered in a sunny location for 10 days	
			
6	*<u>Collecting data for shoot to root length.</u>*	1. Take a white sheet of paper and mark one inch on x and y axis with a ruler 2. Mark each level of the IV on the x-axis 3. For each container (level of IV), carefully take a sample of grass with both shoot and root 1 cm by 1 cm of soil 4. Place the grass sample on the white sheet of paper on the x-axis 5. Take measurement from the tip of the root to the tip of the shoot 6. Record the measurements	Icing Spatula, white sheet of paper, pencil, grass, ruler 
7	*<u>Collecting data for blade density.</u>*	1. For each container (level of IV), carefully take a sample of grass with a spatula both shoot and root 1 cm by 1 cm of soil Place it on the white sheet of paper 2. Count the number of grass blades in the sample 3. Record the data of number of grass blades	White sheet of paper, grass, spatula 

How to use effective carbon sequesters in your plants:
By: Veda Murthy and Varsha Gunda

Hello! Did you know that in 2019, about 36.8 billion metric tons of Carbon Dioxide was produced? This increase in CO_2 has had numerous effects on the planet, from rising sea levels to increases in hurricanes and tsunamis. Soil stores about 2,500 gigatons of Carbon Dioxide. However, in urban environments, topsoil is being excavated for urbanization.

Our solution uses cost-effective materials to enhance the soil and help the soil effectively absorb CO_2. One main material that we use in our solution is cat litter, it contains aluminum silicate, which is used in industries for CO_2 absorption. In addition to cat litter, we also used clay and cow manure, which has nutrients that are vital to the soil.

We have provided samples of our solution for all of you. Using our solution is very simple - all you need to do is add these pellets to a plant, and you will see an increase in the plant growth. We hope you enjoy this process, and if you want to continue, just reach out!

<u>Mission verification:</u>
<u>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.</u>

We are team CQuestrators. We identified the problem of the increase in carbon emissions in our community due to urbanization, burning of fossil fuels, and cutting down trees. This impacts our community with rising sea levels and increase in health issues in addition to the global impact. We conducted extensive research on different ways to mitigate this problem. We researched carbon sinks, which are natural or artificial reservoirs that absorb vast amounts of CO_2. Oceans are the planet's main carbon sink, but soil (specifically the microorganisms in the soil) is also an essential carbon sink. In urban environments, trees are being cut down and soil is being excavated, liberating trapped CO_2. Our community needs a solution to help absorb carbon emissions.

We took a two-pronged approach to reduce carbon emissions. **1) Increase local carbon sinks** and **2) Increase awareness of the problem**. We researched eco-friendly materials that absorb carbon to be effective carbon sinks. We considered Zeolite as it is used in the industry for carbon sequestration. We then thought of coating zeolite with materials such as cow manure and clay to make this more cost-effective. Using the scientific inquiry method, we created our solution - **Carbon Sink Pellets**. To increase awareness of the problem, we shared our carbon sink pellets with neighbors, and they were thrilled to use our solution in their lawns to make an impact on the carbon footprint! Our next step is to take our carbon sink pellets and implement it at a county-wide level.

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From: Neelima Tummala

Date: February 26, 2021 at 10:49:28 AM EST

Subject: Re: eCybermission project feedback

Hi Veda-

Thank you for the email! Do you have time today to chat? I am free until 2:30pm.

If not, tomorrow anytime before 10am or from 12-4pm, I am available. I am also free all day Sunday. Let me know and I can call you then!

Neelu

From: Veda Murthy

Sent: Thursday, February 25, 2021 9:18 AM

To: Neelu Tummala

Subject: eCybermission project feedback

Good morning Dr. Tummala,

My name is Veda Murthy, and I am a 7th grader from Fairfax County. I am working on a project for eCybermission, which is a US army sponsored program. In this, we have to pick an issue in our community and come up with an innovative solution to solve it. This year, I am working on ways to reduce carbon emissions in our community. I came across your petition to Fairfax county on how carbon emissions are affecting both the mental and physical health of children and adults. I would like to discuss more about this with you and also get some feedback on my project. I would really appreciate it if we can meet over the phone anytime this week! If you have some time tomorrow to talk to us, that would be great. Thank you!

Best regards,

Veda Murthy

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Veda,

Dan and I were very impressed by your project last year, and it's very nice to hear from you again!

We’re holding most of our meetings on Webex now, so if that platform works for you, I can schedule a meeting for us. I took a look at my calendar for when I thought you might be available after school, and I could meet next week on March 1, 4, or 5 anytime 3-5pm. I’m unsure if my coworker’s schedules will allow them to join us, but I’m including Dan Schwartz, our soil scientist (who you’ve met) and Meredith Keppel, a member of the education and outreach team, on this email in case they’re able to attend the meeting time that works for you.

Best,
Ashley

Ashley Palmer
Conservation Education Specialist
Northern Virginia Soil & Water Conservation District

From: Veda Murthy
Sent: Tuesday, February 23, 2021 12:35 PM
To: Palmer, Ashley ; Schwartz, Daniel
Subject: eCybermission project feedback

Hi Ms. Ashley and Mr. Daniel,

How are you? My name is Veda Murthy, and I am a 7th grader. I had met you both last year regarding our food composting project as a part of eCybermission challenge. This year, I am working with my partner Varsha Gunda. My partner and I are working on enhancing carbon sinks in the urban environment. We would like to share our project with you and get your valuable feedback.
Appreciate if you can please let us know if you are available sometime this week for a phone call?

Looking forward to hearing from you,
Veda Murthy
7th grade
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Dr. Tummala: 2/27

1. Feedback
2. Medical impact - within carbon sinks homes, will this help with aeration? Do you think it would help? Would it have any harmful impact?
    a. Air pollution - the air quality → asthma
    b. Indirect impact → decreasing climate change → less wildfires and air pollution/natural disasters→ less asthma
    c. Cardiovascular health → correlation between heart disease
    d. Mental health disease → extreme heat → increased risk → increased anxiety, depression,
    e. Mental health → more natural disaster → post traumatic stress disorder
    f. Mental → people being worried about climate change
    g. Vector borne diseases
    h. Allergies
3. In your opinion, what other materials are safe and could be alternatives?
    a. Compost → nutrients
4. What programs are in place currently from the VA government to help reduce CO2 emissions at community levels?
    a. Transportation → improving number of electric vehicles
    b. Hospitals → improving hospital waste
    c.
5. How significant of a problem do you think Carbon emissions are in Northern Virginia?
    a. 2nd largest emitter in the world
6. Did you see a reduction of asthma and other environmental cases in 2020 due to less human activity?
7. Do you think awareness is an issue in Northern VA? If so, what is currently being done about it?
8. Are you aware of any initiatives being done to reduce emissions at a household level
    a. Giving input → changing out lightbulbs etc
    b. Virginia banned styrofoam
    c.
9. Do you specifically recommend anything to do around the house to reduce asthma triggers?
    a. Improving environment → dusting, removing mold, regular cleaning, air purifiers
    b. Decreasing dust and moles, more air pollution rather than carbon emissions
        i. Regular Cleaning, and mainly about allergies.
        ii. Burning Gasoline, or smog from natural disasters
        iii. Not on a carbon level
10. Is there a direct impact between CO2 and humans?
    a. We have a way to monitor the health impacts.
    b.
11. ***<u>RGGI</u>***
12. Transportation and climate initiative

Removing carbon does not remove particulate air pollutants

- Cardiovascular Health (heart disease)
- Global Warming
    - Mental health disease
        - Extreme heat is associated with mental illness
            - Anxiety, depression, suicide rate related to global temperature increasing
            - More natural disasters
                - Post traumatic stress disorder because of the loss of people or loss of their home and lifestyle.
            - EcoAnxiety
                - People are concerned over the global temperature causing stress in younger people about the future.
    - Mind diseases
- Spreading diseases such as mosquitos.
    - Or other animals that are changed from the global temperature
- Allergies, global
    - Pollen
- Global Impact, not just neighborhoods
- Coating Materials
    - Compost
        - Nutrient rich like cow manure
        - Also helps with waste control
        - Cheap
- Other Programs to reduce Carbon Dioxide
    - Transportation factor
        - Clean cars
    - Medical Standpoint
        - Healthcare sector
            - Some hospitals are initiating sustainability
            - Inova healthcare, specific for designated hospitals
            - Usually waste problems
                - Unnecessary Equipment
    - Banned Styrofoam
- HouseHold Level
    - Specific, designated for each family
        - Water bills, electricity bills
    - Not mandated
        - Save money
        - Decrease the amount of waste you have
        - Recycling
    - Not on a global scale
        - None of these are actually solutions to help on a global scale

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Ms. Ashley, Mr. Dan: 3/1

Conservation Education Specialist

Northern Virginia Soil & Water Conservation District

1. What are some of the problems you are seeing in the field as a result of Carbon emissions?
2. What is your feedback about our solution?
3. Do you think it is feasible and can be easily adopted?
    a. Aeration - add this while airaiding. Maybe for new homeowners.
    b. Education - educate more, explain more couple steps. Conclusion slide - tie back to the main theme.
    c. Marketed as an additive - commercial supply and composted manure - we have a little zeolite added
    d. Aeration, so the zeolite on top doesn't just fall into the nearest river. Aeration is a solution.
    e. Talk more about the chemistry of Zeolite and cow manure, and make it more pleasing to the eye. And easy to understand and comprehend.
    f. Why does it help me? What does it do for me?
4. What are some of the county resources that we can avail of to make this feasible?
    a. Landscaping companies - offers aeration
    b. Rent an aerator
    c. Gardens, garden beds
    d. Aeration has been used by millions of landscaping companies
        i. https://www.pennington.com/all-products/grass-seed/resources/why-aerate-your-lawn#:~:text=Aeration%20is%20good%20for%20lawns,%20but%20it%20can,fill%20in%20areas%20where%20aerator%20equipment%20exposes%20soil.
    e. https://fungi.com/blogs/articles/permaculture-with-a-mycological-twist
    f.

Soil is not absorbing - the microorganisms (need to specify)

Porosity - zeolite absorbing

Chemical reactions - look more research

Secure in the soil - plant stakes

a. Lay out thin blanket of compost
b. Soil airaid
c. Incorporate better into the soil
d. Change mix - composted manure

Rooftop

a. Yes it is feasible for rooftop gardening

Coating Materials:

a. Compost
b. Hydromulching

This is an event that showcases student work in conservation. It is held during earth week and will be virtual, more info will be on the website soon and you may be interested in submitting your project: http://www.novaoutside.org/events/school-environmental-action-showcase/

Some basics on hydroseeding:
https://completelandscapingservice.com/our-services/hydroseeding-services/

Slides suggestion - visuals are very important, if you are speaking and use the slides as a supplement, you can take out some repetitive text - Ashley

Garden centers - ask for a trial run - merryfield
Compost producers - louden compost -
Cooperative extension - FCPS
Local chapters of master gardeners

You can find your local District Supervisor here:
https://www.fairfaxcounty.gov/boardofsupervisors/members-and-districts

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Outreach in the neighborhood:
Due to covid situation we could not meet the neighbors in person, we gave an informational text about carbon emissions in our area and its harmful effects in our community and the steps we are taking to mitigate the issue.

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QUESTION 1: How was your team formed? Was your team assigned or did you choose to work with each other?

Initially we had a four member team but due to other commitments of 2 members, two teammates were not unable to continue. This did not stop us from continuing with the eCybermission project as we were passionate about eCybermission and solving a problem in our community so we became a two member strong team! Veda & Varsha - The CQuestrators!

The two of us (Veda and Varsha) met in an online class outside of school, and we immediately became friends. We shared the same interests, and we found ourselves very STEM oriented and liked mathcounts, biology, chemistry, debate, etc. Since we had similar interests, we decided to work on eCybermission together. We also found it easier to collaborate outside of school because of the COVID situation. Solving the problem of increase in carbon emissions was an interesting topic for both of us, and we decided to work on this together. This was our first project together, and we both enjoyed working on it!

QUESTION 2: Provide a detailed description of each team member's responsibilities and jobs during your work on the Mission Folder

We both shared team responsibilities since we were a two person team. We shared the tasks of doing extensive research into the problem and solution, designing and monitoring our experiments, creating our presentations, working on the mission folder, etc. However, we leveraged our different strengths, and focused on different areas that we were interested in. Here are the areas that each of us focused on:

Veda (Darth Veda): Veda mainly focused on the research and came up with the problem that we would solve in our community. We both did the research when it came to choosing the project, but she came up with the final problem that our community was facing. She also came up with the concept of creating a carbon sink with locally available resources which is our solution.

Varsha (Chicken Little) - Varsha mainly helped with the experimentation aspect of this project. She researched techniques to test CO_2 absorption. She helped brainstorm the experimentation layout and the experimental design. We both researched on different coating materials to use and came up with the optimal materials to use in our experiments as a team.

QUESTION 3: Did your team face any problems working together? If so, how did you solve them? If not, why do you think you were able to work together so well?

When our team was formed, we had 4 students interested in the eCybermission project; however due to online school and other activities, two of them could not continue. The remaining two of us had to pick up quickly and complete the research and experiments. This was challenging as most other teams have 3-4 members, and we were a 2 person team.

Splitting up work was another challenge as a 2 person team. Usually, we both evenly divide the work. However, since we had strengths and differences, we saw that Veda was strong in research and data representation, and Varsha was strong in the Experimental Design Process. We used our strengths and differences for our advantage. Veda took lead on the data representation and researching, and reaching out to subject matter experts for feedback. Varsha took lead on the Experimental Design.

QUESTION 4: What were some possible advantages to working together as a team on this project? How would working as individuals have made this project more difficult?

Working together as a team benefited us in numerous ways. When we would brainstorm ideas, we could effectively communicate and provide feedback. We would use venn diagrams, mind maps, and charts. To some, working online is a challenge. However, our team found that working online is more effective. It is easier to organize thoughts, and is easier to collaborate on google docs and over zoom. Additionally, since we live relatively far from each other we found that meeting over zoom was more time effective.

Working together also helped distribute the workload for this project evenly. Every week, we would assign ourselves different topics to research upon and come prepared with research. This helped us cover more topics as well as gain knowledge on a variety of topics. We researched extensively in our independent variables (coating materials), as we wanted to find the optimal materials. For example, Veda found the material zeolite, and found all it's properties and its past usage in carbon sequestration. Varsha found more about clay and how it is good for water retention and nutrient value of the soil. This made our team and solution strong and backed up with research and evidence. Working together as a team is always fun!